DESERTIFICATION AND REHABILITATION

—— CASE STUDY IN HORQIN SANDY LAND

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PREFACE

Horqin Steppe is one of most important and largest rangeland areas in China.The most part of the steppe is located in the territory of Jirem Prefecture, Inner Mongolia. Some parts of Hinggan Prefecture, Inner Mongolia, Tongyu County in the west of Jilin Province and Zhangwu County in the northwest of Liaoning Province belong to Horqin Steppe. The protogenic natural landscape of Horqin Steppe was temperate sparse woodland rangeland in semi-arid zone. But because of fragile ecological environments, such as thick loose sand composition on surface, the frequence of strong winds in drought season and large gap in variance of annual precipitation, the consequences of excessive land use during last ten decades and other human activities for economic development caused the disequalibrium of ecosystem and started environmental degradation. The previous undulating sparse woodland rangelands were gradualy degraded and a landscape of interspersion of mobile dunes among semi-fixed dunes on surface where drift sands and blowout phenomenoa are frequent and land desertification process was developed in a progressive way. It is estimated that by comparison and analysis of air photos at end of 1950's and the end of 1970's different types of desertification-prone lands in Jirem Prefecture were enlarged from the 20% in the total land area in 1950's to 53.8% in the total land area in 1970's. Such desertification-prone lands are mainly concentrated in the dry-farming areas where grazing lands and rangeland were over cultivated and sandy steppe was much cropped. And in such areas, desertification-prone lands are widely spreading in the manifestations of soil erosion and spot-shaped sands or sand sheets.Meanwhile, in the areas where vegetated dunes were cultivated, grazing lands were overgrazed, fuelwoods were irrationally cut, dense sand sheets were enlarged and fixed dunes were reactivated, desertification - prone lands are spreading in a most severe way. The consequences of such two processes led the reducement of biomass of land and the decline of available land resources. In last more than 10 decades, 21,567 km^2 of land was lost due to the spread of desertification-prone lands, in which, 5.4% was entirely turned into bare mobile sands without any productivity, 17.6% was basically degraded without potential of productivity and 77% is fraught with risk of the loss of land productivity. Taking the dry-farming areas on the steppe where desertification-prone lands are on-going spreading as an example, in the case of misuse of land resources, the latent land desertification was enlarged and turned into the on-going land desertification. Along with the increase of the intensity, the yields of dry-farming land was decreased 30-40%. It is estimated averagely that farmers lost 15-20 RMB Yuan per ha.; we can calculate according to the lost areas of arable lands during last 25 years, Jirem Prefecture, in speaking of only land production, lost totally about 200,000,000 RMB Yuan.

The environmental degradation caused by the spread of desertification brings not only impacts on people's living environment and developments of agriculture and livestock, but also accelerate the land degradation of Horqin Steppe. These impacts harm the agricultural production in the west of Northeast China Plain. Therefore,this is a problem of ecological environment which should be carefully considered and controlled with suit artificial measures.

It should be pointed out that Horqin Steppe is situated in semi-arid zone with the characteristics of self-reversing ecological ability. Namely, when the excessive human pressures were dispelled, desertification-prone lands will be rehabilitated. Acceptable measures and rational utilization of land can not only guarantee the ecological, but also economic benefits. The pilot experiments on rehabilitation of desertification - prone lands in Jirem Prefecture can exemplify this effort. Therefore, before we start our researches on the process of desertification and the rehabilitation of desertification-prone land, some feasible studies for the pilot purposes on Horqin Steppe in Jirem Prefecture are significant both in scientific and practical aspects. Particularly, it is necessary to mention that the areas with great risks of land desertification in Northern China are mainly situated at the two sides along Da Hinggan Ling and at the transitional areas of dry-farming and steppe at the marginal parts of Inner Mongolian Plateau. In this transitional area,on the one hand,ecological environment is fragile and is easily be desertified, but on the other hand, this transitional area is characterised by high potential of agricultural and livestock productions and by the advantages of self-reversing ability in ecological aspect and the easiness of rehabilitation. This is a "dynamic area" to be furtherly desertified or rehabilitated. Desertification-prone land on Horqin Steppe is one of typical situation in this "dynamic area". The rehabilitative principles and methods we developed on the pilot experiments of desertification-prone land on Horqin Steppe are active and practical ones to be popularized in the whole region of the transitional areas of dry-farming and steppe in the semi-arid zone. This feasible study on desertification-prone lands on Horqin Steppe will be used as evidences to identify the successes of technique, economics and ecology which developed for rehabilitating desertification-prone lands in coming years.

The research was started during the period from 1981 to 1985. In fact, the pilot experiment on stablization of shifting sands along railway track in Naiman section from Beijing to Tongliao was began in 1972. Since 1981, after the stablization of shifting sands along Beijing-Tongliao Railway Track, regional integrated study was started dealing with the following topics: (1) Historical process of desertification , it refers the latent natural factors of the occurrence and development of desertification and the impacts on desertification from human activity and its developmental process during the historical period under the situation of fragile ecological environment; (2) modern process of desertification, it refers the process of the disequilibrium of ecology under excessive human influences during last ten decades; (3) physical process of desertification, it refers the process of the growth of desertification and its evoluation process which caused by drifting sands under wind force after the destruction of vegetation by human activity and the further development of desertification; (4) reversing process of desertification, it refers the process in which artificial measures are adopted and regulation of land use structure was made to rehabilitate the degraded and desertified lands for both economic and ecological benefits.These four processes, in fact,consist of an entire process of the occurrence, development, evoluation and rehabilitation of desertification-prone land and they are the key points of the research on desertification. Therefore, the methods we adopted include:integrated investigation and research, semi-fixed position ground observation, summary of people's experiences, comparison and analysis of air photos in different stages, and fixed position case study (as what we are conducting at Naiman Desertification Research Station). These methods are closely combined and adopted. Because our research work on desertification process and rehabilitation is recently started in Jirem Prefecture and more data are needed for further analysis and discussion of the techniques to control the disasters of desertification-prone lands in the region. All of the viewpoints in the publication are personal ones.

Chapter One. Distribution of Desertification-prone Land and Causes of Desertification

Jirem Prefecture in the Eastern Inner Mongolia is situated at transitional zone of Northeast China Plain and Inner Mongolian Plateau. The prefecture is noticed by its location in the interior of Horqin Steppe Geomorphic frame can be divided into three parts, as Fig.1 shows, namely Da Hinggan Ling (Great Hinggan Mt. Ranges) is northeast-southwest oriented to syncline and cross the northwest part of Jirem Prefecture;low mountains and loess hills span that the north fringes of the mountain ranges of Hebei and Liaoning span the south part of the prefecture; the inter-mountain areas of south and north mountains are the open plain of Xiliao River. The plain of Xiliao River is the principal part of arable land (occupy 73.1% of the total land area of the Prefecture. Table 1).The plain area is most serious area where desertification spreads uncotrolledly.

Table 1. Land Resources in Jirem Prefecture

Geomorphic unit	Land pattern	Area (ha.)	Percentage in total(%)
Medium-low Mts.	Hammock, hills	1385853	23
Hilly and terraces	Loess hills and terraces	235473	3.9
The Plain area of Xiliao River	Undulating dunes	3034880	50.4
	Inter-dune areas	553980	9.2
	Low terraces along rivers and flooded beachlands	785953	13.1
	Lakes and water catchment	24080	0.4
Grand Total		6020213	100.00

A. The Area of Desertification-prone Land and Its Distributive Characteristics.

According to air photos and ground observation (Table 2), the total area of deserti-

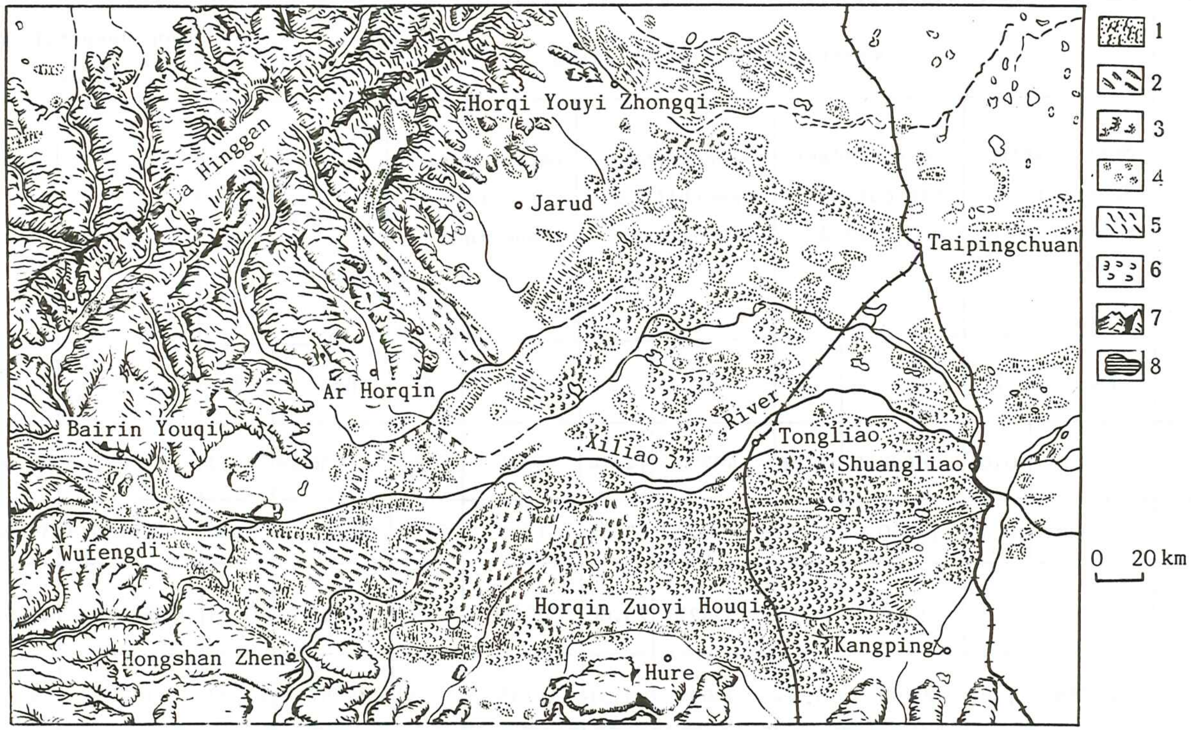


Fig. 1. Sketch Map of Horqin Sandy Land.

1. Mobile Barchans and Sand Ridges 2. Semi-fixed Longitudinal Dunes 3. Semi-fixed Honeycomb Dunes on Sand Redges 4. Semi-fixed Lush Vegetated Dunes 5. Fixed Longitudinal Dunes 6. Fixed Honeycomb Dunes on Sand Ridges 7. Mountain and Hills 8. Lake

Table 2. Statistics of Desertification-prone Lands in Every Counties of Jirem Prefecture, Inner Mongolia

Type / Counties	Desertification-prone lands										Non-desertified lands		Total area	
	Most severe desertification-prone land		Severe desertification-prone land		On-going desertification-prone		Latent desertification-prone land		Total		Area (ha.)	%	Area (ha.)	%
	ha.	%	ha.	%	ha.	%	ha.	%	ha.	%				
Tongliao	2110	0.61	6488.5	1.86	49253	14.14	57513	16.51	115364.8	33.12	232945.2	66.88	348310	100
Kailu	2023.8	0.47	13860.4	3.20	154007.5	35.61	117127.5	27.07	287019.2	66.36	145480.8	33.64	432500	100
Horqin Zuoyi Zhongqi	/	/	1764	0.18	255427	23.60	320269	32.98	577460	59.64	393680	40.54	971140	100
Horqin Zuoyi Houqi	21758	1.87	109758	9.45	696699	60.01	17357	1.50	845571	72.83	315379	27.17	1160950	100
Hure	19321	4.08	46249	9.77	142782	30.17	7679.5	1.63	216031	45.65	257199	54.35	473230	100
Naiman	72238	8.78	191269	23.23	194787	23.66	113521	13.79	571815	69.46	251455	30.54	823270	100
Jarud	/	/	11112	0.61	165754	9.16	446903	24.68	627769	34.45	1187041	65.55	1810810	100
Total of the Prefecture	117450	1.95	380500	6.32	1658710	27.55	1080370	17.95	3237030	53.77	2783180	46.23	6020210	100

fication-prone land is 3,237,030 ha. occupying 53.8% of the total land area of the prefecture. In which, the most severe desertification-prone land is 117,467 ha.occupying 2.0%, severe desertification-prone land is 380,533 ha. occupying 6.3%,on-going desertification-prone land is 1,658,733 ha. occupying 27.6%. That is to say the half part of the total territory of Jirem Prefecture is desertified in varying degree.

The occurrence and developmental process of desertification is restricted by specific regional conditions on certain scale, and thereby, the distribution of desertification land is characterized by its regional diversities. In Da Hinggan Ling Mountain areas in the north and in the low mountain areas and hilly regions in the south, desertification-prone lands are distributed in varying degree, but they can be found only in some parts of river valley. If we look at the map of desertification distribution of the prefecture, we can find out that the desertification-prone lands are concentrated in the plain areas of Xiliao River, especially in the undulating vegetated dune areas. If we analysis the situation in each county, we can classify them as following: According to the coverage ratio of the most severe and severe desertification-prone lands, Naiman is the most serious county where desertification spreads widely. Hure County and Horqin Zuoyi Houqi County are the second districts where desertification spreads on certain scale. The north part of Kailu County, the west part of Horqin Zuoyi Zhongqi County, the south part of Jarud County and some parts of Tongliao County are the districts with the risks of the spread of desertification in different developmental degree (reference the Maps of Present Statue of Desertification in Horqin Region) (1:500,000).

It can be seen from above-mentioned analysis that desertification-prone lands in Jirem Prefecture do not only occupy large areas, but also are manifested by its concentrative distribution. The desertification-prone land (occupying 53.8% of the total land area of Jirem Prefecture) is mainly concentrated on the plain areas which occupying 73.1% of the total land area of the prefecture. This distributive characteristics is interrelated to the causes of the occurrence and development of desertification.

B. Analysis on the Causes of Desertification.

The protogenic natural landscape in the region was the temperate sparse woodland steppe in semi-arid zone. Ecosystem here is fragile and excessive landuse activities made the ecological environment be degraded, the undulating sparse woodland steppe in the past was gradually destroyed and the drift sand and blownout activities are frequent now. On surface, desert-like landscape of interspersion of shifting sand are inter-distributed with fixed or semi-fixed sand dunes. Mobile dunes are high and vegetated sand mounds are reactivited and desertified. As same as that in other desertification-prone land areas, the occurrence and development of desertification process in the prefecture are the results of natural and human factors. The concrete manifestations of the natural and human factors are different in the regions with different conditions. The following are the analysis of the two sorts of factors:

I. Natural Factors:

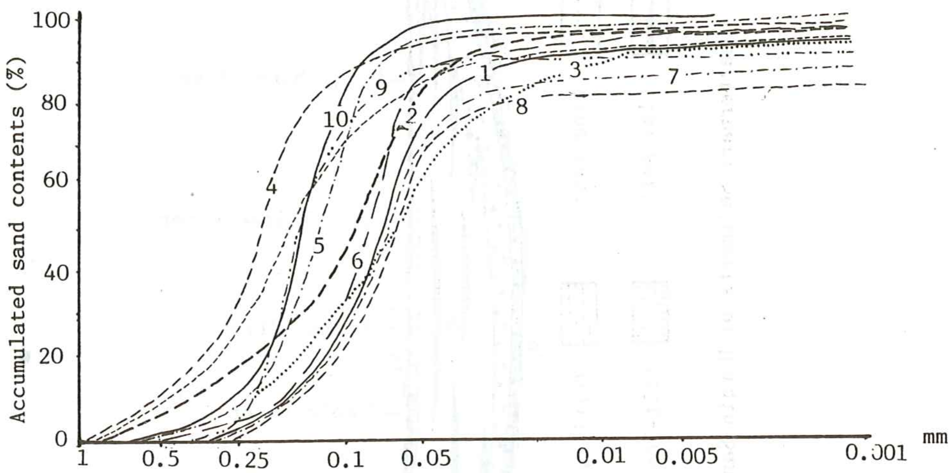
(1) Characteristics of surface composition and the sources of sandy materials. Investigation data show that, except the rocky hills of Da Hinggan Ling in the north and the low rocky hills in the south, the vast plain area of Xiliao River, including alluvial-diluvial piedmont incline plain in the north and the loess ridges of terraces in the south, are covered by very thick loose Quaternary sediments. The surface compositions are mainly physical sand grains or sandy soils, which are both loose and cohesive forces are poor. In plain areas, where desertification-prone lands are concentrated, regardless of low terraces or flooded beachlands along river banks,or the undulating dune areas or inter-dune areas in dry region, the grainness of surface earth mass are different because of the differences of land type and zonal distribution. But the contents of physical sand grain are high, generally is little more than 60%, beside some mud covered inter-dune areas (Table 3).

It can be seen from Fig. 2 that, from the viewpoint of space distribution,the grainness of surface soil becomes fine and fine from west to east or from north to south. The grainness of surface soil indicates on certain scale, that the original causes of parent material of soil are interrelated to the flow direction of water system of Xiliao River and to the local wind regime. It should be pointed out that today's undulating vegetated and unvegetated dune areas on Xiliao River Plain were,in fact,the fixed sandy lands caused by the soil formation on aeolian dunes and gentle undulating sandy lands in the Holocene period, so the grain fractions of ancient vegetated and unvegetated dunes are basically similar to that of modern eolian sands.

The surface sediments which composed of sand materials and the wide distribution of sandy soil in the prefecture are the material base to form desertification-prone land in the region. The sand source is closely related to the paleogeographic environment.

The underlying base of the plain of Xiliao River is the newly faulted basin (Fig. 3) which formed at the Early Stage of Later Tertiary Period. Therefore, the sources of eolian sand in plain areas are closely related to the sedimental sands at following two different stages:

(a) Guxiangtun Sediment in the Upper Pleistocene epoch (Q3): fine sands and dust sands in yellowish or grey-green colour are horizontally bedded, where fossils of snails are found. This sediment is alluvial one and distributed frequently in plain areas in a depth of 0-20 meteres. This loose texture sediment is the major sand source in the prefecture.



1 --- Fixed dunes (Daqinggou of Horqin Zuoyi Houqi County)
2 --- Alluvial plain (Jiaolei River terrace of Naiman County)
3 --- Alluvial plain (river terrace near Gulibenhua, Naiman)
4 --- Depression (Qinghe village, Naiman)
5 --- Depression (Taishan Mutou village, Naiman)
6 --- Sand-loess plain (Xinshuwa village, Hure County)
7 --- Loess terrace (Tuchengzi village, Naiman)
8 --- Loess terrace (Qinglongshan village, Naiman)
9 --- Meadows (Husiou, Horqin Zuoyi Houqi County)
10 --- Daqinggou stratum

Fig. 2. Curves of Soil Composition of Various Lands.

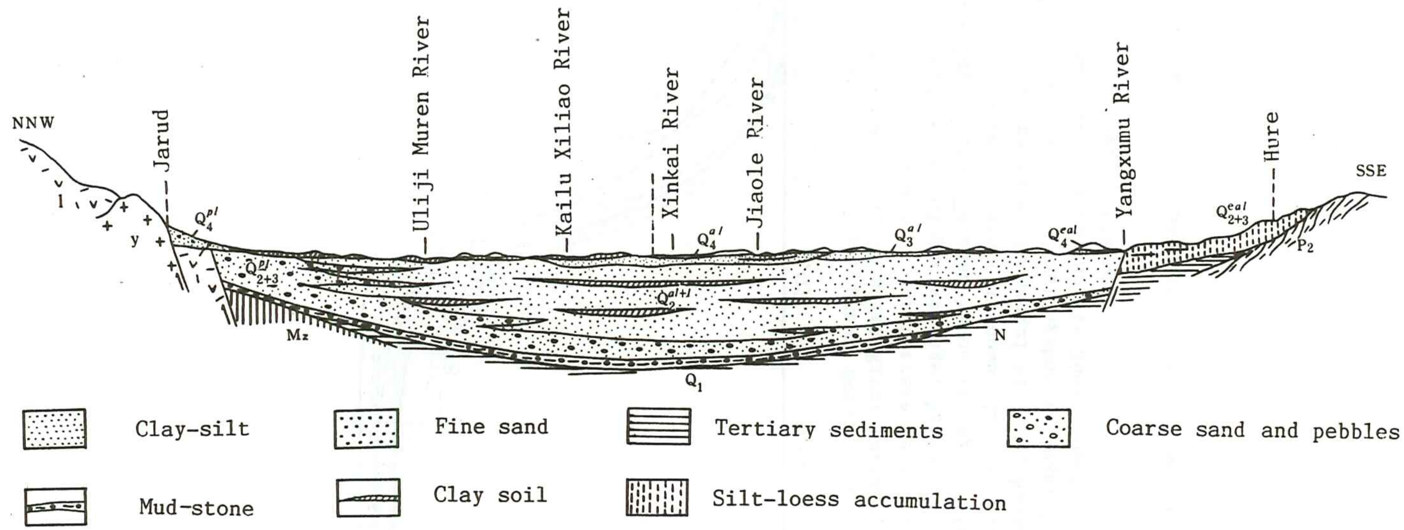


Fig. 3. Quarternary Sediments of Horqin Sandy Land

Table 3. Grainness of Surface Earth Mass of Different Land Type

Land Type	Sampling areas	Depth (cm)	Hcl (%)	Contents of Various sand grains (Diameter of grain: mm) (%)					
				1-0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001
Fixed dune	Da Qing Gou	0-15	1.14	14.71	82.24	1.50	0.20	0.14	0.07
		0-15	2.12	15.89	67.88	12.24	0.38	0.84	0.65
		15-40	1.34	16.23	80.19	2.14	0.02	0.08	0
Undulating fields	Taishan	0-30	4.00	11.60	82.25	3.35	2.71	0.02	0.07
		30-85	6.14	3.88	88.91	4.41	0.03	0.02	2.75
	Mutou	85-135	3.31	5.99	89.07	1.97	0.54	0.71	1.72
		135-200	2.25	8.96	89.32	0.67	0.02	0.15	0.88
	Xinlong	0-20	1.42	50.89	43.08	4.46	0.21	0.53	0.83
		20-34	2.99	42.79	48.03	5.81	0.41	0.44	2.52
		34-96	1.86	46.80	45.77	5.02	0.05	0.69	1.76
		96-144	1.42	61.51	35.86	1.62	0.66	0.25	0.10
Loess hills and ridges	Qinglung Shan	0-250	7.45	0	85.09	10.23	0.17	0.57	3.94
		Below 250	10.99	0	56.78	30.55	1.28	2.31	9.08
Loess hills and ridges	Tu Cheng-zi	0-8	9.77	1.10	70.24	19.00	1.06	0.70	7.90
		8-24	11.19	2.30	74.81	14.53	0.15	1.51	6.70
		24-48	37.36	5.49	53.21	21.93	3.13	1.92	14.32
		48-83	37.55	7.02	55.20	20.36	0.93	2.97	13.52
		Below 83	7.99	8.75	62.04	11.75	2.08	1.98	13.40
	Xin Shu-wa	0-14	2.10	0	80.16	13.84	2.95	0	0.95
		14-50	2.71	0	74.33	18.51	4.35	0.10	0
		50-66	3.74	0	93.85	2.11	0.17	0.13	0
		66-94	3.74	0	93.38	2.70	0.08	0.10	0
Wet depression and meadow	Husiao	0-14	11.74	16.55	68.18	2.67	0.27	0.33	0.26
		14-33	10.50	3.67	83.14	2.13	0.18	0.17	0.21
		33-115	12.33	0	84.23	2.65	0.35	0.44	0
		115-135	1.99	0	97.25	0.61	0.08	0.07	0
White-grey sand layer (Da Qinggou)	Inter-dune Areas	0-30	1.39	9.30	88.97	1.09	0.64	0	0

(b) Da Qinggou Sediment in Middle Pleistocene epoch (Q2): Grey-white or grey-green dust sands are horizontally or synclinally stratified with regular sorting (Fig.3). They are composed of mainly pure quarts sands with interbeddings of some grey-green clay and some rust leaching layers at the bottom. They are alluvial and lacustrine sediments with a depth of 5-10 metres thick and exposed by wind force in the inter-dune areas and they are the direct sources of eolian sands.

It can be seen from above analysis that the alluvial and lacustrine sediments of the Middle and Later Quarternary Period are widely distributed with a thickness of 180 metres and they are the rich sources of eolian sands . Of course, the sandy materials of alluvial diluvium in Holocene or modern river valley and basin are the sand sources of eolian activities.

(2) Climatic Condition:

Horqin Steppe is situated in the transitional zone of subhumid and semi-arid climate of temperate zone and belongs to continental monsoon climate. Annual average precipitation varies from 315 mm to 490 mm and evaperation is 1,800 mm, or equal to 5 times of precipitation. Annual average absolute humidity ranges between 5.5-8.5 millibar. Relative humidity is mostly less than 60% and aridity index ranges from 1.09 to 1.76 (Fig.4).

(a) Precipitation.
The southeast monsoon in summer season is the leading agent to form precipitation in the region. Precipitation in the region is characterized by following points : First: regional distribution of precipitation is disequilibrium and it is seriously impacted by topography. The mountain areas in North Hebei and West Liaoning provinces stop the northward movement of humid air current. The mountain areas are the places with much more precipitation and the west end of plain area is the place with less precipitation in the prefecture. According to the meteorological data during past years, average precipitation in Meixin Village of Kailu County, Inner Mongolia is 314.8 mm. In the North, humid air current is blocked again by Da Hinggan Ling Mountain Ranges and orographic rain is formed at the southeast of the mountain system. Beyond the main peak of Hanshan Mountain, precipitation goes down suddenly . Therefore, the spatial distribution of precipitation in the prefecture is characterized by highness in the east and sparsity in the west, richness in the south and north and sparsity in the middle of the prefecture. Secondly: seasonal distribution of precipitation in the prefecture is not well-distributed and annual variation is large and rainfall is concentrated in summer season. The precipitation from June, July and August occupy 70% of the total precipitation of whole year. Only the precipitation in July occupy 31.5-35.5% of the total precipitation of whole year.There are few snow in winter season and which occupy only 0.7-1.6% of total precipitation

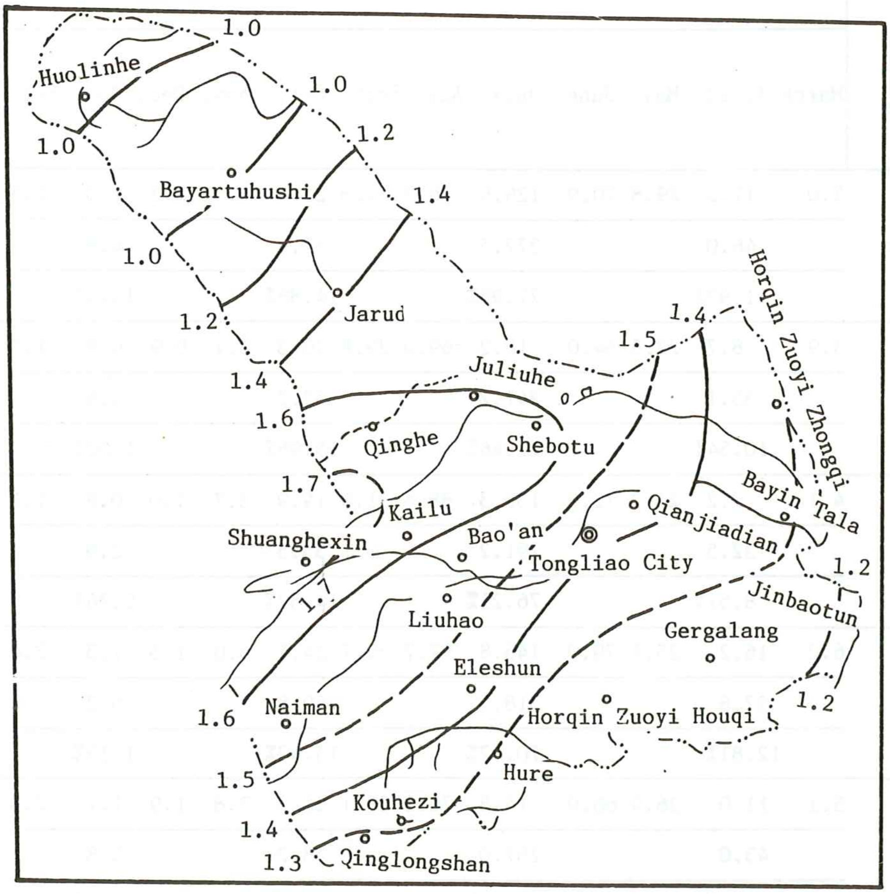


Fig. 4. Aridity Index in Jirem Prefecture, Inner Mongolia.

Table 4. Distribution of Precipitation in Each County of Jirem Prefecture from March to February

Seasons / Month / Location	Precipitations in every month, season and percentage in total												Whole year from 1959 to 1978
	Spring			Summer			Autumn			Winter			
	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	
Tongliao	5.0	11.2	29.8	70.9	129.9	76.7	31.5	21.4	4.5	1.3	1.0	2.5	385.7
		46.0			277.5			57.4			4.8		
		11.93%			71.95%			14.88%			1.24%		
Kailu	3.9	8.7	22.5	54.0	118.2	69.0	29.8	20.3	3.1	0.9	0.8	1.7	332.9
		35.1			241.2			53.2			3.4		
		10.54%			72.46%			15.98%			1.02%		
Jarud	4.1	7.2	21.2	72.3	130.3	88.6	31.9	19.9	3.7	1.0	0.8	1.1	382.1
		32.5			291.2			55.5			2.9		
		8.51%			76.21%			14.52%			0.76%		
Horqin Zuoyi Houqi	6.2	16.2	35.4	79.0	146.8	92.7	39.7	24.1	6.0	1.5	1.3	2.4	451.3
		57.8			318.5			69.8			5.2		
		12.81%			70.57%			15.47%			1.15%		
Naiman	5.1	11.0	26.9	66.0	114.8	76.2	33.1	21.3	3.8	1.9	1.1	2.8	364.0
		43.0			257.0			58.2			5.8		
		11.80%			70.61%			15.99%			1.59%		
Hure	4.1	14.9	32.0	71.7	151.4	99.2	39.0	26.2	4.3	1.4	1.1	2.2	447.5
		51.0			322.3			69.5			4.7		
		11.40%			72.02%			15.53%			1.05%		
Horqin Zuoyi Zhongqi	6.5	11.8	33.2	59.2	144.5	86.3	42.1	20.6	5.4	1.3	1.0	2.2	414.1
		51.5			290.0			68.1			4.5		
		12.44%			70.03%			16.44%			1.09%		

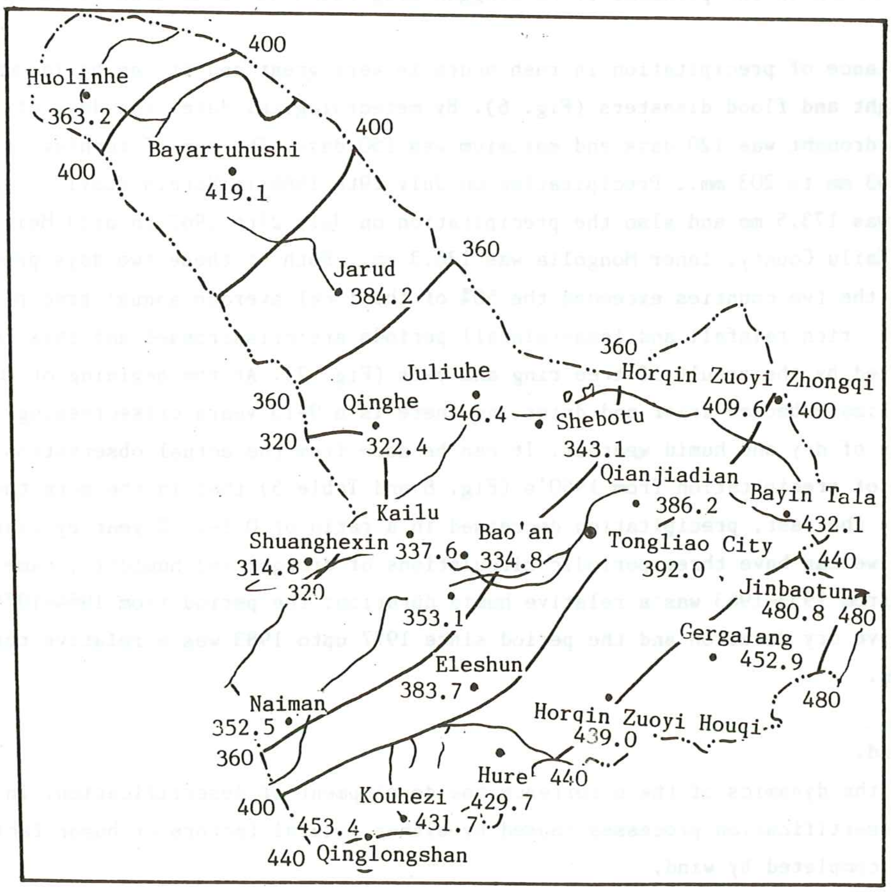


Fig. 5. Annual Precipitation in Jirem Prefecture, Inner Mongolia

of the whole year, namely only 6mm of precipitation in winter season (Table 4).

The annual variance in precipitation is large. Precipitation in rich-rainfall year is 2-3 times high than that in less-rainfall year. Taking Tongliao County as an example, the precipitation in 1956 was 592.2 mm and that in 1980 was only 198.7 mm. . The average variance of annual precipitation in the whole prefecture is 58-87 mm.relative annual variance is 16-22% and variation index is 0.20-0.235. The variance of precipitation in the piedmont of Da Hinggan Ling (such as Jarud County) is large.

The variance of precipitation in rush hours is very great and it can be identified by drought and flood disasters (Fig. 6). By meteorological data, the days of continuous drought was 120 days and maximium was 150 days. The sum of running rainfall varies 63 mm to 203 mm.. Precipitation on July 29th 1966 in Horqin Zuoyi Zhongqi County was 173.5 mm and also the precipitation on July 27th 1962 in arid Meixin Village, Kailu County, Inner Mongolia was 136.3 mm.. Both of these two days precipitation in the two counties exceeded the 50% of the local average annual precipitation. Thirdly: rich-rainfall and less-rainfall periods are crisscrossed and this can be identified by the result of tree ring analysis (Fig. 7). At the begining of this Century, climate became drier and drier and there is a 9-13 years crisscrossing circulation of dry and humid weather. It can be seen from the actual observation statistics of precipitation from 1950's (Fig. 8 and Table 5) that in the more than 30 years in the past, precipitation decreased in a ratio of 0.8-2.3% year by year. From Table 5 we can have three periodic circulations of drought and humidity, namely, the period from 1953-1963 was a relative humid duration; the period from 1964-1975 was a relative dry duration and the period since 1977 upto 1983 was a relative turbulent duration.

(b) Wind.

Wind is the dynamics of the occurrence and development of desertification. In a region, desertification processes caused by either natural factors or human factors are finally completed by wind.

(i) Wind regime. In winter, this region is controlled by the anticyclone from Siberia and so the dominant wind direction is northwest. In Spring, because of the increase of surface temperature, the centre of anticyclone is northwardly moved. Lower pressure is appearred in the south (35 degree to 40 degree N) and gradually move to the north in the manifestation of strong wind. Under the impact of the weather in Northeast China, air currents from the south and the north form highly convective in the region. This phenomenon causes strong wind force and blown sand activity. In summer, this region is controlled by the southeast monsoon. The air currents pass over Liaodong Peninsula and the mountain areas of Hebei and Liaoning Provinces hit the whole region and form a weather of rich rainfall and winds. In Autumn, the surface of continental interior of China becomes colder and colder and the continental high pre-

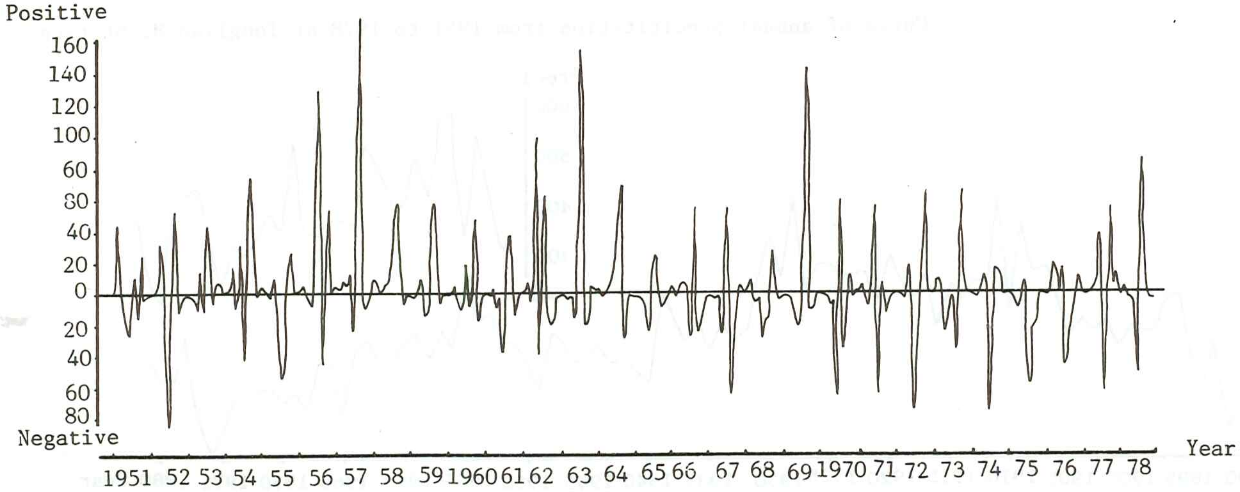


Fig. 6. Curve of Precipitation from 1951 to 1978 at Tongliao Meteorological Station

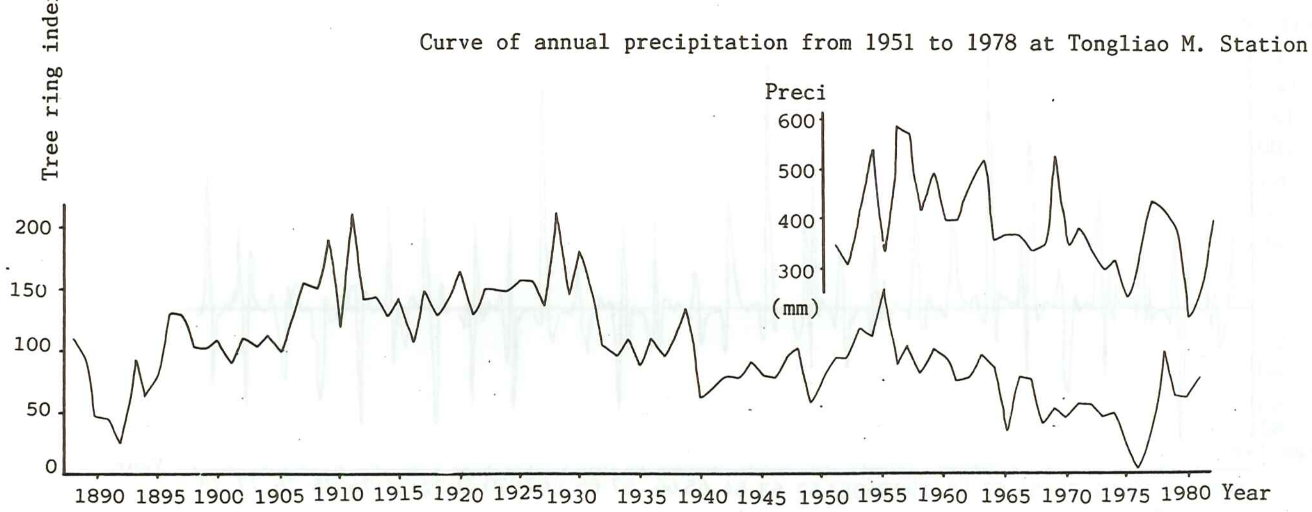


Fig. 7. Curve of Tree Ring Index

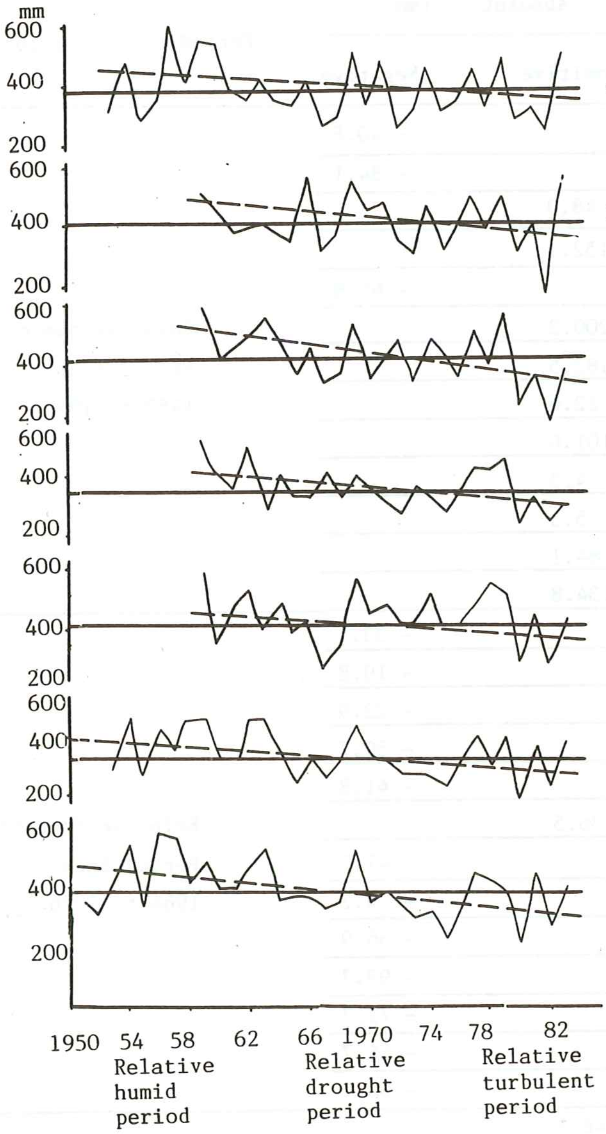


Fig.8. Curves of Precipitation at M. Station of Each County of Jerim Prefecture, Inner Mongolia

Table 5. Precipitation of Tongliao M.Station from 1951 to 1983

Items / Year	Annual Precipitation (mm)	Absolut (mm) Positive	Absolut (mm) Negative	Periodic Circulation
1951	351.2		- 40.8	
52	307.9		- 84.1	
53	440.4	48.0		Relative humid Period from 1953 to 1963
54	544.1	152.1		
55	326.2		- 65.8	
56	592.2	200.2		
57	574.5	182.5		
58	414.6	22.6		
59	493.6	101.6		
1960	396.3	4.3		
61	397.3	5.3		
62	476.1	84.1		
63	526.8	134.8		
64	358.9		- 33.1	Relative drought Period from 1964 to 1976
65	372.2		- 19.8	
66	369.1		- 22.9	
67	332.3		- 59.7	
68	350.2		- 41.8	
69	528.5	136.5		
1970	344.8		- 47.2	
71	387.8		- 4.2	
72	335.1		- 56.9	
73	298.3		- 93.7	
74	319.7		- 72.3	
75	236.3		-155.7	
76	333.3		- 58.7	
77	438.3	46.3		Relative turbulent Period Since 1977
78	421.0	29.0		
79	376.4		- 15.6	
1980	198.7		-193.3	
81	435.8	43.8		
82	261.2		-130.8	
83	398.0	6.0		
Total	12937.1			
Annual average value	392.0			

ssure system is reformed and reinforced. In the west and the north parts of the region winds blew west and north. In the east part of the region, dominant wind blew southwest.

Topographic and geographic positions are the leading impacts on wind force and wind direction. For example, in Tongliao which located in the central part of Xiliao River Plain and Horqin Zuoyi Houqi which located at undulating plain at the southwest of Xiliao River Plain, south wind is prevailling one. Also in Horqin Zuoyi Houqi County, northwest wind is prevailling one during winter, spring and autumn seasons. In Jarud County which located at the valley mouth of Tengle Gol River of Da Hinggan Ling, northwest wind is prevailling in the whole year.

(ii) Windforce. In the whole prefecture, wind force is strong. Annual average wind velocity is 3.3-4.4 m/sec. and average velocity in spring is 4.2-5.9 m/sec.. There are 210-310 days with threshold wind (≧ 5 m/sec.) every year. According to meteorological data at the Bayar Tuhushuda, Jarud County, there are 330-340 days with threshold wind velocity (≧ 5 m/sec.), and in consideration of blowing season, threshold wind prevails mainly in Spring (March, April and May) occupying 27-29% of the total wind and 24% respectively in other three seasons. (Fig.9).

Wind force 8 at Beaufort scale (wind velocity is ≧ 17m/sec.),which causes dust storm and sand devil, are concentratedly distributed in Spring season. In plain areas, Spring wind occupies 61-65% of the total wind in the region. In piedmont and mountain areas, Spring wind occupies 42-43% of the total wind in the region. By analysing meteoroligical data, although threshold wind prevails in all season, but the strong wind can cause serious erosion and dune movement prevails mainly in Spring season (Table 6).

In the region,Winter and Spring precipitations occupy only 11.5-13.5% and Spring rainfall falls mostly at the end of May. This phenomenon causes synchronization of wind and drought, aridity of soil. In such case, exposed surface is influenced under drifting sand and blownout activities.

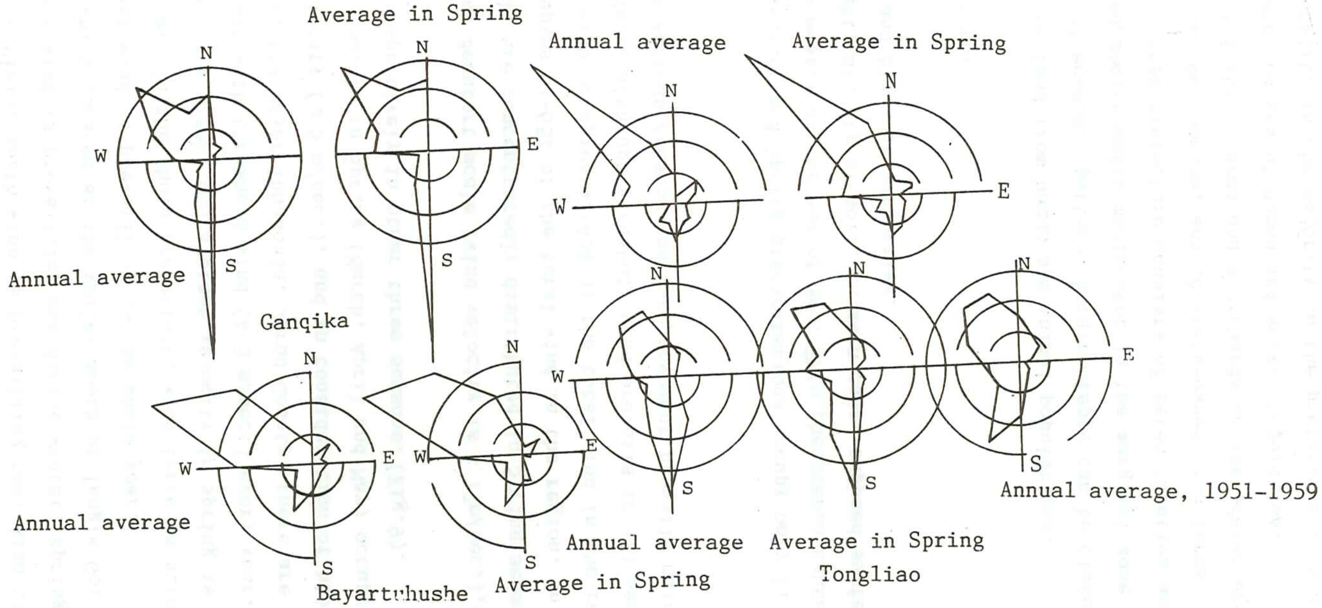
II. Human Factors.

(1) Pressures on land from human and animal populations.

From viewpoint of economic pattern, Horqin Steppe can be classified into a region of semi-farming and semi-nomadic management in the marginal zone of dry-farming and animal grazing. Jirem Prefecture consists of seven counties and one city. There are 6,920 villages in 166 commune, and 18 state-owned crop farms, 18 stock farms, 55 forestry farms, 18 fishery farms and 6 orchards in the prefecture.

(a) Increase and changes of human and animal population.

Mongolian Nationality is the majority in the prefecture with different percentage of



Notice: besides the last one marked with statistic year, others were prepared on the statistics from 1971 to 1973

Fig. 9. Direction of Threshold Wind ≧ 5m/s in Some Counties of Jirem Prefecture, Inner Mongolia

Table 6. Threshold Wind ≧5 m/s and ≧8 Windforce on the Beaufort Scale (days)

Meteo. Stations	Items	Spring			Summer			Autumn			Winter				Duration of data
		March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Whole	
Tong-liao	Threshold Wind ≧5m/s	28.7	29.0	28.3	27.3	29.3	26.3	21.3	24.0	25.3	22.3	24.0	22.3	308.1	1971-1973
		27.91%			26.91%			22.91%			22.27%			100%	
	≧8 Wind-force at Beaufort Scale	4.7	9.7	8.0	1.3	2.3	2.0	0	1.0	3.3	1.3	1.0	1.7	36.3	
		61.71%			15.43%			11.85%			11.01%			100%	
Horqin Zuoyi Houqi	Threshold Wind ≧5m/s	27.7	28.3	27.7	18.0	29.7	21.3	18.0	25.7	24.7	25.0	23.0	22.3	291.4	1971-1973
		28.72%			23.68%			23.47%			24.13%			100%	
	≧8 Wind-force at Beaufort Scale	6.7	10.3	7.0	2.0	2.3	1.0	0	1.3	2.3	0.7	1.0	2.4	37.0	
		64.86%			14.33%			9.73%			11.08%			100%	
Jarud	Threshold Wind ≧5m/s	29.3	29.3	30.0	26.7	28.0	23.0	20.0	23.0	25.0	27.3	25.0	25.0	311.6	1971-1973
		28.43%			24.94%			21.82%			24.81%			100%	
	≧8 Wind-force at Beaufort Scale	4.4	6.7	2.7	1.7	0.3	2.3	0.6	1.7	3.7	4.0	1.3	3.3	32.7	
		42.20%			13.15%			18.35%			26.30%			100%	
Hure	Threshold Wind ≧5m/s	30.0	30.0	30.5	30.0	30.0	23.0	23.5	28.5	25.5	30.0	26.0	27.0	334	1972-1973
		27.10%			24.85%			23.20%			24.85%			100%	
	≧8 Wind-force at Beaufort Scale	9.0	17.0	12.5	6.0	4.5	4.0	2.0	6.5	8.0	7.0	3.5	9.5	89.5	
		43.02%			16.20%			18.44%			22.34%			100%	

Table 7. Population Density, Agricultural Population and Manpower in Each County of Jirem Prefecture, Inner Mongolia

Items / County	Total land area (km^2)	Total Populations	Agriculture Population	Village manpower	Manpower for farming forestry fishery and side products	Population density (man/km^2)
Total of the Prefecture	60202	2501000	2064000	586000	556000	41.5
Tongliao city	325.3	239000	61000	19000	17000	734.7
Tongliao county	3158	375000	350000	118000	109000	118.7
Kailu	4325.3	328000	296000	93000	90000	75.8
Horqin Zuoyi Zhongqi	9711.4	357000	384000	95000	91000	36.8
Horqin Zuoyi Houqi	116093	439000	313000	69000	65000	37.8
Naiman	8232.7	363000	335000	104000	10000	44.1
Hure	4732	149000	127000	40000	38000	31.5
Jarud	18108	251000	198000	48000	46000	13.9

other nationalities. According to statistics in 1983, the total human population in the prefecture was 2,501,000. In comparison with that in 1949, 190% has been increased. The average growth rate of human population during last 34 years (from 1949-1983) was 3.19%. In the total human population of Jirem Prefecture, agricultural population is 2,064,000 occupying 82.53% and in comparison with that in 1949,170% have been increased. No-agricultural population is 437,000 occupying 17.47%.

The population density in the prefecture is averagely 41.5 person/km² and concentrated mainly in towns and on the Xiliao River Plain areas. The undulating hilly and mountain areas are less populated. Table 7 shows the difference of population density in each county.

Percentage of agricultural and nomadic population: In Tongliao and Kailu Counties, agricultural population occupies 80% or little more; in Horqin Zuoyi Zhongqi, Naiman and Hure Counties, agricultural population occupies 40-56%; in Jarud County, nomadic population occupies 50% or little more. According to data in 1979, each agricultural population in the prefecture occupies only 0.487 ha. arable land. Each manpower can manage 1.74 ha. of arable land. Each nomadic population has 9.02 heads of animals. Each nomadic manpower breed 34.4 heads of animals.

There were 4,296,000 heads of domestic animals in 1982, in which drought animals and lesser animals were 3,189,000 heads. In comparison with that in 1949, the domestic animals have been increased for four times, especially lesser animals have been quicklly developed (Table 8). Cattle in Horqin Zuoyi Houqi County occupies 28.8% of the total amount of animals of the prefecture. Sheep in Naiman County occupy 27.4% of the total of the prefecture.

Along with the fast increase of human population, the high growth of animals bring serious pressure and risk on land in Jirem Prefecture.

(b) Land resources and productive potential.
The total land area in Jirem Prefecture is 60,202 km² (6,020,000 ha.) (Table 1).Hammock and rocky hills are distributed in the north of the prefecture which covered by forests. Except small scale cultivation in the inter-mountain basins and valley areas, the most part is used as grazing land. Loess hills and terraces are mainly distributed in the southwest of the prefecture (Hure and Naiman Counties). These areas are used for cultivation with small areas of grassland. Soil and water erosions are serious. Depressions, inter-dune areas and dunes are mainly distributed in Hure, Naiman and Horqin Zuoyi Houqi Counties at the central part of the prefecture. And also there are some distributions of inter-dune areas,dunes and low-lying areas in the north of Kailu County, Horqin Zuoyi Zhongqi and Tongliao City.Such areas are mainly used for grazing with small cultivation on them, but crop yield is very lower.

Table 8. Animal Statistics in Jirem Prefecture

Animal / Year	Total of Animal	Drought Animal	In Which: Cattle	Donkey	Horse	Mule	Camel	Lesser Animal	In Which: Sheep	Goat	Hogs
1949	549000	425000	294000	108000	19000	2000	2000	124000	58000	66000	317000
1959	1802000	923000	694000	138000	82000	6000	3000	879000	332000	547000	437000
1969	2392000	1239000	830000	180000	207000	20000	2000	1152000	735000	417000	474000
1979	3281000	1368000	901000	173000	267000	25000	2000	1913000	1440000	473000	326000
1982	3189000	1277000	865000	170000	219000	22000	1000	1912000	1534000	378000	1107000

Table 9. Annual Population in 1949 and 1982 in Each County of Jirem Prefecture, Inner Mongolia

Year / Items / County	1949: Drought Animal	In which Cattle	Lesser Animal	In Which Sheep	Hog	1982: Drought Animal	In Which Cattle	Lesser Animal	In Which Sheep	Hog
Total of Whole Prefecture	425000	294000	124000	58000	317000	1277000	865000	1912000	1534000	1107000
Tongliao City	1000	100	100	100	3000	11000	3000	9000	8000	53000
Tongliao County	38000	14700	1400	800	52000	74000	37000	92000	89000	216000
Kailu	40000	24500	3700	1600	32000	104000	57000	255000	235000	183000
Horqin Zuoyi Zhongqi	84000	56500	5800	1600	96000	299000	216000	179000	172000	174000
Horqin Zuoyi Houqi	89000	71400	5400	1700	55000	317000	249000	227000	187000	165000
Naiman	85000	60300	55600	34900	42000	131000	74000	453000	420000	156000
Hure	50000	36600	30300	200	30000	88000	57000	153000	106000	59000
Jarud	38000	29900	21700	7100	7000	253000	172000	544000	317000	101000

Wind erosion and blowout hazards are severe. Lower flat areas in depression are good feilds for cropping and grazing but saltilization and waterlogging are the threats on certain scale. Xiliao River and Jiaolei River Plains are mostly cultivated for cropping and they are the base for food production of Jirem Prefecture. Local secondary salinization phenomenon is frequent in such areas. For controlling water floods from rivers, several reservoirs have been built on the Xiliao River, Jiaolei River and other big rivers, totally 15 reservoirs, and they are aimed to irrigate farmlands and fish industry. Table 10 shows the present land use status of Jirem Prefecture. The land areas for agricultural practice, grazing animals and for forests cover 75.81% of the total land area of the prefecture and the rest 12.09% used for other purposes.

From 1949-1983, average grain yield per unit area in the whole region was 1131.25kg/ha. (1951). Meat production in 1981,1982 and 1983 was respectively 3 kg, 3.675kg and 4.2 kg/ha..

Surface water, except the use for irrigating farmlands,is used for fishery and from 1958 to 1983, fishery products were 58.35 kg/ha. and maximum production was 96.75kg/ha. in 1960,and minimum was 24.75 kg/ha. in 1949,1979 and 1980. Forestry production is very weak in the region.

To summarize above analysis, as Table 2 shows, average arable lands for each person and grasslands for each animal was reduced due to the fast growth of human and animal populations. There is a close interrelationship of restriction between people and food and between land and land productivity. Their relationship can be indicated as following formula:

$$Z = \frac{IP}{n}$$

Where Z indicates the number of population in a regional scale; I is the acreage of arable land in the region; P is the average productive potential per unit area in the whole year in the region (kg/ha.); n indicates the amount of farm produce of average requirement of each citizen during the whole year in the region (kg).

According to agricultural productive standards from 1949 to 1983 (area of crop cultivation was 654,427 ha.crop yield was 1131.75 kg/ha.), it is estimated that each citizen needs 450 kg of grain in the whole year (includes seeds, forage and food). But the crop production in the region can feed about 1.65 millions of human population.

In the grazing land areas, because of high carrying capacity, rangeland production is low and imbalance between animal and grass biomass is normal. According to the productive potential of grassland, the optimum carrying capacity should be 51,620,000 sheep units, and now the grassland overgrazed and 2,720,000 heads of animals are

Table 10. Landuse and Percentage in Total in Each County of Jirem Prefecture, Inner Mongolia

Items / County	Total land area ha.	%	Arable land ha.	%	Wood land ha.	%	Grassland ha.	%	Lands used for other purpose ha.	%	Non-utilized land ha.	%
Total of Whold Prefecture	6020200	100	814067	13.5	516933	8.6	3232933	53.7	728000	12.1	728200	12.1
Tongliao City	32533	100	14866	45.6	2600	8.0	2667	8.2	10200	31.4	2200	6.8
Tongliao County	315800	100	135600	42.9	28467	9.0	80000	25.4	36333	11.5	35400	11.2
Kailu	432533	100	83133	19.2	35400	8.2	174733	40.4	64800	15.0	74467	17.2
Horqin Zuoyi Zhongqi	97113	100	188467	19.4	572000	5.9	534600	55.1	102200	10.5	88667	9.1
Horqin Zuoyi Houqi	1160933	100	119867	10.3	70533	6.1	720667	62.1	91667	7.9	158200	13.6
Naiman	823267	100	110067	13.4	155867	18.9	346667	42.1	65133	7.9	145533	17.7
Hure	473200	100	98733	20.9	61400	13.0	174067	36.8	48933	10.3	90067	19.0
Jarud	1810800	100	63333	3.5	105467	5.8	1199533	66.2	308800	17.1	133667	7.4

(1) Data in Table 10 collected from County Statistics;

(2) Woodland includes forests, bushland and plantation;

(3) Land used for other purpose include water area,mineral spots,river system, living quarters and roads;

(4) Non-utilized lands include mobile dune, salinied fields and hammock;

suffering from lack of fodder and forage (Table 12).

If we image that each nomad feeds 16 heads of animals (sheep unit) can ensure normal living standard, the optimum carrying capacity can ganrantee and feed 320,000 people, and we plus agricultural population for cultivation, there will be totally 2 millions approximately.

At present, in the case of lower living standard, the population density in the rural areas in the prefecture should be 32.7 person/km^2. and carrying capacity should be 516.2 heads animals/km^2..In 1983, population density in the whole prefecture was 41.5 person/km^2., and population density exceeded 8.8 person/km^2.. Carrying capacity in the prefecture in 1983 was 2.72 millions sheep unit. UNEP developed a threshold limitation in semiarid region, that is 20 person per km^2. and one animal unit per ha.. This is the serious situation on grassland in the prefecture.

The high density of population, overgrazing and misuse of land resources produce very serious pressure on the fragile land resources. For their own survival, human being has to exploit more from nature. In Jirem Prefecture, although natural resources are rich, but are strictly limited. The growth of human being must be controlled according to the output of natural resources. The growth rate of human population in recent years goes blindly beyond the potential of natural resources and the balance and stableness of ecosystem were impacted. The occurrence and development of desertification-prone land was brought in a manifestation of environmental degradation. When desertification was caused, the productive potential of land, as a result, was reduced, and land became unproductive. There is a risk that such desertification-prone lands will be completedly desertified and destroyed if we could not stop the process of desertification.

(2) Irrational landuse.

The occurrence and development of desertification-prone land are relatively impacted by human economic activities. Recognization of natural environmental condition, of property, characteristics and regularity of natural resource are the key links to utilize rationally natural resources and to transform nature. When we held correct understanding, we can have a real consideration of economic benifit and acceptable thought to preserve natural ecosystem, and make scientific use of natural resources. Otherwise, we will have the tendency to concentrate on quantity alone and make blind use of resources and cause not only irrational development and utilization of natural resources, but also leads environmental degradation and imbalance of ecosystem. The present existing situation of desertification-prone land in Jirem Prefecture give us a lesson that the irrecognization is one of the important agent of the spread of desertification.

In the past, there was a lot of landscape of sparse woodland steppe, which can be

Table 11. Lands Occupied by Man and Animal

year	Land area (ha) occupied by man	Average arable land (ha) for each man	Arable land (ha) for each farmer	Grazing land (ha) for each sheep
1949	7	0.86	0.94	1.813
1983	2.41	0.287	0.353	0.353

Table 12. Disequilibrium Status Between Animal and Acreage of Grazing Land in Jirem Prefecture, Inner Mongolia

Area of grassland (ha.)	Avai-lable grazing land (ha.)	Carrying capacity of avai-lable grazing land (Head)	Animals fed by fresh forage (Heads)	Animal fed by crop straws (Heads)	Animals fed by Autumn stubbles (Heads)	Animals fed by forage farms (Heads)	Animals fed by stubble of fodders (Heads)	Present carrying capacity (Heads)	Optimum carrying capacity (Heads)	Animal over-loaded (Heads)
3233000	2740667	336000	43000	109000	117000	90000	40000	7882000	5162000	2720000

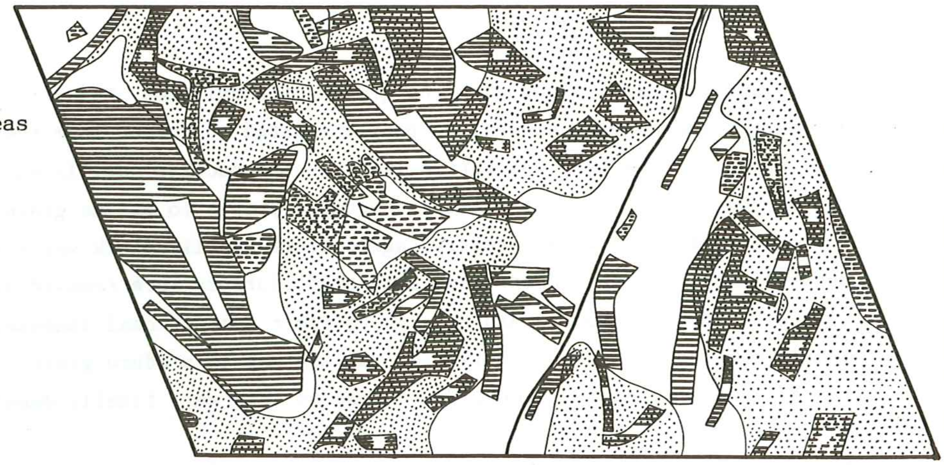
found now in Olun of Hure County, in Da Qinggou, Wudan Tala, Adugin of Horqin Zuoyi Houqi County, in the south part of Horqin Zuoyi Zhongqi County with survivals of wild apricot (Prunus armeniaca L.) Ulmus spp. Populus spp. and other species, and it shows us that the landscape of Jirem Prefecture in the past was not as much desertified as today.

Since long time ago, along with the growth of population, human requirements on food and energy became more needed, so people started to pursue from the land which human relying on and the land was turned into an unproductive one. In early 1960's, great mistake on food production policy encouraged people to pursue grain production and the relationship between forestry, agriculture and livestock was misunderstood. Consequently, livestock industry was abandoned, forests were removed away and all land was cultivated and people has to give up their tranditional landuse. Land became unfertilized and extensive cultivation was the way to produce grains. As a result of plunder use of land resources, vast areas of land were finally desertified.

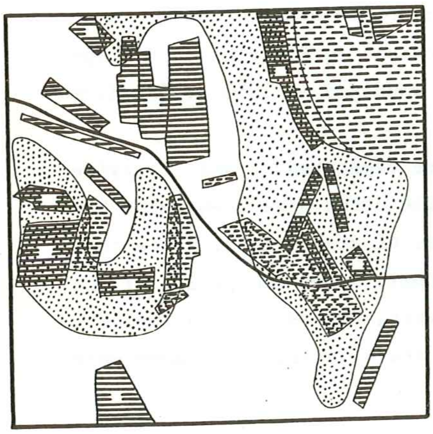
For instance, in 1950's, Huanghua Tala Village of Naiman County was vegetated with dense plant communities and because of continuing cultivation, 5300 ha. of arable land (25.3% of the total) was left. At the same time, tranditional rotation unharvest cropping system was carried out and land was averagely cultivated each three years later. A great deal of vegetation was destroyed and surface was exposed under wind erosion and desertification. In Chaohai (means dense woodland in Mongolian) Village of Horqin Zuoyi Houqi County, there was a large area of woodland in 1950's. "Produce high yield on dunefield" was a modern slogan in 1960's.
Since then people was called to open sand dunes (most are vegetated) and lowlying areas. It is recorded that 1949 ha. of such vegetated dune areas have been opened for cropping purpose, and averagely each people had 1.353 ha. of arable land. Since then vegetated dunes were artificially reactivated and now mobile dunes occupy 22% of the total land of the village. In Jilitu Village of Hure County, depression and lowlying vegetated dunes were opened for cropping, but only four years later, these areas were abandoned due to drifting sands on surface.

In 1983, we organized ground observation on cultivation in Dong Mandou (East Mandou) and Xi Mandou (West Mandou) Villages of Horqin Zuoyi Houqi County and Houxieli Hua Village of Hure County. The result is drawn on Fig.10 A.B.C.

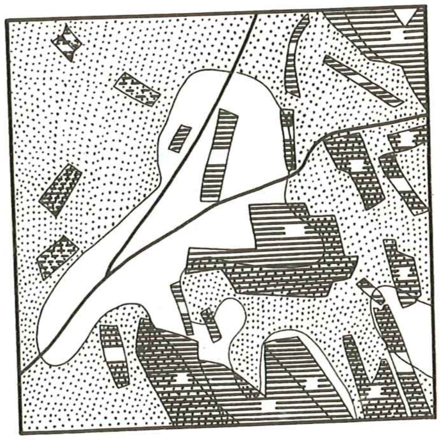
Table 13 is the statistics of the three observation plots. From the table 13 we can see that the arable land occupies 23.1% of the total of observed plots and abandoned arable land occupies 7.8%, we combine them to consist of 30.9%. In particularly, in West Mandou Village, arable land occupies 32.8% and abandoned arable land occupies 5.1%. It can be understood from this statistics that cultivation or over reclamation is the leading human factor to cause land desertification.



Vegetated dune areas
Roads
Arable land
Abandoned land
Inter-dune areas



Vegetated dune areas
Inter-dune areas
Abandoned land
Road
Arable land



Vegetated dune areas
Inter-dune areas
Abandoned land
Road
Arable land

Fig. 10. Sampling of cultivated area on sandy land (A. B. C.)

Table 13. Arable and Abandoned Lands in 1983 (ha.)

Sampling No.	Village	Sampling Acreage (ha.)	Arable land		Abandoned land		Arable and Abandoned lands	
			(ha.)	Percentage in Sampling Acreage (%)	(ha.)	Percentage in Sampling Acreage (%)	(ha.)	Percentage in Sampling Acreage (%)
A	West Mandou Village, Horqin Zouyi Houqi	30.37	9.96	32.8	1.56	5.1	11.52	37.9
B	East Mandou Village, Horqin Zuoyi Houqi	16	2.587	16.2	2.64	16.5	5.23	32.7
C	Hou Xelihua, Sanjiazi, Hure	16	3.26	20.4	0.287	1.8	3.55	22.2

As a result of large scale reclamation and cultivation, the acreage of grazing land was reduced and quality of grassland became poor. At the same time, nomadic farmers like to have large amount of livestock on their hands without consideration of qualities of animal and grassland. This is the factor causing over grazing. Simultaneously, frequent tramplings of animal destructed topsoil and the ability to anti wind erosion was declined. Soil erosion was accelerated and land desertification was spread. For instance, the productivity of natural grassland in 1982 in Hure County was declined 40% than that in 1960's. Because of reactivation of vegetated dunes in Horqin Zuoyi Houqi County, grazing land was degraded and the lowlying or depression areas were overgrazed by high carrying capacity. The proportion in animal composition was changed and the amount of cattle was reduced. In the middle of 1950's, cattle occupied 65% of the total animal population, but now only 43%. The carrying capacity of grassland in Naiman County in 1963 was 1.65 sheep/ha. and was increased to 2.55 sheep/ha. in 1982. In 1960's, the phenomenon of over-grazing was serious and it became more weak today. The productivity of natural grassland today is much more poor than 1960's. Our observation on production of grassland shows that the yield of grass was only 50% of that in 1963. The phenomenon of rotation grazing and "seizing grazing" destroyed natural vegetation and accelerated the spread of land desertification.

In Jirem Prefecture, native people is used to heat and cook by fuelwoods. It is estimated that each family needs at least 5000 kg fuelwoods for heating annually. Such large requirement of energy source is met by plunder cutting of natural vegetations. This is one of the factors to cause land desertification in the prefecture.

The above-mentioned over cultivation, over grazing and plunder cutting of vegetations destroy a great deal of natural plants and topsoil. Surface vegetative coverage is reduced and fragile surface is exposed under threat of wind erosion. On the basis of rich sand materials, the deflation process of soil accelerates the fast spread of desertification. This is the consequence of irrational activities on land use.

(3)* The problem in the utilization of water resources.

(a) Surface Water: Some longer rivers in the Jirem Prefecture are transit rivers that belong to the Liaohe River system. The southern and northern mountain areas are two water sources of rivers in this prefecture. The Wunugeqi tributary of the Huolin River which originates from the nothern mountain (Da Hinggan Ling) belongs to the Nen Jiang River system. The Baiyinjuliu River and Wujimuren River as well as the Tengle Gol River are infiltrated into the underground as soon as being out of the mountain valley. As a result, they become the none-tail river or empty into the lake nearby. The Muniu River which originates from the southern mountain area belongs to the Daling River system. The Yangxumu River and Liaohe River (Beida River, Xinkai

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* This paragraph is translated by Chen Hao.

River) belong to the Liuhe River (Liaone tributary) system. The average of total discharge in years is 272.1 millions cubic meters. These rivers depend on the recharge of precipitation and groundwater in the mountain area. Therefore, the seasonal change of runoff, and alternate cycle of water both in large and small quantity in years are obvious with the seasonal and annual changes in precipitation. Among them, the annual runoff of rivers originate from the northern mountain area has a large variation. On the contrary, the annual runoff of rivers come from the southern mountain area has a little variation. There are much rainstorm in the southern mountain area which is influenced by the typhoon. The cyclone rain is mainly occurred in the northern mountain area. In the southern hilly area, the vegetation cover is low and the soil surface is loose. The river bed is sheared deeply and the valley is narrow. There is a poor capacity of water storage. These conditions promote the high frequent flood water, flood peak concetration, and short duration of flood. In general, the modulus of flood peak is 0.6 - 0.2 m^3/sec. km^2. The silt concentration is high, too. The vegetation cover in the Da Hinggan Ling area of northern part is dense. Most of the area of river valley is bedrock area. The modulus of flood peak is only 0.09-0.02 m^3 per sec. km^2 . The silt concentration is lower than that of southern part.

Since last 30 years, people of Jirem Prefecture have contributed their hard work to the water conservancy projects. They have built 30,000 water conservancy works and water catchments. The total capacity of reservoir is 95 millions m^3 . The available land irrigated by the surface water through the key water control projects is 45,893 ha.. The average annual channel water is 100-200 millions m^3 (75% for farming, 19.8% for pasture and 4.6% for industry). The surface water is used in a large quantity , which lead to the change of environment. This condition has made the surface runoff obviously decresed. In this case, the river cutout is occurred. On the plain areas, water is misused. (Tables 14 and 15). Taking the Tongliao station of Xiliao River as an example, from 1966-1975, the average annual discharge was more than 120 millions m^3. In 1966, the discharge was suddenly reduced to 93.1 millions m^3. After 1985, the river has been dried up except the rainy season.

Water is a very active agent in the environment. The cutout of surface water has led to a series of changes in the environmental situation. The main problems are as follows: (i) The recharge amount of infiltration to the underground in the lower reach of river is suddenly decreased. The underground water table is dropped. This case leads to a series of chain reaction in the drought of lakes, biological degradation, and so on; (ii) After the river been dried up, sand materials are exposed on the dried river bed, which are the direct sand source to this area.

(b) Underground water. The Horqin Sandy Land has a thick accumulation of Quaternary clastic rocks. Most of the surface is covered with the sands. There is a better condition of infiltration and storage for water. It is a plenty of underground water.

Table 14. River Systems in Jirem Prefecture

Regions	Rivers	Observation station	Areas of River System (km^2)	Annual discharge (million m^3)	Percentage in different rate 20%	50%	75%
Northern mountain area	Wunugeqi River	Qianjincun	1227	51	0.77	0.43	0.24
	Tengle Gol River (Shengli River)	Lubei	1396	26	0.40	0.20	0.10
	Baiyinjuliu River (Tengge River and Guangxin River)	Xiaohexi		15	0.23	0.13	0.07
	Total amount			92	1.04	0.76	0.41
Xiliao River Plain Area	Wulijimuren river	Meijinmiao	18361	206	3.11	1.73	0.99
	Xilamulun River (Xinkai River)	Taihekou	28961	711	10.24	6.33	3.98
	Laoha River (Xiliao River)	Sutaibao	24486	1139	16.40	10.14	6.39
	Jiaolai River	Xiawa	2033	136	1.90	1.22	0.82
	Total amount			2192	31.65	19.42	12.18
Southern hilly area	Muniu River	Liuhecheng	2183	123	1.70	1.09	0.76
	Yangxumu River	Sanjiazi	825	100	1.17	0.98	0.85
	Liuhe River (Beida River, Xinkai River)	Shimenzi	2405	187	2.43	1.76	1.33
	Tieniu River (Wugenggao River)	Beimiaozi	345	27	0.39	0.23	0.15
	Total amount			437	5.69	4.06	3.09
	Grand total			2721	38.74	24.24	15.68

Table 15. Water Volumes From Xiliao River and Xinkai River from 1962 - 1978 *

Duration	River	Station	Average annual water amount (Millions m^3)	Percentage of the use of water	Remark
1962 to 1969	Xiliao River	Sujiabao	1089	34.6	1. Hunshan Dam was built in 1960 and operated from 1962. 2. Sujiabao water conservancy project was built in 1969 and operated from 1970.
		Tongliao	713		
	Xinkai River	Taihekou	790	83.0	
		Sanhetang	134		
1970 to 1978	Xiliao River	Sujiabao	542.1	88.0	
		Tongliao	65		
	Xinkai River	Taihekou	494	88.2	
		Sanhetang	59		

* By the report of water conservancy project in Jirem Prefecture.

The underground water is mainly stored in the coarse sand, fine sand and silt of the Daqingou in the Middle Quaternary period. The richness of water in the aquifer is limited by the geological structure.

The alluvial plain of Xiliao River is subsided depression. In the central depression (Kailu County and the northeast of Naiman County), the aquifer has a thickness of 150 - 200 meters. The water from the single well with 300 mm in diameter and 5 m in depth is 150 - 300 m^3/hour. To the east, the south, and the north, the aquifer becomes less. Up to the edge of depression, the aquifer has a thickness of 70 - 100 m and the water from the single well is 50 - 100 m^3/hour. Especially in the Horqin Zuoyi Zhongqi County, the thickness of aquifer becomes less because of the influence of uplift of Jiamatu. The lithofaces become finer as the silt. The water from the single well is less than 50 m^3/hour. Because of fine lithofaces in the low-land of front edge of the alluvial fan to the east of the Jarud, the water from the single well is less than 50^3m /hour in common.

The phreatic water table goes down 1 - 2 meters deep in the upper reaches in the plain area, 2 - 3 meters in the lower reaches of the river, and in the developed area, the phreatic water table is reduced to about 5 meters. In the dune and inter - dune land area, the phreatic water table is changed with the height of dunes. The water

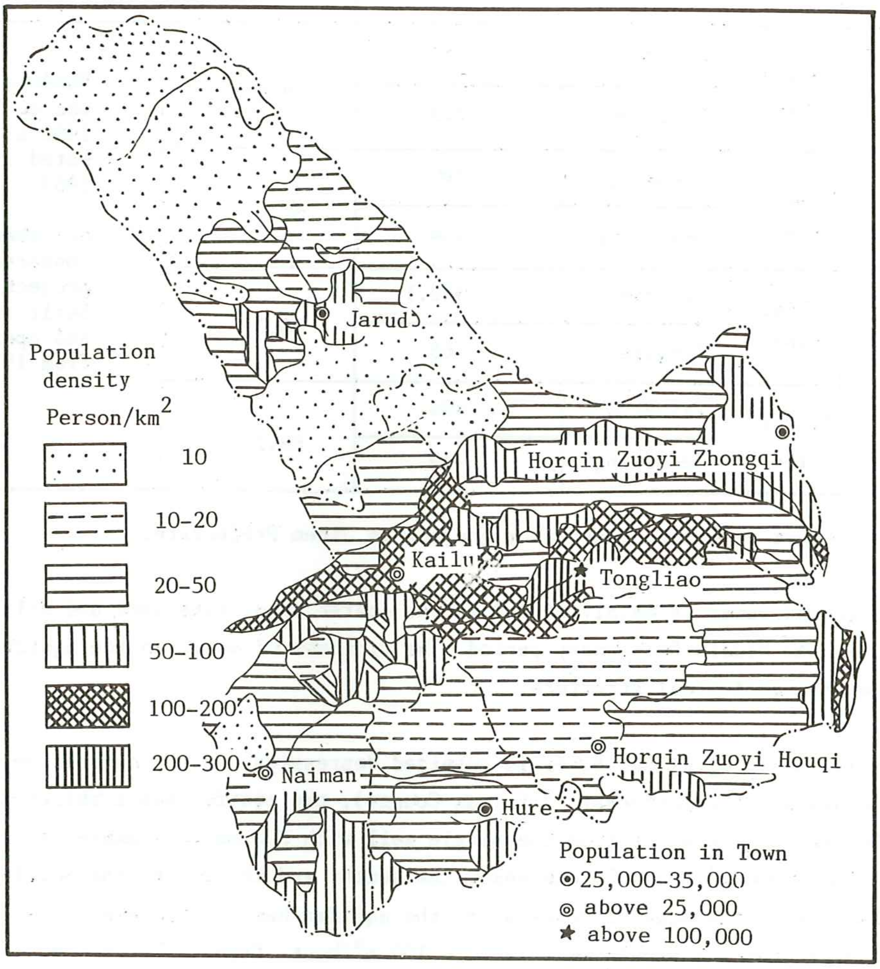

Fig. 11. Human Population Density in Jirem Prefecture, Inner Mongolia

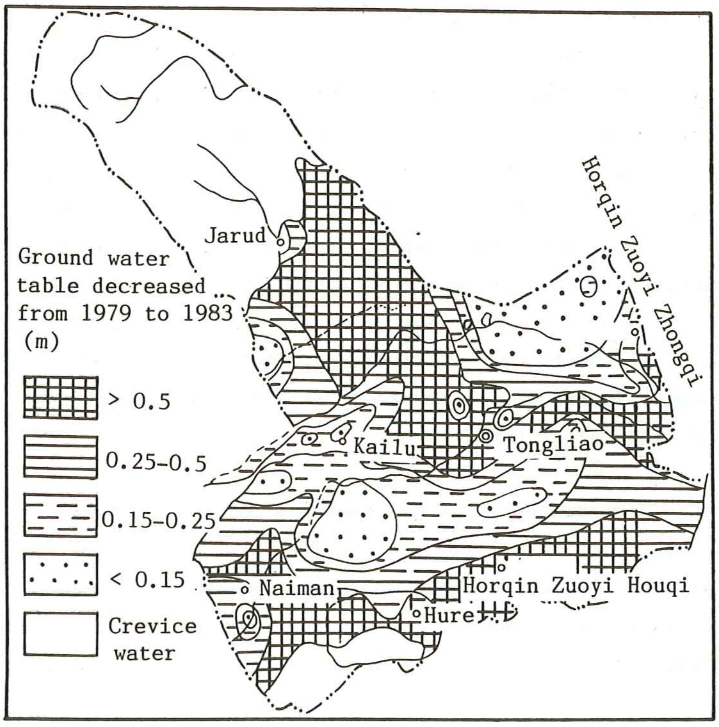

Fig. 12. Change of Ground Water Table From 1979 to 1983, Jirem Prefecture

table in the low lying land area is 1 - 2 meters in general. In the low lying land with a poor drainage system, the groundwater is overflown.

Both surface water and ground water are drinkable with a good quality in the region. The mineralization of groundwater is lower than 1 g/liter normally. PH value is 7-8, and they are mostly $HCO_3 - C_a$ or $HCO_3 - C_a$ and $HCO_3 - N_a$. The mineralization of water and PH value in the plain reservoirs and flood catchment are little bit high . The water is rich in alkaline.

The recharge of goundwater is mainly depended on the infiltration of precipitation which covers 67% of the total. The groundwater is also replenished from the infiltration of surface water which covers 22%. Furtherly, the groundwater is recharged from the replenishments between aquifers, the leakage from the reservoir, and the infiltration from the irrigation. The direction of groundwater is conformed to the direction of surface water. In the Xiliao River plain areas, groundwater flows from the west to east. In the north part, water flows from the northwest to southeast and in the south part, water flows from the southwest to northeast. The hydraulic gradient is 1/1000 - 1/3000. The main ways of groundwater drainage are evaporative one which covers 82.5% of the total, artificial explorative one covers 17% and the others are runoff drainage. Therefore, the dynamic pattens of groundwater are infiltrative, evaporative, and explorative ones.

The decline of the groundwater table has caused a series of changes in the environment: (1) In Kailu County where it is a confluence of Xiliao River, Jiaolai River and Xinkai River, the groudwater table was high. In additional, the land was irrigated by surface water. As a result, the secondary salinization was appeared.The decline of groundwater table improved the water cycle condition and salinized soil was ameliorated; (2) After the decline of groundwater in the sandy and low lying lands the hydrophilous plants are decreased and even to be vanished, and regenerated with the drought-resistance species. In particular, the trees with much water demand is withered and the vegetation cover is reduced. Consequently, the ground surface is exposed under wind erosion. The sand dunes are reactivated. These conditions caused the spread of desertification; (3) After the decline of groundwater table in the low lying land, lakes in the central district are dried up and wet depressions are turned into arid ones. The vegetation is changed under this situation. These phenomena mentioned above accelerate the occurrence and spread of desertification.

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Chapter Two: Processes of Desertification

A. Historical Process of Desertification

Archaeological findings as well as historical records reveal that this area witnessed a long history of development and has undergone desertification processes on a number of occasions in this long history. This has also been proven by field surveys conducted of the geomorphological features in the area.

1. Human Activities in the Past

Since the Neolithic Age of some 4000 to 5000 years ago, traces of human activities have been found in Jirem Prefecture. In the view of archaeologists, these human activities fall into two types. The first type is what we call the Fine Stone Implement Culture characterised by the emergence fishing and livestock breeding. In this culture numerous stone arrows, stone peelers and scrapers were in use. The second type is what we call the Hongshan Culture characterized by farming practices. This conclusion is based on the fact that of the large quantities of stone artifacts unearthed, most were agricultural implements. As far as their geographical distribution is concerned, most of implements excavated in the northern part of the site were fine implements, while the southern part of the site contained many factors pointing to the Hongshan Culture, which indicated that the inhabitants at that time were engaged not only in agricultural production and but also livestock breeding and hunting. For example, near the Wujiazi Reservior of the Changshen Commune, Horqin Zuoyi Houqi County, which is an ancient site, a variety of artifacts were unearthed including stone axes, crescent-shaped stone knives and stone mills as well as stone scrapers, sharpened stones and pointed stone implements, evidently used for hunting and livestock breeding purposes.

Towards the Bronze Age, Xiajiadian Culture came into being in the area. Large numbers of stone spades and picks as well as stone sickles and other cutting tools showed that an agricultural economy existed in the area. Archeologists identified it as belonging to the culture of late period of the Xia Dynasty in North Plain, which is basically identical with the Hongshan Culture in distribution.

Then came the Xiajiadian Upper Stratum Culture. Pottery making in this period appeared more coarse and primitive than in the Xiajiadian Lower Stratum Culture. Pottery wares suggested a baking process in the kiln of a lower temperature, with the surface displaying an uneven red and brown. The tools of production consisted chiefly of primitive ones used for knocking and smashing and stone picks and spades were nowhere to be found. Viewed either from the art of pottery making or agricultural production, Xiajiadian Upper Stratum Culture was much more backward than Xiajiadian Lower Stratum Culture. The area to the north of Xar Moron River was dated by means of C_{14} as somewhere between the Shang and the Zhou Dynasties (16th Century BC-221 BC) whereas the area to the south more or less belonges to the early stage of the Spring and Autumn Period (770BC-476BC)

This showed the Xiajiadian Upper Stratum Culture evolved from the north to the south.It is presumed that in the early Spring and Autumn Period, the nomadic tribe moved down to the south and replaced the tribe previously dwelling there engaged in agricultural activities, known probably as Donghu tribe as described in ancient books.

During the Spring and Autumn Period and Warring States, (770BC - 221BC) the southern part of the area used to be the site of Yanguo State according to historical records. Later on such shires as Liaoxi, Youbeiping and Shangu were established and the Great Wall built to prevent from the invasion of the Hu tribe. The Great Wall built in the Yanguo State winds its way eastwardly in the south of the two counties of Hure and Naiman, as they are called today. In the south of Naiman County, in addition to the remains of the Great Wall of the Yanguo State, large quantities of artifacts belonging to the Warring State, the Qin Dynasty and the Han Dynasty were also found, among which there were iron farming tools, indicating the booming agricultural activities in the area at that time. And also in the Laoye Temple of the Horqin Zuoyi Houqi County and the north of Hure County were unearthed ancient coins called Wu Zhu Qian, which were buried in the ancient layer of soil. This discovery convinced us that the Han Dynasty had extended its influence to this area. And then in the long ensuing years the area was successively occupied by the Xiongnu, Wuyuan and Xianpi tribes (these are three ancient nationalities in China), under whose rule, livestock breeding were burgeoning at the expense of agriculture. Towards the Shui and the Tang Dynasties the area came under the rule of another powerful nomadic tribe commonly known as Qi Dang which started with a nomadic life and later shifted to farming.

Qi Dang was originally a sect of the Xianpi tribe, which emerged from aproximately 4th Century to 9th Century A.D. In the early days it roved around in search of pastureland between Heng Shui (today's Xar Moron River) and Tu He (called now Lao Ha River).According to a History of the Liao Dynasty, "it is rich because of its great herds of horses and powerful because of its big army of troops. The horses live on grass and the people subsist on horse milk and meat." After the 6th Century A.D., the Qi Dang Tribe began to prosper and an alliance of different tribes formed. And it gave up its traditional nomadic life and settled down for agricultural production in an environment of fertile land, plentiful water resources and lush grass. Later on they began to develop such handicrafts as textile, foundry and salt drying. In the year of 938, it adopted its national designation as Liao State with its capital in the city of Bo Lo,southeast of today's Bairin Zuoqi County. A History of the Liao Dynasty has this to describe: The Capital had 36,500 households, 25 armies and 10 counties under its jurisdiction. Thus a new political centre took shape, ushering in a long historical period of confrontation with the Northern Song Dynasty (960-1127 AD).

At the early period of time when Qi Dang State was founded, the later Liang Dynasty collapsed. As a result the ancient central part of China was thrown into chaos. Taking advantage of this chaotic state, the Qi Dang State stormed many cities and took large numbers of Han prisoners of war to the Qi Dang State. According to historical statistics recorded in a History of Liao Dynasty, as many as 10000 households of prisoners scattered in 4 counties were brought from the conquered cities in the Bohai State in the east and as many as 6500 households of prisoners scattered in two counties were taken from the conquered Yangyu in the south. While another 7000 households of prisoners from two other conquered counties were brought to Qi Dang. The Han people to the south and the Bohai State to the east were both basically agricultural population in nature. Needless to say, to prisoners taken from these two areas lent great influence to the economy of the Qi Dang State. Towards mid-10th Century, the area along with Liaohai area had developed into an agricultural base where "tens of thousands of households were engaged in weaving and farm land extended for miles around". The vast number of agricultural implements and farming tools excavated in the areas also backs up the fact that the areas had witnessed a fairly high level of agricultural development in history. In the area around today's Tumufuzhou of Bairin Zuoqi County, so far a total of 55 human settlements had been identified in history as against 40 or so in the present days, which shows a great intensity in human activities in the bygone days.

The Liao State, whose political centre was in Shanjing, extended its territory to the Songhuajiang River and Liangning Plain in the east, the Da Hinggan Ling in the northeast, the Hebei and Liaoning mountainous area inhabitated by Xi tribe in the south and the Inner Mongolia Plateau in the west. Ample historical recordings can be found of the past landscape and human activities in the area. For example, a travelongue by Wang Yi, an ancient famous official, has this to say: "Having passed by Gubaikou (pass of the Great Wall), I entered the barbarian territory. The local inhabitants there resided in wooden houses with thatched roof and tilled the land. However, I saw no mulberry trees and the crops were grown on the ridges banked up with drifting sand." In the mountains, towering luxuriant pine tree and heavy foliage prevailed everywhere.Down in the valleys, people made a living by burning charcoal and various kinds of livestocks including cows, sheep and camels were visible. One would see hunters in carriages chasing game in the grass. Porridge used to be their principal food. Another source called Annals of Wei Yin in a History of Liao has the following passage: "The area thirty miles away from Yongzhou in the southeast looked smooth and level, with a stretch of sandy land around. Most of the trees there were willow and Ulm. As it was warm in winter, herdsmen would put up their tents for the winter." The site of Yongzhou in the past was the present site of Dalahan Temple in the Beiyin Tala Commune to the east of Ongniud County of Inner Mongolia bordering with Naiman, not far off the converging point of the Xar Moron River and Laoha River. Near Yongzhou there was a mountain called Mu Ye Shan which has changed its name to Haijin Shan today. A Song Dynasty official, Su Ce by name, was dispatched there on a diplomatic mission and wrote a verse which reads: Drifting sand here and there, no matter you went where. From this description, one needs no stretch of imagination to conclude that even in those days the area was desertified and drifting sand dunes were no rare sight. Towards to 12th Century of the Jin Dynasty, desertification further deteriorated in some part of the area, so much so that the dwellers began to immigrate to where there was water and grass. In other words, drifting sands had begun to threaten their lives. Wang Shu, scholar of the Jin Dynasty in his travelongue of the city of Hanzhou which is now called Wujiazeguchen in Horqin Zuoyi Houqi County mentioned that the city had undergone four facelifting efforts and three removals, due to the invasion of drifting sands. Most of Cultural remains of the Jin Dynasty is buried under the sand dunes, with wind-eroded sands on top of the cultural relics. A point in case is Long Hua between the Laoha River and the Jiaolai River, and Chang Lin that lies between the Xar Moron River and the Laoha River. This also applies to the graveyard of the Liao Dynasty on the present Erlin Forest Farm in Tongliao County, Inner Mongolia and lots of ancient sites of the Liao and Jin Dynasties.

With the establishment of the Yuan Dynasty and the Ming Dynasty after the 13th Century, power centre had gradually shifted southwardly. As a result, the area was basically under the rule of Mongolians, with livestock breeding as their main occupation. Farm land had been reduced in scale and the demand for industrial land use lessened to some extent. Consequently natural vegetation had been somewhat recovered. Early Qing Dynasty, by in the 17th Century the area had again reverted to a fine pastureland where great herds of horses, cows, sheep, and camels were grazing leisurely. Many of the enclosures and pastureland of the Qing Dynasty were located in the area. However, towards Mid - 18th Century, the Qing administration pursued a policy of encouraging massive farming by raising the prices of agricultural produce, thus ushering in another historical period of large-scale reclamation. Based on the surveys conducted of a few counties, it was concluded that large-scale agricultural reclamation in the area east of Horqin Steppe and south of the Xiliao River took place between 1750 to 1876. All the pastureland and cattle farms were open to acclamation in 1898 (24th year during the reign of Guan Xu Emperor). Land reclamation in the area north of the Xiliao River were carried out somewhere between 1887 to 1900. The wasteland reclamation projects were also carried out chiefly during the reign of Guan Xu Emperor following the adoption of land reclamation encouragement policy. Needless to say, this policy inevitably led to destruction of natural vegetation. It was assumed that vast expanse of drifting sands known as Taming Chakan Desert north of Yangxumu River in Hure County, the desertified land composed chiefly of drifting sand dunes west of Laoha River and Daqin Tala in Naiman were probably traceable to the land reclamation encouragement policy of that period. The area was originally characterized by a mixture of spotty drifting sand and fixed or semi-fixed sand dunes and it was only latter under the impact of that policy that it had became totally desertified.

2. Historical Process of Desertification and Human Impacts in the Light of Characteristics of Eolian Sand Dunes.

The desertification process denotes the dynamics of wind erosion which covers the wind erosion of the surface, surface roughening, the development of block drifting sand and the formation and evolution of intensive sand dunes. The historical process of desertification can understandably be revealed from the characteristics of eolian sand dunes.

From the profile of the fixed and semi-fixed sand dunes, one can clearly see a number of black or greyish brown layers of ancient soil buried underneath between layers of greyish yellow fine sands. The ancient soil has a full range of developmental layers, generally three in number. Viewed vertically from bottom to top, their profile (Fig.13) consists of:

1. horizontal layer of fine sand. The bottom appears white, while the upper part appears black due to the action of rotten organic matters. This is the first layer of ancient soil with apparent effect of soil formation.

2. greyish yellow layer of silt sands.

3. layer of dark brown ancient soil. The quality of this layer of sand is similar to layer 2, but a bit harder. It appears that this layer of ancient soil was formed of decayed vegetation.

4. layer of greyish brown fine sands.

5. layer of light brown ancient soil, with similar characteristics and appearance to layer 3.

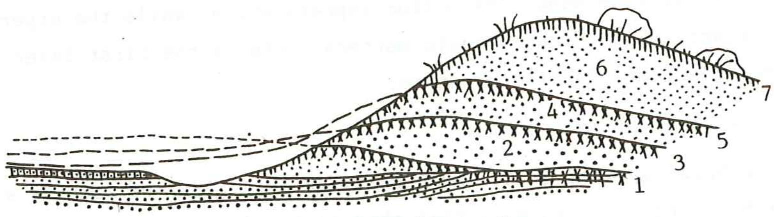
6. layer of light yellow fine sands.

7. surface layer of fixed sand dunes. The sands are dark brown and fine. This layer is possible of forming soil.

As far as their occurrence goes, the first layer appears more or less horizontal, the other two layers of ancient soils appear arch-shaped spatially. Generally speaking, the lower part is smoother than the upper part. They are 0.5 to 1.0 meter in thickness. Normally, the lower it lies, the thicker. In quality, layers of ancient soils are not much different from greyish yellow fine sands except that the former has plant root-induced and insect-caused holes and darker in colour due to the action of decayed organic matters. For this reason, the ancient soil layers are very distinct in the profile.

The ancient soil layers buried deep underground were the outcome of vegetation-induced soil formation when the desertification process was in the relative stable period. The fact that the ancient soil layer and eolian sands were interlocked and overlapped each other shows that sand dunes in their development process had undergone a number of stabilization and reactivation periods. And it is generally recognized that the movement of sand is markedly periodic.

Investigations showed that there were cultural relics layers unique to that period from the Neolithic Age to the Spring and Autumn Period. It was further discovered that the cultural relics layer of the Liao and the Jin Dynasties were located above the third ancient soil layer. From the position of the cultural relics layers in the sand dunes



(1) Horizontal fine sands in white colour
(2) Grey yellowish silt sands
(3) Dark brown old soil layer
(4) Grey yellowish fine sand layer
(5) Light brown old soil layer
(6) Light yellowish sand layer
(7) Brown yellowish fine sands on vegetated top

Fig. 13. Profile of Vegetated Dune

profile, it is known that Prior to the Hongshan Culture, which has a history of four to five thousand years old, the area had already been desertified to some extent as a result of wind erosion. Judging by the general outline of the ancient geographical surroundings after the Later Pleistocene epoch it was presumed that sand movements must have been active and extensive in the Xiliao River basin, with sand dune formations taking place only on a small scale. Since the Hongshan Culture, it now becomes known that at least twice in history sand movements had been vigorous. That is, before and after the Liao and the Jin Dynasties, those in modern times not counted. These two vigorous sand movements played a decisive role in tne dune growth and rate in history of the region. From what has been described above, we can conclude that historically, desertification had been in process in this area periodically and on an ever increasing scale.

The fact that stabilized sand dunes contain ancient soils, that is, black sandy earth, can be seen everywhere in Horqin Sandy Land. But the number of layers varies with the individual sand dunes due to the difference in their development history. At least two layers of ancient soils sandwiched in shifting sand pilings can be seen from profile of most sand dunes. This again shows sand movements took place periodically in the past and the law by which on a wide scale. Thus we can come to the conclusion that desertification is not a local phenomenan and that it is caused entirely by human activities. The sand dune developmental evolution suggests that there were several fluctuations and changes of climate in the region.

However, the fact that in the area desertification took place repeatedly in the past also suggests the ecosystem in the area was fragile and vulnerable. Analysis of sporangia indicates that in spite of the fluctuations in the climate, the area essentially remained semi-arid in nature with pastureland or sparsely-wooded pastureland as its distintive feature. It is possible that these climatic fluctuations in the area were characterized by the given landscape. Therefore one can say that in its long history the potential factor leading to desertification was all along present in the area and its ecosystem remained in a fragile and uncertain state. Under the circumstances, human activities had undoubtedly triggered off or accelerated the desertification processes both in intensity and scale. With historical changes taking place over the years in the area, with the changes in ruling nomads and in the modes of animal husbandry as well as farming, intensity in economic activities varied greatly in different historical period. For example, the policy on agricultural development adopted in the Liao and the Jin Dynasties and the policy on the reclamation of waste land for farming pursued in the Qing Dynasty had, to varying degrees, aggravated desertification in the affected areas. Climatic swing from dry to wet and vice versa accompanied by different intensity in human activities over the years had kept the area in a state of gradual desertification.Though at times relatively stable, the area displayed the general trend towards a deteriorating desertification process.

B. A Contempory Perspective of Desertification Process and Its Fcological Changes.

Desertification process in a contempory context refers to that which has occurred in the more recent century, namely from the Qing Dynasty onward when the reclamation campaign had boosted agricultural development. It was in this period of time that the area had shifted from a roming farming style to a settlement agriculture, thus ushering in a period of large-scale agricultural development. Particularly since the 1949 Revolution, population expansion, the change in the relationship of production and the development of productivity have all contributed to propelling human economic activities to a high unprecedented both in breadth and depth in the past. If the contribution of human activities in the past to desertification was only limited locally, it is no exaggeration to say that in the modern times the omnipresent human activities have an effect on desertification without any geographical limitations. One glance at any map of desert can tell that spotty or stripy desertified land is invariably where human activities are concentrated, such as human settlements, or areas close to the sources of water, or areas in the vicinity of human or livestock tracks. One can see an entirely different landscape inside the Daqinggou Natural Reserve in Horqin Zuoyi Houqi County from outside, and it is the demarcation barbed wire that makes the difference! Inside a landscape of primary sparsely-wooded grassland leaps into sight, while outside the demarcation barbed wires, what greets your eye is large patches of wind-eroded land, wavy sands and sand dunes interspersed with low shrubbery. Evidently it is not physical surroundings that causes the marked difference. Facts have convinced us that human factors is the direct cause leading to the area's desertification in modern times (with the help of wind tunnel experiment, we shall indirectly prove this from the angle of wind action later on).

As stated above, human factor is the direct cause resulting in desertification. But essentially it is the rapid growth of rural population directly dependent on land that has aggravated desertification, because rapidly expanding population increase the need for food, livestock products and cooking fuels, which in turn leads to overexploitation of land. For example, the overgrazing of pastureland from late 50's to early 60's and from late 60's to mid 70's had a devastating impact on the desertification of the area. over- reclamation of sandy grassland will before long lead to the serious desertification. A case in point is the Chaohai Commune in Horqin Zuoyi Houqi County.Investigations show that in early 50's in many of the areas southwest of Horqin Zuoyi Houqi County, north of the Yangxumu River in Hure County (with the exception of the strip of severely desertified land along the river), and south of Horqin Zuoyi Zhongqi County, there used to be large patches of primary sparsely-wooded grassland. But these places are now being rapidly desertified or have been seriously desertified.

Human activities including irrational reclamation, overgrazing of pastureland and indiscriminate cutting of trees for firewood, as stated already, will cause desertification to different degrees, but all these human activities have one thing in common:they contribute to destrustion of vegetation and soil structure, which in turn leads to the occurrence of wind action on the soil, so that the soil is eroded by wind, displaying a rugged surface, patchy shifting sand typical of a desert landscape (as in Tamin Chagan, north of the Yangxumu River). Fig. 14 shows the degradation of the primary sparsely-wooded grassland landscape into that similar to a desert landscape, a destruction process of ecosystem.

The desertification process shown in Figure 14 is a vicious circle, starting from a landscape of primary sparsely-wooded pastureland and ending in becoming seriously desertified land as a result of loss of potentials for producing biomass. This process is a process of ecosystem degradation which can be proven:

1) Degradation of Vegetation

Throughout the process of desertification, alternation and degradation of vegetation took place. The status of vegetation found at the different stages of desertification process sheds adequate light on how it became degradated. (based on case study in the area around Daqingguo district).

a. Latent Desertification-prone Land: it is characterized by better preserved vegetation and dense vegetative coverage with topsoil unaffected. Land composed of sand essentially falls into this type. Take the sparsely-wooded grassland near Daqinggou for example. As it was not as seriously destructed as elsewhere, primary vegetation for the most part remained untact. The vertical distribution of plant species in the community is as follows: Ulmus macrocarpa, U. pumila, Acer truncatum; Crataegus pinnatifida, Prunus sibirica, Lespedeza bicoior, Rhamnus davurica, etc; artemisia gmelinii, Ephedra sinica, Prunus huilis, Hedysarum fruticosum, Artemisia frigida; Aneurolepidium chiense, Artemisia capillaris, Arundinella hiirta, Cleistogenes polyphylla, C. squarrosa,Pofentilla anserina, Medicago faicata, etc. It is found that there is a great variety of species which are growing well. Most of the shrubbery and herbs can be used as fodder for livestocks. The percentage of cover for plant community vertically is 0.30 per cent for Ulmus macrocarpa; 0.40 per cent for Crataegus and for Artemisia and Aneuroiepidium could be as high as 70 to 80 per cent. Their average height is 50 to 60 cm with biomass reaching 3750-4500 kg per ha..

b. On-going Desertification-prone Land: In this type of land the predominant species are perenial Artemisia and Aneurolepidium spp. including chiefly Artemisia halodendron, Artemisia siewereiana, Pennisetum fiaccidum, Lespedeza hedysaroides, Polygon divaricatum. community coverage stands at 30-40 per cent and their average height is 40-50 cm for the Aneurolepidium layer, with biomass amounting to 3000 kg per ha..

c. Severe Desertification-prone Land: This type has a species distribution more or less the same as the above-mentioned types. Their great difference lies chiefly in the quantity. Salix godijiv, Hylodendron and some other one to two-year life cycle plants such as Setaria viridis, Corispermum deciinatum, Chenopocium acuminatum, Xanthium sibiricum

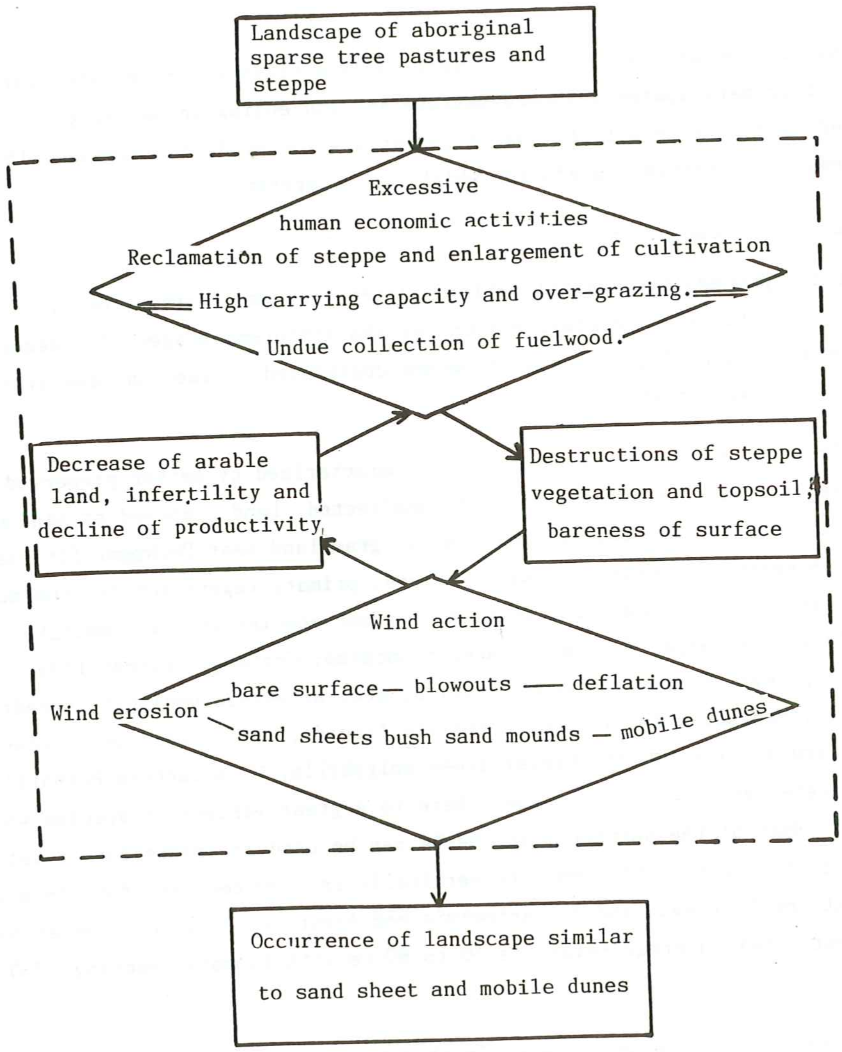


Fig. 14. Modern Processes of Desertification.

are representive of vegetation in this type of land. During the month of April, this type of land looks like shifting sand dunes; while in July and August, the average coverage of annual plants reaches 60-70 per cent and their fresh biomass can come up to 2250-3000 kg/ha.. But these species can not been trampled and chewed and munched by livestocks. Perennial plants found in this type of land include Salix godijiv, Aremisia hylodendron, Pennisetum fiaccidum, and Lespedeza. Their average coverage is 20-30 per cent, with biomass reaching 1500 kg/ha. or so.

d. Most Severe Desertification-prone Land: The distinctive feature of this type of most severe desertification-prone land is that vegetation degradation has reached its zenith and that the land has lost all its value for utilization. Occasionally you can also find a little vegetation scattered here and there on the sand dunes which chiefly include Agriophyiium, squarrosum and Polygn divaricatum, etc., with a coverage rate of less than 10 per cent and average height of 30 cm. But their biomass ranges from 375 to 750 kg/ha..

Compare vegetation on the different types of desertification-prone land and one can come to the conclusion that firstly the vegetation degradation more or less takes the following evolutionary pattern: sparsely-wooded pastureland-bush community - perennial Artemisia, and Aneuroiepidiuym-Artemisia sievereiiana and grass-unique psymophytes. Secondly the succession trend of the vegetation is a) from complex community to simple one. For example, the vertical distribution of the sparsely-wooded pastureland is from arbor to herb, generally with 4 to 5 tiers. With the intensification of vegetation degradation, the tiers are gradually reduced in number and more simply structured. As a result, the shrubbery bush and perennial herbs are progressively succeeded by Psymophytes (Table 15); b) from more biomass to less. Biomass here in this context refers to the quantity of fodder that animals can feed on. Vegetation degradation is characterized by lower height of plants, greater sparsity, less dry matter and consequently less biomass. For detailed information on the heights of various species of perennial herbs and their biomass, readers are requested to see Table 16; c) Pastureland has been deteoriorated in quality, which can be seen from reduced percentage of legume and the grass species in the community that can be consumed by livestocks.

2) Changes in the Soil Composition

In the process of desertification, significant changes take place in the soil composition and the amount of nutrients such as organic matters and total nutrients, microelements and minerals. Such changes are usually brought about by the differentiating effect of wind. The nature and scope of these changes are determined, however, by different topsoil.

(1) Changes in the Soil Composition and Grainness of Particles on Surface.

(a) Changes in Particle Grainness Before and After the Reactivation of Vegetated sand dunes.

Table 16. Vegetative Nature on Various Desertification-prone Land.

Indicators / Vegetation Community / Various desertification		Latent desertification-prone land sparse woodland	On-going desertification-prone land bush and perenial herbs	Severe desertification-prone land severe perenial herbs. Artanisia	Severe desertification-prone land Artemisia spp. weeds.	Most severe desertification-prone land Psgmophyle vegetation.
Verticle Distribution of Species in Plant Community	Arbor	(Ulmus macrocarpa) (U. Pumila) (Acer truncatum)				
	Bush	(Crataegus Pinnatifida) (Prunus sibirica) (Lespedeza bicolor)	Cretaegus Pinnatifida Prunus sibirica Lespedeza bicolor		(Salix fiavida)	
	Semi shrub	(Artemisia gmelinii) (Ephedra sinica) (Hedysarum fruticosum) (Artemisia frigida)	Ephedra sinica Artemisia gmelinii	(Artemisia gmelinii) (Lespedeza hedysaroides) (Artemisia halodendron) (Artemisia sieversiana) (Artemisia frigida) (Hedysarium fruticosum)	Hedysarium halodendron	Hedysarium halodendron
	Herbs	(Aneurolepidium chinense) (Artemisia capillaris) (Arundinella hirta) (Cleistogenes polyphylla) (C. squarrosa) (Potentilla anserina) (Medicago falcata)	(Stipa baicalensis) (Aneurolepidium chinse) (Cleistogenes polyphylla) (Allum ramosum)	(Artemisia capillaris) (Aneurolepidium chiense) (Pennisetum flaccidum) (Polygonum divaricatum)	(Coris permum declinatum) (Setaria viridis) (Chenopodium acuminatum) (Xanthium sibiricum)	(Polygon divaricatum) (Agriophyllum sguarrosum)
Total coverage of various plant community		70-80	50	30-40	20-30	10
Average height of herb species (cm)		50-60	50-60	40-50	30-40	30
Eatable fresh biomass (kg/ha.)		3750-5250	3750-4500	3000	1500	375-750
Percentage of eatable legum and herb species		48.5	52	49	28.6	11.3

Due to different duration of stablization, the growth of surface structures differs from area to area. Compared with swamp area, sand dune usually came into being at a later stage and its soil formation is weak. Apart from a stable layer of soil supporting the growth of grass, all the sub-surface structures consist of loose-sand brought about by wind. As a result, any movement of the vegetation such as tillage, may lead to the formation of moving sand dune under wind effect. The late stabilization and fixation of surfaces results in changes in the composition of particles mostly on the surface.

Table 17. Changes in the Size of Sand Grains Before and After Reactivation of Vegetated Sand Dunes

Duneforms	Depth (cm)	% of Hydrochloric acid lost	% of Grainness of Soil Particle (Diameters: mm) 1-0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001
Fixed sand dunes	00-10	1.78	11.13	74.4	10.88	0.16	0.65	1.00
	10-25	0.95	12.46	84.01	2.43	0.03	0.12	0
	80-100	0.88	8.2	90.01	0.16	0.11	0.05	0
	00-16	1.41	43.98	44.38	9.25	0.8	0.18	0
	16-72	1.38	65.08	32.69	0.3	0.28	0.27	0
	72-100	0.61	71.55	26.21	1.12	0.26	0.26	0
	00-31	12.69	27.72	39.98	10.25	3.6	7.31	11.14
	31-67	2.11	37.44	51.12	10.27	0.01	0.7	0.46
	67-103	1.91	42.14	53.04	2.99	0.03	1.8	0
Semi-fixed sand dunes	00-15	1.66	20.77	71.4	5.07	0.26	0.11	0.73
	15-35	0.99	25.03	71.08	5.11	0.32	0.47	0
	20-100	0.77	18.87	79.83	0.17	0.11	0.25	0
	00-30	1.09	19.87	74.5	3.64	0.8	0.1	0
	00-12	1.19	19	76.65	3.97	0.01	0.25	0.12
	12-28	2.07	13.55	76.23	8.9	0.34	0.33	0.65
	28-60	1.26	16.38	81.22	0.86	1.54	0	0
	60-90	1.9	15.41	82.86	0.51	1.22	0	0
Shifting sand dunes	00-10	1.1	52.21	46.28	0.12	0.29	0	0
	30-40	0.58	61.86	37.28	0.04	0.1	0.14	0
	80-100	0.92	17.51	81.29	0.23	0.01	0.04	0
	00-25	0.91	76.96	21.99	0.11	0.02	0.01	0
	00-10	0.79	31.5	66.81	0.54	0.28	0.08	0
	10-30	1.04	41.65	55.44	1.21	0.13	0.53	0
	30-50	1.19	42.08	55.87	0.13	0.42	0.31	0
	50-100	2.87	56.38	40.05	0.29	0.01	0.01	0.39

Table 17 shows that soil in different depth is formed in different sand dune areas. One common feature in the composition, however, is that the fine particle is concentrated on the surface. Surface physisorption ranges from 0.98-14.45 percent. The amount of sand particle with diameters from 1-0.05 is about 67.70-88.36%. The ratio of sand increases from stabilized sand dune to semi-fixed sand dune to moving dune, usually from an average of 80.53 to 94.06% or 98.58%. At the same time, the amount of physisorptive particle decreases from 8.08 to 0.71 or 0.23 per cent, as surface particle turns coarse.

(b) Changes in the Soil Composition in Swamp Areas.

Lowlying land, a type of undulating sand field, forms a peculiar type of land in Jirem Prefecture, largely as a result of stablization of sand dune and soil formation. In the process of desertification, the changes of soil composition is similar to that of stablized sand dune. The only difference is that these fields are often used as cropping land. Deflation is prevalent and moving dune is restricted in area.

In the lowlying land area in the North of Naiman, the surface layer (0-20 cm) of the depth of 144 cm contains 93.97 per cent sands and 1.57 per cent physisorptive particle. The next layer (20-34 cm) contains 90.82 per cent of sands and 3.37 physisorptive substance. From the first layer to the next, fine particle decreases by 1.8 per cent.

In the lowlying land area in the South of Naiman, once moving dune occurs, sand increases by 12.33% and fine particle decreases by 2.24 per cent compared with that of underlying layers (Table 18).

Table 18. Changes in the Size of Sand Grains in Lowlying Land Area

Sampling areas	Depth (cm)	% of Hydrochloric acid lost	% of different sand grains (Diameter: mm)					
			1-0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	>0.001
Xingrong Zhao	00-20	1.42	50.89	43.08	4.46	0.21	0.53	0.83
	20-34	2.99	42.79	48.03	5.81	4.01	0.44	2.52
	34-96	1.86	46.8	45.77	5.02	0.05	0.69	1.67
	96-144	1.42	61.51	35.86	1.62	0.66	0.25	0.1
Shalihao-lei	00-100	3.79	26.15	59.07	10.77	0.7	0.77	2.54
Mobile dunes	00-10	2.3	43.85	53.7	0.68	0.14	1.63	0
Chaogutai farming land	00-15	4.49	0	91.33	4.39	0.83	0.34	3.11
	15-30	5.6	0	89.86	4.98	0.3	0.27	3.59
	30-50	5.82	0	85.31	8.96	0.01	1.78	3.94
Chaogutai abandoned farming land	00-15	6.69	0	95.05	1.17	0.09	0.65	3.04
	15-30	5.71	0	29.51	3.72	1.73	0.64	4.4
	30-50	4.68	0	92.91	7.09	0	0	0

In the cultivated dry crop land of the lowlying land area in the South of Naiman, the increase in thickness of sand particle led to the abandonment of farming after three years of continuous cultivation: For instance, in Chaogutai, the seeding layer (0-15cm) of cropping field contains 91.33 per cent of fine sand (0.25-0.05 mm) and the tillage layer contains 89.86 per cent in 1982, a difference of 1.14 per cent. As the years go by and cultivation continues, surface will become coarse and the amount of fine sand will increase to 95.05 per cent, close to moving dune, which necessitates the abandonment of further cultivation.

(c) Changes of the Composition of Sand Grains in Depression Area.

The soil in the depression is of a better soil than the rest of Jirem Prefecture whose farming land is situated in the depression and river terraces. However, the depression is also under certain degree of desertification, although relatively much less serious than the cases in lowlying land area and fixed dune area. And its arable land is growing smaller in acreage.

In the depression areas where desertification has not take place, the grainness of soil particle is basically similar to the stablized sand dunes, containing 87.38% of sand and 1.83% physical clay particle. A soil profile shows us that the size of the particle increases with depth. In terms of space distribution, east part of the depression area has smaller particle than the west part of the depression. The descent of underground water level and over-grazing have led to changes in the water content of the soil and the destruction of vegetation and consequently desertification. Table 18 shows that due to desertification, the topsoil in the south part of the depression area in Guri Benhua contains 89.89% of sand, 3.83% more than the subsurface, and physical substance decreases by 1.73%. The cultivated area in the depression is facing the similar problem.

Table 19. Changes in the Size of Grains in Depression Areas

Sampling areas	Depth (cm)	% loss of Hydro-chrolic acid	1-0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001
Xingmin Village of Horqin Zuoyi Houqi	00-14	11.74	16.55	68.18	2.67	0.27	0.33	0.26
	14-33	15.5	3.67	83.14	2.13	0.18	0.17	0.21
	33-115	12.22	0	84.23	2.65	0.35	0.44	0
	115-135	1.99	0	97.25	0.61	0.08	0.07	0
Jileshun Village of Hure	00-17	8.57	9.57	78.5	2.91	0.14	0.13	0
	17-80	6.71	25.86	65.81	1.27	0.23	0.12	0
	80-100	2.5	42.36	54.36	0.63	0.06	0.09	0
Huanghua Tala, Naiman	00-15	3.68	0	82.88	8.91	1.98	0.16	2.38
	15-30	0.15	0	89.41	8.37	0.71	0.01	1.35
	30-50	11.76	0	72.05	7.58	1.31	1.74	5.56
Guri Benhua, Naiman	00-14	3.91	29.86	60.03	8.47	0.01	0.35	1.28
	14-25	3.78	27.16	58.9	10.58	1.36	0.38	0.63
	25-50	2.99	28.08	66.13	4.76	0.12	0.43	0.48
	50-82	3.63	27.36	69.73	2.04	0.48	0.05	0.34
	82-104	1.83	35.11	63.06	1.05	0.27	0.54	0
	104-124	1.39	9.3	88.97	1.09	0.64	0	0
Mandou (Cultivated land) Horqin Zuoyi Houqi	00-25	0.84	33.6	58.98	5.56	0.37	0.28	0.37
	25-40	1.31	31.99	59.37	5.3	0.23	0.66	1.14
	40-70	0.7	15.35	77.69	5.28	0.21	0.77	0

Loess hills with silt-sand are distributed mostly in the south part of the region . Table 20 shows that the top soil on loess land is being becoming coarse. Where fine sand such as Baiyinchang forms more than 60 per cent of the subsurface, there is a tendency to develop mobile sands in addition to going coarse. This concurs with the conclusions drawn from an early study on the desertification in north Shaanxi Province, silt-sand area on Loess Plateau.

Summarizing, it is clear that regardless of the original soil pattern, once desertification starts, the composition of the surface material starts to change and coarse grains occur due to loss of fine materials.

Table 20. Changes of Silt-loess Composition and Grains in Loess Hilly Areas.

Sampling area	Depth (cm)	Hydro-chrolic acid %	Contents of grains (Diameter mm) (%) 1-0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001
Qinglong Shan	0-250	7.45	0	85.09	10.23	0.17	0.57	3.94
	below 250	10.99	0	56.78	30.55	1.28	2.31	9.08
Baiyin Chang	0-25	22.40	0.86	59.10	26.68	0.29	2.89	10.18
	25-50	18.91	0.59	51.39	29.73	2.94	1.53	13.82
Baiyin Chang (Under-lying Sediment of dune)	0-15	7.99	2.59	77.01	9.72	1.26	1.42	8.00
Mobile dune	0-15	1.52	14.54	84.20	0.41	0.21	0.35	0.29

(2) Changes in Soil Nutrition, Trace Elements and Minerals:

Desertification caused by the reactivation of stablized sand dunes is developing at an extremely fast rate across the most extended areas in Jirem Prefecture. The following comparison offers some insight between the composition of soil nutrition, trace elements and minerals before and after the reactivation of stablized sand dunes.

(a) The same type of stablized sand dunes may differ greatly in terms of nutritional contents. Table 21 indicates that the amount of organic matters in stablized sand dunes of different areas varies from 0.9, 1.19 and 1.4 per cent respectively,all higher than lower levels underground. By vertical profile, organic matters decrease with depth,the surface containing 9.7, 7 and 7.8 times more than the subordinate levels. The changes in the level of nitrogen and phosphate are comparable to organic matters, which decreases with depth. The vertical distribution of potassium, however,is relatively even with all sections having a high level of potassium.

Semi-fixed sand dune is formed in two ways. First, the fixed sand dune may degenerate through ecological destruction into semi-fixed sand dune. Secondly, moving sand dune may reverse into semi-fixed sand dune. Despite the fact that both are in the state of semi-fixation in terms of surface stability, their soil quality differ in that the first type is similar to stablized and the second type to moving sand dune, and therefore the composition of their organic matters and nutrients are very different. Degenerating from stablized sand dunes into moving sand dunes, the percentage of organic matters decreases from an average of 1.19 to 0.59 as in semi-fixed sand dune to 0.09 as in moving sand dune, which is only 7.6 per cent of that in stablized sand dunes.The nitrogen content also decreases from 0.048 to 0.027 or 0.004 percent, moving sand dune containing only 8.3 percent of the nitrogen content of stablized sand. Phosphate decreases from 0.05% in the surface of stablized sand dune to 0.021% and 0.009% respectively, that in moving sand dune being 18% of stablized sand dune. The change in the level of potassium is insignificant.

Stablized sand dune contains both more organic matters as well as other nutrients in the top soil than moving sand dune, the biggest difference lies with organic matters, followed by nitrogen and lastly phosphate.

Table 21. Changes in Nutrients Before and After Reactivation of Fixed Sand Dunes

Duneforms	Depth (cm)	Organic matters (%)	Total nutrients (%)		
			N	P_2O_5	K_2O
Fixed sand dune	00-10	0.97	0.035	0.031	2.87
	10-25	0.26	0.003	0.01	2.95
	80-100	0.1	0.001	0.009	2.95
	00-16	1.19	0.064	0.046	2.58
	16-72	0.51	0.029	0.026	2.48
	72-106	0.17	0.006	0.013	2.48
	00-31	1.4	0.047	0.074	2.88
	31-67	0.46	0.019	0.031	2.84
	61-103	0.18	0.005	0.035	3.04
Semi-fixed sand dunes	00-15	1.04	0.033	0.032	3.02
	15-35	0.44	0.008	0.013	2.74
	80-100	0.11	0.002	0.007	2.8
	00-30	0.45	0.008	0.016	3.09
	00-12	0.27	0.029	0.014	2.25
	12-28	0.55	0.09	0.021	3.02
	28-60	0.2	0.036	0.011	2.88
	69-90	0.1	0.019	0.011	3.18
Mobile dunes	00-10	0.09	0.008	0.009	3.02
	30-40	0.08	0.008	0.008	3.16
	80-100	0.08	0.008	0.006	2.69
	00-25	0.07	0.001	0.008	2.87
	00-10	0.11	0.004	0.01	2.45
	10-30	0.1	0.003	0.111	2.13
	30-50	0.08	0.007	0.012	1.93
	50-100	0.09	0.003	0.015	1.55

(b) Changes in the Trace Elements in Soil

It can be seen from Table 22 that trace elements decrease from surface to depth in stablized sand dunes, but are richer in the surface, upper and lower sections than the middle section in semi-fixed sand dune. The changes trace element in moving sand dune are insignificant. Trace elements disappear gradually with the process of degenerating from stablized to mobile sand dune.

Table 22. Changes in Trace Elements Before and After Reactivation of Fixed Sand Dunes

Duneforms	Depth (cm)	Trace Elements (PPM)						
		Ti	Mn	V	Cr	Ni	Co	Zn
Fixed sand dunes	00-10	582	126	10	19	7	8	47
	10-20	382	124	7	14	5	7	49
	80-100	238	67	4	14	5	7	43
	00-30	987	126	12	13	7	8	56
	30-70	128	41	3	11	7	9	40
	00-25	2720	303	17	39	10	2	72
	25-60	1680	136	7	25	7	2	45
	00-20	628	113	7	14	7	4	27
	20-40	295	39	3	9	5	4	18
Semi-fixed sand dunes	00-20	410	103	8	15	5	7	50
	20-40	380	112	7	23	8	8	51
	80-100	274	71	5	11	4	7	43
	00-25	170	51	2	7	4	4	24
	00-30	302	62	3	8	4	4	27
	00-30	169	32	3	16	6	2	51
	00-30	254	41	5	13	8	8	58
Mobile dunes	00-10	191	55	3	16	7	3	54
	30-40	277	59	3	14	6	2	60
	80-100	778	99	6	16	6	2	60
	00-30	108	59	3	10	6	7	50
	00-30	126	52	5	12	7	9	53
	00-30	156	30	3	9	6	7	49

(c) Changes of Mineral Elements in Soil (Table 23).

The silicon dioxide concentration in fixed sand dunes and shifting sand dunes are respectively 83.13 per cent and 84.85 per cent while in the topsoil the average concentration is 77.69 per cent for fixed sand dunes and 84.88 per cent for shifting sand dunes. There is marked higher oluminum oxide and ferric oxide in the surface of the fixed sand dunes than in the lower part. The average concentration of these elements is higher in the fixed sand dunes than that in the shifting sand dunes. There is more or less the same amount of sesqui oxide with little change in upper and lower layers discovered in the profile of shifting sand dunes. However there is a higher concentration of other elements, with the exceptin of potassium oxide, in the fixed sand dunes than that in the shifting sand dunes, particularly so in the surface. Little change in the potassium concentration in different layers of different profile of sand dunes is found.

Table 23. Changes in Mineral Composition Before and After Reactivation of Sand Dunes

Duneforms	Depth (cm)	Minerals as percentage of										Ratio		
		SiO_2	Al_2O_3	Fe_2O_2	CaO	MgO	K_2O	Na_2O	TiO_2	P_2O_5	MnO	SiO_2/R_2O_3	SiO_2/Al_2O_3	SiO_2/Fe_2O_3
Fixed sand dunes	00-15	77.45	8.45	1.59	0.8	0.79	2.73	1.25	0.33	0.04	0.01	13.88	15.55	129.1
	15-40	87.77	6.03	0.57	0.4	0.3	2.76	0.81	0.07	0.02	0	23.22	24.8	365.75
	00-30	76.2	10.16	2.21	1.1	0.82	2.55	1.77	0.48	0.04	0.03	11.14	12.7	90.71
	30-70	86.31	7.05	0.53	0.45	0.26	2.63	1.6	0.1	0.01	0	19.99	20.86	479.67
	00-16	80.32	9.57	2.33	0.91	0.7	2.52	1.48	0.38	0.01	0.03	12.27	14.22	89.13
	16-72	84.59	8.39	1.12	0.71	0.55	2.57	1.21	0.23	0.01	0.02	15.84	17.2	201.43
	72-100	86.63	6.96	1.04	0.71	0.23	2.61	1	0.17	0.01	0	19.25	21.24	206.29
	00-0.5	80.58	10.04	1.33	0.78	0.49	2.55	1.61	0.31	0.01	0.03	12.67	13.7	167.88
	0.5-10	82.37	9.47	1.04	0.56	0.47	2.51	1.46	0.2	0.02	0.02	13.73	14.76	196.14
	10-22	84.57	8.96	0.91	0.58	0.3	2.59	1.33	0.19	0.01	0.02	15	16.02	235
	22-46	85.35	8.47	0.81	0.4	0.38	2.59	1.39	0.14	0	0.02	16.17	17.14	284.6
	46-100	85.55	8.07	0.88	0.38	0.31	2.59	1.36	0.1	0.02	0.02	16.87	18.05	237.07
Mobile dunes	00-10	84.88	8.46	0.73	0.38	0.23	2.59	1.26	0.01	0.01	0.02	16.08	17.05	283
	10-30	84.44	8.61	0.87	0.48	0.2	2.51	1.22	0.14	0	0.02	15.81	16.75	281.4
	30-50	85.04	8.18	0.71	0.43	0.15	2.55	1.16	0.07	0	0.01	16.87	17.71	354.25
	50-100	84.11	8.8	1.04	0.46	0.21	2.67	1.23	0.11	0	0.02	15.08	16.3	200.29
	00-30	85.78	7.84	1.32	0.57	0.36	2.28	1.03	0.25	0.01	0.04	16.82	18.57	178.25

From what is stated above, it is conslusive that the changes in organic matter,nutrient concentration, trace elements, and composition of minerals have a great deal to do with the stage of soil development and composition of grain. The composition of grain is the dicisive factor determining the distribution of chemical elements in the desertified land. The finer the grain, the more chemical elements it sets free and absorbs, resulting in a higher concentration. Conversely, the coarser the grain, the less chemical elements it contains, and the less fertile the land. Either in the fixed sand dunes or shifting sand dunes, the average SiO_2 concentration exceeds 80 per cent, which is the principal elements of sand grain composition, and can withstand wind erosion to a large extent. Even if it is weathered, it can not provide nutrients, because of its composition of SiO_2. Therefore as far as fixed sand dunes are concerned, there is a greater amount of fine grain in the top. Due to the wind action on it, which is actually a process of desertification, the fine sand grain is progressively reduced, resulting in greater amount of coarse grain. This process eventually leads to the formation of shifting sand dunes composed of equally-sized grain. In the process, the organic matter, nutrients and other chemical elements diminish in quantity with the deminishment of fine sand grain in the top, leading to the loss of fertility of the land. This is the desertification process that occur in the severe desertification-prone land. The same changes in the composition of elements in the topsoil take place in other desertification-prone lands.

3. Changes in Water as Contained in the Soil

Water is the extremely important factor in ecosystems in general and in the desert ecosystem in particular. In deserts wnere there is little precipitation and high evaperation plus an extremely deep ground water table, water understandably becomes a major constraint on the growth of plants.

Underground water not counting, rainfall is the only source of water replenshment in desert surface. The depth of moist layers depends on the frequency and intensity of rainfall. as well as the characteristics of the soil in question (figure 15).

From figure 15, one can perceive that the depth of moist layers in the desert is proportional to the amount of one given rainfall. Based on the measurements obtained and surveys conducted from April to July, it was found that the changes in the amount of water contained in the shifting sand dunes change with the timings of rainfalls. After a rainfall, it was discovered that sand layers contained some 5 to 7 per cent of water and in some depth it could exceed 7 per cent. In the absence of rain, the amount of water contained in the upper layer stands below 1% which is generally known as dry sand layer. 10 centimeters below this dry sand layer is recorded a 1-2 per cent or 2-3 per cent of water. Further below this depth is a 3-5 per cent water layer. It is generally believed that it is in this depth of layer this amount of water remains unchanged. Whereas in the semi-fixed sand dunes the amount of water contained in the corresponding

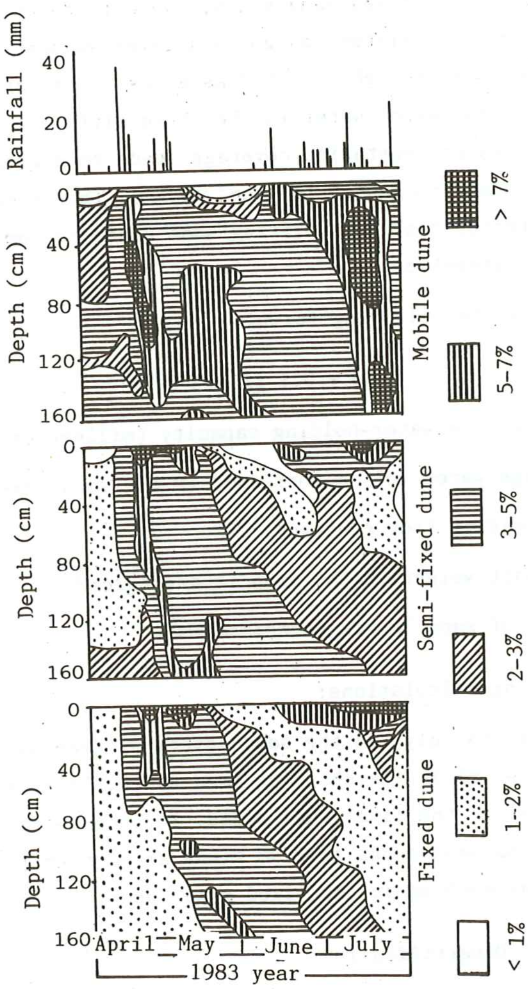


Fig. 15. Water Contents in Various Dunes in Daqinggou, Horqin Zuoyi Houqi County, Inner Mongolia

layer stands alternatively at 1-2 per cent, 2-3 per cent or 3-5 per cent with no apparently stable water concentration. With fixed sand dunes, the figure is alternatively 1-2 per cent, 2-3 per cent or 3-5 per cent. As there was no rain for days in succession before 22 April, the sub-surface layer contained only 1-2 per cent of water. As time went on, this percentage of water infiltrated into a depth of 160 centimeters. From 13 May to 10 June, a dry spell again set in. From 20 May, the sub-surface layer of the desertified land again contained 1-2 per cent of water, gradually lowering to a depth 160 centimeters. In the fixed sand dunes, there is relatively a dense vegetation coverage where the plant root system can go to a layer as deep as 45 centimeters. This limited amount of water soon enough vanished as a result of fast evaperation. Judging from the changes in the amount of water in the three different desertified lands, it is believed that the greater vegetation coverage leads to a greater degree of stability which speeds up the drying process in the sand layers. Therefore one can conclude that water availability deteriorates from shifting sand dunes to semi-fixed sand dunes and to fixed sand dunes progressively.

It may be calculated by the following formula:

$$Be = 0.1\ (P-Pz)\ 0^{\delta}.H$$

Where, Be refers to effective water-holding capacity (millemeter/per unit),

P refers to the average water volume contained in the sand layers (per centage),

Pz refers to fading humidity (per centage),

0^{δ} refers to average unit weight in the sand layers (g/cm^3),

H refers to thickness of sand layers (centimeters),

We obtained the following calculations:

In the months from April to July, in the sand layers as deep as 160 cm, the average effective water is 102.46 ml in the shifting sand dunes, 51.79 ml in the semi-fixed sand dunes, and 41.09 ml in the fixed sand dunes. In other words, the effective water available in the shifting sand dunes is 1.98 times as much as in the semi-fixed sand dunes, and 2.49 times as much as in the fixed sand dunes.

(c) Physical Process of Desertification

Physical process of desertification refers to the process of wind action and the changes of surface features caused therefrom.

1. Process of Wind Action

Wind tunnel experiments show, a given grain has a given threshold wind velocity. The diameter in the grain and thresholding wind velocity relates to each other as shown in figure 16. From figure 16, one can see a grain with a diameter of approximatly 0.1 mm would require a minimum thresholding wind velocity. Therefore one could conclude that

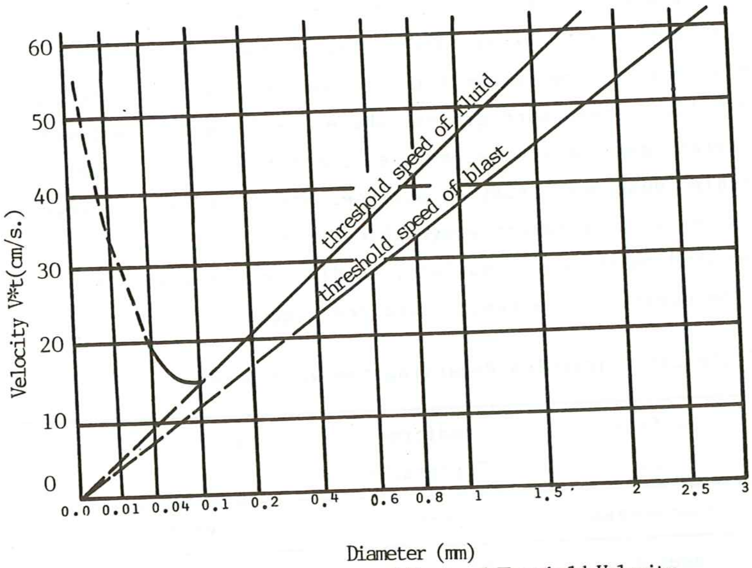


Fig.16. Relationship between Grainness of Sand and Threshold Velocity

residue in the form of physical sand grains in their free state or sandy soil are most vulnerable to the wind action.

This is also the basic dynamics causing roughness of earth surface. However there are many other very complicated factors affecting the wind action. Some scientists, listed a number of variables in relation to wind erosion (Table 24). It is obvious that from the view point of wind action, the wind action process in the semi-arid grassland is different from that in arid desert area. Their major difference lies in the lower part on which the wind acts. The latter for the most represents a free sand surface covered with dry and fully exposed sand grains, while the former has a lower part with an entirely different and complicated nature. There is not only vegetation on the earth surface, but also dust-moss crust on surface. What is more, the vegetation and surface crust also varies with different geograghical areas. All these factors complicate the action of the wind on the earth surface. We did conduct a wind tunnel experiment in relation to the question. The result obtained suggest:

Table 24: Variables Regarding the Wind Erosion

Wind (1)	Surface (2)	Landform Topography (3)	Soil (4)	Surface effect (5)
wind speed	coarseness	flatness	stratification	movement
direction	vegetative coverage	hills	structure	accumulation
structure	barriers		organic matter	sand ripples
humidity	temperature	break through	water-holding capacity	sand ridge
temperature			soil viscosity	
sand trans-porting rate				

(1) Under the impact of wind (without sand transporting), the sandy surface with a certain structure developing soil strong wind of 15.5 m/s without the protection of vegetation. Once the surface is eroded, however, the threshold wind velocity will be immediately slowed down.

(2) Under the impact of sand-transporting air current, the surface with the original topsoil structure and protected to a certain extent by vegetation is susceptible to wind erosion instantly. consequently, wind deflation and blowout are developing at a very fast rate.

Based on the results of this experiment, and also taking into consideration of the wind conditions in the area (Table 6), one can see that the sandy surface will not be eroded by wind unless it is not covered with protective vegetation and the structure of the surface is damaged. Once the topsoil is exported or disrupted either as a result of irrational land reclamation or human impact or animal trampling, thus baring the surface, erosion will occur, resulting in the formation of air current mixed with sand. Once erosion does occur, it will accelerate till the otherwise unaffected section of the area also comes under the influnce of wind action. This accounts for the fact that the patchy shifting sand, bush vegetated sand mounds or shifting sand dunes generally occur in a spotty or striped arrangement and are located where there are human settlements and water source..

It is not difficult to understand why the sand-transporting air current has a greater erosion effect on the surface than the air current without sand transporting under the same wind force. In the case of wind without sand transporting, the surface is acted on by shearing stress, the intensity of which changes with the difference of the wind speed and the value of air density. While in the case of sand-transporting air current, the sand grains exert direct impact on the soil. The strength of this impact depends on the speed of the dashing sand grains and also has something to do with the weight of the sand. The difference in density between air and sand grains is very wide. In normal conditions, the air density value is p=1.25 x 10 (gram/cm^3), while the sand density value is δ =2.65 (gram/cm^3), a difference as great as several thousand times! This may well account for their difference in erosion effect. In this sense,efforts to stabilize sand are more meaningful than efforts to shelter from the wind.

Table 25. Comparison of Wind-sand Impacts on Surface of Different Dunes Under Various Stablization (Horqin Zuoyi Houqi County, April-May, 1983)

Items / Surface feature	Coarseness (cm)	Statistical regression of sand volume Q and wind speed V	Co-efficient	Value coefficient at 0.01
Mobile dune	1.100×10^{-3}	$q=1.15 \times 10^{-4}v^{4.73}$	0.93	0.83
Semi-shifting bush-vegetated sand mounds	2.851×10^{-1}	$q=1.10 \times 10^{-3}v^{3.64}$	0.87	0.74
Semi-fixed bush-vegetated sand mounds	1.600×10^{0}	$q=1.78 \times 10^{-4}v^{3.56}$	0.88	0.71
Fixed dunes with scattered sands	2.334×10^{0}	$q=1.70 \times 10^{-6}v^{4.57}$	0.83	0.77

Field observation indicates that desertified land of varying degrees under the same wind effect can produce quite different sand activities due to surface feature. Table 25 shows that between fixed to mobile dunes, the size of surface particles may differ, because of different vegetation conditions, to several factors. Thus the threshold wind velocity on mobile dune is around 5 m/s (2 meters high above ground),while for semi-fixed bush sand mounds it is 8 m/s. For fixed sand field with bush, it requires a wind speed of at least 18.3 m/s. Further, under the same wind effect, the amount of sand carried may also differ to a factor of two.

By this observation and according to the frequent distribution of different threshold wind velocity (≧5 m/s.) in the area, mobile dune carries much more sand than fixed sand field under threshold wind velocity (≧5 m/s.) and is much more active for longer duration. It can be concluded from the differing wind effect therefore that sand fields of varying degrees of desertification develop at different rate.

Summing up the observation both in wind tunnels and field, two basic points emerged: (1) Arid steppe is the base of wind erosion; and (2) Different stablization of dune surface can resist wind erosion at different scale under wind force.

2. Change of Surface Feature.

Over-grazing, over-reclamation of grassland and undue collection of fuelwood in most cases have led to the destruction of vegetation on protogenic pasture land, changed topsoil composition and created blowouts for wind effect, caused sand movement and the changes of surface features, and growth of eolian landform. This process did not only destroy protogenic vegetation and soil composition, but also caused topographical change. This is an obvious indicator and evidence to interprete desertification and its intensity on aerial photographs and landsat images. The process of topographical change can be understood by studying the surface feature of sand field during different stages of desertification. Despite the differing topography in their original state, which to some extent determines the later development, all areas are subject to wind erosion, proliferation of wild bush, sand sheets and develop further into barchans or sand dune chains. Under continued wind effect, the characteristics of wind erosion become more and more marked both in intensity and scope. Table 26 is an illustration of the process of topographical change through desertification in fixed bush vegetated sand mounds and fixed undulating sand dunes in the area.

The desertification process in this area is characterized by its hereditary nature, which means that it is caused by the reactivation of existing vegetated sand dunes.The most apparent feature of this process is the gradual change from fixed bush vegetated sand dune to semi-shifting sand dune to eventually mobile dunes in the forms of barchans and barchanoid chains.

As mentioned above, wind effect which leads to particular spatial distribution of surface, is based on certain condition. It turns out that most of such conditions are related to human activities. Therefore, such features are also most visible in the areas inhabited by human, instead of being directly related to wind. Yet mono-form of dune or surface feature such as breakthrough and blowouts often develop to a particular position to sand dunes. For instance, a number of such blowouts occurred on the north bank of Yangxumu River, Hure County and located on the west slope of vegetated dunes. In Daqinggou District of Horqin Zuoyi Houqi County, blowouts are developed on the southwest slope of vegetated dunes, indicating local wind regime.

Table 26. Changes of Surface Features

Surface factures / stages	Vegetated Honey-comb Dune	Undulating Fixed Dune and Sand Flats
The stage with potential risk	Emergency of blowouts on windward slope with scattered sands and bush communities	Scattered blowouts, without clear indication of wind erosion. Dry farming is slightly eroded. Tillage system on abandoned fields can be seen.
Developing stage	Blowouts expanding on windward slope of dunes and gradually covered by sands. Sand dunes become semi-fixed bush-vegetated sand mounds.	Sand sheets and sand accumulation occurred in scattered way. Dry-farming lands without tree shelterbelts turn into inferilized. Tillage system become eroded.
Severely developing stage	Blowouts on windward slope of dune expand to cover upper part of dunes. Sand accumulation at leeward slope of dune and vegetated dunes were turned into mobile one.	Scattered sands spread, bush-vegetated dunes were redeveloped, and tillage system was deflated.
Most severely developing stage	All vegetated sand dunes are covered with sands accumulation to form mobile dunes and leeward slope of dune is formed.	Mobile dunes, bush-vegetated dunes and eroded land developed.

d. Issues of Desertification Trends in the Region

We have made a comparative study, using aerial photographs at three different stages, on desertification in Daqingguo District in Horqin Zuoyi Houqi County, an area of around 33,000 ha., from 1958 to 1981, and listed results as in Table 27, which indicates the increase and reduction of desert areas and duneforms.

Table 27. Area of Desertification-prone Land from 1958-1981 in Daqinggou District, Horqin Zuoyi Houqi County, Jirem Prefecture

desertified lands / year	Most severely desertified land	Severely desertified land	On-going desertified land	Land with potential risk of desertification
Percentage in total land area in 1958 (%)	2.74	9.43	37.89	15.64
Percentage in total land area in 1981 (%)	11.19	29.46	24.94	3.95
Percentage of the enlarged area from 1958 to 1981 (%)	8.45	20.03	-12.95	-11.69
Average growth * (%)	6.31	5.08	-1.80	-5.81

* Calculated by $\alpha = \sqrt[23]{\frac{S_1}{S_2}} - 1$, in which S_1 means the area in 1981, and S_2 refers to the area in 1958.

Table 27 shows that from 1958 to 1981, desertification in the area went through a process of acceleration. Although desert areas of lesser degree at two locations decreased to some extent, desert as a whole has expanded. This points to the fact that some of what used to be lesser desert has worsened and part of what once was good land has turned into desert.

According to available records, desertification in Jirem Prefecture had during the same period expanded, from 20 percent in the Fifties to 53.8 percent by the end of the Seventies, and is still developing.

With regard to the forecasting of desertification trends in this area in the years to come, aerial photographs and landsat images of different periods can be used to construct a feasible dynamic model. As a typical example, a forecasting model has been made to study the desertification process for Daqinggou District in the next few years. As state, however, there are many factors, both natural and human, contributing to the desertification process, often complicated and always changing. What can be shown is only an indication of trend.

Table 28. Increase of the Area of Desertification-prone Land in Naiman (Coverage: 2964 km^2) from 1958 to 1975.

Items / desertification-prone lands	Type	1958's areas	1975's areas	1958–1975 increased area	Annual increase (decrease)
Most severely desertified land	Undulating sand dune	53.72	59.26	5.54	0.86
	Barchans	356.58	437.62	81.04	
	Moving sand field	30.03	12.21	-17.82	
Severely desertified land	Semi-shifting dune	20.82	27.71	6.89	2.04
	Semi-shifting sand mounds	101.4	114.12	12.72	
	Semi-shifting sand mounds	15.59	13.3	-2.29	
	Semi-shifting sand field	20.98	68.73	47.75	
On-going desertification-prone land	Semi-fixed undulating dune	283.78	575.27	291.49	4.41
	Semi-fixed sand mounds	265.73	554.9	289.17	
	Semi-fixed sand field	33.81	83.82	50.01	
Land with risk of desertification	Undulating fixed sand field	70.52	6.21	-63.31	-3.3
	Fixed bush-vegetated dune	611.4	386.34	-255.06	
	Fixed sand field	139.71	86.85	-52.86	
Non-desertified land	Irrigated land	2.2	2.76	0.56	-3.12
	Cultivated land	391.37	276.06	-115.31	
	Abandoned land	340.6	24.78	-315.82	
	Depression pasture	74.49	65.42	-9.07	
	Woodland	40.69	77.23	36.54	
	Waters	37.85	29.6	-8.25	
	Salt field	44.26	24.04	-20.2	
	Swamp areas	6.53	10.43	3.9	
	Residential areas	19.03	30.28	11.25	

It should be pointed out that desertification in the region shall continue to expand unless significant improvements are made in the land utilization of the steppe and the extensive management of a plundering nature is stopped, not to mention the ever increasing population which is at present of a pyramid structure. Based on aerial photographs taken of Naiman County, covering 2964 square kilometers, the annual rate of desertification of varying degrees is around 3.12 per cent. According to the average increasement rate of desertification, a total land area of 133,000 ha, 2.2 per cent of the Prefecture, will be severely desertified and 10 million ha., 8.6 per cent of the Prefecture, will be desertified and 3.2 million ha. or 52.6 per cent, will start the process of desertification upto 2000. By then, nearly all the steppe and dry farming land will be turned into desert. Desertification in the area is not only threatening the human lives, the environment and agriculture, but is also casting a shadow over the future. It is therefore a challenge which deserves utmost attention and immediate actions.

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Chapter Three. Rehabilitation of Desertification-prone Land

A. Pinciples, Ways and Countermeasures for Desertification Control

The traditional farming, no matter in the past or at present,always depends on various environmental conditions, as well as proper coordination of these conditions. Irrational utilization and overuse of limited environmental conditions will inevitably cause deterioration of land resources, and even completely lose its potentiality of production. The appearance of desertified land in this area is a result of an excessive use of the land as well as ignorance of the characteristics of natural environment of the sandy ground surface in semi-arid zone. This is a profound historical lesson.

The history of agricultural development in this area has showed that how to rationally utilize land resources as well as greatly to explore the natural potentiality of agricultural resources has become a more and more important issue for the development of agriculture.

Thus, it has required the exploration of some new methods to enhance the agricultural level from the aspects of exchange and equilibrium between internal materials and energy of agricultural ecosystem, as well as coordination and integration between agricultural biology and environment. The objectives for land control in this area are as follows:

With a view of long-term development, it is necessary to encourage the local people in combine the protection of resources for their ever-lasting utilization with the development of production, properly arrange the land for production, harness desertified land, reverse the ecological disturbance, set up highly efficient ecological agriculture in diversified economy with proper arrangement of animal husbandry,farming and forestry in accordance with the characteristics of agricultural natural resources in this area so as to tap productive potentiality of the land, strengthen the capability of resisting disasters and raise people's income as well as people's living standards. For this reason, the control of desertified land must be based on the principle of the integration of ecological effect with economic results and the coordination of exploration and utilization with control and protection. In view of previous lessons of considering only immediate interests and gains, but neglecting long-term interests and ecological consequences, and thinking of only one system or one link in a system but ignoring chain reactions of other systems and links, when we set up an agricultural ecological system, we should consider not only conditions of economic technology and long-term needs of the society, but also feasibilities of natural conditions in this area. Only a comprehensive analysis and studies in the above-mentioned two aspects are completely conducted, can practical and effective ways and measures be worked out. Now, we would like to make following suggestions:

First, Adjusting the Agricultural Production Structure and Its Layout, as well as Greatly Strengthening the Construction of Forestry and Grassland According to Local Conditions

Based on natural conditions of agriculture and differences of areas in this region, adjustment of agricultural production structure and layout suited to the local conditions has become the most economic effective measures to bring natural potentiality in various areas into play, and to restore and improve the agricultural ecological environment so as to promote the coordinated development of farming, forestry, animal husbandry, side-line occupations and fishery.

According to the statistics of 1981, of the total agricultural production of the whole prefecture of Jirem, Inner Mongolia, 57.34% was crop's production; 6.8 % came from forestry; animal husbandry accounted for 25.35%; side-line occupation amounted to 11.04%; and fishery earned 0.19%. Among the crops production, grain production was a major production.

From the above-mentioned figures, we can see that how to change a single production, how to properly deal with the relations among the "Five Productions"(farming,forestry, animal husbandry, side-line occupation and fishery), especially, how to increase the proportions of animal husbandry and forestry among the "Five Productions" in accordance with the local conditions, are still issues which should be fully taken into consideration.

In the past, due to the overemphasis on the grain production,as well as restrictions on commodity production, the general characteristics of the natural conditions in semi-arid areas as well as the differences between the areas in the region were ignored. Overemphasis on the grain production caused not only the stagnation of the grain production (annual increase of the grain production from 1966 -- 1981 was only 0.6%). but also deterioration of the whole agricultural resources and rapid expansion of desertified land as well as the ignorance of animal husbandry, damage to forestry and blind reclamation for the grain production. As we investigated that blind reclamation in lowlying and depression areas was more severe because reclaimed land in those areas were not accounted as "cultivated land". Actually, cultivated land, on average, only accounted for about 30% of the investigated areas. This also showed that there was still a great difference between the actual proportion of the land for farming and animal husbandry and the figures in the statistics. Irrational land utilization, particularly, blind reclamation still exist. And land for animal husbandry and forestry, especially, for animal husbandry could not be guarantteed.

In the light of general characteristics of agricultural natural resources and the current production status as well as the direction for its development, it is very important to make it clearer about the relationship and positions of farming,forestry and animal husbandry in agricultural production of this region.

Since the ecological system for grassland has more stronger suitability in this region as well as more stronger capability of disaster-resistance as compared with the ecological system for farming, there are about 340,000 ha. which can be utilized as grazing land (accounting for 53.7% of the total arable land), and animal husbandry has a long history with a material technology base as well as a great potential for the development of animal husbandry. It is important to make full use of this advantage and insist on the production principles of taking the development of animal husbandry as the major production in the combination with the development of farming, forestry and animal husbandry, and correctly deal with the relations as well as the positions of farming, forestry and stock raising. In short, these relationship and positions can be refered as self-suficient farming (referring to the grain production), protective forestry, commercialized animal husbandry.

The principle of taking animal husbandry as the key production means that it should first correct the phenomena of ignoring ecological conditions and blind reclamation for grain production, and strictly control the area of reclamation so as to guaranttee the land for stock raising. Animal husbandry should be really given priorities in terms of technology and funds. Meanwhile, the major layout of crops production should be arranged in plain along rivers, depression areas, and farmland in lowlying areas between hills, where relatively good conditions of water and manure are available. It should also work hard to increase per unit yield of grain, as well as positively develop cash crops under the prerequisite of guaranteeing grain production and ensuring self-sufficiency of food in the whole region. Shelter forests should be taken as a major production of forestry. The layout of forestry production should be determined by the demand of shelter forests, protecting farmland, grazing land, villages, roads etc. from harms of wind and sands. It should change the business idea of "large plantation of trees but less shrubs". The matter of importance is to select specieses of shrubs which can survive in local sand dunes and sandy land. Afforestration of windbreaks and energy forests can not only bring desertified land under control as soon as possible, but also mitigate contridictions of scrambling for " three materials" (forage, fuelwood and manure).

According to the principle of land suitabilities, the scale of farmland threatened by desertification should be cut down in a planned way under an unified plan so as to enlarge the proportion of forests and grazing land by expansion of forests and development of animal husbandry. By doing so, "three stabilities" (stability of farmland, grazing land and forest land) may be implemented,and "three blinds"(blind reclamation, blind cutting of fuelwood and blind overgrazing) should be prevented.

Second, Transforming Extensive Cultivation into Intensive Cultivation

The extensive cultivation mainly refleted the phenomena of "three blinds": as for the plantation, widely sowing and planting with low yields, emphasis on utilization and little attention to cultivation, even worse, only attention to the use and no cultivation are conducted; in speaking of animal husbandry, high carrying capacity and overgrazing or violent utilization of pastures, etc. have taken place. Such plundered extensive cultivation has brought in severe crises to the agricultural ecology in this region, and caused a great lose to the natural resources. Meanwhile, along with the human population growth, arable land area per person has dropped down, the intensive cultivation of land, topping maximum production potential of per united land resources, as well as raising per unit area yield, has become a general tendency for the development. Intensive cultivation has a great potentiality and also serves as a basic way for the development of agriculture.

Thus, the construction of agricultural production should be greatly strengthened.First, intensive cultivation should be implemented in these areas where water and manure conditions are fairly good, so that basic farmland with stable yield and stability of cultivated land could be set up. More manpower and materials could then be put on the basic farmland with intensive and careful cultivation, building water conservancy and improving soil fertility. Efforts should also be made in building up shelter forests so as to strengthen the capability of resistance to natural disasters, and to achieve stable and high yield, as well as to guaranttee the self-sufficiency in grain.As self-sufficiency in grain is obtained, then the rest of the land, manpower and funds can be invested in developing animal husbandry and forestry, and creating conditions for harnessing desertified land. For instance, Baiyin Tala Village of Hure County (Fig.18) has transformed 330 ha. of depression land in hilly areas into the basic farmland for intensive cultivation of crops production under the conditions of irrigation as well as networks of shelter belts. Its average per ha. yield of grain and beans has increased from 300-375 kg in 1960s to about 1500 kg at present. The total output of crops has increased by more than 100%. About 130 ha. grazing land have been build up by reducing the cultivated land. Thus, animal husbandry and forestry have been greatly expanded. The output value of farming and stock raising have changed respectively from 51.9 % and 33.2% to 37.9% and 39.8%. The output value of stock raising has showed that on the basis of self-sufficiency in grain, intensive cultivation of the basic farmland can release more land to expand grazing land as well as forests.This is not only favorable to renovating ecological environment, but also to coordinating the development in all fields, and to properly bring all local advantages into play.

The production of animal husbandry should be based on the valume of grass. In other words, on the ecological principle of maintaining the balance between the valume of grass and heads of animals, the rational rotation grazing and proper utilization of pastures should be carried out. Crops producing areas should take their advantages to develop crops production, and promote animal husbandry by increasing farming production and, in turn, to support farming by the development of animal husbandry, so as to stimulate both the development of crops production and animal husbandry, and to adopt the system of cowshed feeding and semi-cowshed feeding in combination of grazing and

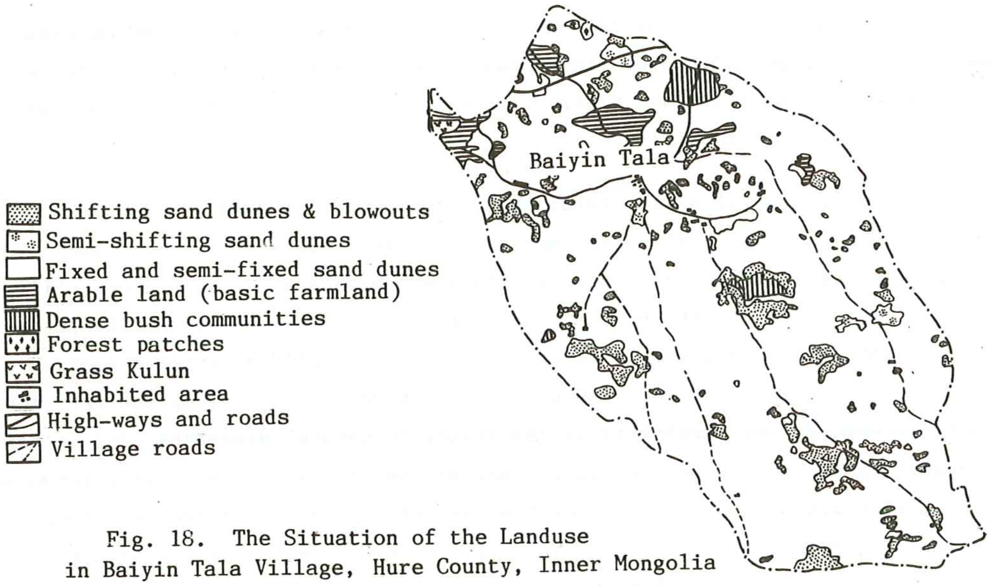

Fig. 18. The Situation of the Landuse in Baiyin Tala Village, Hure County, Inner Mongolia

intensive fatten. It should considerably build up man-made grass land, construction of forage farm, as well as enthusiastically change the traditional practice of raising animals by natural resources. Only the production construction and scientific management on grass land and animal husbandry are strengthened, and the economic level and economic effects for animal husbandry are increased, can the issues of ignorance of stock raising and blind reclamation be really solved. In doing so, it can be adjusted to the seasonal imbalance of grass production on grass land and solve the contradiction between the grass volume and the quantity of animal husbandry as well as the issue of high carrying capacity and overgrazing on the current grassland.

Thirdly. It Is Very Important to Take Some Measures to Change Energy Structure in Rural Area, Particularly, the Fuel Structure for Cooking so as to Improve Ecological Environment as well as Mitigate the Shortage of "Three Materials", (Forage, Fuelwood and Manure)

Among the "three materials", the shortage of fuel is the most serious problem. The reason for the shortage is not only the increasing demand by the human population growth, but also the mono-composition of the energy from agriculture and forestry. And the backward means of energy utilization is another major reason for the shortage of energy. As an investigation shows that 90% of the fuel source in this region comes from bio-energy, such as crops stems, tree branches, grass, animal wastes, etc.. When crops stems are used as fuel, the rate of the energy utilization is rather low, in general, only 10% of its total energy is used, and 90% is wasted. Even worse, Such elements as nitrogen, phosphate, potash in crops stems are all gone. Organic matters can not go back to the land. Thus, "one material" (fuel) consumption causes the waste of other "two materials". Meanwhile, the shortage of fuel for cooking forces people to spend a great deal of manpower in plundering cutting of fuelwood, and seriously destory the natural vegetation. This is one of the major factors which causes water loss and soil erosion, as well as land desertification. For this reason, it is a matter of importance to solve the problem of fuel shortage (for agriculture and animal husbandry) through various ways suited to the local conditions.

With a view to broadening energy sources and reducing its consumption in the years to come, except for strengthening the measures of heat preservation in houses for farming and livestock during the winter, it should also develop fuelwood plantation, positively disseminate biogas technology and "energy-saving stove", pay attention to the techniques for developing and utilizing solar energy and wind energy in accordance with the local conditions. Only multiple kinds of energy are developed, and complemented each other, can the increasing demand for energy be met.

Expansion of biogas technology is of a great ecological economic benefit. According to the experience from various areas, using biogas can increase energy utilization rate of biological energy from 10% to about 30% and be able to retrieve 50 - 70 % of dried stuff (biogas residue) as manure, of which organic matters account for 30--35%, and all elements of nitrogen, potash, phosphate in the crops stems are almost all preserved. If crops stems are used as fodder, and animal wastes are used as materials for biogas, the scrambling of "three materials" can be turned into the circulation of "three materials". The experience shows that the development of biogas technology can greatly increase the utilization rate of bio-energy, but also cease the contradiction of the shortage of fodder, manure and fuels.

In this region, to make full use of solar energy and build a large scale of fuelwood plantation with characteristics of proper close planting, quick-growth and stronge capability of light absorption, is another important measure for solving the problem of the shortage of fuel and the scramble of "three materials" in a long run, because such energy forest can become a permanent fuel source in 3-5 years after its afforestration.

In a short, only the problem of cooking fuel in rural area is solved, the current energy structure is changed, and a great quantity of crops stems first are used as fodder, after they become animal wastes, then they are applied to land (or use animal wastes as materials for biogas, and apply the residues to land), can the fundamental changes in soil nutrients be taken place and the soil fertility is enhanced, and can the problem of destorying vegetation by irrational cutting of fuelwood be eventually eliminated. Meanwhile, the ecological balance can be maintained and the stable development of farming and stock raising can be guarantteed.

Fourthly. Rational Adjustment and Full Utilization of Water Resources in the Prefecture

At present, there are some serious phenomena of irrational utilization and development of water resources. For instance, Kailu County as well as the northern part of Naiman County are considerably rich in ground water, and located in the upper and middle reaches of Xiliao River with a number of reserviors, and dam sluice gates. Local people are used to utilize surface water nearby. This practice has brought about the problem of high ground water table and secondary salinization of soil, as well as create the preconditions for the development of desertified land. Meanwhile, in the areas at the lower reach of Xiliao River such as Tongliao region, because surface water is not availible for the irrigation, the ground water is over explored,this has caused a great decrease of ground water table.

In a view of rational utilization of water resources, it is necessary to adjust the utilization of water resources. In the upper reach, ground water exploration and utilization should be stressed. And its surface water should be divered to the lower reach, and to solve the contradiction of scrambling for water by agriculture and industry as well as the decrease of the water table there. Measures should be taken to strengthen flood control and flood storage effect of all kinds of reservoirs, and solve the inequilibrium of waterlogging and drought, as well as upgrade the utilization rate of water resources. At present, the utilization coefficient of surface water irrigation canals are only 0.5-0.6, some only about 0.3. The land is uneven,irrigation canals are not systematic, management system is in chaos, the irrigation technique is extensive. In many areas, flood irrigation is still used. As some statistics shows that the volume of water for irrigation each time reaches 6000 m^3/ha.in well-irrigated areas of Tonliao, it reaches 7800 m^3/ha.

It is necessary to level the land and innovate irrigation techniques.Some new techniques, such as sprinkling irrigation, dropping irrigation, as well as plastic house, etc. should be gradually used in these areas where conditions permit.

In the prefecture, the biggest consumer of water resources is agriculture, which accounts for over 90% of the total water consumption. To reduce the excess of water for channelling it into fields is a major issue for saving water resources as well as making the most effective use of water.

In wet sandy areas of lowlying and depression land, the drainage canal system can not be over-emphasized on large scale depression areas. It is good enough to be able to drain water during the period of rainy waterlogging. Drinking well construction should be developed so as to make full use of ground water and to build up the land which can produce stable, high yields irrespective of drought or waterlogging. At the same time, using ground water for irrigation can replace drainage to lower ground water level, and protect as well as control salinization of land, and reduce the probability of rainy waterlogging as well. In recent years, because the rainfall has decreased and ground water level has gradually dropped down, the moisture content in sand dunes has been also affected. There has been a large number of trees in some lowlying areas withered to death. Grass coverage has deteriorated. Desertified land has expanded. In some areas where conditions permit, ground water should be pumped out from lowlying areas to sprinkle trees in sand dune areas, thus promoting the circulation of ground water.

Fifthly. Effectively Control Human Population Growth and Reduce Its Impact on desertified land

The average density of the agricultural population has reached 41.7 per square kilometer in this region. Farmland, pastures, inhabident areas and sand dunes(sandy land) have been distributed with the pattern of interlocking, which has showed that the human activities have exerted a great impact on environmental resources. Thus, expect for the implementation of family planning and strict control of the population growth, manpower resources in current desertified areas should be fully mobilized to develop rural township enterprises as well as industries which can be locally undertaken without using land. The government should also provide these areas with some employment opportunities such as constructions of mines so as to lessen the impacts on desertified land by human activities.

Sixthly. Making Policies with Further Relaxing Restrictions and Trying to Lighten People's Burden

In desertified areas, especially in these interlocked areas of farming and stock raising, because of the harms of desertification, the land productivity is decreasing and some areas completely lose their productivity. People's living standard in these areas is very low. In some rapidly, seriously developed desertified areas, per capita income is only 50-100 Yuan (RMB). The harms of desertification has become a vitally important issue related to the people's destiny and living standard in those areas.

In order to quickly impove the current ecological environment and let people in sandy areas have the opportunity of rehabilitation, the government should make policies to give more free hands to the local people in some violently or seriously developed desertified areas, and try its utmost to lighten people's burden and give priorities as well as assistances in investment to control desertification (Figure 17).

B. Division for the Control of Desertification-prone Land

1). The principles of the division and the division of the region

As the characteristics of the distribution of desertified land and historical as well as modern processes of desert formation and development have showed that the formation of desertified land not only has been closely related to the characteristics of human economic activities, but also has been different under various natural conditions. And its reversing processes as well as control methods can be also various. For this reason, in the nationwide division of desertification-prone land,* the principle of natural climatic zone is regarded as the first index, and this region is distinguished into the big zone--"the desertification-prone zones in semi-arid steppes and desert steppes". Based on that principle of the division, in accordence with the similarities of differences of the areas of natural climatic conditions within the same natural climatic zone, we take geographical unit and land types as the first class index, in other words, this is the first class index for the division of control in this region, and the status of desertification expansion is taken as the second class index of the division. In the consideration of regional differences of agricultural production, we divided the areas which should be harnessed in the whole prefecture into 5 districts and 13 subdistricts <<A divisional figure of the types of desertified land and its control in Jirem Prefecture of Inner Mongolia Autonomous Region>>. And their names and localities as described in the table 29:

(Note: * The division of desertification processes and its control in the northern part of China, written by Prof. Zhu Zhenda and Prof. Liu Shu, published by The Forestry Press of China)

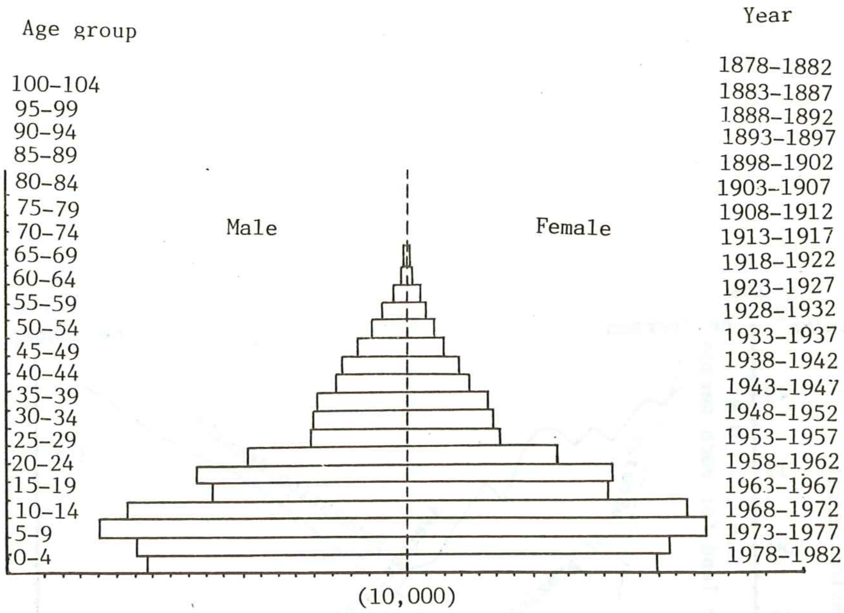

Fig. 17 (A). Population Pyramid of Jirem Prefecture

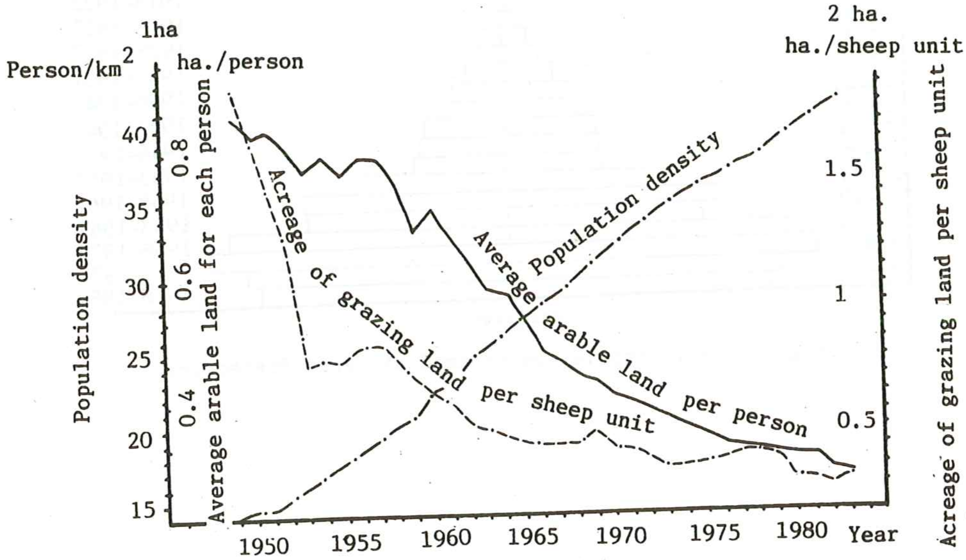

Fig. 17(B). Curves of Human Population Density, Average Arable Land for Person and the Acreage of Grazing Land

(A)

Table 29. Divisional Figure of Desertified Land Control in Jirem Prefecture, Inner Mongolia

Divisional areas: Districts	Divisional areas: Subdistricts	In administrative divisions	Area (km^2)	Areas of all types of desertified land (km^2) and their percentage: severe desertified land	violently expanded desertified land	desertification-prone land under development	potential desertification-prone land	none-desertification prone land
1	2	3	4	5	6	7	8	9
I. Medium and low mountain area in Dahinggan Ling	I-1. Subdistrict of none desertification on medium and low mountains	Northern part of Jarud County (including the mining area of Houlinhe Coal Mine, Hanshan Forest Farm, Wulan Hada, Bayaertuhushuo, Geercaolu, Bayanbaoligao, Jurihe Township, Qianjin Township, Batala Township and a part of Xiang Shan Township)	9683 (100%)		206.6 (2.1%)	381.4 (3.9%)	9095.0 (94.0%)	
	I-2. Subdistrict of potential desertification-prone land on shallow hills	Mao Do Township of Jarud County, Gong Nong Township, Xiang Shan Forest Farm, East part of Qian Jin Township, Wunugeqi, Most part of Yiheshumu, Northwest part of Wulijimuren	3480.7 (100%)		10.7 (0.3%)	184.5 (5.4%)	1216.5 (35.6%)	2009.2 (58.7%)
II. Declivitous fringe plain areas in the north	II-1. Subdistrict of potential desertification-prone land of modern diluvial fringe	Qiande Township of Jarud County, Wunugeqi Grazing land, Qizhi Grazing land and Forest Farm, Northwest part of Daolaodo, Middle part of Wulijimuren.	2460.5 (100%)		38.6 (1.5%)	235.8 (96%)	1190.4 (48.4%)	995.7 (40.5%)
	II-2. Subdistrict of desertification under expansion in the old alluvial diluvium plain of the northern part of Xingkai River	Bayanmangha Township of Jarud County, Southeast part of Daolaodo, South part of Wulijimuren; Baiyinhua Township of Horqin Zuoyi Zhongqi County, Zhurihe Grazing land, Qinghe Grazing Land	5371.2 (100%)		211.4 (4.0%)	2703.7 (50.3%)	2187.8 (40.7%)	268.3 (5.0%)

Table 29. (B)

1	2	3	4	5	6	7	8	9
III. Alluvial plain in Xiliao River	III-1. Subdistrict of none desertification-prone land in the plain along Xiliao River and Xinkai River	Kailu County (Maixin, Heilongba, Dayushu,Heping, Xinghua, Beixing, Donglai Township,etc., Most parts of Baoan, Kundoling,Jianhua, Xiaojieji and Xingan,etc.) Tongliao City, Tongliao County (Shengli, Taiping, Yuliangbao, Xiliufang, Tangjiawopu,Mulitu, Minzhu,Fengtian, Qianjiadian, Kongjiawubu Township, Jiaogan, Liaohe, Aolibo and a part of Hulihai Township) Horqin Zuoyi Zhongqi County, (Parts of Shebotu Township, Yiaomangha, Anle, Baiyin Tala,Malaqin,Xibohua,etc.) Horqin Zuoyi Houqi County (Parts of Pingan and Xingyang Township, and Shengli Farm, Seed Multiplication Farm).	5275.8 (100%)		20.3 (0.4%)	525.7 (10.0%)	1083.3 (20.5%)	3646.5 (69.1%)
	III-2. Subdistrict of potential desertification-prone land between Xiliao River and Xinkai River	Kailu County (Kailu Town,Dongfeng, Sankeshu, Xiaojieji,Baian, Jianhua,Kundoling Township) Tongliao County (Qinghe, Chagan Township,Melimiao Sheep Farm, Gaolintun Livestock Farm,Aolibu, Hulihai,Parts of Shengli Township) Horqin Zuoyi Zhongqi County (Aobao, Huatugula, Baijinhua, Wulijitu, Aobentai Township etc. Dongshu Forest Farm, Baixingtu, Huitianzhao, Xiedaiwusitu, Elunshuke, Taiping Township, Anle, Part of Bayin Tala, Malaqin Township)	5156.3 (100%)	15.9 (0.3%)	65.5 (1.3%)	1695.0 (32.9%)	2014.1 (39.0%)	1365.8 (26.5%)
	III-3. Subdistrict of potential desertification-prone land in a large scale dry depression area in Tubuxin plain (Horqin Zuoyi Zhongqi County)	Northeast part of Horqin Zuoyi Zhongqi County (Yiaolimaodo, Harigantu, Daolantaobu,Hailijin, Yandengtu, Jiamatu, Tuanjie, Xinhe, Nurimu, Wulanhua, Jubaoshan, Shengli,Chagan, Tubuxin, Qikeshu Township, Baokang Town, Animal Breeding Farm, etc.)	3954.3 (100%)			275.9 (7.0%)	1168.5 (29.5%)	2509.9 (63.5%)

Table 29. (C)

1	2	3	4	5	6	7	8	9
	IV-1. Subdistrict of severe desertification-prong land in the area of Laoha River, Jiaolai River, and northern part of Yangxumu River	Naiman County (Weiliansu, pingandi, Mingren, Qinghe, Zhian, Desheng, Dongming, Baxiantong, Toliantala, Yamen Yingzi, Baiyintala, Bagapelihe, Zhanggutai, Maonai, Gulibenhua Township, Daqintala Town, Number sixth farm, and northern of Taishanmutou, Chaogutai Township, etc.) Hure county (south part of Eleshun, and Mang Han, Northern parts of Liujianzi, and Sanjiazi.)	6018.5 (100%)	833.4 (13.8%)	2124.4 (35.3%)	1782.0 (29.6%)	310.7 (5.3%)	901.4 (16.0%)
IV. Lowlying and depression land plain on the south of Xiliao River	IV-2. Subdistrict of violent expanded desertification in the northern part of Hure County and the western part of Horqin Zuoyi Zhongqi County	Hure County (Northern part of Mang Han and Eleshun Township, most part of Sanjiazi, Wafang Grazing Land) Horqin Zuoyi Houqi County (Wulanaodao, Huadeng, Manduo, Chaohai, Aogusitai, Chaolutu Township) Naiman County (Southern part of Nailin Township Zhian Township, Most part of Haotu and Gulibenhua Township)	5109.1 (100%)	70.3 (1.4%)	502.2 (9.8%)	3721.3 (72.8%)	223.4 (4.4%)	591.9 (11.0%)
	IV-3. Subdistrict of desertification under development on the east of Horqin Zuoyi Houqi County	Horqin Zuoyi Houqi County (Bahuta, Yihuta, Agula, Haisigai, Maodaotu, Adaqin, Ouli, Baya, Siguleng, Budunhalagen Jinbaotun, Baiyinmangha, Xieesu, Haodan, Jiegelang, Wusuaili, Husiao, Tieniu, Changsheng, Sanduo, Gonghelai Townships, etc. parts of Halawusu and Chaolutu two townships Tongliao County (Shangbao Township and southern part of Dalin Township)	8909.9 (100%)	250.8 (2.8%)	810.6 (9.1%)	4948.0 (55.5%)	141.4 (1.6%)	2758.5 (31.0%)

Table 29. (D)

1	2	3	4	5	6	7	8	9
V. Loess Hilly area on low hills in the south	V-1. Subdistrict of desertification under development in the south swamp of Naiman.	Naiman County (Taihe, Yilongyong, Huanghua Tala, Xinzheng Township, Taishanmutou, Southern part of Chaogutai Township, Northwest of Shalihaolai) Hure County (Liujiazi Township, the northwest of Haergao Township)	1630.2 (100%)		16.1 (1.0%)	195.1 (12.0%)	877.2 (55.8%)	541.8 (33.2%)
	V-2. Subdistrict of potential desertification in loess hilly area in the south of Hure County and Naiman County	Naiman County (Baiyinchang, south part of Shalihaolai Township,most part of Tuchengzi Township) Hure County (Pingan, Shuiquan, Haergao, Baiyinhua, Xianjin, Nailin, Yuanbaoshan, to the south of Yangxumu River in Sanjiazi Township)	2457.8 (100%)	4.1 (0.2%)	5.2 (0.2%)	90.6 (3.6%)	3.2 (0.1%)	2354.7 (95.8%)
	V-3. Subdistrict of none desertification in low rock hilly areas on Qinglongshan Mt.	Naiman County (Qinglongshan, Naiwanzi Township, Southern part of Tuchengzi Township) Hure County (most part of Kouhezi Township)	754.0 (100%)			21.7 (2.9%)		733.1 (97.1%)
The Whole Region			60202.1 (100%)	1174.5 (2.0%)	3805.0 (6.3%)	16587.1 (27.6%)	10803.7 (17.9%)	27831.8 (46.2%)

2). Basic characteristics of each district as well as the methods for desertification control

I. Medium and Low Mountain Areas in Da Hinggan Ling (Divided Into 2 Subdistricts in the Light of Desertification Degrees.)

I-1. Subdistrict of None Desertification on Medium and Low Mountains:

The major mountain area of the Da Hinggan Ling Mountain is 9683 km^2. The peaks in Hanshan Forest Farm are over 1,400 m high (above sea level) and generally more than 500 m high above the ground. It's climate is cold and humid, annual mean temperature is 0.3-2.5^oC; annual rainfall is 363-420 mm; mean relative humidity is 57--65%. But sunlight resource is rich, especially in the area of Huolinhe Coal Mine on the northern part of the Mountain, which has 3280 hours of sunshine per year. ≥ 10^oC accumulated temperature accounts for 1900-2250^oC. Frost-free period is only 90-114 days. It is suitable to the growth of conifer forests. The whole country approximately has over 2 million ha. forests (including man-made forests and secondary forests), but shrub forests and sparse shrub steppes cover a considerable part of it. There are some grazing meadows distributed in the basins in the mountain areas. Some of them are reclaimed into farmland (at present, there are over 13,000 ha. cultivated land). Da Hinggan Ling is the major water source for the rivers in the north of Jirem Prefecture and Huo Lin River leading to Hinggan Prefecture and its branches as well.Surface water runoff is in the depth of 24-41 mm, the total volum of surface water runoff is 210-4,000 million m^3 per year. This is the place which has the strongest and frequent wind in the whole region. Annual mean wind velocity over Huo lin River area on the northern part of the Mountain is 4.7 m/second. Every year there are average 56-76 days of over ≥5 fresh gale. Thus, the vast mountain area has a fairly good vegetation coverage, water loss and soil erosion are minor, no desertification appeares (none-desertification-prone land accounts for 94%), but there are some distributions of fixed, and semi-fixed sand dunes in the valley areas extended along the direction of dominant wind in the areas of Dalelin River, Baiyin Juliu River, Denglin River, Jibuju River, etc. in the southeast. The coverage rate of vegetation on nearby slops is obviously dropping down. There are also some potential desertification-prone plots as well as a small portion of desertified land under expansion distributed within the mining area of Huolin River. In the future, it is necessary to close off the hills and protect trees, and energetically to expand forests and strictly to zone the area for the grazing rotation, as well as properly to utilize pasture land resources. The fixed and semi-fixed sand dunes in the valley areas should be closed of so as to prevent grass from sand harms. It should not be encouraged to farm on arid land. It is very important to set great store by environment effects after the exploitation of the Huolinhe Mine. We should take this matter as a specific topic to make some predictions as well as estimations. In particular, we should take it into serious consideration on a series of ecological environment issues, such as the land desertification, water loss and land erosion as well as river polution etc. which may be possibly occurred after the exploitation of the Mine.

I-2. Subdistrict of Potential Desertification-prone Land in Shallow Hills: The whole subdistrict is a rocky hill area, which is less than 750 m above the sea level, and its average height is 200-400 m above the ground. Rocky hills are in round shape. Valley land is wide. The total area of this subdistrict is 3420.7 km^2. Its temperature is higher than that of medium and low hill areas. Mean temperature is 3-5^{o}C. ≧ 10^{o}C accumulated temperature reaches 2500-3000^{o}C. Annual peak precipitation is 380-400mm. Surface water is also relatively rich, which makes it easy to develop irrigated farming. Shrub forests and pastures, shadily exposed rockhill, fixed and semi - fixed sandy land by thin layer of sands, respectively account for about 30%. Some semi-shifting dunes are distributed in the valley areas of Baiyin Juliu River and Denglin River. Most of the subdistrict is grazing land. There is a small proportion of farmland in the valleys and basins. In this subdistrict, stock raising should be taken as the principal production, and the development of forestry should be properly planned (at present, there are about 33,000 ha. cultivated land), the violently expanded desertified land must be controlled (0.3% of the total area). The desertified land under expansion should be protected and, meanwhile, properly utilized (35.6%).

II-1. Subdistrict of Potential Desertification-prone Land of Modern Diluvial Fringe: This subdistrict has a total area of 2460.5 km^2, belongs to the zone of modern diluvial fringe, but the fan bady doesn't develop. The lowlying land within the fan fringe and in the front of the fan is quite obvious. Since cold currents are blocked by the hills on the north, a "warm belt", which is not too wide, is formed in the front of the hills. For instance, in the Lu Bei Town, annual mean temperature is 6^{o}C, higher than that of neighboring areas on the south. ≧ 10^{o}C accumulated temperature is 3083.7^{o}C on average, the frost-free period averages 150 days, the longest period lasts 175 days. It has much rain. Annual precipitation is about 380 mm. In addition, the majority of the streams and rivers in this mountain area are dispersed in the diluvial fringe or gathered in the lowlying land in the front of the fan after they flow out of the Mountain. Thus, there is a vast of marsh grazing land and gently salinized grass land, which become an excellent grazing land as well as a cattle raising base. However, due to clay and silt clay sediments of surface layer in the lowlying land in fan fringe, and fine sands of the water contained layer, the ground water resource is not abundant. The water volume pumped out of each well is 10-15 m^3/hour in the northern part, and 50-100 m^3/hour in the southern part. The plain in the front of the southern part of the Mountain is covered with a thin layer of stablized sands. There are some semi-shifting sand land and sand dunes in the northern part of Qian De Township. Desertified land (including latent desertification-prone land) covers 60% of the total area, but doesn't seriously expand. Thus, this subdistrict should take stock raising as the principal production,meanwhile, pay attention to developing fuelwood plantation as well as forests for stablizing sands.

II-2. Subdistrict of Desertification under Expansion in the Old Alluvial Diluvium Plain of the Northern Part of Xin Kai River:

This subdistrict covers a total area of 5371.2 km^2. Its general feature is to incline gently from northwest to the Xin Kai River on southeast. Its topography is mainly semi-fixed sand land and lowlying land with gently undulating dunes. The proportion of the depression land is increasing on the east. Shifting and semi-shifting dunes are widely distributed in Qaidam in Kailu County on the southwest. The climate is quite dry. Annual mean temperature is 5.6°C. ≧ 10°C accumulated temperature is 3030-3100°C on average. The frost-free period lasts 120-150 days. Annual sunshine is 3020-3070 hours. Annual precipitation is 340-380 mm. Annual average relative humidity is 53-56 %. Except for the seasonal limnetic in swampland, this subdistrict lacks surface water. Ground water is about average level. Water volume pumped out of each well in most of this area can reach 50-100 m^3/hour. The land of desertification in this subdistrict is more serious as compared with that of the above-mentioned subdistricts. Although the proportion of moving sand land is not so large, the land at risk of desertification is widely distributed (95%) and pastures have been severely deteriorated. Thus desertification control has become the most important task for harnessing land in this subdistrict. In accordance with different degrees of desertification, various ways can be explored to harness, to close off as well as to properly utilize the desertified land, simultaneously to strengthen the construction of pastures and to take stock raising as the major production and to forbidden blind reclamation as well.

III. Alluvial Plain in Xi Liao River (Divided into 3 Subdistricts)

III-1. Subdistrict of None Desertification-prone Land in the Plain Along Xin Kai River and Xi Liao River:

This subdistrict covers 5275.8 km^2, belongs to modern alluvial plain of the Xi Liao River and the Xin Kai River. The alluvial stratum is quite thick. Ground surface consists of clay sands and sandy clay. The physical feature of this subdistrict is flat, and rich in water resources. Water conservancy and irrigation are well developed. Water sprinkling land covers over 90% of the total land. Annual precipitation in the area of Xiang Yang Township of Horqin Zuoyi Houqi County on the east reaches more than 480 mm, which is the highest rainfall in the whole area, while the rainfall in the Mai Xin Township (Shuang He Xing) on the west is less than 315 mm, which is the lowest rainfall in the whole area. Annual sunshine of this subdistrict is 2900 - - 3150 hours unevenly. ≧ 10°C accumulated temperature reaches 3100-3500°C on average. The frost-free period averages 138-146 days. The longest period is 171 days. It is a base for the production of grain as well as various crops. It is also a place with the most dense population in the whole area. Around Kailu County, ground water level was high in the past, the land became secondary salinization land in varying degrees because of irrational irrigation. In recent years, people have turned to use ground water and lower the phreatic water level so as to improve the circulation conditions of moisture content, as well as lessen salinization to certain extent. There are some pieces of desertified land in spot-shaped or belt-shaped distributed in the ancient river course within the area.

Due to the good conditions of water and land, abundant manpower resource and relatively high level of agricultural economic technology in this subdistrict, farming should be taken as the principal production, and intensive cultivation of land should be conducted so as to furtherly bring the advantage of crops production into play, widely disseminate the system of cowshed feeding and semi-cowshed feeding, to promote stock raising by the development of farming, in turn, to support farming by the expansion of animal husbandry. As for the forestry, main stress should be placed on the construction of farmland protective forests and river protective forests, as well as on the expansion of energy forests in order to gradually solve the shortage of timber and fuelwood as well.

III-2. Subdistrict of Potential Desertification-prone Land Between Xiliao River and Xinkai River:

This subdistrict covers a total area of 5156.3 km^2, belongs to old alluvial diluvium of Xiliao River. In this subdistrict, there are many traits of ancient river courses. The modern ground surface is composed of fixed and semi-fixed flat sandy land as well as gently undulated wet sandy area. The hour of sunshine and temperature resources in this subdistrict are similar to III-1 subdistrict. Water resources is abundant on the west and poor on the east. There are also a number of small plots of salinized dry depression land on the east. The irrigation system relatively has developed in flat land between hills. But the moisture content conditions of sand dunes in some localities become worse as a result of the decreasing of ground water level there. In this subdistrict, farming and stock raising should be equally emphasized. The farming infrastructure should be strengthened by the means of harnessing water and improving land. Intensive cultivation should be conducted in the area with relatively good water and soil conditions. In order to lessen the impacts on grazing land, it should stop tilling some desertified areas and try to turn them into forests or grazing land.

III-3. Subdistrict of Potential Desertification-prone Land in a Large Scale Dry Depression Area in Tubuxin Plain.

Situated on the northeast of Horqin Zuoyi Zhongqi County, covers a total area of 3954.3 km^2. This subdistrict is based on an alluvial plain. The sediment of Quaternary Period is relatively thin. Ground surface materials are rather fine. It consists of many large-sized dry depression areas extending from northwest to southeast, and has more rainfall on the east and less rainfall on the west. The annual precipitation in Horqin Zuoyi Zhongqi County (Baokang Town) is 409.6 mm, towards west, it reduces to 340 mm. The sunshine is from 2820 to 2905 hours. ≥ 10°C accumulated temperature reaches 3040-3150°C. The frost-free period lasts 137-142 days on average. It is poor in ground water. Irrigation projects are only along the banks of Xin Kai River. The scale of depression area is large, ground surface mainly consists of sandy clay and muddy sandy soil. The capability of water permeability is low. Its runoff has a drainage difficulty. For this reason, the land salinization is rather severe (mainly alkaline depression area), and becomes a major obstacle for the agricultural development in this subdistrict. Economic development in this subdistrict mainly relays on both the development of farming and animal husbandry. For the dry-farming, the stress can be placed on oil crops (sunflower) and sugar crops (beet) suited to saline soil. In those areas where conditions permit, they should develop green manure crops, apply organic fertilizer, improve the agricultural production conditions.

IV. Lowlying and Depression Land Plain on the South of Xiliao River (Devided into 3 Subdistricts)

IV-1. Subdistrict of Severe Desertification-prone Land in the Areas of Laoha River, Jiaolai River and North of Yangxumu River:

This subdistrict has the most severe desertification in the whole prefecture,covers a total area of 6018.5 km^2. Shifting and semi-shifting sand dunes are widely distributed. Some sand dunes are very high (reach 20 m). Wind erosion in lowlying areas is severe. Grey-white colored alluvial sand layer frequently appears. Some localities have some trees such as elm, etc.. However, it forms a landscape of sparse forest and pasture. The depression area accounts for a small proportion of the whole area. The large proportion is lowlying land. Crops production concentrates on the areas along Jiaolai River as well as some depression areas and swampland with relatively good water and soil conditions. Land desertification has become a major obstacle to the agricultural production in this subdistrict. But this subdistrict has quite good water and thermal conditions. Surface water comes from Jiaolai River, Laoha River and Yangxumu River. Because it is near the center of the basin, the ground water remains in a quite thick water contained layer. The output of water from each well on the northern part is > 100 m^3/hour, while in most of the area is 50-100 m^3/hour. Annual mean temperature is 6.2-6.4°C. ≥ 10°C accumulated temperature reaches 3130-3160°C. The frost-free period is 146 days on average. Thus, this subdistrict should become the key area for harnessing and controlling desertification in the whole prefecture, setting up a typical experiemental area for harnessing desertified land so as to accumulate experience as well as to widely extend its experience.

IV-2. Subdistrict of Violently Expanded Desertification in the Northern Part of Hure County and the Western Part of Horqin Zuoyi Houqi County:

This subdistrict has 5109.1 km^2, and mainly consists of semi-fixed sand dunes. The ratio of the area between lowlying land and depression land is 8:2. Due to blind reclamation and ignorance of wastland, desertified land expands rapidly. Since the adoption of "crop field on lowlying land", desertified land there has been improved. But agricultural cultivation is still rather extensive. Stock raising mainly concentrates on sheeps and cattles. The rainfall on the western part of this subdistrict is comparatively good. Ground water is also quite abundant. The output of water from each well in most of this area is 50-100 m^3/hour. The thermal of sunshine and in this subdistrict are the same as that of the above-mentioned IV-1 subdistrict. As practice has already approved that to close off desertified land for restoration of its potentiality of production has been the most economic effective measure.

IV-3. Subdistrict of Desertification Under Development on the East of the Horqin Zuoyi Houqi County:

This subdistrict covers a total area of 8909.0 km^2, located between a sand belt extending from east to west, consisting of semi-fixed sand dunes, and a large-scale wet lowlying land. Its depression area has good conditions of moisture content, and frequently stores up water. It serves as a good grazing meadow. Animal husbandry mainly relies on cattles. It is one of the well-known bases for commercial cattle products in Inner Mongolia Autonomous Region. In recent years, it has been a success to dig ditches to drain waterlog in a large-scale depression area for the production of crops. For instance, some depression areas in Jiergulang, Xinming and Sandu have already become the important grain producing areas. This is one of the highest rainfall subdistricts in the whole Prefecture. Annual rainfall in the southeast of this subdistrict averages 480 mm. Its ground water also abounds. The output of water from each well reaches > 100 m^3/hour. The sunshine and thermal resources are also abundant. Desertified land there generally can be harnessed after being closed off for 3-5 years. Afforestration and grass planting are also under favourable conditions.

V. Loess Hilly Area on Low Hills in the South.

This area is situated between the southern part of Yangxumu River and the northern part of mountain areas of Hebei and Liaoning. From the south, there are rockhill land, loess hills and undulating loess terraces to the north. The rainfall is rich. Annual precipitation in the mountain area reaches 430-453 mm. But, because of the nature of loess itself, floods are easily to be formed. The flood peaks modeling figure in each river averages 0.2 m^3/second/km^2. The highest peak reaches 0.63 m^3/second/km^2 (Wugengiao River). Grains in the water contained layer are fine. It is poor in ground water. Water and soil erosions are severe. There are many stormed cracks. Its sunshine and thermal resources are relatively abundant. Annual sunshine averages 2950-3110 hours. Annual mean temperature is 6.4-6.8°C, which is the highest mean temperature in the whole prefecture. ≧ 10°C accumulated temperature averages 3100-3220°C. The frost-free period is 143-156 days. It is a comparatively developed area for dry-farming (this area can be divided into 3 subdistricts).

V-1. Subdistrict of Desertification Under Development in the South Swamp of Naiman:

This subdistrict is located in the south of the crack of Yangxumu River, belongs to sandy loess zone. Its physical feature is gently undulated, and fixed and semi- fixed undulated sandy land. The lower layer of loess contains a large quantity of sands,and there is also a layer of sands. The moisture conditions are rather poor. Irrigated farming can only be conducted in the valley of Jiaolai River. However, the index of reclamation is quite high. The total area of this subdistrict is 1630.2 km^2. Although the area of shifting sand land is not widely distributed, harms of wind and sand currents are quite severe. For instance, along the area of Liujiazi Township of Hure County, wind and sand currents are very active. Shelter belts networks are required to protect dry-farming land so as to gain stable yield. Xingshuwa Village of Liujiazi Township and Huanghua Tala Township of Naiman County etc. enthusiastically have planted shelterbelt networks at a large scale so that they have controlled the harms of wind and sands, and have promoted the development of farming, animal husbandry and forestry, eventually to have become a model for making it rich by the development of forestry.

V-2. Subdistrict and Potential Desertification in Loess Hilly Area in the South of Hure County of Naiman County:

This subdistrict covers 2457.8 km^2, located in the upper reaches of many rivers. The loess texture is quite rough. The dissected gully and valley is sharp. Water and soil erosions are severe. The land between gullies has been all reclaimed into farmland. Natural vegetation is sparsely reserved. The population is quite dense. Its impact on the land is rather heavy. The major grain producing areas of Hure County are distributed in this subdistrict. In the future, it should pay attention to the expansion of forests on hills slops, ditches and river banks, strenghten project construction of water and soil conservation at small river basins, and change the system of rotation cultivation of dry farming into the rotation cultivation of grain and grass, so as to coordinate the developmetn of farming, animal husbandry and forestry.

V-3. Subdistrict of None-desertification in Low Rock Hilly Areas on Qinglongshan:

This subdistrict is small (754.8 km^2), the bedrock of the hilly area is mainly made of gneiss, metamorphic sandstone and grey silicon rock, etc. There are a few remains of natural vegetation. Plots of farmland are mainly between gullies and valleys. This subdistrict has become the major area for the development of man-made forests for the two Counties.

C. Different Measures for Desertified Land Control and Their Effects.
(Taking the existing pilot experiments of desertified land control as examples)

In the past many years, we have conducted surveys of desertification as well as studies for its control in sandy land in Horqin Steppe. We have taken the measure of closely combining scientific research with local production to harness severely desertified land as the major task, starting from sites to expand the whole area. Other types of desertified land have been investigated on the bases of local people's experiences from closing off desertified land for harnessing it.

1. Control Measures for Severely Desertified Land and Their Effect.

One experimental area of desert control is located along the two sides of Beijing-Tongliao Railway Line in the area of shifting sand dunes in Naiman County. Thanks to the favorable natural conditions in this area, with the characteristics of sand stablization along the railway line, biological measure has been taken as a major measure to stablize sands, with mechanical one as a complement. The combination of trees, shrubs and grass has formed as a comprehensively protecting system to block, stablize and fence the sands so as to completely control the encroachment of shifting sands and to guaranttee the trains unblocked.

1).Concrete Measures are as Follows:

(1). The Width of Shelter Belt: a 200-300 m wide belt on the side of dominant wind direction of the railway line, and a 100-150 m wide belt on the side of the secondary wind direction of the railway line, within this area, overall afforestration for sand fixation should be launched.

(2). Sandbreak Measure: In the front part of shelter belt on the dominant wind side of the railway, 5-10 rows of vertical sand barriers, 0.5-1 m high, made of tree branch checkerboards, are placed with 3-4 m row spacing. Between barriers Salix gordejevii, which is tolerant of being buried in sands, are planted, then the barriers can become alive, so as to obtain the goal for blocking sands for a long term.

(3). Sand Fixation Measures:

a). Sand Fixation by Mechanical Measure: With locally available materials, vertical sand barriers with tree branch checkerboard (size as big as the privious one), straw check-board sand barriers and stems or leaves of cattail check-board sand barriers (1m x 1m or 1m x 2m) placed on big-sized shifting sand dunes can block moving sands; on ordinary size shifting sand dunes, barriers (1m x 1.5m) placed in rows can control moving sands.

b). Biological Measure: This is a measure for permanent sand fixation. Following are some concrete methods for sand fixation:

a. Stablization of sand by Artemisia halodedron:
Artemisia halodendron belongs to the community of Composite bushes. Its stems are about 1 meter high. Its branches grow quickly in creeping shape. It has a strong capability of wind-resistance. Artemisia halodendron is an excellent species for sand fixation.

The survival rate of this species is high. During rainy season, the survival rate of wild seeding of this species, dug out with roots, can reach 80-90 per cent.This species planted in belts need not to have any protection of mechanical sand barriers, and can become "living sand barriers" in 1-2 years after its plantation, so as to effectively control the moving sands.

b. Stablization of sand by Caragana microphyla: Caragana microphyla belongs to leguminous bushes. Its trunks are about 1-2 m high, with abundant branches, and good for resisting wind. It is tolerant of aridity and barren, and suitable to grow on the whole sand dunes. This is another excellent species of bushes for sand fixation.

During rainy season, direct seeding for afforestration can be very successful but it requires mechanical sand barriers to protect it, otherwise, it may be blown away during windy season.

c. Stablization of sand by Salix gordejevii: Salix gordejevii belongs to bushes of Salicaceae. Its trunks are over 2m high. It has extremely strong germinating ability, and can sprout a large quantity of adventitious roots and a great deal of branches while it is buried in sands. Salix gordejevii grows very luxuriantly and can play a great role in preventing the harms of wind as well as blocking sands. It is suitable to be planted on the upper part of sand dunes, leeward side and frontal part of shelter belts

Under protection of mechanical sand barriers, 2-3 years old branches of Salix gordejevii planted in Spring or Autumn have quite high survival rate.

d. Stablization of sand by Populus spp.: This species belongs to trees of Salicaceae. It can grow fast under conditions of adequate moisture and fertile soil, but can not grow well on arid and barren sand dunes. The general phonomena are withered tips of trees and "dwarf tree". For instance, some 6 years old Populus simonii on sand dunes are only 52.3 cm high. The height of some 6 years old Populus average 75.6 cm, but the total length of withered branches reach 113.4 cm. For this reason, stablization of sand by Populus spp. is not an appropriate method to be undertaken on sand dunes.

e. Stablization of sand by Pinus Sylvestris var. mongolica: Pinua Sylvestris var. mongolica belongs to Pinaceae & Cupressaceae tree with characteristics of arid-telerance, barren-tolerance and flourishing roots, which is suitable to grow in the areas with sand dunes. The 2 years old seedings of Pinus Sylvestris var. mongolica planted in 1975-78 in an artificial sand fixation area have grown well, with over 60 per cent survived. The height of 9 years old Pinus Sylvestris var. mongolica on sand dunes averages 1.5 m. The highest one is over 4 m with 80 cm in height growth in the current year. From this we can see, Pinus Sylvestris var. mongolica is an excellent species of trees to check wind and stablize sands.

2. Ecological Change

Since the above-mentioned sand fixation methods on severely desertified land have been adopted, a strong shelter belt system has been formed. Ecological conditions have had remarkable changes. For instance, wind velocity is reduced. Wind and sand motion activites are weakened. Temperature, humidity and microclimate etc. have changed. Meanwhile, the properties of physical chemistry in soils as well as the conditions of moisture content, etc. have changes.

(1). Micro-climate Change

a). Wind velocity: As observation data show the wind velocity in 0.5 m above the ground in the sand fixation area with Caragana microphyla is only 17.7-19.3 per cent of the wind velocity in 0.5 m in mobile sands land; the wind velocity in 0.5 m above the ground in the area of sand fixation by crossed rows with Pinus Sylvestris var.mongolica and Caragana microphyla is 30.8 per cent of the wind velocity in mobile sand; the wind velocity in 2 m is 44.7 per cent of that in mobile sands land. This evidence shows that the sand fixation areas can play a great role in reducing wind velocity.

Because of the big-sized tree body of Pinus Sylvestris var. mongolica, its ability to reduce the wind velocity in 2 m above the ground is stronger than that of Caragana microphyla. However, Caragana microphyla has abundant branches and leaves, its ability to weaken wind velocity as well as reduce the volume of transporting sands in 0.5 m above the ground is stronger than that of Pinus Sylvestris var. mongolica. (Table 30).

b). Changes in ground temperature and atmospheric temperature

There are some observation sites in sand fixation area with Caragana microphyla (coverage is 80%), with Pinus Sylvestris var. mongolica + Populus simonii (coverage is 50%), and mobile sands area (making comparason).

Since plants have functions to reduce wind velocity and weaken the threats of mixed currents, the difference of radiation is quite big, the day time temperature in sand fixation area with plants is high, while the day time temperature in mobile sands area without vegetation coverage is quite low. Mobile sand area without vegetation coverage during the day time has comparatively stronger wind velocity and minor difference of radiation. As observation data show that the maximum ground temperature is 45°C in sand fixation area with Caragana microphyla, and 42.6°C in sand fixation area with Pinus Sylvestris var. mongolica + Populus Simonii, while 34°C in the mobile sands area. In

Table 30. Biological Stablizing Areas Exert Effects on Wind Velocity and Sand Transporting Rate.

Observation areas	Wind velocity (m/s)				Sand transporting rate (g/cm^2. hour)	
	0.5 high		2 m high			
	Wind velocity	Rate (%)	Wind velocity	Rate (%)	Sand transporting rate	Rate (%)
Milestone K 634 left side shifting sand dunes (comparision)	10.25	100	13.15	100	474.96	100
Milestone K 634 + 500 left side stablized sand dunes with Caragana microphyla	2.25	22	8.15	62	2.22	0.047
Milestone K 635 left side stablized sand dunes with Pinus Sylvestris var. mongolica	4	39.0	6.7	51		

the evening, the sand fixation area with plants has relatively stronger effective radiation, favorable to pooling cold air, and its ground temperature is lower than that in mobile sands area. For instance, the minimum ground temperature is 11.7°C in the sand fixation area with Caragana microphyla; 11.4°C in the sand fixation area with Pinus Sylvestris var. mongolica + Populus simonii; 11.8°C in mobile sands area.

Temperature change in the soil of shallow layer under ground surface (0-20 cm) is the same as that of the ground surface, however, the deeper it goes, the smaller change it is.

The change of atmospheric temperature above the stratum (50 cm high) has similar laws as it does on the ground surface, e.g. during the day, the temperature in sand fixation area with plants is higher than the temperature in mobile sands area. In the evening, the temperature in sand fixation area with plants is lower than the temperature in mobile sands area.

c). Atmospheric humidity: As observation data shows the relative air humidity and absolute air humidity in sand fixation area with plants are higher than these in mobile sands area. For instance, the relative humidity in the sand fixation area with Caragana microphyla is higher by 6% of relative humidity in mobile sands area. In sand fixation area with Pinus Sylvestris var. mongolica + Populus simonii, the relative humidity is 11% higher than that in mobile sands area; the absolute humidity in sand fixation area with Caragana microphyla is 1.6 millibar higher than that in mobile sands area, the absolute humidity in sand fixation area with Pinus Sylvestris var. mongolica + Populus simonii is 3.6 millibar higher than that in mobile sands area, because the evaporation of plants produce a large quantity of humid atmosphere, which makes the atmospheric humidity in sand fixation area become bigger.

(2). Changes of Physical Chemistry Properties in Soils.

In sand fixation area with plants, because the wind velocity is reduced,the activities of wind and sand currents are weakened. Dusts and particals in air sedimentate . In addition to that, every year, a large quantity of organic materials, such as withered branches, falling leaves and roots etc., with the functions of moisture, thermal condition and edaphon, bring about ramarkable changes in physical chemistry properties in sandy land. (Table 31)

Table 31. Changes of Soil Mechanical Elements in Biological Stablizing Areas

Testing areas	Depth (cm)	Lost volume of chlorhydric acid (%)	Contents of various diameters of grains (%)						Physical clay (%) <0.01 mm
			1-0.25 (mm)	0.25-0.05 (mm)	0.05-0.01 (mm)	0.01-0.005 (mm)	0.005-0.001 (mm)	<0.001 (mm)	
Milestone K 634 left side shifting sand dunes (comparision)	0-5	0.64	6.00	93.06	0.02	0.28	Trace	Trace	0.28
	5-30	0.75	4.67	94.22	0.04	0.03	0.02	Trace	0.05
	30-100	0.80	6.52	92.55	0.13	0.02	0.01	Trace	0.03
Milestone K 634 + 500 left side stablized sand dunes with Caragana microphyla	0-5	1.55	4.58	85.95	6.97	0.94	0.01	Trace	0.95
	5-30	0.94	9.03	89.49	0.48	0.01	0.05	Trace	0.06
	30-100	0.69	8.83	89.98	0.20	0.29	0.01	Trace	0.30
Milestone K 657 left side stablized sand dunes with Artemisia halodendron	0-5	1.48	26.01	59.72	11.36	1.07	Trace	Trace	1.07
	5-30	0.92	39.02	59.00	0.58	0.48	Trace	Trace	0.48
	30-100	0.66	46.42	52.79	0.11	0.01	0.01	Trace	0.02
Milestone K 635 left side stablized sand dunes with Pinus Sylvestris var. mongolica	0-5	1.55	14.92	75.35	7.40	0.76	0.02	Trace	0.78
	5-30	0.89	20.34	77.87	0.41	0.47	0.02	Trace	0.49
	30-100	0.85	13.24	85.87	0.01	0.04	Trace	Trace	0.04

From the table 31, we can see that the content of < 0.01 mm fine grains in the top soil layer of sand fixation area with plants greatly increases. The sand fixation area with Artemisia halodendron shows the fastest increase of < 0.01 mm fine grains, which consists of 1.07%, it is 4 times of the volume contained in the same layer of mobile sands area. The content of < 0.01 mm fine grains in sand fixation areas with Caragana microphyla is over 3 times, and with Pinus Sylvestris var. mongolica is over twice as compared with that in mobile sand area.

From the aspect of nutrients, contents of organic matters in the top layer of sand fixation area with plants obeviously increase. The contents of organic matters contained in all top layers of sand fixation area are 6-8 times as compared with contents of organic matters in top layer of mobile sands area. As for the contents of the total nutrients, the phosphate content in sand fixation area is 1-2 times higher than that in mobile sands area. The contents of nitrogen and potash in sand fixation area doesn't show any increase. Regarding fast-effect nutrients, the content of nitrogen in sand fixation area with Caragana microphyla doesn't see obeviously, nitrogen content in sand fixation area with Artemisia halodendron increases 0.5 time, in sand fixation area with Pinus Sylvestris var. mongolica goes up by 2.4 times. Phosphate content is raised by 0.4-1 time. Potash content is not obevious (table 32).

3. Change in Soil Moisture Content: Under natural conditions the moisture content in sandy layer of shifting sand dunes generally accounts for 3-4%, and reach 5-6% after rain. But it infiltrates into deeper layer soon. If it meets a layer of clay, it can reach over 10%. After planting sand-holding plants, vegetation coverage increases and sand dunes are stablized. But the moisture content in sand dunes decreases, especially in the dry period of Spring and Summer, plants begin growing luxriantly and need more water, thus the sandy layer becomes rather dry. The moisture content in sandy layer can only be complemented when rainy season comes. Because of different water comsumption of different sand-holding plants, the moisture content changes in different sand fixation areas are various.

According to surveys, the moisture content in sand fixation area with Caragana microphyla was the most less, (it meaned Caragana microphyla was the biggest water comsumption), the next was the area with Pinus Sylvestris var. mongolica + Populus simonii, then the area with Pinus Sylvestris var. mongolica + Artemisia halodendron, and the area with Pinus Sylvestris var. mongolica. The moisture content in the area with only Populus simonii was quite good, because Populus simonii did not grow well, and most of them had their branches withered and their leaves belittled, looked like "dwarf tree". Those are reasons of reducing the water comsumption and turning the moisture content in sandy land into good conditions (table 33).

The above-mentioned examples show that mobile sand land after being stablized by plants can improve ecological conditions, reduce wind velocity, weaken wind and sand currents,

Testing areas	Depth (cm)	Organic matters (%)	Total nutrients (%)			Fast effect nutrients (mg/100 gram of soil)		
			N	P_2O_5	K_2O	Water solution N	Fast-effect phosphate	fast-effect potash
Milestone K 634 left side shifting sand dunes (comparision)	0-5	0.071	0.075	0.010	2.83	1.39	1.24	7.9
	5-30	0.081	0.031	0.014	3.07	2.20	1.33	2.7
	30-100	0.061	0.035	0.010	2.95	0.41	1.28	2.7
Milestone K 634 + 500 left side stablized sand dunes with Caragana microphyla	0-5	0.444	0.053	0.020	2.95	1.39	2.10	2.9
	5-30	0.068	0.049	0.010	2.89	1.57	1.18	3.2
	30-100	0.094	0.018	0.010	2.92	1.13	0.92	3.4
Milestone K 657 left side stablized sand dunes with Artemisia halodendron	0-5	0.584	0.033	0.032	2.76	2.03	2.41	10.5
	5-30	0.100	0.053	0.010	2.86	1.48	1.11	2.9
	30-100	0.090	0.005	0.010	2.86	1.28	0.97	3.9
Milestone K 635 left side stablized sand dunes with Pinus Sylvestris var. mongolica	0-5	0.432	0.022	0.022	2.71	4.75	1.78	5.5
	5-30	0.113	0.033	0.010	2.73	0.99	1.02	4.2
	30-100	0.091	0.003	0.010	2.83	1.04	0.91	3.9

Table 32. Changes of Soil Nurients in Biological Stablizing Areas

sedimentate a great quantity of dusts and particals on the ground surface, accummulate a vast amount of withered and falling materials. With the functions of water, thermal condition and edaphone, it can form topsoil crust, as well as develop towards zonal soil. Eventually, it can eleminate harms from wind and sands, ensure trains to be unblocked, enable the development of agriculture and animal husbandry in nearby areas. All these bring about the greatest economic results, as well as a good ecological effects.

As the above shows, moisture content in sandy land, after being stablized by plants, will gradually decrease. This is an unfavourable ecological factor to the steady growth of sand-holding-plants, especially to the steady growth of rare specieses of ever - green trees, such as Pinus Sylvestris var. mongolica.

Testing areas	Depth of the test (cm)														
	0–20	20–40	40–60	60–80	80–100	100–120	120–140	140–160	160–180	180–200	200–220	220–240	240–260	260–280	280–300	Average
Shifting sand dunes	3.33	3.16	3.30	3.28	3.34	3.39	3.49	3.45	3.42	3.46	3.56	3.39	3.43	3.34	3.73	3.40
Sand fixation area with Populus simonii	3.16	3.36	3.32	3.15	2.57	2.85	2.49	2.47	2.69	2.61	2.71	2.59	3.32	3.78	3.71	2.99
Sand fixation area with Caragana microphyla	2.92	2.09	2.01	2.13	2.16	2.13	2.34	2.16	2.09	1.97	2.07	2.15	2.22	2.24	2.22	2.19
Sand fixation area with Pinus Sylvestris var. mongolica	2.12	2.47	2.24	2.44	2.05	1.98	2.19	2.11	1.99	2.01	2.41	2.58	3.64	3.50	3.76	2.50
Sand fixation area with Pinus Sylvestris var. mongolica + Populus simonii	2.29	2.55	2.61	2.73	2.33	2.29	2.08	2.37	2.26	2.21	2.25	2.48	2.44	2.59	2.96	2.43
Sand fixation area with Pinus Sylvestris var. mongolica + Populus simonii	2.03	2.64	2.63	2.70	2.66	2.67	2.39	2.22	2.29	2.22	2.20	2.47	2.93	2.99	3.34	2.56

Table 33. Moisture Contents in Various Biological-stablizing Areas

Date of the test: May-October, 1985

In order to keep the steady growth of Pinus Sylvestris var. mongolica, and furtherly improve the ecological effect as well as economic benefit, moisture content in Pinus Sylvestris var. mongolica woodland should be balanced. In other words, it is important to keep rational close planting of Pinus Sylvestris var. mongolica, and to conduct plant selection for mixed planting. In particular, when Caragana mincrophyla with the biggest water comsumption is selected for mixed planting, the most importance is to seize the opportunity. Caragana microphyla should be planted in the same year or one year later as Pinus Sylvestris var. mongolica is planted, otherwise, it may affect the survival or growth of Pinus Sylvestris var. mongolica. It could hardly have it work, if Pinus Sylvestris var. mongolica was planted in 2-3 years later than Caragana microphyla was done.

With a view to having correct information of rational close planting for various specieses of sand-fixing plants, we have conducted studies on the balance of moisture content in all sand fixation areas, and initial results have been achieved (table 34).

From the table 34 we can see that the biggest water comsumption areas are those with Pinus Sylvestris var. mongolica + Artemista halodendron, as well as with Pinus Sylvestris var. mongolica + Populus simonii, which most severely lack moisture content, then the area with Caragana microphyla and with only Pinus Sylvestris var. mongolica. The area with only Populus simonii has no shortage of moisture content because of unhealthy growth of Populus simonii with many withered branches and beliitled leaves. These are the main reasons for the reduction of water comsumption. The evidence shows that the density of the existing plants are still too close in the above mentioned four areas with the shortage of moisture content. For this reason, it is necessary to conduct cutting between rows, and to adjust properly the density of the vegetation so as to keep stable vegetation coverage, otherwise, it may cause unhealthy growth of plants, as well as natural sparsity as a result of severe shortage of moisture content. In 1950s, there were some sparse woods and grass areas. Due to the irrational utilization of the land, such as blind reclamation, overgrazing and firwood cutting, etc., it brought about destruction to the vegetation on sandy land and caused the expansion of desertified land. From 1970s, annual expansion of desertified land reached 700 ha. By the end of 1970s, the total number of desertified land in varying degrees accounted for 12000 ha, of which 3400 ha. were violently desertified land, forming a big mobile sands belt with the length of 4km and the wildth of 500 m, located in the north of the villages, and severely threatened people's life as well as agricultural production. Because of the harms of sands, three villages (Xing Jian, Shi He, Xin Long) could not making a living and had to imigrate.

Due to the harms of desertification, grazing land deteriorated, farmland was buried by sands, local people in that rural township lived in poverty. In 1978, per capita income was less than 50 RMB yuan. Since 1979, it has launched a large scale compaign for afforestation , about 540 ha. have been afforested. Its emphasis has been placed on the development of forestry, as well as integration of forestry with animal husbandry. It has also cut down over 700 ha. farmland and has controlled the development of animal husbandry,

Table 34. Water Balance in Various Biological Stablizing Areas (The year of 1985)

Testing areas	Sand fixation areas	Number of remained plants (plant/hectare)	Water consumption by evaporation during the growth (ton/hectare)	Input volume of water during the growth (precipitation) (ton/hectare)	Water balance (ton/hectare)
Milestone K_{634}	Moving sands area (comparision)	0	3672	4957	+1285
	Sand fixation area with Caragana microphyla	10000	6674	4957	-1717
	Sand fixation area with Pinus Sylvestris var. mongolica	3700	6279	4957	-1322
	Sand fixation area with Populus simonii	8900	4922	4957	+ 35
Milestone K_{657}	Moving sand area (comparision)	0	4100	4957	+ 857
	Sand fixation area with Pinus Sylvestris var. mongolica + Artemisia halodendron	4000 + 3000	8106	4957	-3149
	Sand fixation area with Pinus Sylvestris var. mongolica + Populus simonii	4000 + 4000	7833	4957	-2876

meanwhile, has rehabilitated forests and grass land as well.

At present, there has been 15 main forest belts with a total length of 94,000 m and 80 m in width, 330 shelter belts to protect farmland, as well as 167 forest network meshes, controlling 1004 ha. farmland and pastures. An initial success has been achieved.

Since 1980, a big mobile sand belt of 3400 ha. on the north has been completely closed off, and banned to cut firwood and grass, as well as to graze. Simultaneously, some methods, such as sowing Caragana microphyla,Garcinia oligantha, Artemisia arenaria and planting Salix gordejevii, have been taken in order to quicken the speed in rehabilitating vegetation. And remarkable ecological effects as well as economic benefits have been obtained.

In October 1985, we took samples (2 x 2 in this closed-off-area for studies), the

Table 35. Vegetation Restoration After the Adoption of Close-off Method in Severely Desertified Land (The year of 1985)

Observation areas	Type of sandy land: Before close-off	Type of sandy land: After close-off	Duration of close-off (year)	Species of plants	Average height (cm)	Biomass (dry weight kg/ha.)	Percentage of total production (%)	Coverage (%)	Biomass (kg/ha.)
North to the Tai He Township of Naiman County	Shifting sand dunes (comparision)	None close-off		A. Squarrosum	19.3	1165.5	97.0	5	1203
				Artemisia halodendron	21.4	37.5	3.0		
The same as the above	Shifting sand dunes	Semi-fixed sand dunes (Hedysarum fruticosum var. lig nosum + Polygonum divaricatum)	5	Hedysarum fruticosum var. lignosum	109	4909.5	74.2	40	6618
				Polygomum divaricatum	59	610.5	9.2		
				Leonurus heterophyllus	99	510	7.7		
				Ixeris denticulata	10.8	208.5	3.1		
				Linaria valgaris	37	175.5	2.7		
				Artemisia sieversiana	10	111	1.7		
				Bassia dasyphylla	18	96	1.4		
The same as the above	Lowlying land between hills	Fixed sand dunes (Calamagrostis epigeios + Artemisia argyi)	5	Calamagrostis epigeios	53	820.5	25.9	90	3162
				Artemisia halodendron	44	208.5	6.5		
				Artemisia argyi	55	144	4.6		
				Swainsonia salsula	30	285	9.0		
				Setaris viridis	23.6	91.5	2.9		
				Kummerowia stipulacea	37	81	2.6		
				Lespedeza davurica	35	51	1.7		
				Melissitus ruthenicus	36	49.5	1.6		
				Hedysarum fruticosum var. lignosum	56	33	1.0		
				Herberious weeds	20-50	1398	44.2		

result was listed in the table 35 . As it showed the vegetation coverage was quickly restored on the shifting sand dunes which were closed off for 5 years, from aboriginal shifting sand dunes with few specieses of plants and very small coverage of vegetation turned into semi-fixed sand dunes with an increased number of specieses of plants and comparatively larger vegetation coverage. Its biomass increased more than 4 times as compared with the biomass before it was closed off. (Due to much rain that year, quite a large number of Artemisia squarrosum appeared and the biomass on mobile sands land increased, otherwise, the biomass on mobile sands land would be much less.)

Thanks to the good conditions of moisture content in lowlying land of hills area, vegetation there grows better. Simultaneously, many excellent grass specieses as well as legum spp. show up. All those are of great significance for the development of animal husbandry.

All in all, by the methods of afforestation as well as setting apart sandy land for grass, Tai He Township over the past 5 years controlled the expansion of desertification, and harnessed 1070 ha. desertified land out of original 1200 ha. At present, it has not only improved original severe situation of ecological environment but also gained remarkable economic benefits. In the past the farmland threatened by wind and sands, sometimes, should be sown 3 times a year with only 1500 kg per ha. yield as the highest. Now, every year sowing once is enough, with per ha. yield of 3750 kg of maize, 2250 kg of millet. Grain production in 1983 reached 4 million kilograms, it was 500 kg of grain for each person, which was the highest in the whole county. At the same time, stock raising had also developed. The whole rural township could harvest 2.5 million kilograms of grass fodder annually. The problem of the fuelwood shortage was mitigated, and its vegetation was also protected. In addition to the annually planned collection of grass and fuelwood from the closed-off-area, it could also harvest 10,000 kilograms of seeds of Garacinia oligantha, which valued 60,000 RMB yuan. As a result, Tai He Township has since got out of the poverty, its per head income in 1983 increased to 315 RMB yuan. In 1984, although it was hit by waterlogging disaster, its per head income still reached 320 RMB yuan.

3. Harnessing Violently Severely Desertified Land and Its Effects.
(Taking Huanghua Tala (Township) of Naiman County as an example)

The Huanghua Tala Township has a total area of more than 20933 ha., and has harnessed 16000 ha. former desertified land caused by irrational utilization of land at the beginning of 1960s. For instance, in 1963, more than 533 ha. were reclaimed.It brought about severe harms of desertification. Many pieces of farmland were buried in sands, grazing land was deteriorated. Per ha. yield of agricultural production was only severe dezons. Every year, over a thousand of domestic animal were starved to death. Local people's life was pluged in severe poverty, and there were 126 families who could not make a living there and had to successively leave for other places to make a living.

Since 1964, local people started to afforest as well as to plant grass to harness desertified land. Meanwhile, they gradually have adjusted the structure of land utilization. Through over 10 years efforts, great ecological effects as well as economic benefits have been obtained. The concrete methods are as follows:

(1). Afforestration of Protective Shelter Forests Have Been Greatly Encouraged:
According to local conditions, the methods of combination of shelter belts, forest patches and forest networks have been adopted. At present, 492 forest belts of all kinds have been set up, with a total length of 287.5 km, forming 433 forest network meshes. Of which 328 are shelter belts to protect farmland, controlling 1820 ha.164 are shelter belts to protect pastures, controlling 2180 ha. grazing land. In mobile sands area, 5800 ha. patch-shaped forests have been built up, so as to expand the area with forests to 8000 ha. in the whole rural township, which has played an important role in controlling the expansion of desertification and protecting the development of agriculture and animal husbandry as well. At present, 8400 ha. out of 10000 ha. violently developed desertified land have been harnessed (accounts for 84%).

We observed the effect of belt forest, which was single-row-ventilating structure, consisted of Populus simonii. The height of tree was 17 m. The result of the observation was listed in the table 36. From the aspects of ground temperature in the shallow layer and atmospheric temperature, the temperature within the shelter belt was higher than that in the open land. The temperature in the early Summer was high and favourable to the growth of plants. It was also very obvious that belt forest could play a role in weakening wind velocity, especially within the distance of 5-10 times of tree height from the belt forest, almost 50% of wind velocity could be reduced. Because of the reduction of wind velocity within the belt forests, the loss of moisture content was less in the belt forest. Atmospheric humidity in belt forest was higher than that in open land, and its moisture content evaporation in soil was also reduced. As the observation of soil moisture content showed that soil moisture content within the distance of 3 - 4 times of tree height from the belt forest was more than one time higher as compared with that in open land (Table 37).

(2). Adjustment of Land Utilization Structure for Agricultural Production:
It should constantly keep about 4000 ha. cultivated land, around 667 ha. grazing land, continuous development for protective forests and completely eleminating harms of wind and sands so as to ensure the steady development and increases of production for agriculture and animal husbandry. After the adjustment, agricultural production has developed, per ha. yield of grain increased from 202.5 kg in 1960s to 787.5 kg in 1984, increased nearly 3 times; the total number of animal increased to 15918 heads, increased 3057 heads as compared with that in 1960. The rate for slaughter was 16.4%; motarity rate was 6.8%. In speaking of forestry, afforestration not only control the expansion of desertification and improve the harsh ecological environment, but also gain direct economic benefits. For instance, it solves the problem of the fuel for cooking and also provides some fodder for domestic animal to tide over the winter. Annual revenue from

Table 36. Ecological Effect of Protective Forest Belts (The year of 1985)

Testing areas	Ground temperature in shallow layer (cm) (oC)					Maximum ground temperature (oC)	Free air temperature (°C)	Relative humidity (oC)	Absolute humidity (millibar)	Wind velocity (m/s)
	0	5	10	15	20					
Open area (comparision)	25.3	21.7	19.7	18.3	17.4	30.8	19.3	73.8	16.4	12.0
Distance from forest belt 3H	27.9	23.9	21.3	19.2	16.3	32.2	19.0	8.1		7.4
Distance from forest belt 5H	29.1	24.0	21.2	18.6	17.8	34.2	19.5	79		6.9
Distance from forest belt 10H	27.9	22.8	20.2	18.3	16.4	34.6	19.3	78.6	17.5	6.8
Distance from forest belt 15H	26.6	22.1	19.9	17.7	16.5	31.8	19.9	75.6	17.0	8.2

Table 37. Soil Moisture Content Within Protective Forest Belt (Water Content %) (The year of 1985)

Testing areas	Depth (cm)									
	0-20	20-40	40-60	60-80	80-100	100-120	120-140	140-160	160-180	Average
Open area (comparision)	8.08	8.13	9.84	10.20	10.68	10.39	10.42	9.21	8.15	9.46
Distance from forest belt 3H	9.99	13.60	17.51	18.28	18.85	25.18	26.48	26.10	26.20	20.24
Distance from forest belt 5H	18.17	13.77	14.13	17.19	18.35	23.87	25.11	25.56	26.21	20.26

lumbering, by means of tinning out, can reach 10,000-15,000 RMB yuan. Thus, the former poor conditions as well as backwardness has changed, and per capita income has increased from several dozens RMB yuan to 175.2 RMB yuan, per head grain has reached 378.5 kilograms.

4.* Preservative Measures and Their Effects on On-going Desertification-prone lands (Taking Bagapolihe Village of Naiman County to Excemplify):

The total land area of Bagapolihe Village is 39,733 ha. which are mostly undulating dune areas and lowlying lands except 150 ha. of depressions. In early 1960's, it is documented that the total land area in the village was covered by black loam soil and the sandy soil in the north of the village was vegetated with 6,667 ha. of natural woodland of Prunus armeniaca and Ulmus pumila. Today only few preserved due to wide cutting of these plants. Irrational landuse (such as over-reclamation, extensive fuel-wood cutting, over-grazing and plunder destruction of vegetation) caused land desertification in the past and in early 1970's, the area of desertification-prone land was enlarged to 24,000 ha. (60% of the total land area in the village), in which 12.667 ha. has been completely desertified and grazing/farmning lands were turned into unproductive. The death rate of animal was 10.3% in 1971 and 7.8% in 1974. Averagely, income per capita for both nomadic and crop farmers was less than 100 RMB yuan in certain years.

Started from 1975, some attentions and activities were made to combat desertification and to increase vegetative coverage, such activities include lessening cropping areas, decreasing animal population, preserving degraded area by fencing desertified lands on large scale, applicating artificial plantation and air seeding of forage grasses and accelerating the regeneration of vegetation. In the first year of preservation, 5,330 ha. has been fenced, but it was not so successful as expected due to poor management. In the second year of preservation (1984), 2,800 ha. has been fenced and air seeding of Melolotus suaueolens ledeb and Astragalus adsurgens ledeb has been done.Expected result has been achieved and degraded vegetation has been refreshed. After only one year of preservation, vegetative coverage has been doubly increased and biomass has been heightened for 40%-200% than before. Such preservations, from the viewpoints of ecological benefit, limited the continueous spread of desertification, promoted the refreshment of vegetation, improved ecological environment, guaranteed the regeneration of Ulmus pumila and totally 14,000 ha. of desertification-prone lands have been lessened from former 24,000 ha. in 1970's. From the viewpoints of economic benefit, these preservations provided 1.5 millions kg of grass yield in 1984, namely, supported 50% of winter and spring forages for the total animals in the village, animal production was enlarged and nomads' life standard was improved and average income per capita in 1983-1984 was approximately 330 RMB yuan. The income of animal production occupied 70% of the total output of the village. This became basic source for nomadic further development for commercial purpose.

* This paragraph was translated by Miss Jiang Weizheng.

5. Pilot Experiment on the Preservation of Severe Desertification-prone Lands.

In the Spring of 1983, Liaoye Miao Village of Horqin Zuoyi Houqi County was chosen to preserve and rehabilitate the severe desertification-prone land on undulating steppe area. After preservation by fencing the degraded area with few artificial measures, vegetation was quickly refreshed and desertified lands were rehabilitated in a short period of time. Various plant communities on the rehabilitated areas increased and occupied different percentages as following: Elymus chainensis (Trin.) Tzvel.community occupied 2.53% of the total plant community, Artemisia frigida willd community occupied 3.53%, Artemisia halodendron turcz community occupied 17.23%, weeds communities occupied 59.2%, and unvegetated lands occupied 17.51%. The unvegetated lands contain the blown-outs and shifting sands, which was sellected to observe the rehabilitation of desertification-prone lands (Fig. 19). After three years of preservation, following five changes have been taken place:

(a) Change of unvegetated land: topsoil crusts were formed on the blownouts and shifting sands and sand-holding pioneer species was gradually regenerated. Our observation on different plant communities in 1985 shows the differences of the percentage of plant communities compare with that in 1983: Elymus chainessis (Trin.) Tzvel community occupied 17.56%, weeds community 56.37% and unvegetated area occupied 5.2% (Fig. 20).

(B) Change of vegetation composition: after three years of preservation in the degraded areas, land potential was developed and vegetation was protected. Vegetation composition was greatly changed although plant species was not increased. Perennial herbs and high value forage species of Artemisia spp. were gradually regenerated to be dominant plants. As a major vegetative pattern, Elymus chinensis (Trin.) Tzvel community was remarkablely increased, after one year of preservation it was increased for 2.53% of the total community, two years later, 6.83% has been increased, and since the third year 10.64% been achieved. As for the vegetative composition, percentage, the Elymus chinensis (Trin.) Tzvel community is the dominant one.

(c) Change of plant production: preservation stopped animal grazing on degraded areas and vegetation was guaranteed to be refreshed, and consequently biomass was greatly heightened (Table 40). The heights and biomasses of Elymus chinensis (Trin.) Tzvel, Artemisia frigida willd, Agropyron cristatum (L.) Beauv, Artemisia annua L. and Cleislogenes squarrosa (Trin.) keng were quantitatively increased. Oppositely, Artemisia halodendron turcz was decreased. Table 41 shows the coverages and productions of each major plant species. According to our observation the biomass of Artemisia frgida willd and weeds communities were straightly increased and the biomass of Elymus chinensis (Trin.) Tzvel were decreased. The decrease of the biomass of Artemisia halodendron Turcz indicates the invasion of good forage species and grassland is being transformed into high quality grazing land. Today the species of Artemisia halodendron turcz is being replaced by pioneer species. It is investigated that the basic production of plants on grazing lands is 2535 kg/ha.. After first year of preservation the average

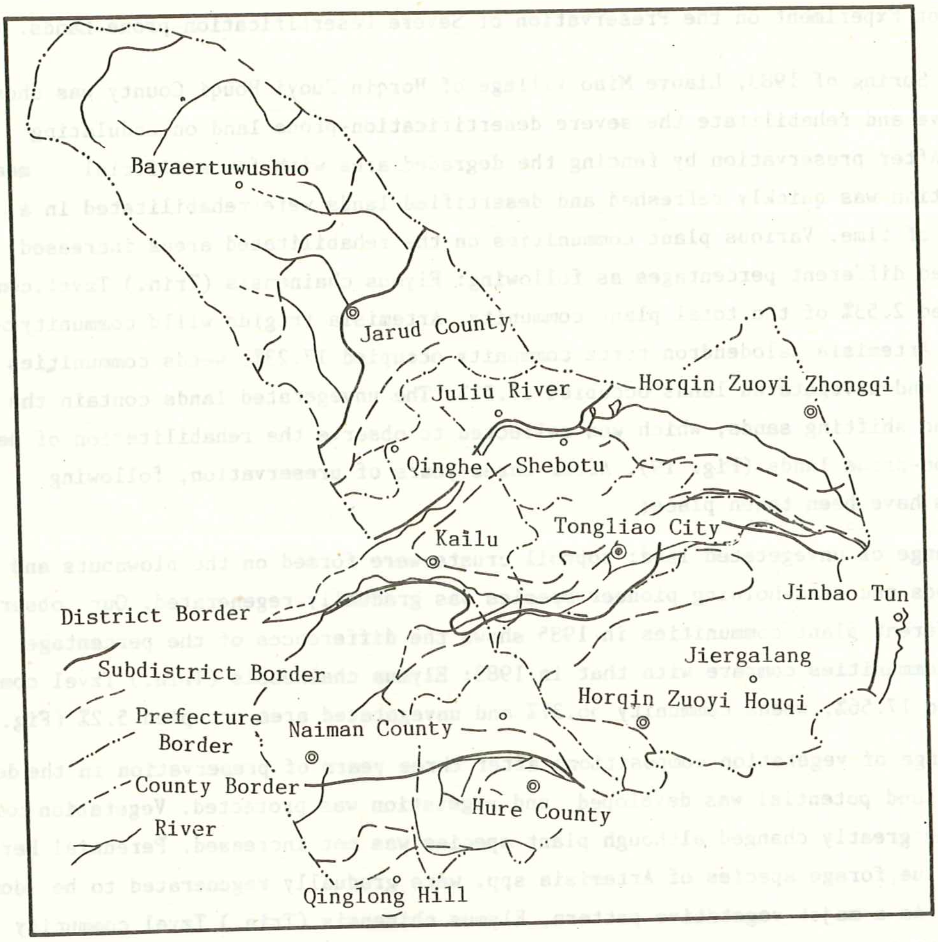

Fig. 19. A Divisional Figure of Desertified Land Control in Jirem Prefecture, Inner Mongolia.

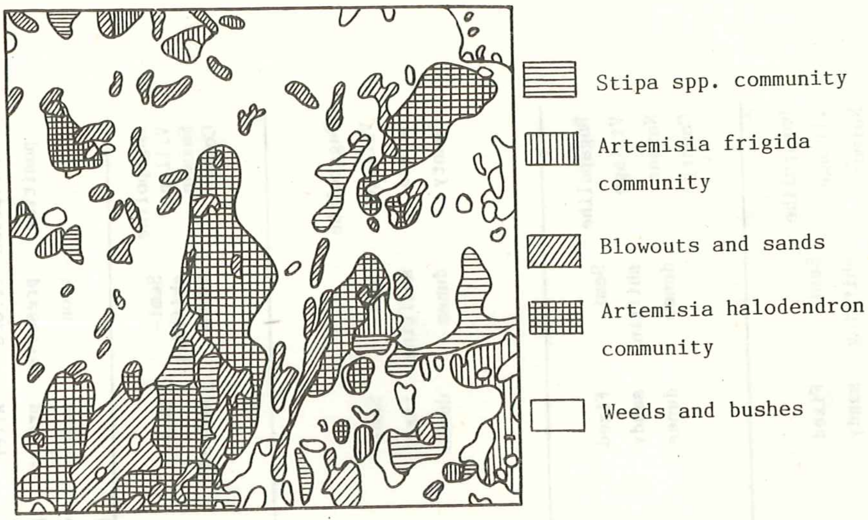

Fig. 20 (A). Vegetation in the Reversed Area of Laoye Mao in 1983.

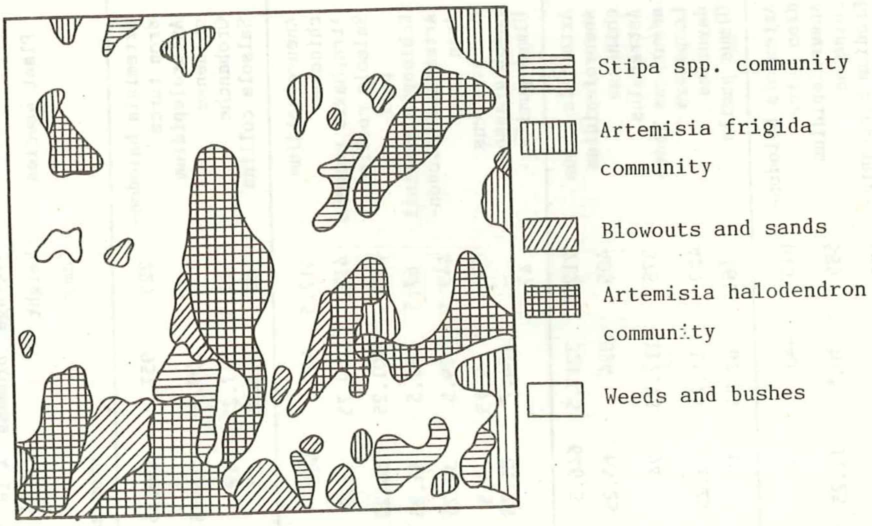

Fig. 20 (B). Vegetation in the REversed Area of Laoye Mao in 1985.

Table 38. Refreshment of Vegetation after Preservation of On-going Desertification-prone Land

Observation position	Dune types: Before preservation	Dune types: After preservation	Duration of preservation (year)	Vegetative Status: Plant species	Average height (cm)	Biomass	% in total biomass	vegetative coverage (%)	total biomass (dried weight kg/ha.)	Remarks
Bagapolihe Village Naiman County	Semi-shifting dunes	Unpreserved	0	Artemisia halodondron turcz	225	957	659.25	150	1089	
				Aneurolepidium chinense	450	109.5	75.75			
				Orobanche	127.5	17.25	12			
				Salsola collina	60	5.25	3			
Bagapolihe Village Naiman County	Semi-shifting dunes	Semi-fixed dunes	1	Aneurolepidium chinense	517.5	942	468	300	1509	93 young Ulmus pumila/ m^2
				Atraphaxis pungens	412.5	129.75	64.5			
				Salsola collina pall	210	101.25	50.25			
				Echinopis gmelinii	67.5	82.5	41.25			
				Artemisia halodondron turcz	442.5	79.5	39.75			
				M.wuaveolens	630	9.75	4.5			
				Ledeb grasses	-	164.7	81.75			
				Ulmus pumila	47.25					
Bagapolihe Village Naiman County	Semi-shifting dunes	Fixed sandy dunes	1	Artemisia annua	712.5	3217.5	646.5	375	3736.5	6 young Ulmus pumila/ m^2
				Aneurolepidium chinense	405	324	65.25			
				Astragalus adsurgens ledeb	375	117.75	24			
				Lespedeza davurica	420	11.25	2.25			
				Ulmus pumila	46.5	62.25	12			
Bagapolihe Village Naiman County	Semi-shifting dunes	Fixed sandy dunes	1	Artemisia halodondron turcz	615	4455	714	525	4674.75	7 young Ulmus pumila/ m^2
				Aneurolepidium chinense	585	70.5	11.25			
				Erodium Stephanianum	375	50.25	8.25			
				Astragalus adsurgens Ledeb	375	33	6			
				Ulmus pumila	47.25	66	10.5			

Fig. 39. The Proporation of Main Species in Plant Communities (%)

pioneer species / year	Elymus chinensis	Artemisia frigida willd	Artemisia halodondron turcz
grazing land (contrast)	43.7	47.6	58.7
first year preservation	46.7	36.4	59.8
Second year preservation	48.9	39.2	56.2
Third year preservation	64.8	57.1	57.2

Table 40. The Mainly Species Growing Condition

years / item / species	grazing land (contrast)		first year preservation		second year preservation		third year preservation	
	height (cm)	fresh weight (g/m^2)	height (cm)	fresh weight (g/m^2)	height (cm)	fresh wight (g/m^2)	height (cm)	fresh weight (g/m^2)
Artemisia Frigida willd	38	62	46	83	52	100	58	155
Artemisia halodondron turcz	52	248	58	384	60	425	62	420
A. Annua L	36	73	42	86	45	196	54	286
Lespedeza hedysaroides	38	14	43	16	45	68	48	46
Agropyron ristatum	46	13	56	23	54	49	56	83
Chenopodium acuminatum	12	2	13	3	36	24	30	58
Senecio argunensis	42	8	46	9	50	23	53	29
Artemisia lavandulae-folia	46	28	52	36	38	64	48	39
Elymus chinensis	37	80	49	142	56	192	62	236

Table 41. The Plant Communities Vegetation Ratio and Productive

years / Item / plant community	grazing land (contrast) vegetation ratio (%)	grazing land (contrast) productivity (g/m²)	first year preservation vegetation ratio (%)	first year preservation productivity (g/m²)	second year preservation vegetation ratio (%)	second year preservation productivity (g/m²)	third year preservation vegetation ratio (%)	third year preservation productivity (g/m²)
Artemisia Frigida willd	30	130	45	228	50	255	65	271
Artemisia halodondron turcz	30	433	40	642	45	755	45	733
Herberious weeds	40	219	55	310	60	321	70	386
Elymus chinensis	35	183	40	304	60	392	65	364

Production of verious plant communities is 3705 kg/ha., namely 46% has been increased. Second year later, average production of plant is 4305 kg/ha,69.8% is being increased. In the third year, average production is 4380 kg/ha, 72.7% is being increased.

(d) Change of root system of plant: The growth of plant below topsoil is closely related to the growth of plant above ground. A better growth of ground-above plant can supplies much more carbohydrate to the root system. Similarly, the better growth of ground-below plant can absorb much more nutrients to provide to the ground-above plant. In sandy steppe, the developed root system can play a role of sand fixation. For instance the species of Elymus chinensis (Trin.) Tzvel, the root biomass in a depth from 0-30 cm in the preserved area is 350 g/sq.m (dried weight),and in the grazing area is 145 g/sq. m (dried weight). The root biomass of preserved area is 241% high than that in the grazing area.

(e) Change of plant quality: the percentage of legumen and Gramineae forage of steppe plant composition is the standard to determine the quality of steppe. After the first year of preservation, legumen and Gramineae species occupied 32.8% of the total plant composition, in the second year occupied 38.6% and in the third 41.6%.

By analysising the changes of vegetation of preservation, it is regarded that the degraded vegetation is possibly be regenerated when acceptable measures were adopted to stop the plunder utilization.

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