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A REPORT ON THE COORDINATED RESEARCH
ON THE DESERT REGION

No 1

- Communist China -

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FOREWORD

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A REPORT ON THE COORDINATED RESEARCH
ON THE DESERT REGION [5]

(No. 1)

-- COMMUNIST CHINA --

[Following is a translation of a report compiled by the Sand Control Team of the Academia Sinica entitled Sha-mo Ti-ch'iu ti Tsung-ho T'iao-ch'i Yen-chiu Pao-kuo (English version above), Peiping, No. 1, Scientific Publishing House, 1958, pp 1-108.]

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INTRODUCTION

The total area of desert in China is about 1.63 billion mou with the greatest part in the arid regions of Inner Mongolia and the Northwest. About 400 million mou is shifting sands. For years the shifting sands have been damaging local agriculture and pastures as well as the development of transportation, affecting the progress of culture and economic life. Since Liberation the Party and the government have tried to lead and organize the people of the desert areas in a continuous struggle against the sands. They have accumulated a great deal of experience and realized some achievement.

Academia Sinica and the Soviet Academy of Sciences jointly organized in 1957-1958 a coordinated research team for the purpose of further improving the utilization of sand, studying the control of sand, and finding better ways of utilizing the sand. Together with the related institutes of Academia Sinica, the Forestry Research Institute of the Ministry of Forestry, the Forestry Department of the Inner Mongolian Autonomous Region, and the Forestry Bureau of Kansu province participated in the study.

The team was divided into seven sections: meteorology, topography, hydro-geology, botany, soil, forestry, and pasturing. For two years the team carried out coordinated research in the areas of Ikhchao League, Alashan Banner of Pa-yen-cho-erh League of Inner Mongolia, Ninghsia Hui Autonomous Region, Yu-lin of Shensi, and Chang-i of Kansu. It has achieved a preliminary understanding of the origin of the sand, the physical characteristics of the desert areas, and the types of sandy areas, and has gained considerable experience in sand control.

However, we must point out that the area studied is only one-fifth of the total desert area. The greater part of the vast desert area remains unsurveyed. The research work had several shortcomings. There was not sufficient coordination between theory and practice, nor was there sufficient stationary observation and intensive investigation. Therefore, our future research work will be to strengthen rather than conclude what has been done so far by organizing stronger teams and going deep into the deserts for a more detailed and longer study.

Our present and future reports will be published as monographs in chronological order based on the development of the team's survey and research. In this way they will be available at an earlier date and will serve as a reference for the promotion of sand control work. Since the reports were written during the survey, some are not very systematic. They will be re-arranged when the research work is concluded. We hope that our readers and related organizations will make comments on our research reports so that we may improve our later editions.

A Report on Desert Survey

In 1957 the Academia Sinica and the Soviet Academy of Sciences jointly organized a coordinated desert research team. The survey covered the Ikhchao League of Inner Mongolia, Pa-yen-cho-erh League, the Ho-hsi Corridor of Kansu, Yu-lin of Shensi province, and Ninghsia plains. (The survey route totalled 11,628 kilometers.) Intensive studies were made in Dzungaria, Chung-wei, Min-ch'in, Chin-t'a, Teng-k'ou, Chan-tan-chao, U-hsien Banner, and Yu-lin.

The mission was to find methods of sand control and sand utilization for the purposes of desert and prevention of shifting sands. Therefore, there must be a general understanding of distribution of deserts, their physical characteristics, and the people's experience in sand control.

After two years of investigation, under the direction of the Party, we have gained some preliminary knowledge of the physical characteristics of the region, the origin of sands, the nature of shifting sands, the types of sand areas, the present methods of sand control, and utilization of sandy lands which has great political and economic significance. However, since we are only beginning our work and still lack experience, our results are far from adequate to meet the demands of the difficult task of sand control. We are presenting our ideas here in the hope of accelerating the transformation of deserts into oases.

(I)

The total area surveyed is about 600,000 square kilometers. The deserts occupy about 172,800 square kilometers, about 28.6 percent of the total area surveyed. A total of 126,800 square kilometers, about 20 percent of the total area, is the area of shifting sands. Gravel gobi comprises 205,000 square kilometers or 34 percent of the total area. Low hilly lands (excluding the Chi-lien Mountains) occupy 127,000 square kilometers, 21 percent of the total area.

One of the characteristics of the area is the low density of population. The Ikhchao League has 4.8 persons per square kilometer; the Alashan Banner has 0.23 persons per square kilometer (one person in four square kilometers); the Ochina Banner has 0.02 persons per square kilometer (one person in 50 square kilometers); the industrial and agricultural bases of Ho-hsi Corridor have 13 persons per square kilometer; the Ninghsia Hui Autonomous Region is more populous and has 31 persons per square kilometer. The population is not evenly distributed.

In Min-ch'in hsien on the border of the Dzungaria Desert, there are 240,000 persons in 10,000 square kilometers, while in the Pa-yen-cho-erh League there are 73,000 persons in 235,000 square kilometers. For the future development of sand control, cooperation must be strengthened in order to properly distribute manpower.

Deserts and semi-deserts are rich in mineral reserves. Pao-t'ou Steel Factory, Chiu-ch'uan Steel Factory, and Oil City are being built. Agriculture and pasturing also have good prospects. The newly built Pao-t'ou -- Lanchow Railway and cross desert railways and highways to be built in the future will create favorable conditions for the development of deserts. Following development, the population will increase. Farming and other productive land must increase to meet the growing demands of socialist construction.

The present farming area is very small. Farming land in the Ikhchao League is only five percent of the total area; in the Pa-yen-cho-erh League, 0.5 percent; in

Ho-hsi Corridor, 2.6 percent, while tillable lands total 5,266 square kilometers (judging by the water supply, 42,000 square kilometers can be developed). Only Ninghsia has 16 percent of the area under cultivation. Pasturing is the main production of Pa-yen-cho-erh and Ikhchao Leagues because of the special natural environment. These two leagues have preserved this production for generations. The Ikhchao League now has 4,122,000 head of cattle, the Pa-yen-cho-erh League, 2,446,000 head and Ho-hsi Corridor, 2,180,000 head.

The altitude of the region is generally more than 1,000 meters above sea level. With the exception of the high mountains in the Holand Mountains between Ordos and Alashan, and those in the Chilien Mountains on the southern border of Ho-hsi Corridor, there are mostly low hills, plateaus, and alluvial plains.

Topographically speaking, Ordos is a sand and gravel plateau. Its groundmass is sandstone of Cretaceous period with some sandstone of Jurassic period. The plateau has a wavy surface and occasionally exposes its groundmass. Its eastern and southern borders touch the loess hillock and its northern and western borders the Yellow River alluvial plains. The shifting sands are distributed mainly along its southeastern part and the Great Wall in northern Shensi province, and are called Mao-wu-su Desert. In the north is K'u-pu-ch'i Desert. On the plateau the area of shifting sand is 3,377,400 hectares, including the 1,377,400 hectares in northern Shensi province.

On the high plains of Alashan west of the Ho-lan Mountains are low hills of old metamorphic rock, such as Ya-pu-lan Mountain, Pa-yin-wu-la Mountain, Pa-yin-na-erh-kung Mountain, Tsung-nai Mountain and Hsiao-hung-ko-erh Mountain. The Shan-yuan-ho-li Mountains separate Alashan from the Ho-hsi Corridor. Among the mountains are gravel basins.

In the west and south there are basins with shifting sand including Pa-tan-chi-lin Desert, Dzungaria Desert, Nan-chi-leng Desert, and She-erh-ka Desert. In the northeast are Pa-yin-wen-tu-erh Desert, (Ya-ma-lei-ke Desert), and Wu-lan-pu-ho Desert. The area of shifting sand is about 3,600,000 hectares. West of the Ochina River are scattered remnants of the Ma-tsung Mountains. Most of the

area along the mountains is clastic rock gobi with few shifting sand areas. According to the materials on the Pa-yen-cho-erh League, the Gobi is about 90,000 (sic) square kilometers in size, of which about 105,000 square kilometers are in Kansu province.

The Ho-hsi Corridor is a descending area. Water running down from the Chi-lien Mountains forms a river and a long alluvial plain in the middle of the Corridor. South of the alluvial plain is a reclining plain. The sand lands in the Corridor vary in size, and are scattered. According to local information, the total area of these sandy lands is 5,300,000 hectares (which may be an exaggerated figure.)

The climate of the region is conditioned by its geographical position which is far from the sea coasts and hidden behind high mountains. The highest yearly temperature is 40 degrees C and the lowest -30 degrees C. The absolute range is always more than 60 degrees C. The average range during the day and night is more than 14 degrees. Because of the drastic change in temperature and the topographical features, are frequently from the north and are dry, cold, and strong.

Thus, moisture from the east is reduced and there is little rainfall. From east to west, the annual rainfall decreases quickly from 400 mm. (in Yu-lin) to 100 mm. and then to below 50 mm. (west of Chin-t'a.) The distribution of rainfall is very uneven. The annual rainfall is often determined by that of the summer, which in turn is determined by that of certain month which, again, is determined by that of a few days.

On the other hand, evaporation increases gradually from east to west, increasing from twice the rainfall to four times, eight times, and more than 25 times. Dry weather and lack of clouds and fog produce sunshine. Most places have more than 3,000 hours of sunshine. In winter there are often more than seven hours of sunshine a day. Strong and long sunshine intensifies the heat, but at the same time improves winter conditions and insures sufficient warmth and time for vegetation. To summarize, dryness, extreme cold and hot weather, long and strong sunshine, and strong and sandy winds are the climate characteristics of this region.

The rivers in the region, with the exception of those running into the Yellow River, are mostly inland rivers. There are many salt lakes (Pei-hai-tzu Lake, Yen-ch'ih, Kilanta., Ya-pu-lang, etc.), and soda lakes (Ch'a-han Lake), which are treasures of the deserts. The lake basins are good pastoral lands.

In Alashan, water can be collected only from the exposed underground water in the low lake basins. The water level is influenced by rainfall and the underground current and has seasonal fluctuations of high in spring and low in summer, returning to a higher level in fall. The water reserve in the plain under the mountains is deep. In addition to the rich surface water sources (16,340 million kung fang), the Ho-hsi Corridor also has rich underground water sources (6,780 million kung fang).

From the standpoint of soil and plants, the eastern part of the region grows mainly shrubs and herb vegetation of dry steppe and has light chestnut earth. West of the Hang-ching Banner has drought-resisting shrub and semi-shrub vegetation of desert steppe and brown soil. Further west are found small shrub vegetation of desert-like steppe and light brown soil. West of the Ho-lan Mountains is entirely desert vegetation and the soil is mainly grey brown desert soil. Further west (west of Chiu-ch'uan), the desert scene is even more typical. There are special plants such as *Zygophyllum fabago*, *Alhagi pseudoalhagi*, *Statice gnelini*, and rare desert vegetation such as a cushion-like gnetaceae. The soil is mainly gravel and limestone, grey brown desert soil, and saline soil.

(II)

The origins of aeolian sand are physical weathering of rock, alluvion of rivers and wind. Under extreme changes in weather and strong weathering, rock is broken into pieces and sent by wind and storm to other places. In Ordos and Alashan, we find sand dunes of weathered rock from Cretaceous, Jurassic, and Tertiary periods.

Ancient rivers, modern permanent and temporary rivers, and surface waters always bring a large amount of sand to the lower reaches or low lands. These sands and sand alluvial soil and lake sediment constitute rich sources of sand which, under the influence of wind, becomes shifting sand. Temporary floods caused by short but strong storms often cut a deep groove on the plains and destroys the surface structure. As the wind blows, it creates sand.

Excessive grazing, wood-cutting, and cultivation destroy vegetation, especially the old desert vegetation, and create shifting sand. In the region surveyed, the east has better conditions for vegetation than the west, and yet the area of shifting sand is larger in the east than in the west.

Although the sources of sand in the east may be richer, the main reason is incorrect utilization of land. The most obvious case is the Mao-wu-su Desert which is a typical example of the result of wanton grazing and farming.

The spread of shifting sand depends on the wind. The wind speed that will raise sand is generally five meters per second (two meters of wind equals a speed above the 4th grade wind in observatory.) This wind occurs about 100-400 times year (according to the observatory's measurement of four times a day). Each wind lasts a day or two. The highest wind power reaches the tenth grade. Therefore, the moving speed of shifting sands is great. Generally speaking, a sand dune moves about five meters a year. The faster ones may move 15 to 20 meters a year, and in some individual cases, a sand dune may move as much as 40 to 100 meters a year.

The sand dune moves in the direction of the wind. The general direction is determined by all sand-raising winds, especially the main and secondary winds.

The sand-raising winds are determined by the circulation of atmosphere and topography. Using the Ochina River as the dividing line, the region can be divided into two wind districts. The east has mostly northwestern and western winds and the sand dunes move towards the southeast. The west has mostly northeastern and eastern winds and the sand dunes move towards the southwest. The topographical features of the area affect the wind locally.

For instance, Ho-t'ao and northeastern Alashan has prominent southwestern and northeastern winds, and the sand dunes move eastward. The Ninghsia plains has prominent east wind and the sand dunes move south. Tunhuang has strong northeast, west and southwest winds, and the sand dunes move back and forth with the wind.

The sand storm creates tragic scenes of destroyed houses, buried farms, nipped grain shoots, and blown fields. Great damage has been done to the people. The southward moving shifting sand choked many rivers, and swallowed many villages and farmlands. For instance, over 20 villages south of the old city of Min-ch'in had more than 20,000 mou of farms. They have been almost completely buried under the sand in the past 200 years, and only three villages with about 3,000 mou in total are now left. Before the sand was controlled, Teng-k'ou lost about 1,000 mou of land every year. In the Ikhchao League 330,000 hectares of land is threatened by sand.

Drought is also a serious disaster in this region. According to the records of Kansu province, during the 83 years between 1865 and 1947, there were 11 serious droughts. One lasted for four years, three for three years, and one for two years. Sand and drought reduce the size of pastoral lands, resulting in a shortage of grazing for cattle. The death rate of sheep in Ta-k'e-hsiang of Hang-ching Banner last winter was 20 percent, and the death rate of cattle in Wu-hsien Banner reached 15 percent. Shifting sands also affect the development of industry and communications. The mining area in the Ya-pu-lan Salt Lake was buried by sand. The newly built Pao-lan Railway was threatened by shifting sand. The highways between Kilantai Salt

Lake and Lao-teng-k'ou, and between Lao-teng-k'ou and San-shen-kung have been buried by sand and are no longer useful.

These few examples show the serious damage the shifting sand is doing to the economic development of the people. For the sake of building socialism, or, to be more specific, for the sake of building communism, it is obviously very important to change deserts into a better environment for habitation.

(III)

Before Liberation, the feudalistic rule did not control the sand and seriously destroyed stable or semi-stable vegetation and "ts'ai-wan" (faggot flat). Thus the area of shifting sand grew continuously.

After Liberation, under the leadership of the Communist Party, the people were organized to struggle against the sand. After nine short years of active work utilizing methods such as sealing the sand and growing grass, forestation, planting sand barriers, and holding down sand dunes, there has been great achievements in sand control.

In wind-prevention and sand-stabilization, according to incomplete statistics the total area of forestation was 352,138 ha (by the end of 1957). Farm land was expanded. Grain and cotton were insured as good crops. For instance, 50,000 mou of farmland in Teng-k'ou that had previously been damaged by shifting sand was again under cultivation and its productivity per unit increased more than three times.

In 1958, under the Big Leap Forward in production, a new high tide for sand control and forestation appeared. The area of forestation doubled. During the rain season that year, airplanes were used in Yu-lin, Min-ch'ing, Chiu-ch'uan, Ku-lang, and Ta-chin to sow sand-stabilizing plants over 44,750 hectares of land. In many places, people grew grass on the sandy land near their farms to control sand.

In the years 1950-1957, 90,000 mou of sand in Teng-k'ou and more than 1,800,000 mou in Min-ch'in were controlled. The largest scale of control is at Liu-pa of Min-ch'ing where the ts'ai wan extends 40 kilometers in length and 10 kilometers at the widest place.

In the area where the sand was controlled, red willow grew as tall as 1.5 meters, forming a long green wall against sand and wind. Furthermore, systematic woodcutting and medical herb and seed collecting add new income to commune members. These simple and easy methods can be used in areas where the density of population is very small.

Installation of sand barriers (wind-breaking walls) is also a popular method. There are two kinds of sand barriers. One is a mechanical sand barrier. It is an effective method for protecting the growth of plants. However, it is only a temporary method. In the city of Min-ch'in, 3,000 li of wind-breaking walls have been built in the past eight years, protecting more than 40,000 mou of farmland. Along the newly built Pao-lan Railway in the section west of Chung-wei where it passes through the desert, sand barriers have served useful purposes.

The other kind of sand barrier is a biological barrier. In areas where the water supply is good and the population large, the method can be used and will gain greater results than the mechanical sand barrier. In the Ho-hsi Corridor, almost every hsien has used or is using this method of "burying sand dune." The method is to level the top of a sand dune and cover it with a layer of 10-15 cm. of wet soil or clay. When the layer is dry, it becomes a smooth and strong coating which will resist wind erosion. Trees can then be planted around the sand dune.

This method has great effect in controlling shifting sands. In Chin -t'a where this method is used 2,140 mou of farmland was protected. According to our observations, no vegetation grew under 40 cm. of dried sand layer of buried sand dune, while plants grew in 8-10 cm. of unburied sand. Therefore, this method is best used in those shifting sand areas in urgent need of sand control where it is difficult to control sand with plants.

The methods must be coordinated in order to achieve the best results. We cannot depend on one method alone. From 1951 to date, Hsieh-po hsiang of Min-ch'in built 52,652 mou of wind-breaking and sand-controlling forests, grew 9,300 mou of sand-controlling grass, constructed 90 li of wind-breaking walls, buried 600 mou of sand dunes, planted 30 li of bank-strengthening forests (from Ta-pa-k'ou to T'ien-pin hisang), and planted fruit trees in 14 farm-protecting zones. Their great efforts have completely changed the appearance of the deserts. This is an example of coordinated control which is worth promoting and following.

(IV)

The purpose of forestation and transformation of deserts is to turn unproductive and harmful deserts into oases, and then turn oases into productive grazing lands, forests, and, if possible, farms, grape orchards, or vegetable gardens. The principles and procedures of desert transformation are, we think, to begin with the nearer places and the easier work, to suit local conditions, to prevent disaster, and to equally stress prevention and control.

Based on these principles, we will discuss forestation of deserts and their transformation and utilization in the following three regions:

1. Ordos and the Mao-wu-su and K'u-pu-chi Deserts in northern Shensi province.

Apart from widespread high altitude marsh land, alluvion of low land rivers (such as the Yu-ch'i, Hung-liu, and Yellow Rivers) and sedimentation of the lakes, the shifting sand in this region is often seen over the ground mass (of Cretaceous period, Jurassic period, red sandstone, or green sandstone). The border of the shifting sand often covers the old abandoned farms (as seen in northern Shensi).

Northern Shensi and the Mao-wu-su Desert in southeastern Ordos is a chain of crescent sand-hills of 4-6 or 10-15 meters in thickness. There are plants like *Agriophyllum arenarium*, *Corispermum patelliforme* and *Psammochloa villosa* in the shifting sand area, and *Artemisia Ordosica* and *Artemisia sphaerocephala* in the hills. The natural environment here is better than in the K'u-pu-chi Desert north of Ordos or the shifting sand area on the plateau. The population here is also larger.

Therefore, we should continue to plant various kinds of willows in order to build a sand-prevention forest zone. Outside the zone, the semi-shifting or shifting sand lands within 5 to 10 kilometers should be sealed and seeded manually or by airplane with sand-solidifying plants such as *Agriophyllum arenarium*, *Artemisia* sp. and *Hedysarum mongolicum*.

If the area outside the zone has mainly thin sand dunes of great mobility, and especially if the shifting sand is close to a communication line, then plants like *Tamarix ramosissima* and white tribulus are needed.

In semi-stabilized sand land, plants like *Caragana korshinskii*, *Salix cheilophylla*, *Salix flavida*, and *Artemisia* sp. can be used. It must be pointed out that on low lands or the inner part of a desert where the rock under shifting sand does not leak water because the sand dune has sufficient water for the growth of desert plants, sand-consolidating plants should be planted among hills.

Judging from the geographical position of the K'u-pu-ch'i Desert and the wild trees grown there, although rainfall is not as adequate as in the south. We feel that the biological method can be used to stabilize the sand. In the crescent-like chains of sand dunes 13-30 meters high, sand-stabilizing plants can be seeded in strips.

However, in the sand hill areas along the Yellow River, seeds of *Hedysarum mongolicum*, *Agriophyllum gobicum*, and *Artemisia* sp. can be spread by airplane. On the beaches along the river, airplanes can spread willow seeds.

If water of the Yellow River can be successfully guided to the edge of the shifting sand, then some willows can be planted to form a protective forest. At the same time, a forest must be built along the river to protect the banks. These forests will produce some timber for consumption.

Large scale grass-growing and seeding by airplane must also take into consideration the growth of grazing grass. The method is to seed perennial grazing grass over the sandy land where underground water is high. In this area, it is important to properly utilize old stable sand-land in order to raise the utility rate. But we must watch the shifting sand which may be created by grazing.

Meanwhile, good perennial grazing grass -- *Medicago denticulata* -- must be selected for stable sandy land in order to improve permanent grazing land. The lake-bottom

low land can be developed for growing feedings. Some land can be used for growing grazing grass and rotating farming of grazing grass can be practised.

Old farmland and alluvial sandy land buried under shifting sand can be agriculturally developed by planting grapes and melons.

2. Alashan Desert.

The Pa-yin-wen-tu-erh Desert and Wu-lan-pu-ho Desert in northeast Alashan are a crescent-shape chain of sand dunes with a general height of 6-8 meters to 15 meters. The highest may reach 30 meters. Under the influence of wind, shifting sand moves toward the east, and covers the ladder and abandoned farmland along the Yellow River. Part of the shifting sand covers the sedimentation on the lakes, and a part also covers the groundmass.

The underground water is fresh with the exception of the sand dunes over the lake sedimentation where it is salty. Plants like *Hedysarum mongolicum*, *Agriophyllum arenarium*, mien-p'ung, *Psammochloa villosa*, *Phragmites communis*, and *Artemisia* sp. are found among sand dunes. In the low and flat sandy lands in these two deserts are forests of *Haloxylon ammodendron*.

In southern Alashan, the western Dzungaria Desert (including the neighboring She-erh-k'a Desert and the Nan-chi-leng Desert), and the Pa-tan-chi-lin Desert have mobile crescent sand dunes. Near the edge of a lake they are about 3-5 meters in thickness. Those in the interior of the deserts may be as high as 10-30 meters. Only in the interior of the Nan-tan-chi Desert can we find sand dunes more than 100 meters high, and in the Pa-tan-chi-lin Desert the highest sand dunes may reach more than 400 meters high.

Apart from sand lands similar to those in the Wu-lan-pu-ho Desert, the southern border of the Dzungaria Desert often sees shifting sand above the sedimentation before mountains where the underground water may be 20-50 meters deep.

On the southern border of the Pa-tan-chi-lin Desert, near Ya-pu-lai Salt Lake, in front of the Huo-la-li-ssu Desert, there is a type of shifting sand which covers salt earth. These two types, and especially the latter type, are difficult for vegetation growth.

Based on the above characteristics of deserts, a belt five kilometers wide, or 10 kilometers wide if conditions are favorable between the fringes of the Dzungaria and Wu-lan-pu Deserts near the Yellow River and the farming areas can be sealed in for growing grass. Seeding plants like *Agriophyllum arenarium*, *Artemisia* sp., *Hedysarum mongolicum*, *Haloxylon ammodendron*, and *Nitraria tangutorum* can be done manually or by airplane.

At the same time, a sand-prevention forest zone 20-60 meters wide can be built around the semi-shifting sand land. This zone can be made of several kinds of salicales. Controlling the shifting sand by surrounding it from the outside will help the development of industry and agriculture. In the interior of the Wu-lan-pu-ho Desert, conditions will be changed because of the planned irrigation by the water from the Yellow River. In the irrigated areas airplane seeding can be done.

One of the special characteristics of the Dzungaria Desert is the interlacing of lakes and deserts. The lake basins occupy more than 20 percent of this desert region. Therefore, sand control can begin with controlling the shifting sand around the lake basins.

By attaching the interior of the desert outside the lake basins and connecting the lake basins together one by one from points to lines, we can cut up the desert and then connect the area between lines until the whole desert is eliminated.

Through forestation we can build a sand prevention zone with *Populus diversifolia* and *Calli. mongolica*. On the semi-shifting sand and shifting sand areas outside the zone, *Artemisa* sp., *Artemisia ordosica*, *Hedysarum mongolicum*, *Calli. mongolica*, and *Haloxylon ammodendron* will be planted. Large lake basins will be sealed for growing grass. Better areas, if possible, will be seeded square by square in order to accelerate forestation.

Along the railways and planned railway lines, sand prevention barriers must be built on both sides within 1,300 meters, and sand-stabilizing plants must be planted within the barriers. The zones two kilometers outside the barriers will be sealed for growing grass in order to protect the railways.

In areas where shifting sand threatens salt lakes, we should depend mainly on establishing a line of barriers on sand dunes or burying the sand dunes with salt water. Also, a line of sand barriers can be built on the range of sand dunes 1,000 meters outside the protected zone in order to raise the height. If there is enough rainfall, sand-stabilizing trees may be planted between barriers.

After beginning sand-stabilizing work, and especially during the first five years, it is very important to solve the problem of water supply and to establish grazing bases in order to insure the development of the pastoral industry. In locations suitable for grazing bases, grazing grasses like medicago denticulate, ts'ao-mu-chi, sugar beets for feeding, and sun flowers can be grown in sand dune areas where *Achnatherum splendens*, *Phragmites communis*, and *Nitraria tangutorum* grow on lake basins.

Dams should then be built, wells drilled, and land irrigated on the plains in front of the mountains in order to develop a grazing field. Grazing grass can be grown on semi-stable sand to make a grass field.

In addition to these methods of development, we must rationally utilize the existing grassland, increase utility of grassland, establish a pasturing and grass-cutting system (following others in pasturing, rotating pasturing, and timely grass-cutting). At the same time, human efforts should be made to expand the utilized area by drilling wells in grassland where there is a shortage of water.

Following sand stabilization is the problem of fuel supply. After the stabilization of sand, fuel will be produced. For instance, one hectare of *Haloxylon ammodendron*

dron can produce 40 tons of fuel. But to meet fuel needs in the early stage, natural resources like sun stove and natural gas be used. Systematic wood-cutting can be done in areas where vegetation is prosperous.

To meet the need of seeds for sand stabilization, it is suggested that cutting the present forests of *Haloxylon ammodendron*, *Populus diversifolia*, *Calli. mongolica*, *Artemisia salsoloide*, *Taxarix ramosissima*, and *Calli. sp.* shrubs be prohibited and that their seed-producing be intensified.

It is also suggested that grape gardens, orchards, vegetable farms, or farmlands be developed near oases and populated lake basins.

3. Ho-hsi Corridor Sand Land.

The main types of shifting sand in Ho-hsi Corridor are: shifting sands of various thickness covering the alluvions of rivers or lakes, or abandoned farms; shifting sands covering the alluvion in front of the mountains, over gravel gobi plains, and over slopes of rocky hills. Except for the first type where the underground water is high, it is difficult to grow vegetation in any of the other types of sand land.

From the standpoint of forestation in the deserts, the Ho-hsi Corridor can be divided into two parts, the east and the west, with Chiu-ch'uan as the dividing line. Different methods should be used in view of their different natural environments.

In the eastern part, for example in Min-ch'ing, efforts should be made to build three lines of defense on the border of the desert in the northwest. The first line is a sand prevention forest zone near the border of oases where underground water is high and irrigation is good and trees and shrubs like *Populus diversifolia*, *Tamarix ramosissima*, *Populus simonii*, and *Salix Cheilophylla* can be planted.

The second line is to build wind-breaking fences on shifting sand dunes and to plant trees like *Artemisia ordosica*, *Tamarix ramosissima*, *Hedysarum mongolicum*, *Artemisia* sp., *Nitraria tangutorum*, and wild jute.

The third line is to seed sand stabilizing vegetation on the outer zone. In future, seeding by airplane should be done mainly on the second and third lines. The interior part of the deserts can be completely sealed. After the sand is stabilized, the second line can produce fuel and grazing grass, and the third line can become pastoral lands.

To supply feed in the early stage, the local people have the custom of cultivating *medicago denticulata* as grazing grass. The systematic expansion of grazing grass fields in the future will occupy 10 percent (100,000 mou) of farmland. This is an example of solving the contradiction between sealing the sand and pasturing. This is also a rational utilization of land and a good method of coordinating agriculture and pasturing, and should be promoted in similar areas.

At the same time, we suggest that we should also stress the cultivation of grazing grass in sealed sand land. In the development of cattle-raising, we should stress growing working animals, meat animals, and pigs. Furthermore, the population of Min-ch'ing is large and neighboring Alashan Banner has a small population and a shortage of labor. Cooperation between the two will greatly help the transformation of deserts.

Natural conditions in the western part of Ho-hsi Corridor are severe. The dry sand layer of sand dunes is one or two meters thick and even sand-growing plants cannot grow. Therefore, to prevent the serious danger of shifting sand, we have to depend on planting sand barriers. However, we must plant sand stabilizing trees when rainfall is sufficient. In areas where the underground water is high, only strong salt-tolerant plants can be grown because of salinization.

The Yuan-yang Water Reservoir in Chin-t'a is threatened by shifting sand and sand barriers should be built. However, sand carried into the channel and reservoir by

water far exceeds that blown in by the wind. Therefore, it is suggested that forestation and vegetation should be developed along both sides of the channel, along with some necessary sand and water control construction.

The shifting sand of sand dunes in the interior part of the oases can be stabilized by planting sand barriers and sand-stabilizing trees. Grapes and melons can be grown on sandy land less than two meters thick.

It is important to control the sand in a large waste land being opened up for cultivation. It is suggested that a protective forest be built in accordance with the irrigation system and the local wind condition.

In the territory of the Corridor, there are many ancient and modern dry river basins (which are sources of sand). Large-scale forestation should be done in order to control sand, and trees should be planted along both sides of highways and rivers. The forestation will not only control the sand but also improve the local weather in the Corridor. It can protect the industrial bases and insure high productivity of cotton and grains.

In addition to the three main regions, there are shifting sands, mobile crescent sand dunes, and sand dune chains of various sizes scattered over the alluvial land along the Yellow River in Ninghsia plains and the valley of the Pa League. The sand is not very thick and the underground water is rather high.

It is therefore, easy to control the sand by plants, as suggested for similar sand lands in the three main regions. However, special attention should be given to the forests along the rivers and channels so that there will be thick forestation.

Now, let us discuss the problem of seeding by airplane.

Seeding by airplane will be the main method used over large sparsely populated sand lands. An An-2 type of plane

can seed about 2,000-3,000 hectares of land a day, which equals 500-700 men working.

The success of seeding by plane depends on selecting the right land, seeds, and season. Most dependable lands are those with more rainfall, high underground water, sufficient moisture in the sand, semi-mobile sand, and less mobile shifting sand during the rainy season. Although rainfall in this region is unstable, we can improve weather forecasting to capture rainfall.

In selecting seeds, the seeds of pioneering plants of shifting sand such as *Agriophyllum arenarium*, *Artemisia* sp., and *Hedysarum mongolicum* may be mixed and spread. The annual *Agriophyllum arenarium* can protect the growth of *Artemisia* sp. The dead *Agriophyllum arenarium* leaves its own seeds which will grow the following year. *Hedysarum mongolicum* is not affected by the weight of sand. Buried under the sand, it will grow the second year if it does not grow in the first.

The *Haloxylon ammodendron* is best planted in semi-mobile land, and (due to the fact that some may die every year) a total of 150 trees after five years will be considered satisfactory. Otherwise, it will have to be seeded again. Some of the seeds spread over shifting sand will inevitably be blown into low lands or dry out, especially during the spring following seeding. However, if only part of the plants survive, vegetation will improve. If vegetation in the year following seeding is 15-35 percent, it should be seeded again until it reaches above 35 percent.

Finally, based on the methods used in the above-mentioned regions, the more general ones can be summarized as follows:

(1) For shifting sand near villages, oases, communication lines, rivers, canals, and important construction bases, all methods (including sealing, grass-growing, tree-planting, and sand-barriers) should be used to control sand. After the sand is under control, systematic grass-mowing or grazing may be allowed.

(2) For shifting sand not far from villages, oases, and communication lines (outskirts of areas mentioned above), seeding by manpower or airplane, or planting sand-stabilizing trees may be done. After the sand is stabilized, the trees can be used for producing fuel.

(3) For shifting sand outside the second region, seeding by manpower can be done. After the vegetation has reached 15-35 percent, seeding by airplane can be done. When the sand is stabilized (five years after the seeding of *Haloxylon ammodendron* by airplane), it can be used for grazing small cattle.

(4) For shifting sand far from villages, oases, and communication lines, generally speaking artificial rainfall or irrigation must be used for seeding stabilizing plants in the interior part of the desert.

The Natural Characteristics of Deserts in North China

(With a map of distribution of deserts and 16 photographs)

The total area of northern Shensi, Ordos, Alashan, Edsingol, Ninghsia, and Ho-hsi Corridor is about 630,000 square kilometers. Of this area, 235,000 square kilometers, or 37 percent, are deserts. About 40 percent, or 108,000 square kilometers of the deserts are shifting sand.

The well-known deserts in this area (see the map of distribution of deserts in north China) are: The Mao-wu-su Desert in northern Shensi and southeast Ordos; the K'u-pu-ch'i Desert in northern Ordos; the Wu-lan-pu-ho Desert, the O-ma-lei-k'e Desert (Pa-yin-wen-tu-erh Desert) northeast of Alashan; Dzungaria Desert, Nan-chi-leng Desert, and She-erh-k'a Desert of southern Alashan; the Pa-tan-chi-lin Desert, and Ho-la-li-ssu Desert of western Alashan. Other deserts are of various sizes and are scattered.

1. Marshland southeast of Ordos and the Mao-wu-su Desert in northern Shensi.

It includes the east and southeast parts of Ordos. Its northern border is Ch'ien-sa-pa and Man-lai (west of Tung-sheng); its eastern border is Hung-hsien-cho; and its southern border is the Great Wall. Its western border begins in the north from Chang-tan-chao of the Ta-la-t'e Banner, through T'ien-chu-miao of the Hang-chin Banner, to Yen-ch'ih of Shensi province on the southern edge of Ordos in the south. This region is steppe land. The average temperature in July is between 23 and 24 degrees C. The rainfall is between 300 and 400 mm. The proportion between rainfall and evaporation is 1:4.

On the southern edge of Ordos, the rainfall decreases from east to west to 259.7 mm. in Yen-ch'ih, while evaporation gradually increases. In the north, there is similar differentiation from east to west.

The volume of the Wu-lan-mu-lun River and the short rivers that originate from the sandy gravel plateau north-east of Ordos and run northward into the Yellow River are small. The Ch'i-ch'iu River that originates in Tao-t'u-hai-tzu of Tsa-sa-k'e Banner, and the Pai River originating from Wu-shen Banner join to form the Yu-ch'i River which passes by Yu-lin and runs into the Wu-ting River. The Hung-liu, the Na-ling, the Hai-liu-t'u, and the Lu Rivers in southern Ordos also run into the Wu-ting River.

Sand lands are scattered over marshlands, alluvial lands, and sedimentations on lowland rivers and lakes. They are locally called the "Mao-wu-su Sand Belt". Shifting sand does not cover much of the plateau, with rocks of the Cretaceous period, Jurassic period, red sandstone, and grey-green sandstone.

In southern Ordos bordering the loess, some shifting sand is seen over loess hills (such as the Ch'ing-yun Mountains in Yu-lin). Shifting sands are mainly crescent sand dune chains of 4-6 and 10-15 meters in height. The crescent sand dunes over the loess hills and slopes are usually below four meters. The shifting sand in the area moves from northwest to southeast.

Covering the crescent sand dunes are the typical sand vegetation: *Corispermum hyssopifolium*, *Agriophyllum arenarium*, and *Psammochloa villosa*, with *Artemisia ordosica* and *Ar. sphaerocephala* among sand dune chains.

In the semi-mobile sand lands (with 15-35 percent vegetation) where the underground water is high, there are *Salix flavida*, *S. mongolica*, and *S. Cheilophylla* in addition to the above-mentioned plants. In stabilized land (with more than 35 percent vegetation) on chestnut earth, there are *Artemisia ordosica*, *Ar. sphaerocephala*, *Caragana korshinskii*, and *Juniperus sabina*. This proves that the physical condition of the sand land is good and that plants can be used for stabilizing the sand.

Lakes with high underground water and lakes of low salinity have shrub vegetation such as shrub willow, *Hippophae rhamnoides*, *Achnotherum splendens*, and *Carex stenophylla*.

The high plateau mainly has light chestnut earth and vegetation like *Stipa bungeana*, *Lespedeza dahurica*, and steppe grasses. Many places have been cultivated and planted with grains and jutes.

2. The K'u-pu-ch'i Desert in north and northwest Ordos.

Its northern border is the Yellow River; its southern border Yen-hai-tzu of Hang-chin Banner. Its western border begins from the Yellow River and runs eastward 270 kilometers to the Ha-t'a-chan River. Its eastern part is 15-20 kilometers in width and the western part is as wide as 70 kilometers. The sand gradually scatters towards the east. The eastern part of the desert is cut by several seasonal rivers such as the K'eng-tui-kou, the Pao-she-t'ai-ch'uan, the Ho-lai-kou, the Shui-tung, and the He-t'ai-chan Rivers, which are 50-500 meters in width.

The deserts in this region are in an area of desert steppe. The local people call them "the K'u-pu-ch'i Desert". As early as the late 19th century, Russian traveler H. M. Przewalski surveyed this region and recorded it as "K'u-tsu-pu-ch'i Desert."

The K'u-pu-ch'i Desert has a crescent sand dune chain that runs from the northeast to the southwest with a height of 13-30 meters. It covers ancient sedimentation of Cretaceous period and some of Jurassic period. Some weathered marble of Ordovician period is found near the He-t'ai-chan River. Along the Yellow River, sand is scattered over the ladder lands. The shifting sand dune has very fine sand. In the alluvial ladder lands of the Yellow River south of the Ta-la-t'eh Banner, 73-88 percent of the sand of crescent sand dune is fine sand.

The low land between sand dunes grow sparse *Caragana korshinskii*, *Clir.tes fruticosa*, *Atraphaxis frutescens*, *Calligonum* sp., *Tragphyrum* sp., *Oxytropis aciphylla*, *Arte-*

misia Ordosica, and Artemisia sphaerocephala. Main vegetation on the shifting sand includes Agriophyllum arenarium, Pugionium cornutum, Psammochloa villosa, and Hedysarum mongolicum. On alluvial lands where the underground water is high, vegetation is more prosperous.

Stable and semi-stable sand lands are located around the mobile sand. Stable sand has sandy soil of brown soil type. The main plants are Artemisia sphaerocephala, Caragana microphylla, Glycyrrhiza uralensis, Eurotia ceratoides, Salsola callina, and reeds.

3. Plateau sand lands in central and western Ordos.

The western border of this region consists of low hills made of old sedimentation of Sinian period and early palaeozoic era such as the Chotzu Mountains, the A-la-pu-su Mountains, and the eastern border of the Ninghsia Plains. Its north connects with the southern border of the K'u-pu-ch'i Desert. Its eastern border is T'ien-tzu-miao of Hangching Banner, K'o-k'e-cho of O-t'o-k'e Banner and Yen-ch'ih which is also the dividing line between desert steppes and dry steppes. Its southern border is the southwestern part of Ordos.

The climate in this region is dry and cold. The average temperature during the month of July is 21.7 degrees C. The rainfall is 252.8 mm. and evaporation is nine times greater than rainfall.

With the exception of rivers originated from the high plateau (1,480 meters in altitude) that run into the Yellow River, the principle rivers are inland rivers such as those running into the Yen-hai-tzu marsh land, the Hao-lai River, and the T'ao-lai River. There are a number of inland soda (Na_2CO_3) lakes (such as the Ch'a-han Lake, the Pa-yen Lake, and the Na-lin Lake) and chloride lakes (such as the Yen-hai-tzu Lake) in the central part of this region.

The low hills of the Cho-tzu Mountains covers the sandy and gravel alluvial plains and western plateau (where the sand rock of cretaceous period is close to or rises above the surface) where the underground water is deep and light chestnut earth is found. The desert steppe vegetation

is scattered *Caragana tragaacanthoides*, *Halolachne soongarica*, *Zygophyllum xanthoxylum*, *Artemisia capillaris*, *Stipa gobica*, and larger areas of *Artemisia frigida*.

On the thin and weathered covering over central Ordos are sandy and gravel plateau rising 20-40 meters in height. Some sand rocks of cretaceous period are exposed in many places. Among those weathered rocks are *Convolvulus chinensis*, *Lagochilus illicifolius*, *Thymus serpyllum*, *Allium mongolicum*, *Oxytropis pubesula*, and *Stellera chamaejasme*.

On the meadow saline soil and salinized meadow soil of low land where rivers run into lakes, the underground water is about 1-2 meters high. The vegetation includes *Carex stenophylla*, *Kalidium gracile*, *Galicarnia fruticosa*, *Suaeda glauca*, *Polygonum ariculare*, *Saussurea amera*, small *Phragmites communis*, *Lactuce tatarica*, *Chenposium albumrlatum*, *Achnatherum splendens*, and *Nitraria tangutorum*.

Aeolianobile sand lands of small size are scattered around. With the exception of some individual crescent sand dunes and some flat sand lands, the topographical feature of the sand lands is mainly crescent sand dune chains 3-5 meters high (with rough and medium-fine sand). Under the influence of the northwestern wind, shifting sand moves toward the southeast. On the shifting sand are annual plants like *Agriophyllum gobicum*, *Corispermum hysopifolium*, *Kochia scoparia*, and *Psammochloa villosa*. As the sand dunes become more stabilized and sand hills more gentle, there is more *Artemisia ordosica*, some *Caragana microphylla*, *Pycostelma lateriflour*, and *Cynachum sibiricum*. When sand dunes become solid sand lands and develop chestnut soil, *Artemisia sphaerocephala* is no longer suitable to the environment and gradually declines. It is replaced by *Artemisia (frigida)*, *Cleistogens squarrosa*, *Thymus mongolica*, and, to a lesser degree, by *Bassia dasyphylla*, and *Jurinea mongolica*.

On sand hills around lakes *Nitraria tangutorum* is mainly found, but when the sand is more than two meters high, this plant will not be able to live and will begin to decline. The stabilized sand hills will then again begin to be weathered. Therefore, it is important to protect this kind of sand hill by planting other plants such as *Tamarix juniperina*.

4. Sand lands of Ninghsia and Ho-t'ao Huang-ho alluvial plains.

This region is located in the northern and central parts of the desert steppe. The altitude of the Ho-t'ao Plains is 1,000-1,100 meters. Its northern border is folded exfoliated mountains made of gneiss, granite, and metamorphic rock, -- the Lang and the Wu-la Mountains. Its southern border is the Yellow River. Its western boundary is the Alashan Desert and the Wu-lan-pu-ho Desert. Its eastern border reaches Pao-t'ou. The Ninghsia Plains is made of valleys of sinking faults. Its western border is the exfoliated high mountains of early Sinian, Cambrian, Ordovician, and Carboniferous periods -- The Ho-lan Mountains. Its southern border is Chung-ning and Chung-wei. Its eastern border is the western edge of Ordos folding zone.

The climate is dry and cold, especially in the north. The annual average temperature is 6.5 degrees C in the north and 9.6 degrees C in the south. The annual rainfall is between 100 and 200 mm. The evaporation is more than ten times as great as rainfall.

On the salinized and farming meadow soil in alluvial plains, there are natural plants such as *Paeonia anomala*, *Scaevola salsula*, *Limonium bicolor*, *Centaurea picris*, *Carex stenophylla*, *Ephedra equisetina*, *Achnatherum splendens*, *Peganum nigellastrum*, *Glycyrrhiza uralensis*, *Agropyron mongolica*, *Salix cheilophylla*, and *Tamarix juniperina*.

In front of the low hills on the alluvial plains of light chestnut soil are dry plants like *Artemisia capillaris*, *Stipa gobica*, *Iljina Regilii*, *Convolvulus tragacanthoides*, *Potaninia mongolica*, *Tetraena mongolica*, *Ilex pedunculosa*, and *Zygophyllum xanthoxylum*.

On the alluvial plains, the typical crescent sand dune chains and individual crescent sand dunes made of shifting sand blown in from the Wu-lan-pu-ho Desert are scattered. The general height of these sand dunes are 2-3 meters, 3-4 meters, or, for some of them, more than five meters. The distance between sand dunes is about 50 or more meters. They are generally floury sand and very fine sand. The mobility of sand dunes is great. Moving toward the south,

they bury farmlands. The underground water beneath the sand land is high, no deeper than three meters, and some less than one meter. Therefore, there are a great variety of plants on the low lands between dunes, such as *Artemisia ordosica*, *Psammochloa villosa*, *Phragmites communis*, *Sophora alopecuroides*, *Calamagrostes epigios*, *Iris eusata*, *Thermopsis lanceolata*, and *Bassia dasyphylla*. On the shifting sand are *Agriophyllum arena rium* and *Corispermum hyssopifolium*. Judging by the vegetation in this region, it is entirely possible to stabilize the sand by plantation.

On the edges of some shifting sands we have some stabilized sand hills and dunes with plants like *Nitraria tangutorum* and *N. sibirica*.

5. The Wu-lan-pu-ho Desert in the northeast Alashan Deserts on the northern slope of the Ho-lan Mountains.

Its northern border is the weathered low hills of metamorphic granite-gneiss, gneiss, and quartzite -- the eastern extension of the Pa-yin-no-erh-kung-liang Mountains (altitude: 1,500-1,600). Its western border is the Kilantai Salt Lake on the plains in front of the Pa-yin-wu-la Mountains. Its eastern border is San-sheng-kung and Lao-teng-kou.

The climate in this region has all the characteristics of a desert climate. Take the records of the Kilantai Salt Lake (altitude 1031.8 meters) for instance. The average temperature in July is 25.3 degrees C.; the rainfall is 106.8 mm.; the evaporation is 26 times greater than rainfall.

The plains in front of mountains on the border of deserts have gray desert soil and scattered small shrubs and semi-shrubs such as *Halolachne soongarica*, *Convolvulus tragacanthoides*, *C. annani*, *Salsola passerina*, *Nitraria tangutorum*, *Potaninia mongolica*, and *Cleistegens mutica*. Around the quaternary Kilantai Salt Lake there is a large area of salinized deserts. The underground water in the mining area is generally 0.78-2.2 meters deep; east of the lake 5.18-12.6 meters; and west of it 18.5-36.1 meters.

East of the salt lake is Pai-yun Lake and northeast is A-erh-ko Lake. Both are in the desert and are connected with ancient rivers.

On the edge of the mobile sands on the gray desert soil in stabilized sand are forests of *Haloxylon ammodendron* which generally last 15-20 years but, due to wood-cutting and camel-grazing, are seriously damaged (some lands in the forests are becoming semi-mobile), and other plants like *Psammochloa villosa*, and *Agriophyllum arenarum*.

Among drifting sand dunes are *Phragmites communis*; in semi-mobile sand land there are mainly *Nitraria sibirica*, *Peptanthus mongolica*, and *Sygophyllum xanthoxylon*; and in the lake low lands, *Kalidium gracile*.

The height of crescent sand dune chains of aeolian alluvion and sedimentation is about 6-8 meters, with the highest 15 meters. The greater part of sands is powder sand. Although the southwest and northeast winds are superior, the shifting sand is influenced by the northwest wind and moves toward the east.

In the western part of the desert, due to the wind condition, the crescent sand dune chains are more complicated and form almost continuous crossing lattice. Generally speaking, the shifting sand land here is in better condition than that in the Ya-ma-lei-k'e Desert.

6. The Ya-ma-lei-k'e Desert (Pa-yin-wen-tu-erh Desert) in northeast Alashan.

The Ya-ma-lei-k'e Desert is in the northwest of the Wu-lan-pu-ho Desert, located in the wide marsh between low hills of the Pa-yin-no-erh-kung-liang Mountains, and the Sa-li-chai Mountains.

On the low hills and in gravel basins among mountains -- semi-plainized high plains (altitude 1,200-1,300 meters), is found ordinary gray desert soil and gravel gypsum desert soil. Representative desert plants are *Halolachne soongarica*, *Salsola passerina*, *Calligonum mongolica*, *Caragana stenophylla*, *Iljinia Regelii*, *Convolvulus chinensis*, *Anabasis bravifolia*, *N. sibirica*, *N. Roborowshii*,

N. spaerocarpa, *N. tangutorum*, *Amygdalus mongolica*, *Ilex pedunculosa*, and *Zygophyllum xanthoxylum*.

The shifting sand of wind-made alluvion and weathered high plains run from east to west like stripes. The topography of mobile sand lands is crescent sand dune chains running from northeast to southwest. The average height of sand dunes is 5.6 meters, with the highest 20-25 meters. There are only a few varieties of vegetation among the sand dunes. Only *Artemisia sphaerocephala* and *Psammochloa villosa* are found. In low and level sand lands (basically stabilized sand) are *Haloxylon ammodendron* (265 trees per hectare), *Ilex pedunculosa*, *Zygophyllum xanthoxylum*, and *Nitroria tangutorum*.

The climate here is drier and colder than in southern Alashan. The humidity of sand dunes is poor. With the exception of the sand land with shallow underground water, the shifting sand lands over the tertiary rock have underground water with high mineralization (9.2g/l) with an average depth of 9.1 meters. It is difficult to stabilize sand with plantation.

7. The Nan-chi-leng Desert, the She-erh-k'a Desert, and Dzungaria Desert in southern Alashan.

Located southwest of Pa-yen-t'e, southeast of Min-ch'ing, west of T'ou-tao-hu (Chao-hua-ssu) of Alashan Banner, and north of Chung-wei, Kan-t'ang, Ho-lo-chin, and T'u-mentzu. This is, broadly speaking, Dzungaria Desert but the local people had a name for it a long time ago. In the report of P.K. Kozlov (1899-1901) and N. M. Przewalski (1871-1873), only She-erh-k'a Desert.

According to our survey, Nan-chi-leng Desert is southwest of Pa-yin-hao-t'eh, and extends south to Shuang-ho-san and west to Wu-ko-san-chin and T'u-lan-t'ai-san. The northern She-erh-k'a Desert touches the southern border of the Nan-chi-leng Desert. Beginning in the east from Chao-hua-ssu on the western side of T'ou-tao-hu lake basin, and extending west to Hei Salt Lake, and south to the southern part of Dzungaria Desert, the name of the desert originated from She-erh-k'a Well. West of these two deserts, and south of the Chung-wei-sa-po-t'ou east of

Min-ch'in and Hsia-ho-lo Well, it is called Dzungaria (meaning heavenly sand) Desert. In this desert area, there are low hills like the Shuang-ho Mountains which are made of Palaeozoic crystalline sandstone, the A-la-ku Mountains (altitude 2,000 meters) made of Permian red and gray sandstone, and the Su-wu Mountains near Min-ch'ing with broken hills.

Widely distributed in this region are strata of Tertiary and cretaceous periods covered by materials of quaternary period. On the mountain land is gravel gray desert soil and drought resisting shrubs and semi-shrubs. The ordinary gray desert soil is found on alluvium and sedimentation. The representative vegetation here are *Halolachne soogarica*, and *Salsola passerina*.

There are a number of soda and chloride lakes. The intertwining lakes (which occupy about 18-20 percent of the area) and sand lands is one of the characteristics of the region. These lake low lands are connected with ancient alluvium and sedimentation. In the western Dzungaria there are many dry lakes. In the Nan-chi-leng Desert are many lakes with limited water supply mineralized to 1-1.6g/l, and seasonal lakes. Soluable salts move continuously into lake basins. In the lake basins are meadow saline soil and salinized meadow bog soil.

The natural vegetation here includes *Carex stenophylla*, *Kalidium caspicum*, *Phragmites communis*, *Achnatherum splendens*, *Nitraria tangutorum*, and some hsiang-p'u. The underground water in lake basins is very high (0.5-2.5 meters). The degree of mineralization varies because of different locations in the basin and the distribution of different plants. According to the analysis of samples made by Cheng Hsun-pao (6774, 7311, 1405) the mineralization of underground water in areas where *Carex stenophylla* grows is 0.5-1.2g/l; that in areas where *N. Roborowskii* and *N. sibirica* grow is 1.4-2.2 g/l; that in areas where *Achnatherum splendens* and *Phragmites communis* grows is 3-5 g/l; and the highest mineralization is more than 5-6 g/l which is the areas growing *Kalidium gracile*.

In the mobile sand land, in the Dzungaria Desert, the crescent sand dunes are 3-5 meters or 30-50 meters in

height. Due to the influence of wind and topography, one kind of crescent sand dunes run in parallel with each other from northeast to southwest and move toward the southeast.

Another kind of sand dunes are as high as 10-30 meters and cross each other and, under the influence of wind, move about seven meters toward the southeast every year.

The crescent sand dune chains in the Nan-chi-leng Desert are as high as 100 meters.

Those in the She-erh-k'a Desert are generally 6-8 meters in height but some reach 16 meters and also some have only a thin layer of sand with only 1-3 meters in height. Plants in mobile sand are scarce. Most often seen are *Agriophyllum gobicum*, *Corispermum hyssopifolium*, *Psammochloa villosa*, *Pugionim*, *Atraphis frutescens*, *Artemisia sphaerocephala*, *Ilex pedunculosa*, *Nitraria tangutorum*, and *Caragana microphylla*.

In the northwestern Dzungaria *Haloxylon ammodendron* is seen. The crescent sand dune chains on the edge of shifting sand land move toward the semi-stabilized crescent sand dunes and sand hills of 2-3 meters in height with *Nitraria tangutorum*. They then move further toward the stable sand dunes of 1-2 meters in height.

8. Pa-tan-chi-lin Desert and Hou-la-li-ssu Desert in western Alashan.

The climate of this region is drier than the above-mentioned regions. The annual rainfall is 50-70 mm. The average temperature for July is above 26 degrees C. Pa-tan-chi-lin Desert is also called Pa-tan-tsa-lan-ko Desert.

This great desert, like other deserts, is cut by basins. The eastern and western parts have large forests of *Haloxylon ammodendron*.

In the west, near O-chi-na River along east Gobi Ku-lung-cho-erh, are natural forests of *populus diversifolia* and *Calligonum* sp. The highest sand dune reaches 400 meters. The Hou-la-li-ssu Desert is located between the Ya-pu-lai Mountains which are 1,500 in altitude and made of ancient metamorphic rock, and the Pei-ta Mountains which are 1,600 meters in altitude.

In the basin between the mountains are the quaternary salt lakes -- Ya-pu-lai Salt Lake and (Na_2SO_4) lakes -- Chung-ch'uan-tzu. Crescent sand dune chains of 3-5 meters in height run from northeast to southwest and have great mobility.

On the shifting sand covering the salt lakes, no vegetation is found because the mineralization of underground water is as high as 387 g/l.

In the crescent sand dunes around the basin are sparse *Artemisia sphaerocephala*, *Hedysarum mongolicum*, *Calligonum* sp., and *Atraphaxis frutescens*. *Psammodochloa villosa* is found only in low lands.

9. Sand lands in eastern Ho-hsi Corridor

The east part of the Corridor means the area between Wu-wei and Chiu-ch'uan. The annual rainfall is between 100-150 mm. When the temperature is 10 degrees C and above, the humidity is always above 5.0.

The Shih-yang and Hei-ho Rivers run through this region and the water supply, both above and underground, is rich. The gravel Gobi on the southern side of mountains is 5-10 kilometers in width and the gravel is 50-100

meters in thickness. The underground water is as deep as 10-50 meters. Only the upper part of the slope is covered by soil for plant vegetation.

On the alluvial plains along the rivers in the north, the underground water is generally no more than three meters deep. On the plains are drought-resisting small shrubs like *Haloachne scougarica*, *Salsoda passerina* and mu-tzu-wan, and ordinary gray desert soil.

On the low land in river valley plains are mostly saline vegetation and carbolic saline soil and sulphite saline soil. On the sand dunes are *Phragmites communis*, *Apocenum handersoni*, and *Sophora alopecuroides*, and developing gray desert soil. There are round sand dunes with *Nitraria tangutorum* and *Tamarix ramosissima*.

Shifting sand lands are scattered and are 3-5 meters, 5-7 meters, or more than seven meters in height. These crescent shifting sands move toward the southeast. Among the sand dunes are *Artemisia ordosica*, *Nitraria tangutorum*, and *Call. mongolicum*.

In the shifting sands west of Chang-1, there are *Artemisia salsoloides*, *Call. polygonoides*, and *Alhagi pseudoalhagi*. In the Hei-ch'uan-Chen Sand Land along the city of Kao-t'ai, there are *Phragmites communis*, *Inula Salsoloides*, and *Suaeda ma ritima*.

10. Sand lands in western Ho-hsi Corridor

This is the area west of Chin-t'a and Chia-ku-kuan. It is a typical desert area. The climate is much drier than the eastern part. The rainfall is about 30-50 mm. The average temperature in July is more than 20 degrees C. The humidity during the stable period of 10 or more

degrees C is 14 or more.

Rivers running through this area are the middle and lower reaches of the Pei-ta and Hei-ho Rivers, the Su-le, and the Tang Rivers and their branches. With the exceptions of the gravel gobi in front of the Nan Mountains where the underground water is as deep as 50-60 meters and the gravel gobi of the ancient deltas (The Tang and Hei-ho Rivers) where the underground water is very deep and little or no vegetation exists, generally speaking the underground water in this area is rich.

It must be pointed out that the clastic rock gobi south of the Ma-tsung Mountains has a thick layer of gravel under the clastic rock strata and the underground water there is also deep. Vegetation is rarely seen in gobi. Only over the water grooves made by storms are sparse plants like Gnetaceae, Calligonum sp., Zygophyllum Xanthoxylum, Anabasis brevifolia, Nitraria sphaerocarpa, Halolachne soongarica and Zygophyllum fabago.

Some springs are found among clastic rock gobi, e.g., Ta-ch'uan and Hsiao Ch'uan of An-hsi.

Some wells are found in low lands but the volume of water is limited. The gobi plain is mainly gravel gypsum gray desert soil and the alluvial plains chloride saline soil.

Shifting sands are found mainly on river alluvial lands and lake sedimentation. Sand are found also on slopes of low hills and those of alluvial gobi.

West of Yu-men, under the influence of east and north-east winds, shifting sands move toward the west.

In Tun-huang, where there are east, west, and south-west winds, sand dunes move back and forth. The condition of sand in this region is very bad. Dry sand is thick,

some as thick as two meters. Vegetation lacks a living condition.

Although the underground water in low lands is high, the water is too salinized. On mobile crescent sand dune chains where the underground water is high, there are *Phragmites communis*, *Call. Zaidamse*, *Agriophyllum arenarium*, and, among dunes, *Alhagi pseudoalhagi* and *Calli. mongolica*.

On stable and semi-stable sand hills are mainly *Tamarix ramosissima*, *T. laxa*, *Nitraria tangutorum*, *Statice gmelini*, *Glycyrrhiza inflata*, *Salsola kali*, and *Phragmites communis*. *Haloxylon ammodendron* is seen west of Tun-huang.

The thickness of sand of crescent sand dunes may reach 130 meters -- e.g., the Ming-sa Mountains of Tun-huang, rarely seen in other regions. Those below 100 meters are the height of hills, not the thickness of sand.

Based on the natural characteristics of these deserts, arranged by the order of their readiness for vegetation, the deserts are Wu-lan-mao-wu-su Desert, and sand lands of Yellow River alluvial plains in Ningsia, sand lands in the east part of Ho-hsi Corridor, Wu-lan-pu-ho Desert, Ku-pu-chi Desert, Dzungaria Desert, She-erh-k'a Desert, sand lands in the west part of Ho-hsi Corridor, O-ma-lei-k'e Desert, Nan-chi-leng Desert, and Pa-tan-chi-lin Desert.

Within each desert, due to the difference in sand, difficulty in forestation and transformation also varies, and more important, the selection of sand-stabilizing seeds, stabilizing methods and utilization also vary.

To determine the types of sand, we must first examine the wind or the strata under the sand to decide the categories. Within each category, we can again divide into

types in accordance with the depth of underground water (within one meter, 1-2 meters, 2-4 meters, over four meters), nature of it (fresh or salinized water), shapes of sand dunes, and thickness of sand (within a meter, 1-3 meters --- small type; 3-5 meters -- medium type; over five meters -- large type).

Other things about the sand lands, such as the types of movement of mobile sand (attacking forward, waving forward, waving), speed, grass condition, vegetation, and the process of destroying stability.

To avoid complication in practical production, it is better not to include in sand types those factors that concern selection of grass and seed and adoption of methods.

According to the above-mentioned standards, we shall classify the deserts surveyed in the past two years. The classification here concerns only shifting sand lands.

Semi-stable sand lands are usually on the edges of sand lands.

The main thing in stable sand lands is to improve vegetation.

Forestation and desert transformation is aimed mainly at non-productive and harmful shifting sands. Therefore, the classification here stresses the shifting sand lands.

1. Shifting sand covering the sedimentation of ancient rivers and lakes.

This type of sand distributes widely in all regions.

The underground water is high, about 1-3 meters and is fresh. They are mainly large and medium-sized crescent sand dune chains.

Small crescent sand dune chains or individual crescent sand dunes are rarely seen. This type of sand is easy to grow trees and conditions for irrigation often exist.

The underground water of or or less meter in depth is salinized. It is often seen on alluvial lands near lakes or rivers in the interior of deserts. Although the underground water is salinized, sand can still be stabilized by planting *Nitraria tangutorum*, *Tamarix ramosissima*, *populus diversifolia* and *Calli. mongolica*.

2. Shifting sand covering the ancient farmlands.

Seen mainly on the borders of deserts in northern Shensi, Teng-k'ou, and Ho-hsi Corridor in Ninghsia, are farmlands buried by shifting sands moved by wind.

The underground water is about 2-4 meters in depth. The soil is good. Sand dunes are mainly medium-sized and small crescent sand dune chains or individual crescent sand dunes.

The physical condition of these lands is good. They can be stabilized entirely by plantation. It is best to select valuable plants for the purpose of sand-stabilization or to develop grape and melons.

3. Shifting sand covering the tops and slopes of loess hills.

This type is found only in northern Shensi. Aeolian crescent sand dune chains are 3-4 or 1-2 meters in thickness. The underground water is deep. But, due to the nature of loess, it is easy to plant trees for stabilizing sand.

4. Shifting sand covering the Tertiary red soil (clay, loam).

Seen in the O-ma-lei-k'e Desert among low hills in northeast Alashan, they are mainly large crescent sand dune chains, generally 5-6 meters in height, with the highest 20-25 meters.

The underground water is nine meters in depth. The mineralization is high. Shifting sands move rather fast. Conditions for sand stabilization are not as good as the above-mentioned types.

5. Shifting sands covering sheets of cretaceous, Jurassic, or tertiary periods.

Seen in the interior of Mao-wu-su, K'u-pu-chi, Dzungaria, Ho-la-li-ssu, and Nan-chi-leng Deserts, they are generally large crescent sand dune chains. The underground water is deep and plants cannot reach it.

In some low lands where the underground water is shallow, the mineralization is high. However, there is enough water in sand dunes to meet the needs of sand-

growing plants. To accelerate forestation, it is very important to carry out irrigation or artificial rainfall.

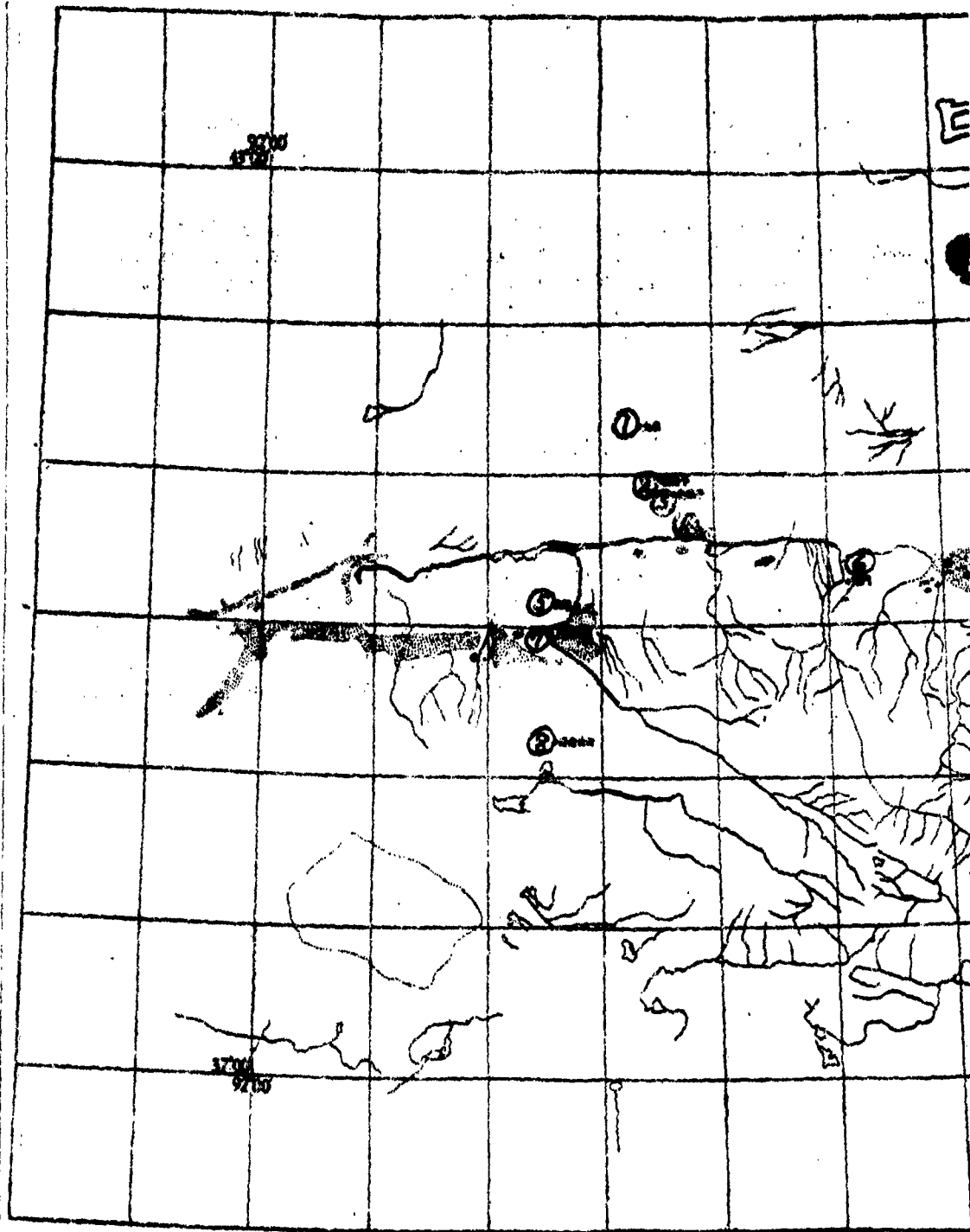
6. Shifting sands covering slopes of rocky low hills.

They are seen in Alashan and Ho-hsi Corridor. Its aeolian sand is thin. Its underground water is deep. Water disappears in slopes. Conditions for vegetation are poor. If this type of shifting sand becomes harmful, sand barriers may be constructed to stabilize sand.

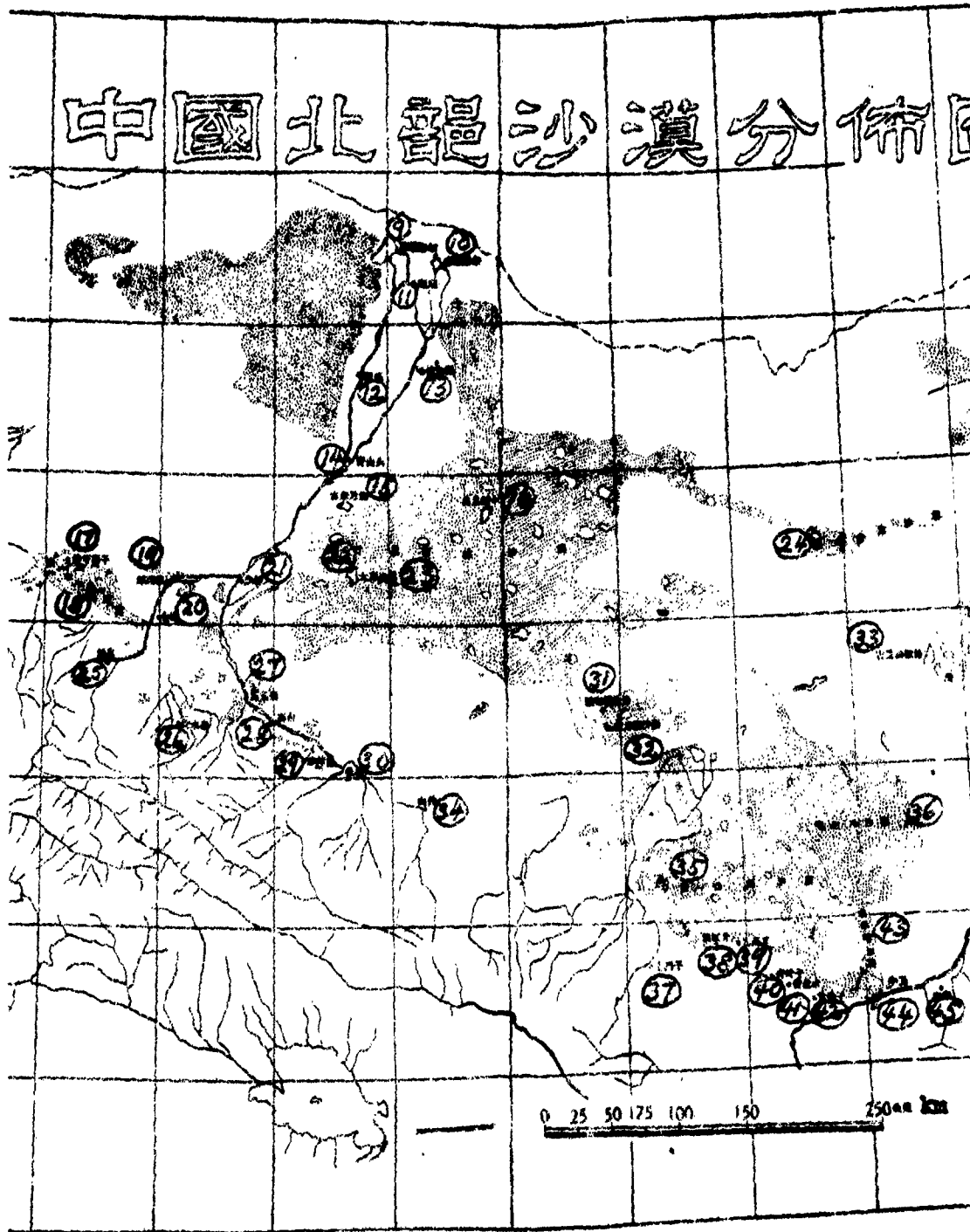
7. Shifting sands covering alluvion in front of mountains.

They are in Ho-hsi Corridor and southern borders of Dzungaria. They are generally medium-sized sand dunes and a few are large ones. The underground water is very deep and cannot be utilized. If plants are used for sand stabilizing, it must be coordinated with dam construction and irrigation.

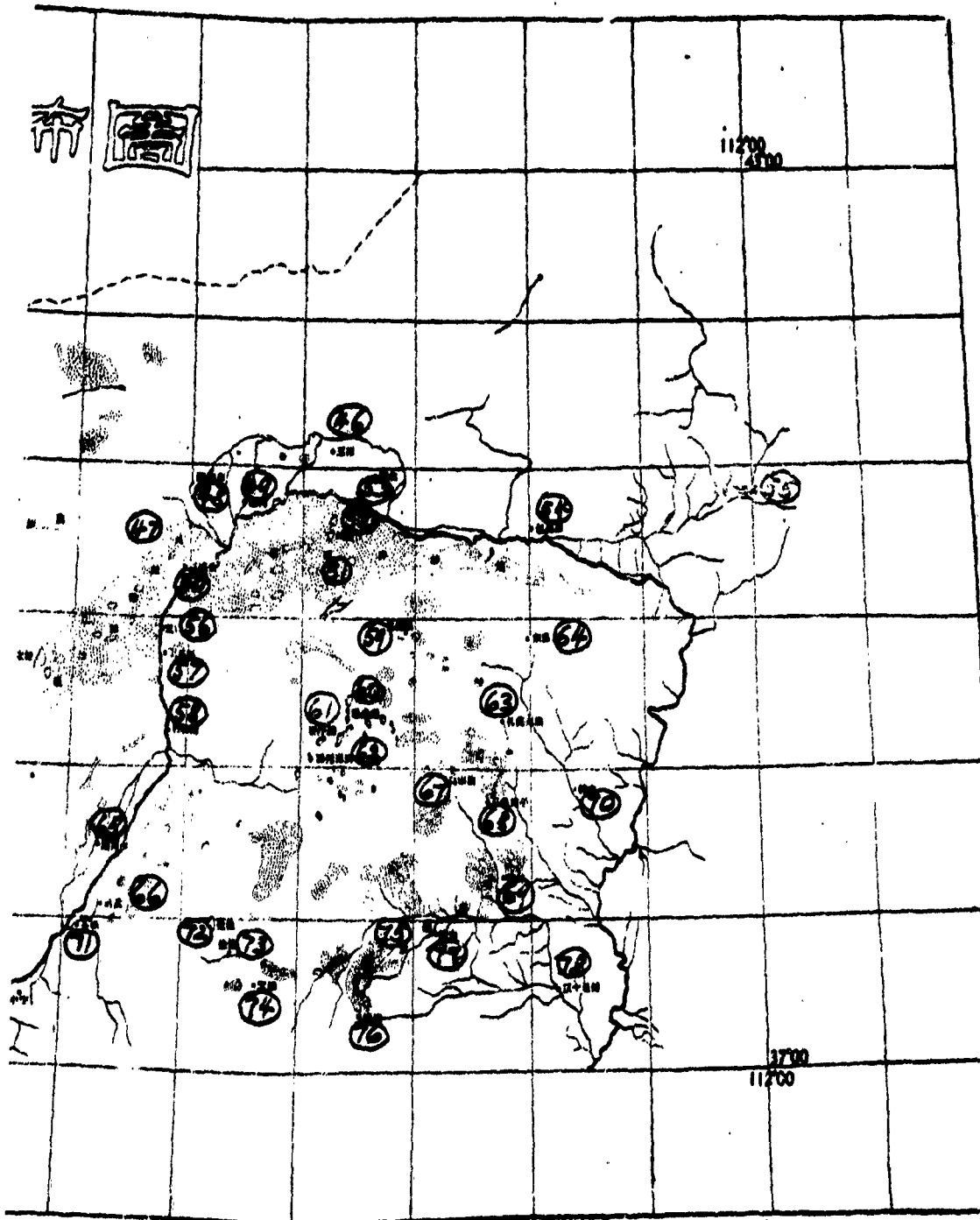
Map of Distribution of Deserts in North China



Map of Distribution of Deserts in North China (Contd)



Map of Distribution of Deserts in North China (Contd)



Map of Distribution of Deserts in North China

Legend:

1. Ta-ch'uan.
2. Tu-shan-tzu.
3. Pai-tun-tzu.
4. An-hsi.
5. Tun-huang.
6. Yu-men.
7. Ming-sa-shan.
8. Tang-ching-shan-k'ou.
9. Chia-shun Nor.
10. [Illegible]
11. Tung-miao.
12. Hsi-miao.
13. Ha-la-hu-t'u.
14. Ch'ing-shan-t'ou.
15. Ku-erh-nai-p'ou.
16. Lu-lan Nor.
17. Sa-tsao-yuan-tzu.
18. Pai-shui-ch'uan Desert.
19. Ch'iu-hai-tun.
20. Chin-t'a.
21. Ting-hsin.
22. Fa-tan-chi-lin Desert.
23. Te-k'u-shui Lake.
24. Ya-ma-lei-k'e Desert.
25. Chiu-ch'uan.
26. Ch'ing-shui-ch'uan.
27. Hsi-ch'uan-pao.
28. Kao-t'ai.
29. Sa-ho-pao.

30. Chang-i.
31. Ya-pu-lai Salt Lake.
32. Ho-la-li-szu Desert.
33. Kilantai Salt Lake.
34. Shan-tan.
35. Dsungaria Desert.
36. Nan-chi-lang Desert.
37. T'u-men-tzu.
38. T'an-chia-chin.
39. Hu-lo-chin.
40. Chin-lin-tzu.
41. Yin-pan-shui.
42. Kan-t'ang-tzu.
43. She-ern-k'a Desert.
44. Chung-wei.
45. Chung-ning.
46. Wu-yuan.
47. Wu-lan-pu-ho Desert.
48. Shan-pa-shih.
49. Lin-ho.
50. San-sheng-kung
51. K'u-pu-ch'i Desert.
52. Ch'eng-hu Lake.
53. An-pei.
54. Pao-t'ou-shih.
55. Huhohut.
56. Ting-k'ou.
57. Wang-yuan-oh'ih.
58. Shih-oh'i-shan.
59. Hang-chin Banner.
60. Pa-yen Lake.

61. Ch'a-han Lake.
62. O-t'o-k'e Banner.
63. Tsa-sa-k'e Banner.
64. Tung-sheng.
65. Ying-ch'uan-shin.
66. Ling-wu.
67. Wu-shen Banner.
68. Tao-mien-wan-tsu.
69. Yu-lin.
70. Shen-shui.
71. Chin-chi.
72. Yen-ch'ih Lake.
73. Yen-ch'ih.
74. Ting-pien.
75. Mao-wu-su Desert.
76. Chin-pien.
77. Heng-shan.
78. San-shih-li-p'u.

[Available photos are not suitable for reproduction]

Photo Captions

I Types of Sand Dunes

A. Mobile Sand Dunes

Fig. 1 Crescent Sand Dune Chains of She-erh-k'a Desert in Alashan

Fig. 2 Sand Dune Ridge of Mobile Dunes

Fig. 3 The Southeastern Part of T'eng-ko-li Desert

B. Semi-Stable Sand Dunes

Fig. 4 Semi-stable Sand Dunes with Phragmites Communis and Tamarix Juniperina

Fig. 5 Semi-stable Sand Dunes With Nitraria Tangutorum

Fig. 6 Semi-stable Sand Dunes with Phragmites Communis

C. Stable Sand Dunes

Fig. 7 Stable Sand Dunes with Nitraria Tangutorum

Fig. 8 Stable Sand Dunes with Apoceum Handersoni

II Harmfulness of Desert

Fig. 9 A Large Amount of Shifting Sand Blown Continuously into Reservoir (Yuan-yang Lake Reservoir)

Fig. 10 Cities and Villages Buried by Sand (T'ou-pao-ch'ang in An-hsi)

Fig. 11 Lakes and Salt Lakes are Continuously Buried by Sand (Ya-pu-lai Salt Lake)

Fig. 12 Roots of Trees Exposed by Weathering (Willows on Sand Lands in Yu-lin)

III Origins of Deserts

Fig. 13 Lake Sedimentation (Sa-tsao-yuan-tzu in Chin-t'a)

Fig. 14 River Alluvium (Shih-li-shao-o in Tun-huang)

Fig. 15 Weather Rock (Low Granite Hills in Chin-t'a)

Fig. 16 Gobi (Northeast of An-hsi)

THE CLIMATE AND RULE OF SAND SHIFTING IN N. SHENSI, W. INNER MONGOLIA AND HO-HSI CORRIDOR

The area under discussion in this article is located in the west of the Yellow River, south of the Mongolia People's Republic, east of the Sinkiang Uighur Autonomous Region, north of the Ah-erh-chin Mountain, the Ch'i-lien Mountain, and the Great Wall. It includes the northern frontiers of Shensi, the Ikhohao League, Ninghsia, Pa-yen-ohc-erh League, and the Ho-hsi Corridor in Kansu Province (the Ho-hsi Corridor indicates the Chang-i Special Administrative District).

The meteorological data for the area are provided by 30 meteorological stations, but the data are short in history and cannot be regarded as representing an accurate picture of the whole area. We are therefore greatly handicapped in our study of the special characteristics of the climate and the relation between the climate and the mobility of the sand.

I. Climate

This area is located in northwestern China and in the hinterland of the Eurasia continent, far away from the oceans. The nearest ocean is the Pacific, which is 1,500 km away. This area is bordered by the T'ai-hang Mountain in the east, the Ma-chung Mountain in the west, the Ah-erh-

chin, the Ch'i-lien, and the Lu-p'an mountains in the south. In the north is a vast open plain, but in the northeast stands the Yin-shan. Lying in the area are the Ho-lan, the Ho-li, and the Lung-shou Mountains. Their altitudes range from 2,000 to 6,000 m, but they have a great effect on the atmospheric circulation, preventing the moisture from moving into the area.

Because of its geographic location, there is a great difference between the length of the day and that of the night, and the yearly temperature range is wide. Since the atmospheric circulation over this area is controlled by the west wind all year round, strong northwest wind is predominant in this area. As to the surface winds, from the north comes the cold, arid air from Siberia; from the south comes the arid and warm air from the Chinghai-Tibetan Plateau; from the east comes the southeasterly monsoon wind. The first two play an important role in both cold and warm seasons, while the monsoon wind has a noticeable effect only in mid-summer.

The geographic location and the atmospheric circulation as described above are the main causes that account for the arid continental climate in this region. Under such a dry climate, large areas of deserts are formed, and the deserts, in turn, intensify the aridity.

The aridity is shown by the scarcity of rainfall and its over-concentration in a short time, and the vast amount of evaporation, which far exceeds the precipitation. The rainfall decreases drastically from 400 mm a year in the southeast to less than 50 mm a year in the northwest (Fig. 1). Practically all the rainfall in the year occurs in

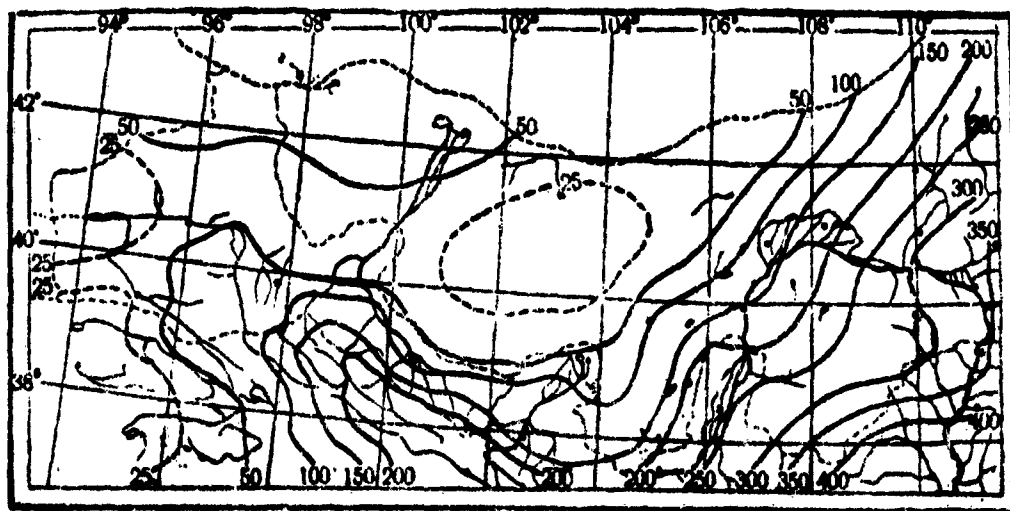


Fig. 1 Distribution of Annual Precipitation (mm)

Scale: 1 : 1,200,000

summer, particularly on a number of rainy days in July and August (Table 1). The annual rainfall varies greatly from year to year. It is not uncommon that the amount of rainfall in one year is two or three times as much as that in another. During the period when the daily temperature is steadily above 10° C, the possible evaporation is

between 400 mm and 550 mm, far more than the precipitation during the same period. The aridity increases rapidly from less than 2 in the southeast to more than 10 in the northwest. Tun-huang has the highest aridity, 25, which means that the the precipitation is less than 1/25 of possible evaporation.

The distinct continental climate is shown by the wide annual and daily temperature ranges. The annual temperature range is as much as 60° C. In 24 hours, one may live through the weather of four seasons of the year. So goes a saying: "One is dressed in cotton quilted attire in the morning, and in linen at noon, and eats water melon while holding a brazier to warm himself." This is a vivid description of this kind of continental climate (Table 2). The drier the place, the more drastic is the change in temperature.

The more drastic the temperature changes, the stronger is the wind, and strong winds give rise to drifting sand. Both strong winds and sand are the products of the local climate, and they in turn account for the worsening of the climate (Table 3).

In the desert, one sees everywhere black shining stones, which show the great intensity of sunshine. (The dark color over the stone, locally known as "desert paint,"

is a coating of molten iron and manganese over the aqueous rock.) The sunshine over the desert is particularly strong because it penetrates easily through the atmosphere in which there is practically no moisture. The total time of sunshine is more than 3,000 hours a year, and the radiation intensity is 4,000-5,000 calories/cm² a year.

High aridity, strong sunshine, drastic change in temperature, strong winds, and a large amount of sand are four climatic characteristics of this area. They are inter-related, and have a cause-and-effect relation with one another. Such a relation is further complicated by the different topography at different places, only making the climatic conditions unfavorable to mankind. The worsening of the natural environments is further compounded by human economic activities under feudalism and capitalism. Only under socialism can man turn the direction of future developments.

The climatic features of this area in four seasons can be briefly described as follows:

In winter this area is under the control of the high atmospheric pressure of Siberia, and the climate is cold, dry, and stable. But when the high pressure moved down from Siberia, this area is invaded by fresh, cold waves. Therefore, the weather in winter is characterized by low temperature, high aridity, intermittent wind storms, and little

snow.

In spring the temperature rises suddenly as the high pressure withdraws to the north (although it returns from time to time). However, there is little snow in the winter despite the frequent movements of the north and south dry air currents. The climate in this season is characterized by high aridity, sudden changes of temperature, frequent wind storms, and the most active movements of drifting sand.

In summer the dry, hot air moves down from the Ching-hai-Tibetan Plateau and mixes with the torrid air in this area. The air current is extremely unstable during this season because of the effect of the heat. Meanwhile, the southeasterly monsoon also plays a part, bringing in plenty of moisture. As a consequence, the climate in the summer is characterized by sudden storms and torrential rains.

In autumn the earth surface cools down quickly, the air current is gradually stabilized, and the precipitation reduces suddenly, but the earth surface still retains some moisture. The clear sky and cool air in autumn give the travelers a very favorable impression, but this beautiful weather is short-lived, as the cold waves suddenly descend from the north.

II. Favorable and Unfavorable Climatic Conditions

The rich resources of solar heat and the serious shortage of rainfall constitute the basic characteristics of this area, as far as the utilization of "climatic resources" is concerned.

1. Sunshine and heat (Table 4)

Sunshine and heat are the two basic requirements for the growth of plants.

The total time of sunshine in this area is 3,000 hours a year, a rare phenomenon in the country. Even in winter when the days are the shortest, the sunshine lasts seven hours. In summer it lasts more than nine hours. The lengthy duration of sunshine accelerates the growth of vegetation (but unfortunately the strong sunshine during the drought is unfavorable to the plants). Not only so, the rich solar energy is a great potential that can be utilized as a fuel or to generate motive power for the local inhabitants.

The solar energy increases from the southeast toward the northwest in this area. In the eastern part, the period during which the temperature is steadily at or above 10°C lasts only 130 days, and the cumulative temperature is less than $2,500^{\circ} \text{C}$. But in the northwest, the

period during which the temperature is steadily at or above 10° C lasts 160 days, and the cumulative temperature exceeds $3,500^{\circ}$ C.

In general, the heat energy is sufficient for any purpose, especially in the west. If there is a sufficient water supply, not only all crops of the temperate zone can be planted, but also all the sub-tropical crops, such as cotton and paddy rice, can be planted in large areas.

2. Moisture condition (Table 2)

Although all the plants in this area has a high resistance against drought, the whole area looks gray and barren when there is a shortage of precipitation. Only after a rainfall does the vegetation turn green again.

In contrast to the distribution of solar energy, the precipitation is getting less and less from the southeast to the northwest. Although most of the rainfall occurs during the growth period of plants (when the daily temperature is stabilized at or above 5° C), the rainfall is insufficient as far as the whole area is concerned. The vast amount of evaporation makes the scarcity of rainfall even worse. All the existing farms in the area depend heavily on irrigation, and centers of population are found only along rivers and near the lakes. Because of the scarcity of rainfall, the abundant sunshine and heat

are harmful to the plants. However, the area also gets its water supply from the melting snow of the Ch'i-lien Mountain, the Yellow River, and underground. As products of the climate, the Yellow River water and underground water fluctuate with the season.

As a consequence, the building of water reservoirs, the digging of water wells and ditches, and, as a last resort, artificial rain-making are not only of key importance to the development of agriculture and animal husbandry, but also effective measures for transforming deserts into good farms.

3. Over-winter Condition for Animals

The long and cold winter presents a serious over-winter problem for the animals, but the bright sunshine alleviates the hardship. On sunny days when the wind is not so strong, the animals can go out to find their own fodders. The scarcity of snow makes it possible for the herdsmen to continue to use their pasture in the winter.

The winter in this area is not as long or as severe as that in Inner Mongolia. The period during which the temperature continues to stay below -5°C lasts only half a month, about 10-30 days shorter than that in Inner Mongolia. The lowest temperature is around -30°C , which is $10-20^{\circ}\text{C}$ higher than that in the east. This situation greatly shortens the time to keep the livestock indoors,

thus reducing the over-winter expenses.

The favorable over-winter condition also helps the over-winter crops, fruit trees, and greenhouse plants.

4. Wind Power (Table 3)

Wind constitutes a cheap source of power. It needs no fuel, nor transportation.

According to the experience of the Soviet Union, a wind driven generator (VU-D-10 type) with a wind wheel 10 m in diameter can produce 5,500 hp/hr of energy, or 4,000 kw/hr of electricity in places where the average annual wind velocity is 3 m/sec. In places where the annual average wind velocity is 4 m/sec, such a generator can produce 12,000 hp/hr, or 8,800 kw of electricity per hour.

A preliminary survey shows that in most places of this area, the average annual wind velocity is close to or over 3 m/sec. In spring, it is definitely over 3 m/sec, or 4 m/sec in many places. This shows that the great wind potential in this area has not yet been utilized.

Since the area is sparsely populated and has a manpower shortage, the building of wind-driven electric generators can open a new avenue for electric power supply and the development of ground water.

5. Unfavorable Climatic Conditions

Up to now, wind is still one of the most unfavorable

climatic elements of this area. It causes the drifting sand to bury pastures, villages, irrigation canals, roads, and farms, and to engulf 12 percent of the land surface in the Ho-hsi Corridor, and 85 percent of the land surface in the Alashan Banner. In May and June, the "torrid wind" (or "hot east wind") often plays havoc to the farms and pastures. The saying, "the west wind beats the seedlings to death, and the east wind dries the seedlings to death," fully describes the damage done by the wind.

The extremely hot and cold weathers also cause great damages. A local saying has it, "a cold wave on the 8th of the 4th moon can freeze a crow to death." Of course, such cold waves cause different degrees of damages to the seedlings of crops every year. In some places, the frost-free period is shorter than the period during which the daily temperature is at or above 10°C. In summer, the temperature on the ground often exceeds 50°C, while the temperature of the air current is above 30°C. The high temperature often kills the plants at their "points of growth" (5 cm beneath the ground surface). It also causes the animals to lose appetite and weight, or even causes epidemic among the livestock.

The sudden torrential rain in the summer causes temporary floods, which not only inundate the villages and pastures, but also wash the vegetation away from the

ground, and leave the sand layer exposed to the air, thus providing a condition for the formation of drifting sand.

Sometimes hail is mixed with heavy rain. Although the hail falls in a small area, it seriously damages the farm crops.

III. Characteristics of Wind and the Basic Rules Governing the Drifting Sand

There are basically two wind systems in this area. In the eastern half, the predominant wind is northwesterly; in the western half, the predominant wind is northeasterly. The dividing line between the eastern and western parts lies somewhere between Alt. 90° E and Alt. 100° E. However, the wind direction in certain areas varies because of local topography. For instance, at Chiu-ch'uan, the predominant wind is southwesterly, and at Pa-yen-hao-t'e, the predominant wind is southeasterly (Fig. 2).

In the winter half of the year, northwesterly wind prevails; in the summer half of the year, easterly wind prevails. This reduces the speed of movement of sand dunes toward the southeast. The wind velocity in most places is at an annual average of 3 m/sec, but at An-hsi, which is known as the "wind reservoir," the wind velocity is at an annual average of 4 m/sec. The wind velocity is highest in spring, reaching 4-5 m/sec. There are 3-5 days

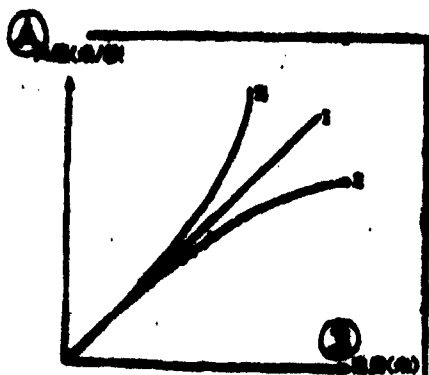


Fig. 2 Direction of Winds That Blow Up Sand
 (Wind velocity ≥ 6 m/sec)
 Scale: 1 : 1,200,000

during which the wind is strong, and 10-15 days during which sand storms take place. In other words, in every other 2-3 days, there is one sand storm, which has a great destructive effect, and is the main cause of the weathering of rocks.

The sand moves not far above the earth surface. In order to understand the relation between the wind velocity and the rule governing the movement of sand, it is important to find the relation between the wind velocity at a certain height from the ground (say 2 m) and the wind velocity measured by anemometer at a height of 8 m at the meteorological stations. The wind stability at different distances

from the ground is shown in Fig. 3.



**Fig. 3 Variation of Wind Velocity
at Different Distances From
the Ground**

Legend

- A. Wind velocity (m/sec)
- B. Distance from Ground (m)
- I. Neutral atmosphere
- II. Unstable atmosphere
- III. Stable atmosphere

According to a one-month (from 16 July to 15 August 1958) gradient observation at Pao-t'ou, we found that the wind velocity at 8 m from the ground is equal to 1.33 times that at 2 m. This is very close to our theoretical prediction, which is 1.26 times.

The movement of sand particles under the force of

wind can be divided into three types (Fig. 4). The first type of movement is rolling. The sand particles which make this kind of movement are large in size, and cannot be blown up by the wind because of its weight. They can only roll along the ground surface. The sand particles which make this kind of movement are smaller in size. When the wind reaches a certain velocity, they are blown up into the air, and then drop down. The path traveled by each of such sand particles is similar to the path of a ballistic projectile. The third type of movement is made by small sand particles, which suspend in the air at different altitudes, and travel a considerably long distance with the air current. It should be pointed out that such small sand particles are not dust or loess particles.

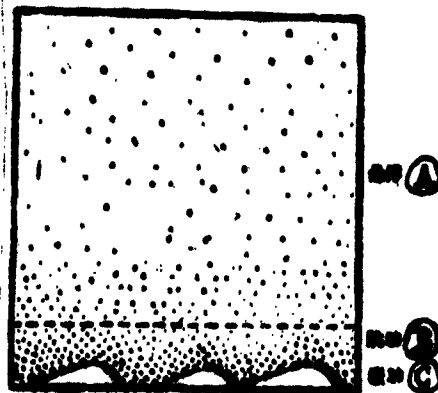


Fig. 4 Movements of Sand Under Force of Wind

Legend

A. Suspending

B. Leaping

C. Rolling

According to our observation, when the average wind velocity measured at a distance of 2 m from the ground reaches 4.5-5 m/sec, sand particles with diameters at 0.25-0.3 mm take the rolling movement. (At this time, the wind velocity measured by anemometers placed at a height of 8 m from the ground at meteorological stations should be around 6-7 m/sec.) Hence the velocity of 4.5-5 m/sec is called critical wind velocity, above which the sand particles will be blown up from the ground.

The height reached by the sand particles which take the leaping movement and the horizontal distance travelled by such particles are of great significance to sand control measures. According to our preliminary observation, the leaping sand particles do not reach a very high distance from the ground. When the wind velocity is around 10 m/sec, they fly up to a height of only a little more than 10 cm. Therefore, it is enough to build a lattice type sand screen to a height of 20 cm. The horizontal distance traveled by a leaping sand particle is about 10 cm when the wind velocity is at 8 m/sec, or several tens of cm when the wind velocity exceeds 10 m/sec. Therefore, the sand screens can be placed about 50 cm apart from each other.

After each big wind, the farms and roads are buried

ly sand. Such sands are not from the sand dunes in far away places, but are sands that take rolling and leaping movements. It is important therefore to know how many tons of sand pass through a unit width (say 1 m) in a unit time (say 1 hr) under a certain wind velocity. Since the amount of sand (Q_0) is a function of wind velocity (u), we have the following relation:

$$Q_0 = 443 \times 10^{-6} u^3 \quad (1)$$

On the basis of this relation, a chart for computing the amount of sand passing a unit width in a unit time under different wind velocities is drawn (see Fig. 5). It should be noted, however, that in plotting the curve the effect of the movement of sand on the wind velocity is not taken into consideration. Hence, the amount of sand so obtained is but an approximate value.

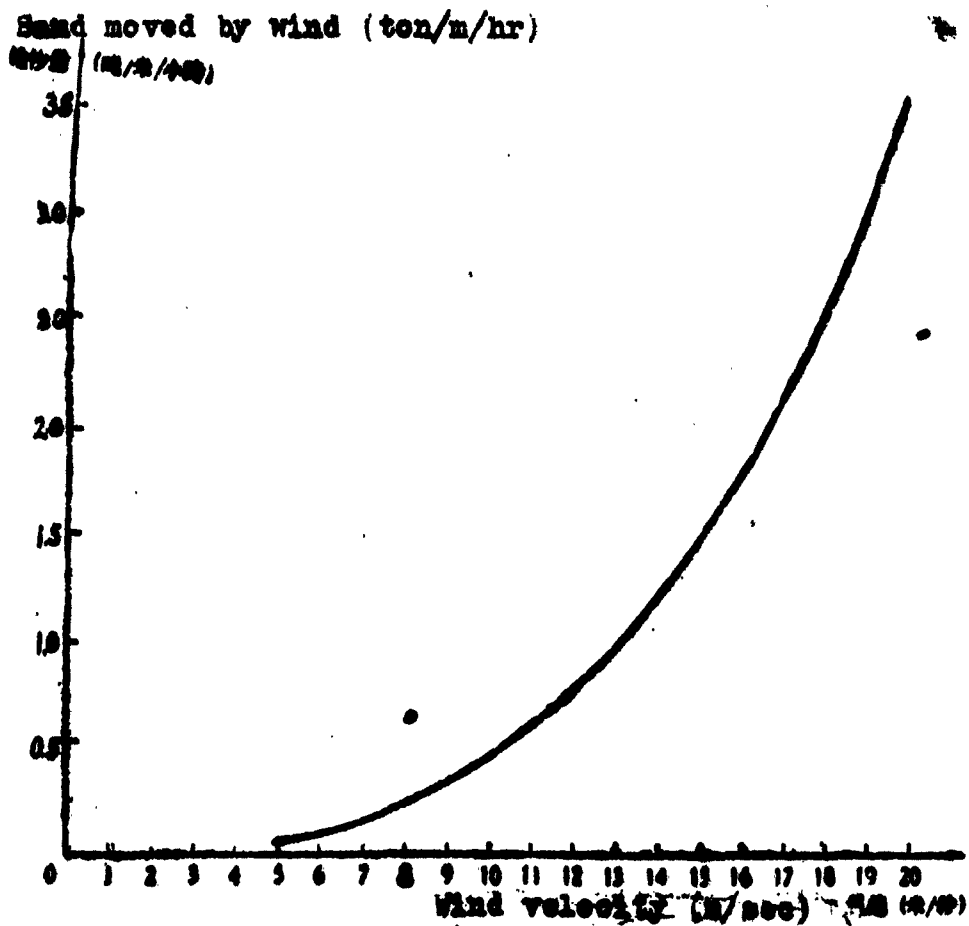


Fig. 5 Curve for Computing Amount of Sand Moved By Wind Close to Sand Layer (Including Both Rolling and Leaping Sand Particles)

(Remark: The curve is plotted without taking into consideration the effect of the movement of sand particles to the wind velocity.)

The sand dunes are formed under the action of the wind and topographical obstacles. Their movement is therefore related to the strength of the wind, the terrain,

and the shape of the sand dunes themselves. As the atmospheric current passes through a sand dune, both its direction and velocity change. Its velocity increases gradually along the windward slope of the sand dune until it reaches a maximum at the top of the slope. From the foot to one-third of the slope, the wind has a noticeable effect of blowing up the sand. After the wind sweeps over the peak of the sand dune, it suddenly slows down. Our preliminary observation at 2 m from the ground shows that the wind velocity at the mid-point of the leeward slope of the sand dune is only 30 percent of that at the peak of the dune. At the same time, the wind becomes cyclotrophic over the leeward slope as shown in the figure below.



Assume the land is flat and without obstacles, then the speed of the movement of sand dunes (C), the amount of sand moved by the wind (Q_0), the density of sand (ρ), and the height of the sand dunes (H) have the following relation:

$$C = \frac{448 \times 10^{-6} u^3}{\rho H} \quad (2)$$

On the basis of this relation, we can plot the curves for finding the speed of movement of sand dunes (Fig. 6). Given wind velocity and the height of sand dunes, we can quickly find the speed of the movement of sand dunes. If we know the duration of the average wind velocity of each wind in the year or a season, we can quickly find the distance the sand dunes move. Figure 7 shows how far and in what direction the sand dunes move in a year.

The rule governing the movement of sand dunes can be summarized as follows:

(1) The speed of the movement of sand dunes is in direct proportion to the cube of the wind velocity, and in inverse proportion to the height of the sand dunes and the density of the sand.

(2) The speed of the movement of sand dunes is in inverse proportion to the distance between the sand dune chains. The shorter the distance between the sand dunes, the slower they move; the longer the distance between the sand dunes, the faster they move.

(3) The speed and direction of the movement of sand dunes are closely related to the direction of the wind. Generally speaking, the movement of sand dunes are faster when their strike is perpendicular to the wind direction.

① 砂丘の移動速度 (m/時)

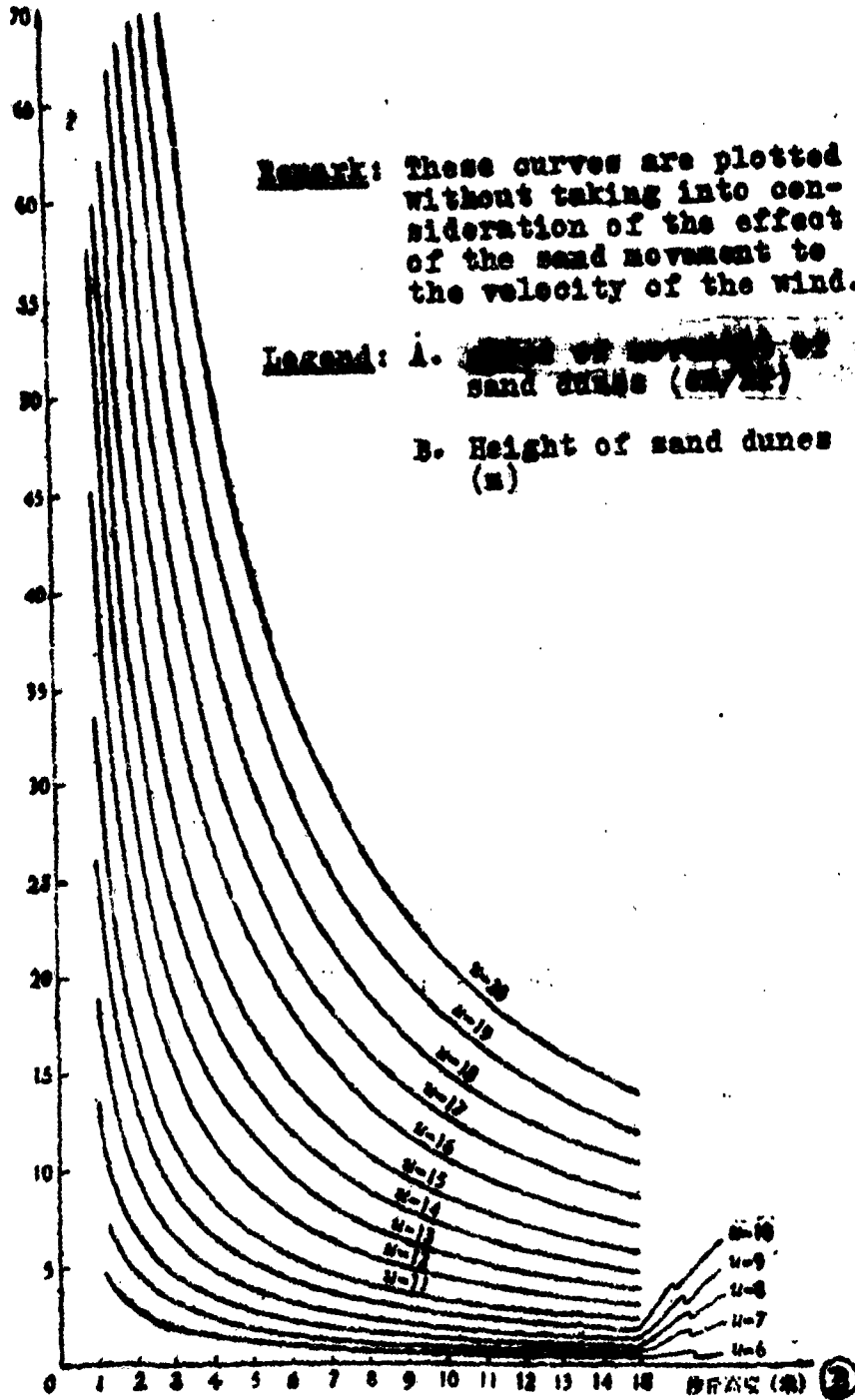


Fig. 6 Curves for Finding the Velocity of the Movement of Sand Dunes

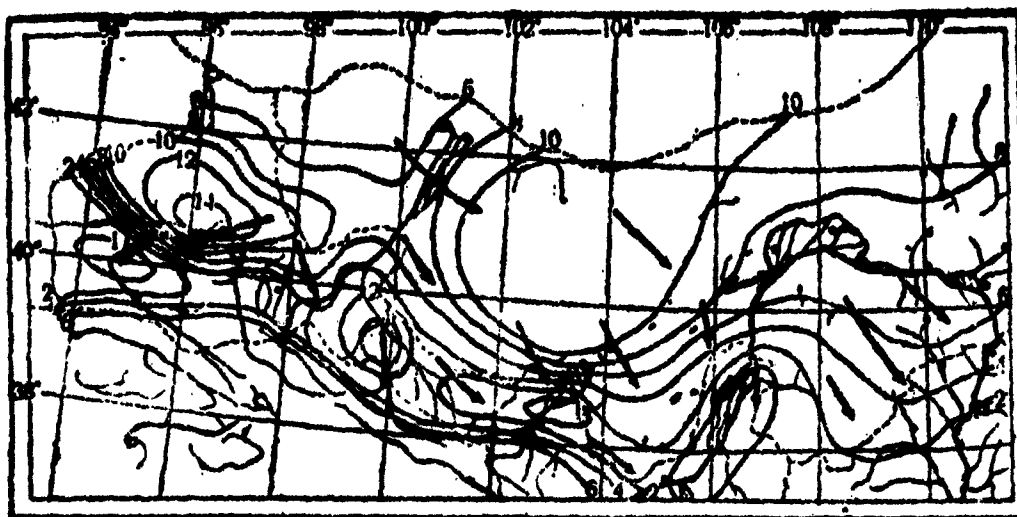


Fig. 7 The Direction and the Possible Distance of Movement (in meters) by a 7 m High sand Dune in a Year.

Scale: 1 : 1,200,000

(4) In areas where the terrain is flat, the sand dunes move faster.

According to our survey, the sand dunes move about 10-15 m a year; the fastest moving sand dunes may shift 15-30 m a year.

For the purpose of sand control, the area is divided into 12 regions according to aridity, direction and possible distance of movement of sand dunes, and the frequency of wind which can blow up the sand (Fig. 8 and Table 5).



Fig. 8 The 12 Climatic Divisions

Scale: 1 : 1,200,000

VI. Suggestions on the Utilization of Climatic Resources and the Transformation of Deserts

1. For solving the fuel problem and for reducing the destruction of natural vegetation, we should not only develop underground resources (such as coal) and make wide use of marsh gas, but also try to utilize the inexhaustible solar energy and wind power.

2. The rational development and utilization of the sources of water and the storage of water are key measures for developing farming and animal husbandry in the area. In spring, the abundant ground water should be stored for use in summer when water supply is scarce. In autumn, the flood water should be channeled to reservoirs for use next

spring, especially in mountainous areas. Before the spring begins, the farm fields should be frozen with irrigation water in order to prevent erosion and increase the moisture in the soil.

3. For finding out accurately the climatic resources for serving the farms and pastures (by, for instance, weather forecasting), a network of meteorological stations should be established, especially in the vast desert area.

4. According to a preliminary survey, it is possible to make artificial rainfall in the eastern part of this area during the summer. If artificial rainfall making is used together with seedling by airplane, then we shall achieve a great deal in stabilizing the sand and forestation.

5. The work of sand control must precede agricultural development. We must first control the sand and then utilize the sand so that agriculture can develop safely under natural conditions.

6. In the eastern part where the annual precipitation is 150 mm, we may build forests to stabilize the sand, but in places where the precipitation is less than 50 mm, we may use mechanical screens and vegetation to stabilize the sand.

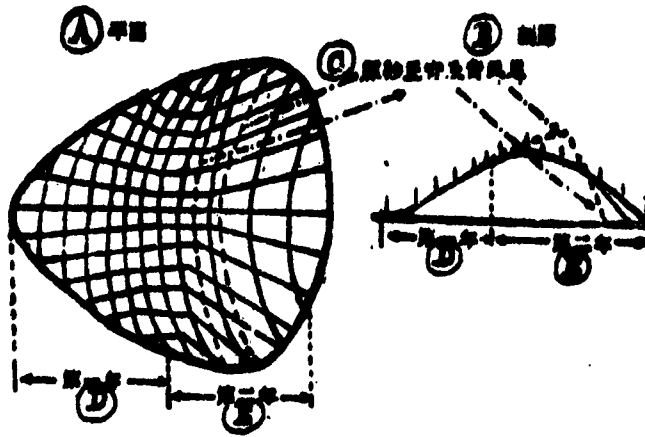
7. In forestation, consideration should be given to the direction of the movement of sand dunes. In the east

of Jo-shui, forests should be built to prevent the north-westerly wind. To the west of Jo-shui and in the Yellow River Bend area, forests should be built to prevent the northeasterly wind. In Ninghsia, forests should be built to prevent the northerly wind. In the Yellow River Bend area, forests should be built to prevent the westerly and northeasterly wind.

8. Among the sand screens, the lattice type sand screen is most efficient. But the lattice should be made in accordance with the strength of the wind and side winds. Generally speaking, tile-shaped lattice with non-uniform density is more economic and more effective than the square lattice (Fig. 9).

9. Because of the shortage of manpower in this area, it is necessary to use airplanes to seed the deserts for forestation. Seeding should be done in the summer in places where the annual rainfall exceeds 150 mm. Aerial seeding should be done on days when the wind is slow.

10. The deserts, which are seeded in the spring, should be frozen with irrigation water (if water is available) before the time of thawing in order to prevent the sand from drifting and increase the moisture in the sand, thus providing favorable conditions for the germination of the seed.



**Fig. 9 Diagrams of Tile-shaped
Lattice Sand Screen and
Mobile Sand Dune**

Legend

- | | |
|---|-------------------------|
| A. Front elevation | B. Cross-section |
| C. Original ridge and the foot of the leeward slope of the sand dune | |
| D. First year | E. Second year |

Table 1 Precipitation and Aridity Condition

| 站名 | A 各月雨量 | | B 各月最大雨量 | | C 最大雨量 | | D 干旱 | | E 干旱 | | F 干旱 | | 站名 |
|-------------|--------|----|----------|----|--------------|-----|-----------------------|-------|------|-------|-------|---------|----|
| | 雨量 | 站数 | 雨量 | 站数 | 雨量 | 站数 | 雨量 | 站数 | 雨量 | 站数 | 雨量 | 站数 | |
| ① 头 | 303.5 | 30 | 48.0 | 46 | 22/8 1953 | 79 | 1/1-2/9 1953 | 291.7 | 77 | 421.0 | 1.85 | 1951-54 | |
| ② 托克 | 219.3 | 35 | 42.7 | 46 | 10/8 1955 | 61 | 20/10-17/12 1955 | 207.5 | 68.3 | 289.4 | 1.98 | 1955-56 | |
| ③ 林 | 404.7 | 38 | 29.9 | 23 | 17/8 1954 | 119 | 10/11-19/3 1952-53 | 312.2 | 77 | 404.7 | 1.26 | 1951-54 | |
| ④ 河 | 187.5 | 35 | 47.2 | 64 | 6/9 1955 | 79 | 1/1-19/3 1953 | 189.6 | 61 | 516.0 | 3.22 | 1951-56 | |
| ⑤ 河 | 116.0 | 38 | 26.3 | 20 | 3/8 1954 | 118 | 4/9-31/12 1957 | 97.0 | 64 | 460.7 | 4.76 | 1954-57 | |
| ⑥ 河 (中河) | 161.6 | 29 | 23.0 | 48 | 6/9 1955 | 110 | 25/12-14/4 1951-55 | 119.6 | 74 | 445.5 | 3.72 | 1954-57 | |
| ⑦ 河 | 71.5 | 76 | 20.2 | 27 | 2/8 1957 | 66 | 20/10-31/12 1957 | 29.8 | 42 | 420.4 | 14.40 | 1957 | |
| ⑧ 河 | 112.0 | 45 | 27.2 | 66 | 20/8 1957 | 91 | 4/1-20/3 1955 | 66.1 | 75 | 423.6 | 5.33 | 1953-57 | |
| ⑨ 河 | 126.5 | 30 | 46.7 | 59 | 15/8 1954 | 61 | 6/3-25/5 1951 | 111.7 | 61 | 432.8 | 3.67 | 1951-57 | |
| ⑩ 河(会河) | 26.7 | 37 | 6.8 | 31 | 3/8 1955 | 126 | 18/3-31/12 1957 | 21.6 | 82 | 475.9 | 15.00 | 1955-57 | |
| ⑪ 河 | 68.0 | 25 | 25.9 | 28 | 1/8 1953 | 146 | 18/8-10/1 1954-57 | 68.9 | 76 | 445.2 | 7.13 | 1951-57 | |
| ⑫ 河 | 51.4 | 34 | 24.9 | 61 | 12/7 1957 | 112 | 12/3-1/7 1955 | 31.9 | 63 | 506.5 | 17.76 | 1951-57 | |
| ⑬ 河 | 68.0 | 39 | 21.2 | 26 | 1/8 1957 | 109 | 20/10-1/4 1955-56 | 71.5 | 66 | 546.7 | 7.31 | 1954-57 | |

Legend for Table 1

- | | |
|--|--|
| A. Total annual amount | B. Month in which most of the year's rainfall occurs |
| C. Day on which the largest amount of rainfall occurs | D. The longest drought period |
| E. Period during which daily temperature $\geq 10^{\circ}$ C | F. Year in which data were taken |
| G. Total amount | H. Percentage as compared with annual precipitation |
| I. Month of occurrence | J. Amount of the day |
| K. Total rainfall of the month | L. Percentage as compared with the rainfall of the month |
| M. Date of occurrence | N. Number of days |
| O. Starting and ending dates | P. Total amount |
| Q. Percentage as compared with annual amount | R. Possible amount of evaporation |
| S. Aridity | |
| a. Pao-t'ou | k. Otok |
| c. Yu-lin | d. Yin-ch'uan |
| e. Teng-k'ou | f. Ch'a-fang-miao (Chung-wei) |
| g. Ya-pu-lai | h. Min-ch'in |
| i. Chang-i | j. Chin-hua (Chin-t'a) |
| k. Chiu-ch'uen | l. An-hsi |
| m. Lao-hsi-miao | |

Table 2 Temperature Condition

| 站名 | A 平均气温 | | | | | | | | | | | | B 最低气温 | | | | 配发年代 | | | | | | | | |
|------------|---------|------|------|-----|-------|--------|--------|------|--------------|-------|---------------|---------|--------|----|----|----|------|----|----|----|----|----|----|-----|-----|
| | 1月 | 2月 | 3月 | 4月 | 5月 | 6月 | 7月 | 8月 | 9月 | 10月 | 11月 | 12月 | 全年 | 1月 | 2月 | 3月 | | 4月 | 5月 | 6月 | 7月 | 8月 | 9月 | 10月 | 11月 |
| (a) 包头 | -13.0 | 7.7 | 23.1 | 7.0 | (6.0) | 14.6 | (20.1) | 30.4 | 8/7 1953 | -20.0 | 6/1 1955 | 1953-55 | | | | | | | | | | | | | |
| (b) 鄂托克 | -14.5 | 6.1 | 22.0 | 5.1 | 6.3 | (15.9) | 27.1 | 35.0 | 2/7 1955 | -29.4 | 10/1 1953 | 1955 | | | | | | | | | | | | | |
| (c) 林林 | -10.3 | 9.9 | 23.8 | 9.0 | 6.7 | 13.3 | 31.1 | 38.6 | 9/7 1953 | -22.7 | 22/12 1954 | 1953-56 | | | | | | | | | | | | | |
| (d) 乌拉 | (-10.8) | 10.0 | 23.1 | 6.8 | 8.6 | (13.3) | (24.3) | 39.3 | 8/7 1953 | -20.6 | 4/1 1955 | 1953-55 | | | | | | | | | | | | | |
| (e) 鄂口 | -11.0 | 9.7 | 22.9 | 6.5 | 7.1 | 18.1 | 34.6 | 36.4 | 22/7 1955 | -22.4 | 25/12 1954 | 1954-57 | | | | | | | | | | | | | |
| (f) 茶坊旗(中) | -6.6 | 12.5 | 24.0 | 9.5 | 9.5 | 11.6 | 22.8 | 37.0 | 16/7 1955 | -27.5 | 22/12 1954 | 1954-57 | | | | | | | | | | | | | |
| (g) 准格尔 | -11.1 | 11.3 | 22.0 | 7.1 | 9.3 | - | 37.1 | 39.3 | 4/7 1957 | -24.6 | 5/2 1957 | 1957 | | | | | | | | | | | | | |
| (h) 达拉 | -9.8 | 9.5 | 23.9 | 7.4 | 7.9 | (14.8) | 33.7 | 39.5 | 10/6 1957 | -27.3 | 22/12 1954 | 1953-57 | | | | | | | | | | | | | |
| (i) 鄂托 | -10.5 | 8.9 | 21.6 | 6.7 | 6.9 | 15.8 | 22.1 | 37.4 | 21/7 1955 | -27.4 | 7/1 1955 | 1951-57 | | | | | | | | | | | | | |
| (j) 准化(金) | -11.2 | 10.3 | 21.5 | 7.3 | 7.9 | 14.7 | 35.7 | 37.6 | 31/7 1955 | -27.0 | 9/1 1955 | 1955-57 | | | | | | | | | | | | | |
| (k) 达拉 | -10.9 | 9.4 | 22.3 | 7.5 | 7.7 | 14.0 | 34.2 | 39.4 | 7/7 1953 | -31.5 | 15/2 1952 | 1951-57 | | | | | | | | | | | | | |
| (l) 准西 | -10.9 | 11.4 | 22.3 | 8.4 | 9.6 | 16.7 | 37.2 | 42.5 | 26/7 1952 | -29.3 | 7/1 1952 | 1951-57 | | | | | | | | | | | | | |
| (m) 准东 | -12.1 | 11.6 | 20.1 | 7.4 | 6.1 | - | 32.2 | 38.3 | 27/8 1957 | -28.6 | 7/1 1955 | 1955-57 | | | | | | | | | | | | | |

Legend for Table 2

- | | |
|----------------------------------|----------------------------------|
| A. Average temperature | B. Extreme temperatures |
| C. January | D. April |
| E. July | F. October |
| G. Yearly | H. Daily range |
| I. Yearly range | J. Maximum yearly range |
| K. Maximum | L. Date of occurrence |
| M. Minimum | N. Date of occurrence |
| O. Year in which data were taken | |
| a. Pao-t'ou | b. Otok |
| c. Yu-lin | d. Yin-ch'uan |
| e. Teng-k'ou | f. Ch'a-fang-miao (Chung-wei) |
| g. Ya-pu-lai | h. Min-ch'in |
| i. Chang-i | j. Chin-hua (Chin-t'a) |
| k. Chiu-ch'uan | l. An-hsi |
| m. Lao-hsi-miao | |

Table 3 Wind Conditions in Four Seasons

| | ② 平均风速(米/秒) | | | | | ③ 大风出现日数 | | | | | ④ 特殊风况出现次数 | | | | | | | |
|-----|-------------|-----|-----|-----|-------|----------|------|------|-----|------|------------|------|------|------|------|------|------|------|
| | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ | ⑧ | ⑨ | ⑩ | ⑪ | ⑫ | ⑬ | ⑭ | ⑮ | ⑯ | ⑰ | ⑱ |
| ① 春 | 3.6 | 3.4 | 3.8 | 3.8 | 3.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ② 夏 | 3.4 | 4.1 | 3.6 | 3.0 | 3.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ③ 秋 | 1.6 | 2.6 | 2.9 | 2.4 | 2.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ④ 冬 | (1.7) | 3.4 | 2.1 | 1.8 | (1.8) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ⑤ 春 | 4.1 | 3.9 | 3.3 | 3.2 | 3.9 | 6.1 | 11.8 | 9.0 | 3.8 | 31.0 | 30.5 | 32.5 | 32.5 | 32.5 | 32.5 | 32.5 | 32.5 | 32.5 |
| ⑥ 夏 | 3.3 | 3.4 | 3.2 | 2.7 | 2.9 | 0.0 | 4.0 | 0.0 | 0.0 | 4.0 | 34.5 | 34.5 | 34.5 | 34.5 | 34.5 | 34.5 | 34.5 | 34.5 |
| ⑦ 秋 | 3.0 | 4.1 | 3.9 | 3.2 | 3.6 | 3.0 | 16.9 | 13.0 | 0.0 | 33.0 | 34.0 | 34.0 | 34.0 | 34.0 | 34.0 | 34.0 | 34.0 | 34.0 |
| ⑧ 冬 | 3.4 | 3.6 | 3.3 | 2.4 | 2.6 | 1.0 | 13.8 | 12.0 | 8.0 | 34.6 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 |
| ⑨ 春 | 1.5 | 2.3 | 1.2 | 1.4 | 1.8 | 1.0 | 4.4 | 2.8 | 0.2 | 2.6 | 19.5 | 19.5 | 19.5 | 19.5 | 19.5 | 19.5 | 19.5 | 19.5 |
| ⑩ 夏 | 3.8 | 4.0 | 2.6 | 2.5 | 3.3 | 5.0 | 11.7 | 5.6 | 2.7 | 25.6 | 72.9 | 72.9 | 72.9 | 72.9 | 72.9 | 72.9 | 72.9 | 72.9 |
| ⑪ 秋 | 2.8 | 3.4 | 2.7 | 2.4 | 2.8 | 6.6 | 14.1 | 10.8 | 5.3 | 36.9 | 45.5 | 45.5 | 45.5 | 45.5 | 45.5 | 45.5 | 45.5 | 45.5 |
| ⑫ 冬 | 3.3 | 4.1 | 2.9 | 2.2 | 3.7 | 5.8 | 12.5 | 5.6 | 6.6 | 79.6 | 85.6 | 85.6 | 85.6 | 85.6 | 85.6 | 85.6 | 85.6 | 85.6 |
| ⑬ 春 | 3.1 | 4.5 | 3.9 | 3.2 | 3.6 | 11.0 | 40.0 | 23.5 | 3.0 | 97.8 | 34.5 | 34.5 | 34.5 | 34.5 | 34.5 | 34.5 | 34.5 | 34.5 |

Legend for Table 3

- A. Average wind velocity (m/sec)
- B. Number of days during which typhoon occurs
- C. Number of occurrences of wind that blows up sand
- D. Winter E. Spring F. Summer
- G. Autumn H. Whole Year I. Winter
- J. Spring K. Summer L. Autumn
- M. Whole year N. Winter O. Spring
- P. Summer Q. Autumn R. Whole year
-
- a. Fao-t'ou b. Otok c. Yu-lin
- d. Yin-ch'uan e. Teng-k'ou f. Ch'a-fang-miao
(Chung-wei)
- g. Ya-pu-lai h. Min-ch'in i. Chang-i
- j. Chia-hua k. Ch'iu-ch'uan l. An-hsi
- m. Lao-hsi-miao
-
- * Winds that can blow sand particles up are Grade 4 winds, or winds with velocities ≥ 6 m/sec. At Fao-t'ou, Otok, Yu-lin, and Yin-ch'uan, the number of occurrences of such winds are calculated on the basis of wind velocity.
- ** Data were taken on the basis of periodical observation.

Table 4 Light and Heat Condition

| ① 日曬時數 | ② 天 氣 期 | | ③ 日 照 > 5° 總 時 數 | | ④ 日 照 > 10° 總 時 數 | | ⑤ 記 錄 年 代 | | | | |
|----------|---------|-------|------------------|------|-------------------|-----|-----------|------|-----|--------|---------|
| | ① 季 | ② 日 | ③ 日 | ④ 日 | ⑤ 日 | ⑥ 日 | | | | | |
| ① 816.9 | 13/4 | 1/10 | 172 | 19/4 | 11/10 | 176 | 3133.8 | 22/3 | 134 | 2011.3 | 1951-55 |
| ② 200.0 | 12/5 | 25/9 | 137 | - | - | - | - | - | 124 | 2109.8 | 1955-56 |
| ③ 222.1 | 25/4 | 3/10 | 108 | 19/4 | 19/10 | 106 | 3109.1 | 2/5 | 154 | 3116.7 | 1951-56 |
| ④ 222.2 | 22/4 | 8/10 | 170 | 12/4 | 19/10 | 190 | 3517.0 | 29/4 | 159 | 3137.0 | 1951-56 |
| ⑤ 237.9 | 26/4 | 23/9 | 151 | 13/4 | 9/10 | 174 | 3242.5 | 19/5 | 142 | 2879.2 | 1954-57 |
| ⑥ 251.3 | 19/3 | 10/4 | 220 | 10/4 | 21/10 | 195 | 3009.9 | 2/5 | 131 | 2761.0 | 1954-57 |
| ⑦ 255.4 | 12/4 | 27/10 | 199 | 21/4 | 14/10 | 174 | 2915.5 | 4/5 | 119 | 2997.1 | 1957 |
| ⑧ 271.5 | 6/4 | 21/10 | 202 | 17/4 | 10/10 | 177 | 3261.3 | 4/5 | 141 | 2935.0 | 1953-57 |
| ⑨ 289.5 | 2/4 | 29/9 | 181 | 17/4 | 11/10 | 178 | 3066.4 | 7/5 | 145 | 2708.4 | 1951-57 |
| ⑩ 310.5 | 9/4 | 2/10 | 177 | 13/4 | 17/10 | 195 | 3395.7 | 6/5 | 147 | 2929.8 | 1955-57 |
| ⑪ 3124.6 | 2/4 | 17/19 | 192 | 17/4 | 12/10 | 190 | 3239.6 | 10/5 | 142 | 2915.6 | 1951-57 |
| ⑫ 324.4 | 11/4 | 21/10 | 197 | 12/4 | 17/10 | 199 | 2914.9 | 1/5 | 109 | 2510.8 | 1951-57 |
| ⑬ 3319.3 | 9/4 | 19/11 | 225 | 21/2 | 9/10 | 194 | 3793.5 | 22/4 | 162 | 3416.8 | 1956-57 |

• 1953-55

△ 1956

Legend

- | | |
|---|----------------------------------|
| A. Hours of Sunshine | B. Frost-free period |
| C. Period during which the daily temperature is steadily $\geq 5^{\circ} \text{C}$ | |
| D. Period during which the daily temperature is steadily $\geq 10^{\circ} \text{C}$ | |
| E. Year data were taken | |
| F. Winter | G. Summer |
| H. Whole year | I. Starting date |
| J. Ending date | K. Number of days |
| L. Starting date | M. Ending date |
| N. Number of days | O. Cumulative temperature |
| P. Starting date | Q. Ending date |
| R. Number of days | S. Cumulative temperature |
| a. Pao-t'ou | b. Otok |
| c. Yu-lin | d. Yin-ch'uan |
| e. Teng-k'ou | f. Ch'a-fang-miao (Chung-wei) |
| g. Ya-pu-lai | h. Min-ch'in |
| i. Chang-i | j. Chin-hua (Chin-t'a) |
| k. Chiu-ch'uan | l. An-hsi |
| m. Lao-hsi-miao | |

Table 5 Climatic Regions And Their Special Characteristics

| A | B | C | D | E | | F | G | H | I | J | K |
|----|---|---|---|---------|----------|---------|---|---|---|---|-----------|
| | | | | ① | ② | | | | | | |
| 1 | ① | ① | ① | 200-400 | 1.0-2.0 | 100-150 | ① | ① | ① | ① | 8-12 |
| 2 | ② | ② | ② | 150-300 | 2.0-4.0 | 150-250 | ② | ② | ② | ② | 10-16 |
| 3 | ③ | ③ | ③ | 150-300 | 3.0-7.0 | 50-150 | ③ | ③ | ③ | ③ | 6-12 |
| 4 | ④ | ④ | ④ | 150 以下 | 3.5-7.5 | 50-150 | ④ | ④ | ④ | ④ | 4-12 |
| 5 | ⑤ | ⑤ | ⑤ | 100-150 | 5.0-7.5 | 200 以下 | ⑤ | ⑤ | ⑤ | ⑤ | 0-16 以上 |
| 6 | ⑥ | ⑥ | ⑥ | 100-150 | 5.0 以上 | 200-250 | ⑥ | ⑥ | ⑥ | ⑥ | 0 以下 |
| 7 | ⑦ | ⑦ | ⑦ | 100-150 | 6.0-0.7 | 100 以下 | ⑦ | ⑦ | ⑦ | ⑦ | 4-8 |
| 8 | ⑧ | ⑧ | ⑧ | 50-150 | 7.0 以上 | 150-250 | ⑧ | ⑧ | ⑧ | ⑧ | 4-16 |
| 9 | ⑨ | ⑨ | ⑨ | 50-150 | 7.0 以上 | 250-400 | ⑨ | ⑨ | ⑨ | ⑨ | 16 以上 |
| 10 | ⑩ | ⑩ | ⑩ | 50 以上 | 7.0-10.0 | 250-500 | ⑩ | ⑩ | ⑩ | ⑩ | 5-16 以上 |
| 11 | ⑪ | ⑪ | ⑪ | 25-50 | 15.0 左右 | 200-300 | ⑪ | ⑪ | ⑪ | ⑪ | 6-16 |
| 12 | ⑫ | ⑫ | ⑫ | 50-50 | 15-25 以上 | 50-110 | ⑫ | ⑫ | ⑫ | ⑫ | 1.5-30 以上 |

Legend for Table 5

- | | |
|---|--------------------------|
| A. Number of District | B. Name of district |
| C. Scope | D. Whole year |
| E. Encroachment of sand dunes (7 m high) | |
| F. Precipitation | G. Aridity |
| H. Number of occurrences of wind that blows sand up | |
| I. Direction | J. Possible distance (m) |
- a. E. Ikhohao-N. Shensi
 - b. Southeastern part of Ikhohao League and the three-pien area (Ohing-pien, An-pien and Ting-pien) of N. Shensi
 - c. Western Ikhchao
 - d. Western part of Ikhohao League and the Yellow River Bend area
 - e. Ninghsia
 - f. Ninghsia Hui Autonomous Region
 - g. Eastern part of the Ho-hsi Corridor
 - h. Wu-wei--Chang-i area to the east of Ho-hsi Corridor
 - i. Wu-lan-pu-ho
 - j. Western part of Wu-lan-cho-pu League and the North-eastern part of Alashan
 - k. Dzungaria
 - l. Southeastern part of Alashan

- m. Min-ch'in
 - n. Min-ch'in Hsien of Kansu Province
 - o. Kao-t'ai--Chiu-ch'uan
 - p. Kao-t'ai and Chiu-ch'uan hsien of Kansu Province
 - q. Ma-chung district
 - r. Western part of O-chi-na Banner, and the northwestern part of the Ho-hsi Corridor
 - s. Pa-chung
 - t. Central and western Alashan and eastern O-chi-na
 - u. Chin-t'a--Yu-men
 - v. Chin-t'a and Yu-men hsien
 - w. An-hsi--Tun-huang
 - x An-hsi and Tun-huang hsien
-
- | | | |
|---------------|-----------|---------------|
| aa. Less than | bb. About | cc. More than |
| dd. SE | ee. E-SE | ff. S |
| gg. SE | hh. E-SE | ii. S-SE |
| jj. SE | kk. S-SE | ll. S-SW |
| mm. SE | nn. SE | oo. SW |
| pp. More than | | |

GEOMORPHOLOGY OF HO-HSI CORRIDOR AND EASTERN ALASHAN

The 1958 survey covered two areas; namely, Eastern Alashan (east of Ya-pu-lai Mountain, west of Ho-lan Mountain, south of Sa-erh-cha Mountain, and north of the Great Wall), and the Ho-hsi Corridor. Since the area under survey is too big, the emphasis was put on the distribution of drifting sand along the route of survey.

I. Geological Foundation of the Area

From the viewpoint of geological structure and the history of geological development, this area has three distinct tectonic elements: the Ch'i-lien-shan fold; the Alashan Pre-Sinian land mass; and the Ma-chung-shan platform. There are striking similarities between the latter two in stability, in geomorphological development, and in geological development after the Hercynian Period. These two areas are often known as the Ma-chung-shan--Alashan platform. Thus the area under survey has but two general tectonic elements. The boundary line between the two lies in the north of the Tang-chin Mountain, the Chao-pi Mountain, the Hung-liu Mountain, the Ch'ih-chin Mountain, the Hei Mountain, the Ho-li Mountain, and the Lung-shou Mountain. It extends eastward across the T'eng-ke-li Desert and the Ch'ing-yang Mountain, and terminates at the Ho-lan

Mountain.

1. The Ch'i-lien-shan Fold

Prior to the Sinian Period, the Ch'i-lien-shan fold region had thick sedimentary and magmatic rocks. During the Luliang movement, these rocks became a solid base of the Tunhuang system and the Kaolan system. During the lower middle Palaeozoic Period, geosynclinal sedimentation was formed because of the Caledonian ingression. But at the end of the Devonian Period, the Hercynian movement raised the lower middle Palaeozoic sedimentary fold to become high mountains. Thus violent folding and volcanic movements took place, changing the lower middle Palaeozoic sedimentation into the new foundation of the Ch'i-lien-shan area. The rock foundation belongs to the Nan-shan system, which includes quartzite sandy rock, sandy rock, phyllite, slate, crystalline calcareous rock, and silicon calcareous rock. Later on, very thick Lao-chun-shan gravel of the lower Carboniferous Period was accumulated on the depression in front of the ancient Ch'i-lien Mountain. (The sources cited in the Geological Report prepared by the second session of the National Petroleum Prospecting Conference sponsored by the Ministry of Petroleum Industry classified the Lao-chun-shan gravel as belonging to the Devonian Period. As a consequence, the Ch'i-lien-shan fold is regarded as a Caledonian folding zone.) By the time of the middle of the

Carboniferous Period, transgression took place in the west. Later on, the eastern part was submerged, and the ancient Ch'i-lien-shan became an isolated island. However, this time the transgression was not of the geosynclinal type. After the regression of the Permian sea water, there was no more marine facies sedimentation. Nevertheless, the Ch'i-lien-shan geosynclinal zone did not stop its activity after the Hercynian folding. During the Alpine Period, this geosynclinal zone went through block upheaval several times, and continued to rise until they became the high mountains we see today. The Nan-shan paraclase was formed during this period. At the same time, in the settled area, thick continental sedimentation was accumulated. After the Triassic Period, the continental facies stratum was as thick as 7,000 m. Even during the Quaternary Period, the neo-tectonic movement was still active.

2. Ma-chung-shan--Alashan Platform

The Ma-chung-shan--Alashan platform is situated north of the Ch'i-lien-shan geosyncline, measuring 1,000 km from east to west, and 350 km from south to north, and adjacent to the Ho-lan-shan paraplain in the east, the Ch'i-lien-shan geosyncline in the south, the Tsaidam land mass in the southwest, and the Sino-Outer Mongolia boundary in the north. The Ma-chung-shan platform and the Alashan land

mass have their similarities and dissimilarities. The bases of both continental tables are made of rocks of the pre-Sinian system (granite gneiss) formed during the Luliang movement. But during the Palaeozoic Period, the geological development and the stratigraphic cross-section of Ma-chung-shan were similar to those of the Ch'i-lien-shan geosyncline. (According to Chang Wen-tso (1728 2429 1563), the Ma-chung-shan area was an elevated land without Caledonian ingression, which did not occur until the Carboniferous Period. Thus during the middle-lower Palaeozoic Period, both the Ma-chung-shan and Alashan were eroded areas. As to the common belief that the stratum in this area is made of middle-lower Palaeozoic metamorphic rock, Chang thinks that the metamorphic rock is the result of metamorphism of different lithofacies strata of the Carboniferous Period.) Thus the Nan-shan system stratum and the Carboniferous stratum were formed, but they went through metamorphism because of the Caledonian and the Hercynian movements. However, the Alashan platform had always been an eroded upheaval without Palaeozoic sedimentation. After the Hercynian Period and during the Alpine Period, the Ma-chung-shan platform became gradually stabilized. The Alpine tectonic movement in this area essentially had a block-forming effect, as a result of which some continental ridges running in the east-west

or northeast-southwest direction were formed. The depressed lands between the ridges are accumulation areas formed during the end of the Triassic Period, or the Jurassic Period. The overlying stratum is about 500-2,500 m thick in some places, and the sediments are essentially Mesozoic and Cainozoic sunken basin sediments. After centuries of weathering, the ancient crystalline continental ridges have become low mountains, such as the Pa-yin-no-lo-kung Mountain, the Sa-erh-oha Mountain, the Tsung-nai Mountain, and the San-wei Mountain. The Na-chung-shan has now become a fragmentary paraplain except for some high peaks.

II. Surface Features and Major Geomorphological Types

The general altitude of the area is at 1,000 m above the sea level except in the eastern and southern borders where the Ch'i-lien and Ho-lan mountains rise to 3,000-6,000 m. The relative altitude of the mountains is less than 200 m, except that some of the peaks of the Ho-li Mountain have a relative altitude of more than 500 m. The Na-chung-shan on the northern perimeter of the western sector of the Ho-hsi Corridor is a denuded relic mountain with paraplain features. However, the surface structures

of the individual areas in this vast region are not entirely the same since they went through different developments. The whole region may be divided into three different topographical areas; namely, the Ho-hsi Corridor plain, the Alashan plateau, and the northern relic mountain. Geologically, the eastern part of the Ho-hsi Corridor is a kar in front of the mountains. Topographically, it is a narrow strip high in the south and the north and low in the middle, where the waters from the Ch'i-lien Mountain converge. The center of the Corridor is the lowest place where an alluvial plain is found. Here drifting sand is found only in scattered places. A noticeable feature of the Alashan area is the lack of permanent rivers, and the under-development of the Quaternary sediments. Topographically, the sandy gravel plains are separated by low mountains; or we may say that sandy gravel basins are found between the low basins, and some of the basins (such as the T'eng-ko-li basin) are entirely covered by drifting sand. As to the northern relic mountain, it is located in the western part of the region, but it has a tendency to become a paraplain with a low relative altitude. Among the mountain is the gobi. It can be said that this area is entirely a petrified desert.

The area under survey has the following major geomorphological types:

1. High and medium mountains formed by folding and rift upheaval. The Ch'i-lien and Ho-lan mountains belong to this type. The Ch'i-lien Mountain was formed essentially by metamorphic and intrusive rocks. It measures 1,200 km long from the northwest to the southeast, and its altitude is 3,000 m above sea level, with the highest peak (south of Chiu-ch'uan) at 6,000 m. Many mountain peaks are snow-capped all year round, and all the rivers in the Ho-hsi Corridor are originated from here.

2. Low and medium mountains at the northern perimeter of the Ch'i-lien geosyncline. These mountains were formed by the metamorphic rock of the Nan-shan system. Their altitude is about 2,000 m above sea level, with the highest peaks reaching 3,000 m, and relative altitude ranging from 100 to 500 m. The Ho-li and Lung-shou mountains are of this type.

3. Fragmentary eroded low and medium mountains (such as the Ma-chung Mountain). Because of the dry weather, eluvial pebble is found everywhere, and even the mountain peaks are fully covered by weathered pebble. The highest peak stands at 2,700 m above sea level, with relative altitude at 200 m. Because of ages of weathering, most of the mountains now have the characteristics of paraplains.

4. Dry eroded low mountains. Similar to the mountains of the foregoing type, these mountains are distributed in single strips. Formed by the Cambrian metamorphic rocks, these mountains are 1,600 m above sea level, with relative altitude at less than 200 m. This type of mountains include the hills in the Alashan area and in the western part of the Ho-hsi Corridor.

5. Eroded monadnocks. Consisting of rock formations of different ages, such fragmentary or isolated monadnocks include the Chang-kan Mountain, the A-la-ku Mountain, the Su-wu Mountain in the vicinity of Min-ch'in, the Shuang-hei Mountain, and the Tung-hu Mountain in the T'eng-ko-li desert, but they occupy only a small area in the region.

6. Inclining plains in front of the mountains. Located on the piedmonts of the Nan Mountain, these plains were made of diluvial sediments. Gravel and pebble are widely found on the plains. The inclining plains in the eastern sector of the Nan Mountain are different from those in the western sector. On the inclining plains to the east of Chiu-ch'uan, the water from the Ch'i-lien Mountain cuts through the old diluvial deposits and dry deltas. On the inclining plains to the east of Chang-i, there is a layer of loess (1-3 m thick), which can be used for farming. But in the western part of the Ho-hsi Corridor, the

inclining plains are bare gobi deserts.

7. Alluvial and lacustrine plains. Such plains are found in the Ho-hsi Corridor. Since the water flowing down from the Nan Mountain is controlled by the mountains on both sides of the Ho-hsi Corridor which runs in the NW-SE direction, the alluvial and lacustrine plains extend in the center of the Corridor. The Shih-yang River extends far north because there is no obstruction in that direction. At its lower reaches, fertile alluvial plains are formed. To the west of Chiu-ch'uan and in the vicinity of Chia-ku-kuan, the Hei River and the Pei-ta River flow through the low mountains in the north of Chiu-ch'uan toward the O-chi-na Banner, and finally empty into the Chu-yen Sea. According to the drainage system and topography, the Ho-hsi alluvial lacustrine plain is made of the following accumulation basins: the Shih-yang river plain to the east of Yung-chang; the Hei River-Pei-ta River plain (not including the lower reaches of the two rivers) between the Ta-huang Mountain and Chia-ku-kuan; the Shu-le River-Tang River plain to the west of Chia-ku-kuan; and the Chin-t'a--Hua-hai-tzu plain (the western part of the Hua-hai-tzu basin is a lacustrine plain). These plains have a high productivity.

8. Intermontane sandy gravel basins. These basins are found in the northern part of Alashan. They are

generally covered by a few meters of sandy gravel, under which is the Cretaceous-Tertiary red bed. Outcrops of the red bed often appears on piedmonts, or even stand out like small hills.

9. The T'ang-ko-li basin where drifting sand areas are intermingled with lakes. This vast basin is surrounded by mountains. With the exception of lakes, the basin is almost entirely covered by drifting sand. There are about 100 lakes, each of which measures 10-30 km long and 2-4 km wide. In the lakes, *Artemisia*, *Achnatherum splendens* Ohwi, *Kalidium gracile* Fensl, and *Phragmites communis* Trin. grow. The lakes are oval in shape, and extend in the north-south direction. The orientation may be related to the direction of rivers in ancient times. The landform under the drifting sand may be divided into two types. In the west, the landform is of ridge-shaped hill type, and the base is made of soft sandy rock. The eastern part is a lacustrine plain covered by drifting sand.

Since the precipitation is less than 150 mm a year in most places, and less than 100 mm in the west, the following features are noted:

(1) As the climate is very dry, wind plays an important role in the formation of terrain, and the absence of vegetation makes the weathering more severe.

(2) The change in temperature is drastic (the daily

range is generally 15° C, the annual range is 32° - 38° C, and the maximum annual range is 65° C). The strong sunshine and the scarcity of rainfall make the growth of vegetation difficult.

(3) With the exception of the mountainous land along the southeastern perimeter and the Ho-hsi Corridor, the streams and surface flows on the vast Alashan high plain are of a temporary nature, and cannot carry the weathered pebbles away. The remaining pebble shows a dark color under strong sunlight because of its iron and manganese contents.

In the area under survey, aeolian denudation, drifting sand, and gobi are seen everywhere. The drifting sand will be discussed in another section. The following is a brief introduction of the gobi.

The gobis are found in front of the mountains to the west of Chiu-ch'uan and Chu-yen Sea, on the intermontane lands, and on the piedmonts of the Ma-chung Mountain. They consist of gravel and pebble. The pseudo-gobi to the east of Chiu-ch'uan, and the gravel basin of the Alashan Banner should not be called gobi. Vegetation is very few in the gobi; only occasionally we see such shrubs as *Ephedra przewalskii* Stapf., *Reaumuria soongorica* (Pall.) Maxim, *Calligonum mongolicum* Turcz., *Nitraria schoberi*, and *Asterothamnus centrali-asiaticus* Novopokr.

Such plants grow in ditches which are formed after storms. Each ditch measures a few meters wide, but some ditches in the northwest of An-hsi are 20 m wide. Not deep beneath the surface is the gypsum layer. The gobis in the Ho-hsi Corridor can be divided into three groups:

(1) Gobis formed by ancient Ch'i-lien Mountain diluvial gravel [Such gobis are found on top of the clastic deposits. (Since a great variety of plants grow in the diluvial area with the presence of many streams, such "gobis" cannot be properly called gobis. Nevertheless, they consist mainly of clastics.)]

(2) Gobis formed by river deltas (17 km west of Tun-huang).

(3) Gobis covered by contemporary diluvial-proluvial clastics (on the southern slope of the Ma-chung Mountain).

III. Sand Land

The following interesting phenomena are noted in the distribution of drifting sand: (1) It is found in low-lying places. (2) There is more drifting sand in the east than in the west. This has something to do with the presence of alluvial deposits, but human factors should not be overlooked. (3) Individual mobile sand dunes are founded in oases.

Drifting sand is found in the following areas: (1) The

T'eng-ko-li basin; (2) the southern shore of the Ya-pu-lai salt lake; (3) the Ya-ma-li-ko desert; (4) the alluvial plain at the lower reaches of the Shih-yang River near Min-ch'in; (5) the Chin-t'a area; (6) the alluvial plain formed by the Hei River between Chang-i and Chiu-ch'uan; and (7) the Tun-huang area. The T'eng-ko-li is the largest drifting sand area.

The origin of drifting sand:

Sand originates from weathered rocks. The Oh'i-lien Mountain, the Pei Mountain, and many low hills are the sources of sand in this region. The weathered rocks are accumulated when they are carried by wind or water. The drifting sand in Ho-hsi and Alashan is originated from river and lacustrine deposits, while that in other places is originated from diluvial sediments. Now let us discuss the formation of drifting sand in different areas.

1. The T'eng-ko-li Desert. T'eng-ko-li itself is a basin, low in the middle and high in the surrounding areas. Hence the weathered rock is washed down into the basin by the surface flows. Most of the drifting sand here comes from lacustrine deposits, but in the east the drifting sand in the ridge-shaped hilly area made of red sandy rock may be a local accumulation of the weathered red base rock, while the drifting sand in the southern Hsi-lo-ching area is originated from the sandy diluvial deposits on the

Ch'ang-ling Mountain.

2. Shores of the Ya-pu-lai salt lake. The drifting sand accumulated on the southern shore of the Ya-pu-lai salt lake consists of the lacustrine sand blown up by the northwesterly wind. But in the west, there is a gap connected with the Pa-tan-chi-lin desert. Thus the sand particles are carried by the northwesterly wind through the gap to the south shore of the Ya-pu-lai salt lake.

3. The Ya-ma-lieh-k'o desert. This desert is on the northeastern piedmont of the Pa-yin-no-lo ridge. This is the spot at which the northwesterly wind is weakened by the obstruction of the mountains, and thus the weathered rock carried by the wind gradually settles.

4. Drifting sand in the Ho-hsi Corridor. The drifting sand here is found on river and lacustrine deposits. At the Hsi-ch'eng "sand nest", 15 km west of Chang-i, it can be clearly seen that after the destruction of the primitive land surface made by sandy alluvial deposits, many remnant hills are left. In front of the destroyed land surface, there are sand dunes and a chain of sand dunes. The color and grade of the sand particles on the sand dunes and on the alluvial deposits are the same except that the former lack the clayey material. Thus we can very easily distinguish the sand particles at the source,

and sand particles at the area of accumulation. This distinction can also be noticed at Chin-t'a.

At Tun-huang and Chin-t'a, the drifting sand on the low mountains, on the slopes of low mountains, and on the gobis in front of the mountains, was carried there from the low-lying alluvial plains by the northwest wind.

(1) Classification of mobile sand lands

Sand lands may be classified on the basis of geomorphology, or on the basis of the cause of formation, or on the basis of vegetation. Our classification is based upon the lithological characteristics of the base rocks, the landform, the underground water, the height of sand dunes, and the thickness of the sand layer. As soon as we know the base rock and the landform, other conditions can be predicted. The mobile sand lands may be classified into the following types:

1. Mobile sand land on low mountains and slopes of low mountains made of ancient base rock. Such mobile sand lands are found on the Chia mountain at Chin-t'a, the Ming-sha Mountain at Tun-huang, and the Shuang-hei Mountain at F'eng-ko-li. As such lands have a big gradient and are located above the impervious layer, no plants can grow.

2. Mobile sand lands over comparatively contemporary

sedimentary rocks. The sand lands in the south of the Ya-pu-lai Mountain, on the south shore of the Ya-pu-lai salt lake, and in Lan-chi-lang belong to this type. The underlying bed rock is made of sandy rock of the middle Cainozoic Period. Few plant can grow on such sand lands.

3. Drifting sand land over gravel in front of the mountains. Only small areas of drifting sand are found at Tun-huang and Chin-t'a. There is little underground water available; the problem of percolation is serious; and no plant can grow.

4. Drifting sand land over diluvial-alluvial inclining plains in front of mountains. The drifting sand land at Yuan-chuang-tsu--Ho-lo-ohing, Ta-hung-sha-t'ang, and Kung-hung-teh-k'o belong to this type. Because of the flood water from the mountains, and the comparatively plentiful precipitation, some plants can grow on such drifting sand lands although the underground water is deeply buried.

5. Drifting sand land over river alluvial plains. Such drifting sand land is widely distributed in Ho-hsi, and the underground water level is high (about 2-3 m at Min-ch'in). The drifting sand can be easily stabilized here.

6. Drifting sand land on lake facies deposits. The sand land in the south of the Ya-pu-lai salt lake and that

Chin-t'a Sha-tsao-tzu--Hua-hai-tzu belong to this type. The underground water is heavily salinized.

7. Drifting sand land in alluvial-lacustrine basins. The T'eng-ko-li desert belongs to this type.

The geomorphological features and the height of sand dunes are essentially decided by the conditions of wind and landscape. In Ho-hsi area, sand dunes are 3-10 m high. Under the effect of two winds in opposite directions, the sand dunes in front of the mountains may reach as high as 15 m or higher. In T'eng-ko-li desert, the highest of the Nan-chi-lang sand dunes is about 100 m high, while 30-40 m high sand dunes are often seen. In the southeastern part of the area, mobile sand dunes are high and concentrated under the effect of the northwest wind. The mobile sand dunes generally exist individually, or in different arrangements. In the area under survey, the sand dunes are seen in the following arrangements:

A. Individual crescent sand dunes. Individual sand dunes, which are found in the oases and along the perimeters of deserts, are formed under the effect of the predominant winds, and are often seen at the Sparrow Flat of Min-ch'in, Chang-i, and in the vicinity of Ma-ch'ang lake at Chung-wei.

B. Lateral (perpendicular to the direction of the wind) and parallel crescent sand dune chains. Found in

Ho-hsi and the T'eng-ko-li desert, these sand dunes are formed under the effect of one predominant wind, or two winds in opposite directions.

C. Crescent sand dune lattices. Found in the south and southeast of T'eng-ko-li desert, such sand dunes arranged in lattices are formed under the influence of two winds perpendicular to each other.

In addition, there are big and high sand dunes with nuclei (such as the Ming-sha Mountain at Tun-huang, 130 m high). They are also seen at Nan-ohi-lang. Their outside shapes are often determined by the inner nuclei.

The crescent sand dune chains to the east of Chia-ku-kuan, including the T'eng-ko-li desert, run in the $N20^{\circ}E$ - $N60^{\circ}E$ direction, while those to the west of Chia-ku-kuan run approximately in the N-S direction. Because of the prevalence of the N-E-N wind, the direction of the movement of sand particles in the east and that of sand particles in the west are entirely different.

(2) Grass sand dunes. The grass sand dunes are stabilized or semi-stabilized sand dunes. They are lower and darker in color, with more fine materials in the sand. Irregular in shape, they are often seen in long strips extending in the direction of the predominant wind.

The orientation of the aeolian grove also shows the direction of the predominant wind. Often seen in Min-ch'in and Chin-t'a, such sand dunes are generally 5-7 m high, grown with *Nitraria schoberi*, *Tamarix chinensis*, and *Artemisia salsoloides* Willd. In the T'eng-ko-li desert, such sand dunes are found by the perimeters of lacustrine basins, and by the side of ponds, measuring less than 3 meters in height. Once such sand dunes are dried up, they are blown away by wind.

(3) Sand piles. Aside from the function of stabilizing sand dunes, some plants and plant populations can make the sand particles piling up around them. However, such sand piles are found in areas where the source of supply of sand is limited, otherwise crescent sand dunes will quickly develop. Consequently, they are found along the perimeters of crescent sand dune areas, the lower parts of the inclining rocky deserts, in the vicinity of riverbeds, and on the perimeters of lake basins. Sand piles are found in small areas except in the area from Sha-tsao-yuan to Hua-hei-tzu.

The height of sand piles depends upon the vegetation that causes the formation of such sand piles. For instance, the pile caused by *Nitraria schoberi* is not as big as that caused by *Tamarix chinensis*. The sand piles in

the area under survey can be divided into the following kinds:

1. Tamarix sand piles. Such piles are 3-6 m high, and the highest may reach as much as 10 m. Their diameters measure from several to 20 m, their slopes are steeper than those of the Nitraria sand piles, and the root system of the plants spreads all over the pile. Thus vegetation humus is found in the pile, and the aeolian stratification is clearly seen in the profile. In the Sha-tsao-yuan-tsu --Hua-hei-tzu area, there are two kinds of different sand piles. One kind is made of light brown floury sand mixed with clay. The other is made of light colored coarse sand and fine sand. The former is far away from the gobi in front of the Wu-la Mountain in Chahar, while the latter is right along the perimeter of the gobi in front of the Wu-la Mountain. The former is formed by lacustrine deposits blown by wind from clusters of *Tamarix ramosissima* Ledeb., while the latter is formed by sand blown by the northwesterly wind from the gobi.

2. Nitraria sand pile. The average height of such piles is less than 2 m, and their diameters range from 10 cm to 4 m. Such piles, though small in size, are found in large areas along the brims of the gobis and lacustrine basins, and in T'eng-ko-li and the Ho-hsi Corridor.

3. Oxytropis and Caragana sand piles. Smaller than the Nitraria piles, the Oxytropis and Caragana sand piles are found in the sandy gravel basins in northern Alashan.

4. Haloxylon sand piles. Found in the southeast of Pa-pe-kao-hsiu and the T'eng-ko-li rocky desert, such sand piles are about 3 m high. In the first-mentioned area, the Haloxylon sand piles are mixed with Nitraria sand piles.

As we said before, the height of the sand pile depends upon the species of the plant. In case the sand pile increases in height, the roots of the plants will not be able to reach the underground water level and the plants will wither and die. Hence there is a limit to the growth of the sand piles.

IV. Suggestions for Transformation

(1) Ho-hsi Corridor

1. Because of the dry climate and the strong aeolian effect in the area, the farm lands should be protected by forests, embankments, and canals, otherwise the agricultural lands will become denuded again after the harvest as the fertile fine earth is blown away by wind. It is particularly necessary to build a network of protective

forests at Min-ch'in, Chin-t'a, and Tun-huang. The same should be taken into consideration before reclamation (especially the reclamation of sandy wasteland).

2. The sandy land over alluvial deposits is of great importance because the underground water level is only 1-3 m from the surface, and such sand land can be completely stabilized. Different measures should be taken to cope with different situations. In dealing with the drifting sand which directly threatens production and the local people's livelihood, Professor Petrov's suggestions may be adopted, that is, to plant different kinds of shrubs on different parts of the sand dunes under the protection of lattice sand screens. At present, the measure of build-sand control forests between the oases and the drifting sand area is entirely correct. However, this is still not enough because the sand lands far away from the protective forests are still in a mobile state. It is thus necessary to close the sand land entirely in order to quicken the process of sand-fixation by seeding grass.

3. After "sealing the sand and raising the grass," the pastures will inevitably be reduced in size, but the wasteland can be used to raise fodders. Some of the deserts at Ch'ai-wan in Min-ch'in were originally farma-

lands, which can be used to plant feed grass. Thus the problem of pasture shortage is solved.

4. The Sha-tsao-yuan--Hua-hei-tsu area in Chin-t'a Hsien, where Tamarix sand piles are found, can be used to plant *Haloxylon ammodendron* and other saline resisting plants in large quantities.

5. The river banks (such as the banks of the Wai River in the vicinity of the Su-wu Mountain in Min-oh'in), the dry riverbeds or seasonal dry river beds (such as the the bed of the Tao-lai River at Chin-t'a), and some of the aeolian land (such as the area from the west of Chin-t'a-shu "sand nest" to the banks of the Tao-lai River) should be used to plant trees and grass.

6. The area from the Chung-tung Hsiang at Chin-t'a to Sheng-ti-wen, where sand lands and salinized plains are located, may be utilized for planting agricultural crops. As to the undulating sand lands, they may be used for planting Tamarix, wild hemp, and *Alhagi pseudoalhagi* Desv.

(2) T'eng-ko-li Area

In the T'eng-ko-li area, the drifting sand land and lakes appear alternately. The lakes and the surrounding areas, where plenty of water is available, can be used as

centers of sand prevention and control.

1. Lacustrine basins: The lacustrine basins, where the underground water level is 1 m to several scores of meters deep, where the degrees of salinization differ from place to place, and where grass can be grown, may be used to develop animal husbandry. However, the feed grass must be improved, a rational grazing system must be established in order to increase the number of livestock per unit area. At present, mechanized and semi-mechanized pastures are being built in big lake basins (such as the basins of the Ha-shih-ha Lake, the Cha-han-no-erh Lake, and the Ai-ming-kao-erh Lake). Such projects should be undertaken simultaneously with sand control.

2. Lake shore area. The sand dunes on the shores of the lakes are either stabilized or semi-stabilized. Their height ranges from 10 cm to 2 m. The underground water is found at a depth of 1-2 m, and it is seldom salinized. Under the protection of forests against sand and wind, the lake shores can be used to grow vegetables, grapes, melons, and fruits.

3. Drifting sand area close to lake shores. Although the areas close to lake shores are covered by drifting sand, underground water is found at about 2 m from the surface.

Grass can grow in the whole area, and trees may be planted among the sand dunes.

4. Drifting sand area in lacustrine basins. These basins may be seeded with desert plants by airplane. Aerial seeding may be tried first in sectors where the humidity is satisfactory for the growth of plants (the area to the north of the site of the Fu-lan-t'ai-su-mu government, Ka-ko-t'u and Ti-lu-wa, or the Niu-tzu-ching--Hua-tsai-ching area). After definite experiences have been obtained, aerial seeding can be used together with rain-making over other areas where the natural conditions are less favorable for the growth of plants.

5. Others. The Haloxylon forest in the north of the San-tao Lake (in the west of T'eng-ko-li) is now largely destroyed by local people, and artificial seeding should be done to restore the forest.

The lacustrine basins can be used as bases for sand stabilization. At present, priority should be given to establishing sand stabilization bases in the basins of the Ai-ming-kao-erh Lake, the T'ou-tao Lake (in the west of T'eng-ko-li), the T'ou-tao Lake (in the east of T'eng-ko-li), the Ho-shih-ha Lake, the Pa-yen-cho-erh Lake, and the Shuang-hai-shan Lake.

SOILS OF HO-HSI CORRIDOR AND WESTERN INNER MONGOLIA

For transforming and utilizing the deserts in north-western China, the Academia Sinica organized a coordinated desert survey team, which covered Ordos, Alashan, and the Ho-hsi Corridor. Pedologists were among the team members. The following is a preliminary report on our opinion concerning the transformation and utilization of deserts.

I. General Introduction

The areas under survey are steppes, desert steppes, and deserts (in the order from the east to the west). The soils include light chestnut soil, brown soil, sierozem, gray brown desert soil, and their sub-types. There are also some non-regional soil types, such as the "irrigated farm soil," meadow soil, bog soil, alkaline soil, and saline soil. On the Ho-lan Mountain, the Nan Mountain and the Pei Mountain, there are different kinds of mountain soils. Aside from soil, there are large areas of drifting sand. Thus we may see that there is a great diversity of soils in this region.

I. Distribution and Special Characters of Main Types of Soil

(1) Drifting sand.

The drifting sand occupies a large area in the region under survey. It is found in ten areas: 1. The Ku-pu-ch'i sand belt; 2. the drifting sand area in the central and western parts of the Ordos high plains; 3. the Mao-wu-su sand belt; 4. the Nan-chi-lang desert; 5. the Ninghsia plain desert; 6. the T'eng-ko-li desert; 7. the Pa-tau-chi-lin desert; 8. the sand land in the eastern part of the Ho-hai Corridor; 9. the sand land in Chin-t'a; and 10. the sand land at Tun-huang. The drifting sand covers over different kinds of parent rocks and different kinds of terrains in the form of individual sand dunes, sand dune chains, or sand dunes arranged like the lattices. The height of the sand dunes relative to the low land between the sand dunes ranges from 1-2 m to 50-60 m, or even to 160 m. The undulating sand dunes look like waves in the sea, while the higher ones look like hills and low mountains. The sand dunes are generally denuded except that some of them are covered by *Phragmites communis*, *Agriophyllum arenarium*, and *Artemisia salsoloides* Willd. The humidity in the sand differs greatly because of differences in geographic

location, the thickness of the sand layer, the parent rock underneath, and the terrain. On the Ordos high plains, in eastern Alashan, and in the eastern part of the Ho-hsi Corridor, under a thin dry sand layer (5-25 cm thick) is a moist sand layer, which contains 2-3 percent of water. In the western part of the Corridor, the dry sand layer is very thick, and no moist sand layer is seen as deep as 1 m below the surface. It should be pointed out here that without the influence of the underground water, the moisture condition in the crescent sand dunes differs greatly, depending upon the terrain, and the motility of the base material. The dry sand layer at the lower part of the sand dune is comparatively thin, while that at the top of the dune is very thick. However, after a rainfall a thin layer of moist sand often appears in between the dry sand layers. Near the low lands where the sand layer is not thick, the underground water level is high, and the sand layer is more humid. In places where the altitude is high and the sand layer is thick, the underground water level is lower and the sand layer contains less moisture. Because of the scarcity of vegetation and the heavy accumulation of sand, the pedogenic process of the drifting sand remains in a primitive state. Physically, the drifting sand in this

region consists essentially of fine sand particles with good sortability. Only a small percentage of the drifting sand contains coarse, or floury sand. The drifting sands have different degrees of salinity, but they do not contain humus.

(2) Light chestnut soil

Light chestnut soil is found in eastern Ordos (the western part of the dry steppes in our country), the Otok Banner, and the Hang-ohin Banner. Distributed on high plains, the light chestnut soil covers over the Cretaceous gray green sandy rock. In the eastern part of the high plain, purple sandy rocks are seen. With the exception of farm crops on reclaimed lands, the vegetation is of the dry steppe type, consisting of *Artemisia sphaerocephala* Krasch. *Cleistognes squarrosa* Keng., *Amorpha fruticosa* L., and *Myricaria dahurica* Ehrenb.

The main features of the light chestnut soil are as follows:

1. The schistose order of the humus material is very clear. The thickness of the humus layer is about 20-25 (30) cm, with the humus content ranging from 1.5 percent to 2.5 percent.

2. The entire profile shows lime reaction; only the upper layer of the metamorphic type of the light chestnut soil seen in the eastern part does not show lime reaction. This is because of the more plentiful precipitation and leaching in the east.

3. At the bottom of the profile, there is a clear caliche layer.

4. The entire profile is sandy.

There are in this area also some sand lands which have been stabilized for a long time. Covered by dry steppe plants and desert plants, the sand is gradually developing into light chestnut soil, and we call such sand "primitive light chestnut soil."

(3) Brown soil

This type of soil is the intermediary type between the dry steppe soil and desert soil, and is distributed in the western part of the Ordos plateau, and the eastern part of the Alashan Banner (the diluvial area in front of the Ho-lan Mountain). The vegetation on this type of soil include not only steppe gramineous weeds, but also dry shrubs and semi-shrubs, such as *Stipa gobica* Roshev., *Agropyrum semicostatum* Nees., *Lasiogrostis splendens* (Trin.) Kunth., *Astilifolius*, *Caragana tragacanthoides*,

Oxytropis psammocharis, and *Salsola passerina* Ege.

The principal characteristics of the brown soil are as follows:

1. The humus layer is very clear, measuring about 15-20(25) cm thick, and containing 1.0-1.5(2.0) percent of humus.

2. The entire profile shows lime reaction, and the caliche at the bottom of the profile appears in patches, strips, or shells.

3. The surface has a thin crust, and is slightly covered by pebbles.

4. Analysis shows that there are clayey particles moving down, and a small amount of gypsum appears in the lower part of the profile.

The brown soil can be sub-divided into dark brown soil (found in western Ordos), and light brown soil (found at the ends of the diluvial plains in the Alashan Banner and in front of the Ho-lan Mountain). The two differ not only in the content of humus and thickness, but also in vegetation covering. The dark brown soil is about half covered by herbal plants and half covered by shrubs and semi-shrubs, while the light brown soil is covered by shrubs and semi-shrubs. The latter is usually

stabilized.

(4) Sierozem

Sierozem is largely found in eastern Kansu. In the area under survey, it is found on the Yen-chih Mountain and at Ah-k'o-chai. Wherever sierozem is found, the rainfall is more plentiful, and the vegetation is denser than in other parts of the Corridor. The vegetation, which belongs to the desert steppe type or mountainous steppe type, includes *Stipa glareosa* Smirn., *Stipa gobica* Roshev., *Agropyrum semicostatum* Nees., *Lasiogrostis splendens* (Trin.) Kunth., etc.

The principal properties of sierozem are as follows:

1. The soddy soil and humus at the top layer are underdeveloped, but the "coloring layer" of the humus is thicker than that of the brown soil. As compared with the gray brown desert soil, the humus layer is more distinct.

2. The parent material consists of carbonate loess particles.

3. The entire profile shows carbonate reaction, and such a reaction is even more distinct at the carbonate layer near the base of the profile.

4. The saline has a tendency to seep down in the profile, the bottom of which shows accumulations of saline.

On the basis of the difference in its degree of development, sierozem can be divided into two sub-types: (1) the dark sierozem (found in the vicinity of Ah-k'o-chai); and (2) the light sierozem (found on Yen-chih Mountain).

(5) Gray brown desert soil.

The gray brown desert soil has the widest distribution in the area under survey. It is found in the Alashan Banner (with the exception of the narrow and long diluvial plain in front of the Ho-lan Mountain in the eastern part of the Alashan Banner), and the Ho-hsi Corridor.

Topographically, it is mostly found on diluvial slopes, ancient terraces, gravel hills, and the proluvial deposits in the vicinity of gravel hills. Thus the gray brown desert soil was often classified in the past as belonging to gravel desert landscape. However, such a classification did not exclude the existence of the metamorphic sandy loam.

The vegetation on the gray brown desert soil belongs to the typical desert type. Covering only about 10 percent of the gray brown desert soil, the vegetation consists essentially of semi-shrubs, with little herbal plants.

The structure of the gray brown desert soil profile and its main characteristics are as follows:

1. There is generally a crust and a large amount of gravel on the surface. Under certain conditions, the pebbles show a black, shining color, which is often called "the desert varnish."

2. The light gray or light brown coarse gravel loan layer, which shows a strong lime reaction, has a slight laminate structure with low consistence.

3. The light gray soil layer, which shows a weak lime reaction, has a large amount of pebbles, or gravel. Lime or gypsum are seen at the back of the rocks with aggregate structure and low consistence.

4. The gypsum layer in the profile is in the form of small crystal particles, or coarse fiber-like crystals. Sometimes a whole layer becomes a white or rose-colored fiber-like gypsum layer, which generally shows a weak lime reaction.

5. The layer which contains a large amount of gravel shows strong lime reaction.

On the basis of the condition of development, the gray brown desert soil can be divided into the following three sub-types: (1) Primitive gray brown desert soil; (2) ordinary gray brown desert soil; and (3) gypsum gray brown desert soil. The following is a discussion of their

special characteristics:

1. Primitive gray brown desert soil. The primitive gray brown desert soil is found on drifting sand, on salinized or semi-salinized sand lands, and on the alluvial sand in wide and dried riverbeds. As a result of the growth of vegetation, the drifting sand is gradually stabilized, and gradually develops into soil. For instance, the profile begins to show the accumulation of humus, and the surface shows a thin crust. The principal plants growing on this type of soil include *Artemisia salsoloide*, *Hedysarum scoparium* F. et M., *Calligonum mongolicum* Turcz., *Phragmites communis*, *Tamarix chinensis*, and *Nitraria tangutorum* Bobr. The primitive gray brown desert soil can be divided into two sub-types, namely (1) gray brown desert soil type sandy soil, and (2) loose primitive gray brown desert soil.

2. Ordinary gray brown desert soil. It is found in the Alashan Banner and to the east of Chia-ku-kuan in the Ho-hsi Corridor. Topographically speaking, it is found on diluvial slopes, diluvial plains, and in the pseudogobis. The principal plants include *Hololachne soongarica* Ehrenb., *Salsola passerina* Ege., *Asterothamnus centrali-asiaticus* Novopokr., *Nitraria tangutorum* Bobr., *Convolvulus*

fruticosus Pall., and *Caragana tibetica*.

Aside from the common characteristics similar to those of the gray brown desert soil, this type of soil has a thicker surface, a darker color and less gravel. The gypsum layer is located underneath the profile at a depth of 70-80 cm, or more.

On the basis of the structure of its profile and its location, the ordinary gray brown desert soil can be further divided into (1) stone gravel ordinary brown desert soil, (2) the sandy gravel ordinary gray brown desert soil, and (3) the loam (or clayey) ordinary gray brown desert soil.

3. Gypsum gray brown desert soil. It is found along the western border of the Alashan Banner (adjacent to the O-chi-na Banner) and in the west of the Chia-ku-kuan in the Ho-hsi Corridor. It is also found in the gobis (locally called "real gobis" or "black gobis"), on ancient diluvial plains, on eroded monadnocks, and on ancient terraces. The principal vegetation includes *Ephedra Przewalskii* Stapf., *Calligonum mongolicum* Turcz., *Hololachne songarica* Ehrenb., and *Nitraria sphaerocarpa* Maxim.

Aside from the common characteristics similar to those of the gray brown desert soil, it consists of stone

gravel, especially on the surface, which is often covered by black and shining pebbles, and rocks--the so-called "desert paint crust." The gypsum layer is high in the profile, generally close to the surface, and the gypsum crystals show a rose color. This is caused by the very dry climate and high heat.

Like the ordinary gray brown desert soil, it can also be subdivided into three types: (1) the stone gravel gypsum gray brown desert soil; (2) the sandy gravel gypsum gray brown desert soil; and (3) the loam (clayey) gray brown desert soil. It should be pointed out here that the first mentioned type is most widely found.

(6) Irrigated farm soil.

The irrigated farm soil is found on the Ninghsia Plain, and the oases in the Ho-hsi Corridor. Its parent matters consist of alluvial sediments and fine diluvial sediments. This type of soil measures about 1.5-2 m or more thick. Drastic changes have taken place in its pedogenic process because of irrigation and cultivation. A series of changes have also taken place in the chemical, physical, and biological properties of the soil. However, all these changes, such as the thickening of the matured layer, the deepening of the humus layer, and the descending

of the saline, are all favorable to agricultural production. Under certain conditions, local secondary salinization occurs because of irrational irrigation.

It must be pointed out here that the irrigated farm soil picks up local characters in different areas. For instance, the irrigated farm soil on the Ninghsia Plain has the properties of meadow soil, while that in the Ho-hsi Corridor has some of the properties of gray brown desert soil. Thus, we may divide this soil into two sub-types: (1) the meadow soil type irrigated farm soil (indicating the soil on the Ninghsia Plain); and (2) the gray brown desert soil type irrigated farm soil (indicating the soil in the cases of the Ho-hsi Corridor). We think each of the sub-types can be further classified according to its maturity and salinity, because such a classification will have a great significance to agricultural production.

(7) Meadow soil

This type of soil is scattered in the river valleys, on the deltas, and on the low lying lands in the area under survey. The meadow soil is formed because of its location by the side of rivers or lakes, because of the high underground water level, or because of the temporary effect of the summer flood. The vegetation consists of

gramineous plants and plants of the *Cyperus rotundus*. Because of the different degrees of mineralization of the underground water, the soil is salinized, and halophytes is often found. The principal plants include *Aneurolepidium dasystachys* (Trin.) Nevski, *Calamagrostis pseudophragmites*, *Phragmites communis*, *Achnatherum splendens* Ohwi, *Aegilops*, *Iris ensata* L., wei-ling-ts'ai, shui-mei-tung and hai-ju-ts'ao.

The special properties of the meadow soil are as follows:

1. The surface layer has a higher content of humus than other soils.
2. The whole profile shows carbonate reaction, but morphologically there is a distinct carbonate precipitate layer.
3. The middle or the lower part of the profile has a distinct gley phenomenon, reflected by the rust color and the blue-gray spots.
4. The whole profile shows alkaline reaction (ranging from weak to strong), and sometimes accumulations of saline can be seen at the lower part of the profile.

In our opinion, the meadow soil can be further classified.

(8) Bog soil

The bog soil is found in lake swamps and in the center of lowlands, where salinized water accumulates. The vegetation includes "swamp orchid," *Typha minima* (Funk) Hoppe, yang-shu-tzu-ts'ao, hai-ju-ts'ao, shui-wei-tung, and feng-mao-chu. In some places, the soil has turned into peat as a result of the long accumulation of organic matter. In other places (such as Chin-t'a and Kao-t'ai), the bog soil consists of humus and coarse organic matters. The profile of this kind of soil shows a rust color, and blue gray spots, and has a humus odor. The bog soil can be further divided into: (1) Meadow bog soil; (2) coarse organic gley soil; and (3) bog peat.

(9) Saline soil

Saline soil is widely found in the area under survey. Generally it is found in river valleys, along the brims of lacustrine basins, and in low-lying swamps. The vegetation consists essentially of halophytes. In the eastern part of the area under survey, the soil contains carbonate-sulfate, sulfate, and chloride-sulfate. In the western part of the area under survey, the soil contains chloride-sulfate, carbonate-chloride, and chloride. The last two are most widely found.

The saline soil can be divided into five sub-types:

1. Desert saline soil. The desert saline soil is found at the outer perimeters of the oases in the Ho-hsi Corridor, or at the lower parts of the ancient diluvial slopes. The vegetation consists mainly of halophytes. The surface of this soil is full of gravel. A large amount of saline is accumulated at the upper part of the profile, while crystallized gypsum is seen in the middle and the lower parts of the profile. The saline consists of sulfate-chloride.

2. Meadow saline soil. The meadow saline soil is found in the same places as the meadow soil. Its profile shows the accumulation process of saline. Its vegetation consists of plants with high resistance against saline and aridity. The surface of the soil is covered by a crust, which may reach 10 cm thick. (In Kansu, the meadow saline soil is called "cake saline soil," because of the thick crust.)

3. Bog saline soil. The bog saline soil is found in the very center of depressed lands, and occupies but a small area together with the bog soil. The vegetation on this type of soil is the same as that on the bog soil, but some hydrophytes is also found. Containing a large

amount of saline, it has a 1-2 cm thick white crust.

4. Adobe type saline soil. This type of soil is found in small patches on the Ninghsia Plain and in the T'eng-ko-li. No extensive study has been made about this soil.

5. Lake shore saline soil. This type of soil appears on the shores of the Chi-lan-t'ai salt lake, the Ya-pu-lai salt lake, the Cha-han salt lake in the T'eng-ko-li, and the Ka-la-hu salt lake at Tun-huang. Because of the high mineral and saline contents in the water, no plant can grow. Containing 20-30 percent of chlorides, the hard salt crust in some places can be gathered for industrial uses.

(10) Alkaline soil

Alkaline soil is found in the light chestnut soil and brown soil areas on the Ordos plateau, in the low-lying places in wide river valleys, or on the brims of such lakes as the Hung-hai-tzu lake in the eastern part of the Chun-wang Banner, and the Na-ling Lake and the Cha-han Lake in the western part of the Otok Banner. No extensive study has been made about this type of soil.

(11) Mountain soils

In the area under survey, we studied the soils on the

Ho-lan Mountain, the Nan Mountain, and the Pei Mountain on our itinerary. It should be pointed out that the so-called mountain soils do not include all the soils in the mountainous area, nor did we make any extensive study about them. We mention them here merely because they are helpful to our understanding of the natural conditions in the area under study.

We saw brown soil on the western slope of the Ho-lan Mountain at an altitude below 2,000 m, and mountain gray soil under poplar, *picea asprata*, and *pinus tabulaeformis* forests at an altitude of 2,000-2,700 m, and mountain meadow soil at an altitude above 2,700 m.

At Ma-t'i-sze in the Yu-ku autonomous hsien in Ho-hsi Corridor and under the *picea asprata* forests on the northern slope of the Ch'i-lien Mountain at an altitude of 2,300 m, we saw mountain gray soil. However, this soil appears only on the northern slope of the Ch'i-lien Mountain to the east of Chiu-ch'uan, and the west of Chiu-ch'uan. This soil is not seen at all on the northern slope of the Ch'i-lien Mountain even at the same altitude.

On the way from Ah-ko-chai to Tang-chin-shan, we saw mountain desert steppe soil on the southern slope at altitudes between 2,500 m and 2,900 m, and between 3,200 m

and 3,450 m. However, between 2,900 m and 3,000 m, we saw mountain steppe soil. We think the reason why mountain desert steppe soil develops over the mountain steppe soil is attributable essentially to the presence of the extremely dry Tsaidam basin in the south.

Mountain steppe soil is found on the western slope of the Wu-chiao Mountain below 2,400 m, but from 2,400 m up mountain meadow steppe soil appears. (The highway passes the Wu-chiao Mountain at an altitude of 2,900 m.)

Finally, we saw mountain gypsum desert soil on the low mountains to the north of An-hsi and the Chahar Wu-la Mountain in the northwest of Chin-t'a.

III. Suggestions for the Transformation and Utilization of Main Types of Soil

(1) Drifting sand

The transformation and utilization of drifting sand must be combined with prevention and control so that the drifting sand will not appear again. As to the stabilization of the drifting sand, priority should be given to that which is easy to control. Then measures should be taken according to different natural conditions for overall control. In the work of drifting sand transformation

by agriculture and forestry, water plays a very significant role. As mentioned before, under the thin dry sand layer in most of the drifting sand area, there is usually a moist sand layer, the humidity of which is satisfactory for the growth of sand stabilizing plants. In such places, plants should be used essentially for sand fixation. In the western part of the Ho-hsi Corridor where there is no underground water available, where the sand layer is thick, and where there is no moist sand layer, mechanical sand control measures should be employed together with the planting of sand fixation vegetation in years when the precipitation is plentiful. We suggest that in places where the underground water level is 4-5 m below the surface, *Hippophae rhamnoides* L., *Populus simonii* Carr., and *Ulmus pumila* be planted for the purpose of sand stabilization. In places where the underground water level is high (within 2 m below the surface), trees, melons, and fodders of higher economic value may be planted. In places where the underground water is highly salinized, *Haloxylon ammodendron*, *Populus diversifolia* schrenk, and *Tamarix chinensis* may be planted. When the trees grow up, they may be used as timber or fuel. In places where the underground water level is low (more than 4-5 m below),

and where there is a moist sand layer, shrubs and semi-shrubs, such as *Artemisia salsoloide* Willd., *Aristida adscensions*, *Hedysarum scoparium* F. et M., *Calligonum mongolicum* Turcz., and *Caragana microphylla* var. *tomentosa* may be planted. After the drifting sand is stabilized, such places can be used for animal husbandry. It should be pointed out that aerial seeding and rain-making should be used for sand fixation over a large area, while different methods may be employed for sand control in industrial or mining areas and along lines of communication.

(2) Light chestnut soil

The light chestnut soil area in eastern Ordos has been largely reclaimed, and the crops include millet and buckwheat.

Since the soil in eastern Ordos is sandy in nature, it will become drifting sand if not rationally utilized. In the future, protective forests must be built against wind and sand, and wherever possible the soil should be irrigated. More fertilizers should be used, intensive cultivation should be practised, and better feed grass should be grown so as to develop animal husbandry.

(3) Brown soil

The brown soil area in the western part of Ordos and

the eastern part of Alashan cannot be used for agricultural purposes, and are now almost entirely used as natural grazing grounds. Here there are gramineous plants and other superior species of feed grass, which can be used for the development of animal husbandry. In the piedmont area of the Ho-lan Mountain where there is water available for irrigation, bases should be established for farming and the cultivation of fodders. In animal husbandry, efforts should be made to breed animals of high economic value, such as sheep and milk cow.

(4) Sierozem

The sierozem soil areas on the Yen-chih Mountain in the Ho-hsi Corridor, and at Ah-k'o-chai are also used as natural grazing grounds. If these areas are well utilized, the number of livestock per unit area can be greatly increased. If the cultivation of feed grass is improved and better species of animals are obtained by cross breeding, more milk cow, fine wool sheep, and breed horses may be raised in addition to the cattle and sheep to be used for meat for the vast number of people in the Ho-hsi Corridor. As the sierozem area is close to the mountains where the precipitation is more plentiful, and the soil consists mostly of loess mother material, it is particularly

important to adopt measures for the conservation of soil and water.

(5) Gray brown desert soil

The problem of utilizing large areas of gray brown desert soil in the Alashan Banner and the Ho-hsi Corridor should be dealt with according to specific local conditions. The method of "sealing the sand and raising the grass" should be used for protecting and utilizing the primitive gray brown soil found on the outer perimeters of large areas of drifting sand and on fixed sand dunes. In places where the vegetation is more plentiful, grazing by rotation should be adopted.

The problem of utilization of the ordinary gray brown desert soil found in the eastern parts of Alashan and the Ho-hsi Corridor should be considered on the basis of its location. In the central or lower parts of the diluvial plain or close to the outer perimeter of oases, the soil layer is comparatively thick, and can be used for mechanized farming or raising fodders if protective forests are built. As the soil here is salinized to different degrees, the construction of a irrigation system should be considered at the time of reclamation. Since the gray brown desert soil has a low content of organic matter, we must look for

sources of fertilizers. The stone gravel gray brown desert soil and the gypsum gray brown desert soil in the western part of the Ho-hsi Corridor, which have a high content of gravel, sand, and gypsum, cannot be utilized at the present time. Our immediate concern should be the protection of the existing vegetation covering. In places where ephedra grows, consideration may be given to the utilization of this plant to make ephedrine.

(6) Irrigated farm soil

For the improvement and better utilization of the irrigated farm soil on the Ninghsia Plain and in the Ho-hsi Corridor, emphasis should be put on intensive cultivation, more fertilization, and the prevention of secondary salinization. Hence we must seek more sources of fertilizers by raising green manure, by utilizing peat, and by developing pig-raising. For the prevention of secondary salinization, irrigation should be done rationally, and a network of irrigation and drainage systems should be built.

(7) Meadow soil

All the slightly salinized meadow soil can be used for farming, or for raising fodders. Several places where the meadow soil is found can be used as nurseries for tree

seedlings. In places where the underground water level is high, a drainage system must be built in order to lower the underground water level.

(8) Bog soil

As we have said before that the bog soil occupies only a small area, we may at present put off the problem of its improvement and utilization. However, some of the slightly salinized peat swamps in the Ho-hsi Corridor are good sources of fertilizers. For instance, the bog soil at Kao-t'ai has a high content of coarse organic matter.

(9) Saline soil

The improvement and utilization of vast areas of saline soil in the region under survey constitute a very important problem. In our opinion, it is necessary to organize a special survey team and to mobilize the masses to study and solve this problem.

In our opinion, most of the desert saline soil areas have a plentiful supply of water. If an irrigation and drainage system is built, such areas can be used for farming and animal husbandry. As to the utilization of meadow saline soil, we think the most important thing to do at the present time is to protect the vegetation covering, and

to use a part of the area with meadow saline soil for light grazing. In a few places, we may cover the saline soil with sand in order to reduce evaporation and lessen the saline content, and then plant the feed grass.

As to the bog saline soil, the adobe type saline soil, and the lake shore saline soil, they cannot be utilized at the present time because of their high content of saline.

(10) Alkaline soil

Alkaline soil is found in a small area in Ordos. Since alkali is being gathered from alkaline lakes in the western part of Ordos for industrial use, it is therefore unnecessary to consider the improvement and utilization of the alkaline soil on the brim of lacustrine basins. The alkaline soil in the eastern part of Ordos occupies an even smaller area. For its improvement, we may apply gypsum, or organic matter in large quantities.

SAND PLANTS IN WESTERN INNER MONGOLIA AND THE HO-HSI CORRIDOR

The sand plants discussed in this article are arranged in the order of their effectiveness in sand fixation, but opinions on the effectiveness of sand fixation of a plant differ greatly because some plants grow on salinized sand lands, others grow on moist sand lands, and still others grow on stabilized, or semi-stabilized sand lands. Since their environments are different, no absolute criteria can be used to compare their sand fixation effectiveness. Hence, the order of arrangement used in this article is not flawless.

A total of 116 kinds of sand plants are mentioned in this article, including some originated from the Central Asian Desert in the Soviet Union. The nomenclature of each plant consists of its place of origin, its popular name used in literature, its Mongolian name, its Latin name, and its family name. The morphological description of each plant is limited to the aspects that have a bearing on sand fixation. The area of distribution and the environment, the function of sand fixation and the suitable cultivation area, the maturing time of seeds and the

places where the seeds are obtained are discussed for each plant with emphasis on the information obtained during the survey. Since this survey is mainly interested in animal husbandry in the area, the discussions on the uses of each plant stresses its value as a fodder. At the end of this article are a list of names of plants in Chinese (arranged in the order of the number of strokes of the first character) and a list of names of plants in Latin (arranged in alphabetic order) for the reader's reference.

I. *Artemisia sphaerocephala* Krasch., Compositae

1. Area of distribution and environment: A large amount of *Artemisia sphaerocephala* Krasch. is found in northern Shensi, the Ikhchao League and the Pa-yen-cho-erh League of Inner Mongolia, near Chung-wei in Ninghsia Province, and in the vicinity of Min-ch'in in Kansu Province. It grows on mobile and semi-stabilized sand lands.

2. Effectiveness of sand fixation and suitable area of cultivation: A semi-shrub, it has a long main root, and many long side roots. It is suitable for cultivation on sand lands, and highly effective in sand fixation if it is used together with sand screens. It may be seeded on

mobile or semi-mobile sand lands by airplane.

3. Maturity time of seeds: The seeds are mature in late October.

4. Economic value: Its branches can be used to make sand screen, or used as fuel.

II. *Artemisia ordosica* Krasch., compositae

1. Area of distribution and environment: It is found mainly in the Ikhohao League and the Pa-yen-cho-erh League in Inner Mongolia, in Chung-wei of Ninghsia, and Min-ch'in of Kansu. It grows on semi-stabilized and stabilized sand lands, and in swamps in lacustrine basins.

2. Effectiveness of sand fixation and suitable area of cultivation: As a semi-shrub, its root system is not so well developed as that of *Artemisia sphaerocephala* Krasch., but its seeds have the same characteristics as those of *Artemisia sphaerocephala* Krasch. It can be seeded either manually or by airplane in a straight row in swamps or on semi-stabilized sand lands.

3. Time of maturity of seeds: Its seeds mature generally in early November.

4. Economic value: Its branches and stalks can be used to make sand screens, or as a fuel.

III. *Artemisia halodendron* Turcz., *compositae*

1. Area of distribution and environment: It is found on mobile and semi-stabilized sand dunes in the eastern part of the Che-li-mu League and the southern part of the Hu-lun League in Inner Mongolia, and the northeastern part of Liaoning. It forms a belt along the boundary line between the drifting sand area and the stabilized sand land.

2. Effectiveness of sand fixation and suitable area for cultivation: As a semi-shrub, it has many branches. The branches become adventitious roots when they meet moist sand. It is the best sand fixation plant for arid steppes and desert steppes. In 1957, 90 percent of the *Artemisia halodendron* Turcz. planted on big lattice shaped sand dunes at Sha-po-t'ou in Chung-wei survived. It grows faster than the local *Artemisia sphaerocephala* Krasch. and *Artemisia ordosica* Krasch. Furthermore, it sprawls on the ground and has a strong sand fixation effect. This plant can be introduced to areas similar to Chung-wei.

3. Time of maturity of seeds and places where the seeds may be gathered: The seeds mature in October. The seeds may be gathered in the drifting sand areas in the Che-li-mu League, the Hu-lun League of Inner Mongolia and Liao-ning Province.

4. Economic value: Its value as a fodder is low.

IV. *Artemisia salsoloide*, Willd., compositae

1. Area of distribution and environment: Large quantities of *Artemisia salsoloide*, Willd. is found at Chang-i, Chin-t'a, An-hsi, and Tun-huang in Kansu Province. It grows on dry sand land, and in the dry riverbeds on gobis, where the precipitation is scarce. It has a higher resistance against aridity than *Artemisia sphaerocephala* Krasch., and *Artemisia ordosica* Krasch.

2. Effectiveness of sand fixation and suitable area for cultivation: As a semi-shrub, it has comparatively fine branches. An excellent sand fixation plant, it can be planted in large quantities in the Ho-hsi Corridor, and in the dry riverbed area to the west of Chang-i.

3. Time of maturity of seeds and places where the seeds may be gathered: The seeds mature in November.

V. *Hedysarum scoparium* F. et M. leguminosae.

1. Area of distribution and environment: It is found in drifting sand area and semi-stabilized sand lands in Chung-wei, Pa-yen-cho-erh League, the Alashan Banner, and Chiu-ch'uan and Chin-t'a in the Ho-hsi Corridor.

2. Effectiveness of sand fixation and suitable areas for cultivation: As a shrub, its branches grow very fast,

and can survive even under the pressure of sand. Its trunk and roots are strong and big, and can stand weathering. The rate of sprouting of seeds is high, and seeds dropped on the ground a year ago can sprout. Hence, it is an excellent plant for sand lands. In the future, it may be seeded by airplane.

3. Time of maturity of seeds and places where the seeds may be gathered: The seeds mature in September-October, and may be gathered at Ah-ko-tung-no-erh-kung in the Alashan Banner of Inner Mongolia, at Sha-po-t'ou in Chung-wei, at Chin-t'a, and in the area from Sheng-ti-wan to the south of P'en-ti-k'eng.

4. Economic value: It is a fodder much liked by camels, and a good fuel. The seeds are edible.

VI. *Caragana microphylla* var. *tomentosa*, leguminosae.

1. Area of distribution and environment: It is found on stabilized sand lands at Yu-lin in northern Shensi, and in the different banners of the Ikhchao League and the Fa-yen-cho-erh League.

2. Effectiveness of sand fixation and suitable areas for cultivation: It is a shrub, standing at a height of 2 m (the highest is at 4 m). Its branches and leaves are dense, and each shrub occupies an area of 4 m². The root

system is strong and coarse, and highly resistant against aridity. An excellent sand-fixation plant, it can grow many adventitious roots, which may eventually become new plants.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in July, and can be gathered at I-wan-ch'uan in Ninghsia, and at Ta-la-t'e Banner in the Ikhobao League.

4. Economic value: Its branches and leaves can be used as a fodder and a fuel. At Yu-lin and Chung-wei, it is used as a green manure.

VII. *Calligonum mongolicum* Turcz., polygonaceae.

1. Area of distribution and environment: Found in the Alashan Banner and the Ho-hsi Corridor, it grows well on loose and soft immobile sand dunes, but not so well on gravel and gypsum gobis. It is also found in dry riverbeds and gravel diluvial deposits in front of the mountains.

2. Effectiveness of sand fixation and suitable areas for cultivation: A shrub, it stands 20 cm-1 m high. Its leaf is degenerated, and its green branches are thin and fine. It has both horizontal and vertical roots. The former extend several tens of meters long on the

surface to absorb the moisture. Vegetative reproduction is carried on by adventitious buds. With high resistance against aridity, it is a typical sand plant. Since its branches are thin and soft, its sand-fixation effect is low. Nevertheless, it may be planted with other shrubs for the purpose of sand fixation. It may be planted on the less mobile sand lands in the eastern part of the Ho-hsi Corridor and in the Alashan Banner.

3. Time of maturity of seeds and places where the seeds may be gathered: It blooms in June, and bears fruit in July-August. The seeds may be gathered at the Sze-ho Hsiang at Min-ch'in, along the banks of the Hei River near Kao-t'ai, and at the "ten-li sand nest" at Tun-huang.

4. Economic value: It is a good feed for camels, sheep and goat.

VIII. *Salix flavida* Sky. et Chang, salicaceae.

1. Area of distribution and environment: It is widely found on mobile sand dunes in the eastern and northern parts of the Che-li-mu League, the Ikhobao League, the northwestern part of Liaoning, and northern Shensi. Large amounts of this plant are planted at Chung-wei, Min-ch'in, and Chin-t'a. It grows well in places with a thin layer of sand with plentiful supply of water.

2. Effectiveness of sand fixation and suitable areas for cultivation: A shrub, it is taller than *Salix cheilophila* Schneid, has a strong budding ability, and can stand the pressure of sand. Reproducing by cuttings, it is a superb species for sand fixation. It should be planted on river banks, by the side of ditches, and sand lands where the moisture condition is favorable. It grows well at the bottom of the leeward slope of big lattice-shaped sand dunes in the vicinity of Chung-wei.

3. Time of maturity of seeds and places where the seeds may be gathered: The seeds mature in May. The cuttings should be done at the end of winter or the beginning of spring before budding.

4. Economic value: Its branches can be used to make baskets, mats, and containers.

IX. *Haloxylon ammodendron* (X. A. M), Bge., chenopodiaceae.

1. Area of distribution and environment: It is found in various banners of the Pa-yen-cho-erh League, in the western part of the Ho-hsi Corridor and Sinkiang.

It likes to grow on loose and soft sand lands with slightly salinized underground water (at a depth of 1-2 m). It is also found in ancient riverbeds.

2. Effectiveness of sand fixation and suitable areas for cultivation: It is a big shrub but a small tree, with numerous branches, strong roots, and high resistance against the pressure of sand, acidity, and wind. Its leaves are degenerated. Its ovary stops developing after the blooming because of the hot weather. When the weather becomes cooler, it begins to bear fruits. It can adapt to the worst climate in the desert. With a thin peel, the seed may germinate within a few hours under an appropriate temperature. It generally sprouts in early March on drifting sand.

Seeds may be broadcast or seedlings may be planted on the lat sand lands in the Pa-yen-cho-erh League and the Ho-hsi Corridor where the underground water is found at a depth of 1-2 m below the surface. It can also be seeded by airplane on sand dunes grown with phragmites communis in the T'eng-ko-li desert.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in October, and may be gathered to the east of Su-mu No 5 in the Alasnan Banner of the Pa-yen-cho-erh League, in the vicinity of the Chi-lan-t'ai salt lake, and near Tu-shan-tzu in Tun-huang.

4. Economic value: A good feed for camels, and a good fuel.

X. *Tamarix ramosissima* Ldb., tamaricaceae.

1. Area of distribution and environment: It is found in the various banners of the Pa-yen-cho-erh League, and at Chin-t'a, Tun-huang, and Min-ch'ix in the Ho-hsi Corridor. It adapts to moist salinized flats, and the outer perimeters of lake basins.

2. Effectiveness of sand fixation and suitable places for cultivation: A shrub, it produces adventitious roots after its branches are buried by sand. Surrounding the population of *Tamarix ramosissima* Ldb., there are small mounds of sand particle, tree branch and tree leaf deposits as high as 2-4 m, or even 20 m. A good sand fixation plant, it may be planted in large quantities around the lake basins, in the swamps, and on the banks of rivers. In recent years, the masses in Ho-hsi have made remarkable achievements in multiplying this plant by irrigation. The same should be done in other areas where local conditions permit.

4. Economic value: Its branches can be used to make agricultural implements.

(Note) The properties of *Tamarix chinensis* are similar to those of *Tamarix ramosissima* Ldb. It is found on the sand flats on both banks of the Yellow River.

XI. *Hedysarum mongolicum* Turcz., leguminosae.

1. Area of distribution and environment: It is found in the Ku-pu-ch'i desert of the Ikhchao League, and the Che-li-mu League of Inner Mongolia.

2. Effectiveness of sand fixation and suitable areas for cultivation: A shrub, it stands about 1.5 m high. Its sand fixation effect is comparable to that of *Hedysarum scoparium* F. et M. It cannot grow in the Ho-hsi Corridor where the annual precipitation is less than 150 mm a year.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in the middle of September, and may be gathered in the Ku-pu-ch'i desert.

4. Economic value: An animal feed and a fuel.

XII. *Zygophyllum xanthoxylon* Mad. zygophyllaceae.

1. Area of distribution and environment: It is found in a larger amount in the eastern part of the Alashan Banner, and in a smaller amount in the Ho-hsi Corridor. It adapts to loose sandy gravel gobs, pebble-gravel alluvial sediments in front of mountains, and sand lands along dried riverbeds.

2. Effectiveness of sand fixation: A 2 m tall shrub, it adapts to high aridity, but not muddy, clayey, or strongly salinized soil. With some effect in breaking wind and sand, it should be planted on stabilized sand land.

3. Time of maturity of seeds and places where seeds may be gathered: It blooms in April-June, and bears a large quantity of fruits in June-July. Its seeds may be gathered at the second terrace of the Yellow River in the Pa-yen-oho-erh League, the Tung-hu Mountain in the Alashan Banner, and the plain in front of the Shuang-hei Mountain.

4. Economic value: It can be used as a fuel, but not a feed because camels will get stomach disorder after eating this plant.

XIII. *Piptanthus mongolicum* Maxim., leguminosae.

1. Area of distribution and environment: Generally found in the Alashan Banner of Inner Mongolia, and in the vicinity of Chung-wei in Ninghsia Province, it grows on the diluvial plains in front of mountains and on the second terrace of the Yellow River.

2. Effectiveness of sand fixation and suitable places for cultivation: An evergreen shrub, it has the effect of breaking the wind and stabilizing the sand even in winter.

It may be planted along the brim of drifting sand areas and on diluvial slopes.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in July, and may be gathered along the banks of the Yellow River in the Pa-yen-cho-erh League, and on the plains in front of the Shuang-hei Mountain and the Tung-hu Mountain.

4. Economic value: Containing fat and oil, it is the best smokeless fuel.

XIV. *Psammochloa villosa* For., gramineae.

1. Area of distribution and environment: It is found on mobile, semi-stabilized, and stabilized sand dunes in the Pa-yen-cho-erh League. But it grows better on mobile sand dunes than on stabilized sand dunes.

2. Effectiveness of sand fixation and suitable areas for cultivation: A perennial herbal plant, it has subterranean stems, and can stand high aridity. Multiplying fast and capable of withstanding the pressure of sand, it can grow on high mobile sand dunes even its root system cannot reach the underground water level. A good herbal sand fixation plant, it should be widely planted.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in the last decade

of August, but the seeds do not fall easily immediately after the time of maturity. However, the seeds may be gathered in the vicinity of the Ya-pu-lai salt lake.

4. Economic value: It is one of the valuable feeds for sheep, cattle, horse and camel. Its stems can be used to make baskets, and its leaves may be used to make ropes.

XV. *Agriophyllum arenarium* (M. B. A.) Ege., chenopodiaceae.

1. Area of distribution and environment: Found in the Pa-yen-cho-erb League, the Ho-hsi Corridor and the Ordos, it grows at the lower parts of mobile crescent-shaped sand dunes, and on the lowlying lands between sand dunes, but not on soils with clay or pebbles.

Unable to withstand strong salinity, it cannot grow on sand lands where artemisia and other gramineous plants grow.

2. Effectiveness of sand fixation and suitable areas for cultivation: An annual plant, it changes in size and height, depending upon the moisture conditions. In years with a medium amount of precipitation, it is well developed; in drought, it is under-developed. Its seeds are carried by wind to various places in winter. It may be

planted with other perennial plants for the purpose of sand fixation.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in September-October, and may be gathered at Min-ch'in and An-hsi in the Ho-hsi Corridor.

4. Economic value: It is the best feed for camels. With a high content of nutrients, the seeds are edible.

IVI. *Pugionium cornutum* Gaerta., cruciferae

1. Area of distribution and environment: It is found in Ordos, the Alashan Banner, the Ho-hsi Corridor and the northern part of Che-li-mu League. It usually grows between big mobile sand dunes, or in the lower part of leeward slopes individually or in groups. In northern Shansi, it is grown on the leeward slopes of sand dunes as a vegetable.

2. Effectiveness in sand fixation and suitable areas for cultivation: A biennial herbal plant, it grows well on sand lands where precipitation is plentiful. Standing about 1 m tall, it has a weaker resistance against aridity. With two wings, its fruit has thorns in the middle. Hence the fruit is not easily blown away when it drops on the sand land. A good sand fixation plant, it

may be planted between sand dunes or at the lower part of sand dunes together with other perennial sand fixation plants.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in August-September, and may be gathered at Yu-lin, and Sha-po-t'ou in Chung-wei.

4. Economic value: Its seeds may be extracted for oil, and its leaves may be used as a vegetable, or a feed for camels.

XVII. *Corispermum patelliforme* Iljin., chenopodiaceae.

1. Area of distribution and environment: Widely found in Ordos, the Ho-hsi Corridor, and the Ya-yen-cho-erh League, it grows on low-lying lands between sand dunes, or at the base of the leeward or windward slopes of mobile crescent sand dunes.

2. Effectiveness in sand fixation and suitable places for cultivation: An annual herbal plant. It has the same sand fixation effect as *Agriophyllum azenarium* (M. B. A.) Ege.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in July-August.

4. Economic value: It is a good animal feed, and its seeds may be used for extracting oil.

XVIII. *Nitraria tangutorum* Bobr. zygophyllaceae.

1. Area of distribution and environment: Found in Ikhohao League, Ho-hsi Corridor and Sinkiang, it grows in the border area between drifting sand area and lake basins, and on slightly salinized sand lands.

2. Effectiveness in sand fixation and suitable places for cultivation: A shrub in groups, it can accumulate drifting sand, withered branches, and fallen leaves into small hills. One of the good sand fixation plants, it can be planted along the outer perimeters of drifting sand areas where underground water level does not exceed 2-3 m from the surface.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in August-September in large quantities, and may be gathered at San-sheng-kung in the Pa-yen-cho-erh League, along the perimeters of lake basins in the T'eng-ko-li desert, and in the "sealing the sand and raising the grass" area at Min-ch'in and Chin-t's.

4. Economic value: Juicy and edible, the fruits can be used for brewing or making vinegar. It can also be

used as a feed for pigs. Its seeds may be used for extracting oil.

XIX. *Nitraria Roborowskii* Kom., zygophyllaceae.

1. Area of distribution and environment: It is found at Hung-sha-kang at Yung-chang in the northern part of Kansu, and on the sand dunes to the north of Hwo-lo-ching and Chin-t'a along the southern perimeter of T'eng-ko-li. Its area of distribution is more to the west than the area of distribution of *Nitraria tangutorum* Bobr. Even to the east of Chung-wei, *Nitraria Roborowskii* Kom. can no longer be seen.

2. Effectiveness in sand fixation and suitable places for cultivation: Same as *Nitraria tangutorum* Bobr.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in August, and may be gathered at Hung-sha-kang at Yung-chang, Chung-wei, and Hwo-lo-ching.

4. Economic value: Same as *Nitraria tangutorum* Bobr.

XX. *Nitraria sibirica* Pall., zygophyllaceae

1. Area of distribution: Widely found in Ikhchao League, Pa-yen-cho-erh League, and Ho-hsi Corridor, it grows on slightly salinized low sand lands, on sand lands

along the brim of lake basins, and on comparatively heavily salinized sand soils.

2. Effectiveness of sand fixation and suitable areas for cultivation: A shrub in small bushes, it stands about 1 m tall. Its sand fixation effect is slightly less than the foregoing two plants, but it has a higher resistance against salinity. It can be planted on salinized sand lands where underground water level is not too deep.

3. Time of maturity of seeds and places where seeds may be gathered: It blooms in June, and bears fruit from the third decade of July to August. Its seeds may be gathered in the northwest of Yu-men, along the banks of the Hei River, and in the T'a-shih-ho basin.

4. Economic value: Slightly salty in taste, the fruits is edible and can be used for brewing and making vinegar. Its branches and leaves may be used as a feed for sheep and goat, but they are not quite liked by the latter.

XXI. *Stelpnolepis centiflora* Krasch., compositae.

1. Area of distribution and environment: It grows on crescent shaped sand dunes and plains between the sand dunes in the north of the Ikhchao League and the Pa-yen-cho-erh League.

2. Effectiveness in sand fixation and suitable places for cultivation: A biennial herbal plant, it stands 20-40 cm high on drifting sand. In arid years, it appears in single plants, while in years with plentiful of precipitation it appears in large populations, and grows fast. Its branches are fragile and weak, and can be easily blown away by wind. It is insignificant as a sand fixation plant, but it may be planted together with perennial sand-fixation plants.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in July-August, and may be gathered on the drifting sand in Ikhchao League and Pa-yen-cho-erh League.

XXII. *Atraphaxis frutescens* (L.) Ewersm., polygonaceae.

1. Area of distribution and environment: It is found in the north of Ordos, between the Yin Mountain and the Cho-tzu (Table) Mountain in the Ikhchao League, from Pa-yin-hao-t'e to So-so-tsui of the Ya-pu-lai desert in the Fifth Su-mu, outside the Chia-ku-kuan, and in the vicinity of Sha-tsao-yuan-tzu at Chin-t'a.

It adapts to less mobile sand lands, slopes of low mountains covered by pebbles, gobis, and particularly to piedmont plains with sand and pebbles and dry riverbeds.

2. Effectiveness in sand fixation and suitable places for cultivation: Standing 50-70 cm high (highest being 2 m), it is a small shrub, with an extremely high resistance against aridity, and woody thorn-less small branches. It may be planted on less mobile sand lands and on gravel plains.

3. Time of maturity of seeds and places where seeds may be gathered: It begins to bloom in July and bears fruit in September-October. The seeds may be gathered at Yin-keng-ao-pao in the Ikhchao League, in the west of Chiu-ch'uan, and in the northwest of Chin-t'a.

4. Economic value: The tender branches of this plant contains a large amount of protein, and can be used as a feed for goat and camels. In winter, its leaf-less branches can only be used as feed for camels.

XXIII. *Atraphaxis pungens* (M.B.) Taunb. et Spech.
polygonaceae.

1. Area of distribution and environment: Found on the Tung-hu Mountain in the Alashan Banner, on the Shuang-hei Mountain, in the west of Chiu-ch'uan, outside of Chia-ku-kuan, at Hsiang-shan in Chung-wei of Ninghsia Province, and on gravel plains in the vicinity of Yin-ch'uan, it usually grows on the slope of gravel mountains or on level sand lands in front of mountains.

2. Effectiveness of sand fixation and suitable places for cultivation: It is a shrub, standing about 50 cm tall, with numerous branches. Its small wooden branches are thorny at the end; its branches and leaves are dense, with high resistance against aridity. It adapts to plains with sandy gravel.

3. Time of maturity of seeds: It blooms in July, and bears fruit in September-October. The seeds may be gathered at the west of Chiu-ch'uan, and P'ing-chi-pao of Yin-ch'uan.

4. Economic value: It can be used as a feed for camel only.

XXIV. *Salix cheilophila* Schneid., salicaceae.

1. Area of distribution and environment: Found at Min-ch'in, Chang-i, Chin-t'a, and An-hsi in Kansu, the southern part of Ikhohao League, northern Shensi, and Teng-k'ou of Inner Mongolia, it grows on sand land with low salinity and satisfactory moisture.

2. Effectiveness in sand fixation and suitable places for cultivation: A shrub and an excellent sand fixation plant, it is planted by local people as a "live wall." It may be planted by the side of rivers, or in swamps where the underground water level is high.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in May. Cuttings

should be done at the end of winter and the beginning of spring before the budding time.

4. Economic value: Its branches may be used to make household articles.

XXV. *Phragmites communis* Trin., gramineae.

1. Area of distribution and environment: It grows on river banks, in the shallow water of lake basins, and on the drifting sand in the T'eng-ko-li desert and the Wu-lan-pu desert where underground water level is high. It has the function of indicating where underground water level is high.

2. Effectiveness in sand fixation and suitable places for cultivation: A perennial herbal plant, it stands 2-3 m high, with strong stems and fat subterranean stems. It is a good sand fixation plant on moist sand lands, but when the sand is too high and when its root system cannot reach the underground water, it will gradually wither. With strong resistance against saline, it grows in a semi-crawling manner on the saline soil.

3. Time of maturity of seeds and places where seeds may be gathered: The fruits mature in October. Its seeds may be sown in wide areas in moist deserts.

4. Economic value: Its branches and leaves are liked

by cattle, horse, and camel when they are tender. Such tender branches and leaves may be made into hay, while its stems may be used to make mats and other household articles.

XXVI. *Elaeagnus angustifolia* L., elaeagnaceae.

1. Area of distribution and environment: Found in Ninghsia, Kansu, Shensi, Shansi, Honan, Sinkiang and Chinghai, and also at Mu-lin of the O-chi-na Banner and on the banks of the Na-lin River in Inner Mongolia, it can grow on ridges, slopes, sand flats, and swamps.

2. Effectiveness in sand fixation and suitable areas for cultivation: A woody tree, it has high resistance against cold, and saline. With dense branches and leaves, well developed root systems, and big root tubercles, it grows on flat sand land where underground water is high, and on low sand dunes under the protection of sand screens. In places with favorable natural conditions, it may be planted with cuttings.

3. Time of maturity of seeds and places where seeds may be gathered: It blooms in June and bears fruit in October. The seeds may be gathered at Mu-lin of O-chi-na Banner, on both banks of the Na-lin River, and Yin-ch'uan.

4. Economic value: Its trunk can be used as timber; its branches and leaves can be used as a feed; and its fruits can be used for brewing. It is one of the principal trees for sand protection forests.

XXVII. *Hippophae rhamnoides* L. *elaagnaceae*.

1. Area of distribution and environment: Found in Kansu, northwestern Shensi, Ikhohao League, and Shansi, it can grow on any kind of soil, such as the red soil, wet field, or sand land. It likes water, but can stand aridity.

2. Effectiveness in sand fixation and suitable places for cultivation: A shrub, it grows quickly, and multiplies easily, with strong adaptability, dense branches and leaves, and well developed root systems. It can be used for sand fixation, and the conservation of water and soil.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in July-August.

4. Economic value: Its trunk can be used as timber, and its fruits can be used for brewing.

XXVIII. *Populus diversifolia* Schrenk., *salicaceae*.

1. Area of distribution and environment: Found mostly in Min-ch'ia, Chin-t'ia, Tux-buang, An-hsi, Yu-men, and the T'eng-ko-li desert in Kansu Province, and Sinkiang, and

also in the vicinity of Teng-k'ou in Inner Mongolia, it grows on saline soil in ancient riverbeds and on river banks.

2. Effectiveness in sand fixation and suitable places for cultivation: A woody tree, it has a strong resistance against salinity. Its roots have a strong ability of tillering. Found mostly in abandoned riverbeds and on saline soil on river banks, it may be planted on saline soil where the moisture condition is satisfactory. It grows from seedlings, and seldom from cuttings.

3. Time of maturity of seeds: Its seeds mature in July.

4. Economic value: Its timber has a high resistance against moisture, and can be used to make water buckets.

XXIX. *Populus Simonii* Carr. salicaceae.

1. Area of distribution and environment: Found in Shensi, Ikhohao League, Pa-yen-cho-erh League, Ninghsia, and the Ho-hsi Corridor, it adapts to sand lands where the underground water level is high and underground water is plentiful.

2. Effectiveness in sand fixation and suitable places for cultivation: A quick growing woody tree, it likes sunshine, and has considerable resistance against aridity.

but in places where the rainfall is scarce, the underground water level is deeper than 4 m, and there is no water for irrigation, a forest of this tree can hardly be formed. Adventitious roots may grow from branches buried by sand; hence it is a good sand fixation species.

3. Time of maturity of seeds, and places where seeds may be gathered: The seeds mature in late May and early June, and they should be gathered timely.

4. Economic value: The timber may be used for construction, furniture, and wood fiber.

XXX. *Apocynum Hendersonii* Woodson, apocynaceae.

1. Area of distribution and environment: Found in Min-ch'in area in the Ho-hsi Corridor of Kansu Province, Tun-huang and all the way to Sinkiang, it grows on salinized sandy loam.

2. Effectiveness of sand fixation and suitable areas for cultivation: A perennial herb, it has woody stems, and stands 1.5-2 m high. It can stabilize 2 m high sand dunes. It may be planted on sand covered river alluvial deposits, abandoned riverbeds, sand covered farms, stabilized or semi-stabilized sand lands.

3. Time of maturity of seeds and places where seeds may be gathered: Its seeds mature in September, and may be

gathered in large quantities in the west of Tun-huang.

4. Economic value: Its fiber is long and resilient, and can be used to make fabrics, or fabrics for military use. It can also be used for making glue.

XXXI. *Pycnostelma lateriflorum* Hems., asclepiadaceae.

1. Area of distribution and environment: It is found in large quantities at Yu-lin in northern Shensi, on the semi-stabilized sand land in Ikhohao League, and on the desert steppe in the northwest of Yin-ch'uan in Ninghsia. It also grows on dry riverbeds and dry river banks.

2. Effectiveness in sand fixation and suitable areas for cultivation: It is one of the principal sand plants that grow well in the Ku-pu-ch'i desert and the Yin-keng sand area.

3. Time of maturity of seeds and places where seeds may be gathered: Its seeds mature in September.

4. Economic value: It is a poisonous plant. Its juice may cause swelling when it touches wounds on the skin. However, it may be used as a green manure.

XXXII. *Sophora alopecuroides* L. leguminosae.

1. Area of distribution and environment: Found in Shensi, Kansu, Ninghsia, Inner Mongolia, Honan Province, Central Asia and western Siberia, it thrives on the slightly salinized flat sand land on both banks of the Yellow River.

2. Effectiveness in sand fixation and suitable areas for cultivation: With high surviving ability under the pressure of sand, it multiplies by tillering at the root. It may be broadcast on mobile and semi-stabilized sand dunes, and in places where the water condition is favorable.

3. Time of maturity of seeds and places where seeds may be gathered: Its seeds mature from late July to August, and may be gathered along the banks of the Yellow River and along the brims of oases.

4. Economic value: A good green manure in the desert, it can also be used as a feed after the arrival of frost. Its roots can be used as a medicine to cure sore throat, to stop infection, and to alleviate cough.

XXXIII. *Glycyrrhiza uralensis* Fisch., leguminosae.

1. Area of distribution and environment: Found in Inner Mongolia, Chung-wei and San-sheng-kung of Ninghsia Province, on both banks of the Yellow River, at Ting-pien, and at Min-ch'in in the Ho-hsi Corridor, it grows on semi-stabilized sand land and secondary salinized abandoned farmland.

2. Effectiveness of sand fixation and suitable places for cultivation: A perennial herb, it can stand salinity, and grows in large areas. It is therefore a good sand fixation plant along the brim of farmlands, and can be broadcast in areas where irrigation facilities are available.

3. Time of maturity of seeds and places where seeds may be gathered: Its seeds mature in August, and may be gathered in areas where they are found.

4. Economic value: Its branches and leaves may be used as a feed, and its roots may be used as a medicine to alleviate cough, to cure bronchitis, and to treat gastro-intestinal disorder. It is produced in large quantities every year in China's northwestern provinces.

XXXIV. *Glycyrrhiza inflata*, Leguminosae.

1. Area of distribution and environment: Found in Chin-t'a, Tun-huang, and on both banks of the Su-le River, it grows on the lowland along the rivers and on saline soil.

2. Effectiveness in sand fixation and suitable areas for cultivation: A perennial herbal plant, it may be planted on salinized soil in the Ho-hsi Corridor, and on lands covered with drifting sand.

3. Time of maturity of seeds and places where seeds may be gathered: Its seeds mature in August, and may be gathered in large quantities at Chin-t'a, An-hsi, and Tun-huang.

4. Economic value: As a medical herb, it is only next to *glycyrrhiza uralensis* Fisch. in value.

XXXV. *Alhagi pseudoalhagi* Desv., Leguminosae

1. Area of distribution and environment: Found in the Ho-hsi Corridor, and from the west of Chang-i to Sinkiang, it grows on semi-stabilized sand land and in dry riverbeds.

2. Effectiveness in sand fixation and suitable areas for cultivation: A perennial herbal plant, it has deep roots and can stand saline. It may be planted in the border

area between farm land and the drifting sand area, in old riverbeds, and sand land along river banks.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in September, and may be gathered in large quantities in Chin-t'a, An-hsi and Tun-huang.

4. Economic value: A good grazing grass for fadders.

XXXVI. *Eurotia ceratoides* (L.) C.A.A., chenopodiaceae.

1. Area of distribution and environment: Found in Alashan, Ho-hsi Corridor, and Ordos, it grows on gravel plains in front of mountains, or sandy gravel slopes. With high resistance against aridity, it adapts to desert steppes, sandy swamps, and dry riverbeds.

2. Effectiveness in sand fixation and suitable areas for cultivation: A semi-shrub, it stands 20-40 cm high. Its shape and height varies, depending upon the amount of precipitation. It may be planted on semi-stabilized sand land as a sand fixation plant.

3. Time of maturity of seeds and places where seeds may be gathered: Its seeds mature in October, and may be gathered in Pa-yen-cho-erh League and Ikhchao League.

4. Economic value: Its leaves may be used as a fodder.

XXXVII. *Holclachne soongarica* Ehrenb., tamaricaceae.

1. Area of distribution and environment: A predominant plant in deserts and desert steppes, it is found in the deserts and gobis in Alashan and Ho-hsi Corridor. It is also found on the depressed gobis in the north of the Ting-hsi Special Administrative District in Kansu Province, and on the strongly salinized diluvial plain in front of the mountains.

2. Effectiveness in sand fixation and suitable areas for cultivation: A small shrub, it has deep roots. Adventitious roots may grow out of branches buried by sand if the moisture condition is satisfactory. Although a principal sand fixation plant, it also grows on gobis.

3. Time of maturity of seeds and places where seeds may be gathered: It blooms in July and bears fruit in September.

4. Economic value: It can be used as a feed.

XXXVIII. *Myricaria dahurica* Ehrenb. tamaricaceae.

1. Area of distribution and environment: Found around the T'ou-tao Lake in the Fa-yen-cho-erh League and at Chung-wei in Ninghsia, it adapts to river flats and sand land.

2. Effectiveness in sand fixation and suitable areas for cultivation: A shrub, it has adventitious roots when

its branches are buried by sand. A good sand fixation plant, it likes water, and grows on river flats.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in August-September, and may be gathered near Lung-kung Lake at Chung-wei.

4. Economic value: A fuel.

XXXIX. *Juniperus sabina* L., *coniferae*.

1. Area of distribution and environment: It is found on the semi-stabilized sand lands in the south of Ikhchao League and northern Shensi.

2. Effectiveness in sand fixation and suitable areas for cultivation: A shrub, its branches can extend from semi-stabilized sand land to the drifting sand. It is a good sand fixation plant in Ikhchao League.

3. Economic value: A feed for goats only.

XL. *Inula salsoloides* Steud. *compositae*.

1. Area of distribution and environment: Found in Ikhchao League, Pa-yen-cho-erh League, Che-li-mu League and the Ho-hsi Corridor, it grows at the base of mobile crescent sand dunes, at the lower part of semi-stabilized sand dunes, and on the lowland between the sand dunes. But at the Che-li-mu League, it grows on the top of sand dunes.

2. Effectiveness in sand fixation and suitable areas for cultivation: A perennial herbal plant, it stands 29-30 cm high, and grows in population at the base of sand dunes or between sand dunes. It may be planted at the base of sand dunes, or between sand dunes in area under survey.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in July-August, and may be gathered at Min-ch'in and San-p'ing-k'ou.

4. Economic value: A feed for camels.

XLI. *Oxytropis aciphylla* Ldb., leguminosae.

1. Area of distribution and environment: Found on rocky lands on the Cho-tzu (Table) Mountain, in the west of Ho-lan Mountain, and the plain in front of the mountain in the west of Chung-wei, it grows on semi-stabilized sand land.

2. Effectiveness in sand fixation and suitable areas for cultivation: It grows like a cushion, and can gather the drifting sand around it. It may be planted on arid diluvial or proluvial sediments, and on monadnocks.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds may be gathered at Min-ch'in and San-p'ing-k'ou.

4. Economic value: It can be used as a feed for camels.

XLII. *Iris ensata* L., liliaceae.

1. Area of distribution and environment: Found on meadow saline soil or saline soil in north China and north-west China, it forms population during the grazing period.

2. Effectiveness in sand fixation and suitable areas for cultivation: A perennial herbal plant, it stands 30-50 cm, or sometimes 1 m high. With strong roots, it has a good sand fixation and wind breaking effect.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature at the end of August, and may be gathered even in September-October.

4. Economic value: A poor feed. Its tissues can be used to make paper, and its roots may be used to make brushes.

XLIII. *Achnatherum splendens* Ohwi., gramineae.

1. Area of distribution and environment: Found in Ikhohao League, Pa-yen-cho-erh League, and Ho-hsi Corridor, it grows on the second terrace of the Yellow River, and on the brim of lake basins in large population. It also appears in dry river valleys, in the ditches of low mountains, and in mountain valleys.

2. Effectiveness in sand fixation and suitable areas

for cultivation: A perennial herbal plant about 1 m high, it forms a hill-like bush, and furnishes protection to lake basins

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature at the end of August, and may be gathered on the terraces of the Yellow River from Teng-k'ou of Pa-yen-cho-erh League to San-tao-kan.

4. Economic value: It may be used as a year round feed for livestock. It is a particularly important feed in winter and in the drought season. Its stem may be used to make baskets, and all parts above the ground may be used to make paper.

XLIV. *Oxytropis glabra* (Lam.) DC. leguminosae.

1. Area of distribution and environment: It is found on lake shores, in river valleys, or on saline soils in Ikhchao League, Pa-yen-cho-erh League and Ho-hsi Corridor. It is most widely found on the lake shores in Ikhchao League.

2. Effectiveness in sand fixation and suitable areas for cultivation: A perennial herb, it can stand high salinity and high aridity. According to local herdsmen, it thrives in drought years. It has a good sand fixation effect on lake shores. It is poisonous to domestic animals.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in September-October.

4. Economic value: A poisonous plant.

XIV. *Ampelopsis acnitifolia* Ege., vitaceae.

1. Area of distribution and environment: It grows on sandy lands and dry slopes in Inner Mongolia, Che-li-mu League, and northern Shensi.

2. Effectiveness in sand fixation and suitable areas for cultivation: A herbal shrub, it protects rivers from the invasion of drifting sand. It can be used as a sand fixation plant on moist sand land in the steppe area.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in July-September, and may be gathered in the Yu-lin area.

XLVI. *Caryopteris mongolica* Ege., verbenaceae.

1. Area of distribution and environment: Found in Shensi, Kansu, Ninghsia, and Inner Mongolia. It likes to grow in river valleys, in the lower parts of valleys between mountains, and on the terraces of the Yellow River.

2. Effectiveness in sand fixation and suitable areas for cultivation: It may be used as a sand fixation plant on mountain slopes or valleys where the water

condition is satisfactory, and the mobility of sand is low.

3. Economic value: Its flower is beautiful, and can be used for decoration.

XLVII. *Panzeria lanata* (L.) Bge., labiatae.

1. Area of distribution and environment: Found at San-sheng-kung, and the Table Mountain in Inner Mongolia, and Yin-ch'uan of Ninghsia, it appears scarcely on sandy terraces of rivers, on diluvial slopes in front of mountains, and on stabilized and semi-stabilized sand lands.

2. Effectiveness in sand fixation and suitable areas for cultivation: A perennial herbal plant, it may be planted on less mobile sand lands, or between sand dunes which begin to stabilize.

3. Economic value: A feed for livestock.

XLVIII. *Oxytropis psammocharis*, leguminosae.

1. Area of distribution and environment: It is found on sand flats along the rivers, or in sandy riverbeds in Ikhohao League in Inner Mongolia, and northern Shensi.

2. Effectiveness in sand fixation and suitable areas for cultivation: An annual herbal plant, it can grow on drifting sand where the wind is weak. As a short and small plant, it has little sand fixation effect.

3. Time of maturity of seeds and places where seeds may be gathered. The seeds mature at the end of August, and may be gathered at Ikhokao League in Inner Mongolia, and northern Shensi.

4. Economic value: A feed for animals.

XLIX. *Ulmus pumila* L., ulmaceae.

1. Area of distribution and environment: One of the principal woody plants in arid areas, it can grow on different kinds of soils. It is often seen in single plants in the western part of Inner Mongolia. Wild *ulmus pumila* L. usually grows in abandoned riverbeds.

2. Effectiveness in sand fixation and suitable areas for cultivation: It has a high adaptability to aridity, but it requires better soil than the willow. It may be used for forest belts on the brim of lake basins and along the perimeters of oases. It can grow in almost any arid area.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in May.

4. Economic value: Its leaves may be used as a feed for goat and sheep. The timber may be used to make carts, and plows. The withered branches can be used as a fuel; its tender leaves and fruits are edible, and can be

used as a feed for pigs. The tissue of its bark is strong and resilient, and may be used to make ropes or fabrics.

L. *Armeniaca sibirica* Lam., rosaceae.

1. Area of distribution and environment: It is widely found in steppes in northeast China, north China and east Inner Mongolia. It is also found on gravel slopes and stabilized sand dunes.

2. Effectiveness in sand fixation and suitable areas for cultivation: A big shrub, it can grow on poor soil in dry climate. It can be used for wind breaking forests on stabilized sand lands in the Ikhobac League and northern Shensi.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in June, and may be gathered near Ta-ch'ing Mountain in Inner Mongolia.

4. Economic value: Its seed kernel can be used for making oil.

LI. *Amorpha fruticosa*, leguminosae.

1. Area of distribution and environment: It is cultivated in north China, Kansu, and northern Shensi. In the northeast and north China, it has become a semi-self growing plant.

2. Effectiveness in sand fixation and suitable areas

for cultivation: A thriving shrub, it may be planted along the banks of rivers and ditches.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in August-September.

4. Economic value: It can be used as a green manure. Its branches can be used to make baskets. Its leaves and branches can absorb alkaline, and therefore it can be used to transform alkaline soil. In addition, its roots have radicle bacillus, and hence have a soil improvement effect.

LII. *Kochia prostrata* (L.) Schrad., chenopodiaceae.

1. Area of distribution and environment: It grows on saline sand soil in Ikhchao League, Pa-yen-cho-erh League, and Ho-hsi Corridor.

2. Effectiveness in sand fixation and suitable areas for cultivation: A semi-shrub with crawling branches, it stands saline. Hence it may be planted on salinized sandy soil.

3. Economic value: A good feed.

LIII. *Populus sinica* Liu et Wang, salicaceae.

1. Area of distribution and environment: Found on the Yellow River alluvial plain in the Ninghsia Hui Autonomous Region and the Ho-hai Corridor in Kansu, it

usually grows on river banks, by the side of ditches, and in areas surrounding villages where irrigation facilities are available.

2. Sand fixation effect and suitable areas for cultivation: It is a woody tree, and its trunk can grow adventitious roots when it is buried by sand. A good sand fixation plant, it should be planted in places where the underground water level is high and where irrigation facility is available.

3. Time of maturity of seeds and places where seeds may be gathered: It is multiplied by asexual reproduction before the budding time in early spring.

4. Economic value: Its timber may be used for construction, and making furniture.

LIV. *Populus alba* Linn., salicaceae.

1. Area of distribution and environment: Found in Chiu-ch'uan and Tun-huang area, it adapts to places where water is plentiful.

2. Effectiveness in sand fixation and suitable areas for cultivation: A big woody tree, it grows fast, and can stand salinized soil. Its branches and roots have a high tillering ability. With good sand fixation effect, it should be planted along river banks, by the side of

ditches, and areas surrounding water reservoirs.

3. Time of maturity of seeds and places where seeds may be gathered: It multiplies by its roots, which can be gathered at Chiu-ch'uan and the One Thousand Buddha Grove at Tun-huang.

4. Economic value: Its timber may be used for construction, for making furniture, and for making wood fiber.

LV. *Lycium chinense* Hill., solanaceae.

1. Area of distribution and environment: It grows on the second terrace of the Yellow River covered by a layer of loose sand, and in "sealing the sand and raising the grass" areas in the Ho-hsi Corridor where the soil is loose and fertile.

2. Effectiveness in sand fixation and suitable area for cultivation: A 1.5 m high shrub, it may be planted on salinized sandy soil, or along the banks of ditches. Thorn-less and with big fruits, it is cultivated by people at Chung-ning in Ninghsia Province as a medical herb.

3. Time of maturity of seeds and places where seeds may be gathered: Its fruits ripen at the end of July. Its seeds may be gathered at Chung-ning, or on the second terrace of the Yellow River.

4. Economic value: A famous medicinal herb for expert, its roots can be used to cure tuberculosis, and its fruits can be used as a tonic and to cure women's diseases.

LVI. *Thermopsis lanceolata* R. Br., leguminosae.

1. Area of distribution and environment: It grows on low-lying and swampy sandy land and salinized soils in Che-li-mu League, Ikhohao League, and Pa-yen-cho-erh League of Inner Mongolia, Chung-wei of Ninghsia Province, and the Ho-hsi Corridor of Kansu Province.

2. Effectiveness in sand fixation and suitable areas for cultivation: It may be seeded in salinized soils in lacustrine basins.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in August, and may be gathered in Ikhohao League and the T'ou-tao Lake in Pa-yen-cho-erh League.

4. Economic value: A raw material for making green manure.

LVII. *Karelinia caspica* Less., compositae.

1. Area of distribution and environment: Found on the Ninghsia Plain and in the west of Ho-hsi Corridor, it grows on salinized sand land.

2. Effectiveness in sand fixation and suitable areas

for cultivation: A 30-40 cm high perennial herbal plant. Its main root extends horizontally after it reaches about 70-80 cm deep from the surface. Adventitious roots are grown when the main root reaches the underground water level. It may be seeded on slightly salinized sand lands in Ho-hai Corridor.

3. Time of maturity of seeds and places where seeds may be gathered: Its seeds mature in August-September, and may be gathered at Chin-t'a and the Ho-hai Corridor.

4. Economic value: A fuel.

LVIII. *Ephedra Przewalskii* Stapf., gnetaceae.

1. Area of distribution and environment: It is found in the gobis at Chin-t'a, Yu-men, and An-hai in Kansu Province, and on the gypsum desert soil in the vicinity of Na-lin-su-hai-t'u in Pa-yen-cho-erh League of Inner Mongolia. Its most suitable environment is either gypsum gobi, or gypsum desert.

2. Effectiveness in sand fixation and suitable areas for cultivation: A small shrub, it has a strong resistance against aridity, and gypsum. On gobis, a small mound of sand, about 1 m high, gathers around each plant of *ephedra Przewalskii* Stapf. Hence, it has a good effect in fixing the drifting sand in gobis.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in July, and should be gathered in time.

4. Economic value: A medicinal herb, it can be used to make ephedrine and to cure bronchitis.

LIX. *Tetraena mongolica* Maxim., zygothylaceae.

1. Area of distribution and environment: Found only between the Table Mountain and the Yin Mountain in Ikhobao League, it grows on land covered with a thin layer of sand.

2. Effectiveness in sand fixation and suitable areas for cultivation: It is a 50-60 cm high small shrub, but its branches are strong and woody. It has the effect of slowing down the velocity of wind, and the movement of sand.

3. Time of maturity of seeds and places where seeds may be gathered: It blooms in June and bears fruits in September, and its seeds may be gathered in the vicinity of San-sheng-kung and between the Table Mountain and the Yin Mountain.

4. Economic value: A rare plant species, it should be preserved and well protected. It is also a good fuel.

LX. *Penisetum flaccidum* Griseb., gramineae.

1. Area of distribution and environment: A perennial

plant, it has a high adaptability to aridity and poor soil. Its subterranean stems can grow again even after being exposed under the sun for several days, if they are buried in the earth again.

3. Time of maturity of seeds and places where seeds may be gathered: Its seeds mature in September.

4. Economic value: A good grazing grass.

LXI. *Calamagrostis epigeios* (L.) Roth., gramineae.

1. Area of distribution and environment: It grows on river flats in Ikhchao League, Pa-yen-cho-erh League and the Ho-hsi Corridor, and on arid semi-stabilized sand dunes in Che-li-mu League and Liao-ning. It is a principal grass grown on pastures in desert areas.

2. Effectiveness in sand fixation and suitable areas for cultivation: A 1 m tall perennial gramineous plant with rhizoma, it has wide and fan-shaped leaves. More of this plant should be planted in moist sandy areas in order to strengthen its sand fixation effect.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in early September.

4. Economic value: It is not quite liked by livestock, but it may be used as a reserve feed.

LXII. *Aristida adscensionis* L., gramineae.

1. Area of distribution and environment: It grows on semi-stabilized and stabilized sand dunes, on gobis, and in dry riverbeds in Pa-yen-cho-erh League, Ikhohao League and the Ho-hsi Corridor. Sometimes, it appears on mobile sand dunes.

2. Effectiveness in sand fixation and suitable areas for cultivation: It is a 5-15 cm tall annual herbal plant, with stems and leaves growing and expanding from the base. It thrives in years with more precipitation, and it may be seeded on semi-stabilized sand lands.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in September.

4. Economic value: A good feed, animals are often hurt by the thorns on its fruit.

LXIII. *Bassia dasyphylla* O. Ktze., chenopodiaceae.

1. Area of distribution and environment: Found in Che-li-mu League, Pa-yen-cho-erh League and Ikhohao League of Inner Mongolia and the Ho-hsi Corridor, it grows on level sand lands, and at the base of semi-stabilized crescent sand dunes.

2. Effectiveness in sand fixation and suitable areas for cultivation: It is a small 2-3 cm tall annual herbal

plant growing on dry sand lands. In places where humidity is higher, it may grow to 40-50 cm tall. It may be planted between crescent-shaped sand dunes or on semi-stabilized sand dunes as a "vanguard" sand fixation plant.

3. Time of maturity of seeds and places where seeds may be gathered: It blooms in July, and may be gathered on the alluvial plains in front of the mountains in Ho-hsi.

4. Economic value: A feed for animals.

LXIV. *Salsola collina*, chenopodiaceae.

1. Area of distribution and environment: Found in the Ho-hsi Corridor and Ordos, it grows on sand lands, on gravel slopes, and on dry riverbeds. It adapts to slightly sandy base rocks, roadside, and wasteland.

2. Effectiveness in sand fixation and suitable areas for cultivation: It is an annual herbal plant with strong adaptability. It may be planted in populations of *Artemisia ordosica* Krasch. for reinforcing their sand fixation effect.

3. Time of maturity of seeds and places where seeds may be gathered: It blooms from June to September, and bears fruit around September. Its seeds may be gathered in the Ho-hsi Corridor.

4. Economic value: A grass much liked by animals.

LXV. *Potamois mongolica* Maxim., rosaceae.

1. Area of distribution and environment: It is a predominant plant found in the southern and northern parts of the Alashan Banner of the Pa-yen-cho-erh League and on the plains in front of mountains to the west of the Otok Banner of Ikhohae League. Sometimes, it grows together with *Reaumuria soongorica* (Pall.) Maxim., and *Salsola passerina* Bge.

2. Effectiveness in sand fixation and suitable areas for cultivation: It is a small shrub, 40-50 cm high. Its root is 30-40 cm long. It plays dead in drought years, and lives again when it meets water. It may be seeded on dry stabilized sand lands.

3. Economic value: A medium quality feed.

LXVI. *Caragana tibetica*, leguminosae.

1. Area of distribution and environment: It grows on low mountains and on diluvial plains in front of mountains in the southwestern part of the Ho-lan Mountain in Pa-yen-cho-erh League.

2. Effectiveness in sand fixation and suitable areas for cultivation: A cushion-like small shrub, it can prevent the movement of drifting sand on the ground. It may be seeded on diluvial plains in front of mountains, and

on piedmont drifting sand areas.

3. Time of maturity of seeds: The seeds mature in June.

4. Economic value: A feed for camels.

LXVII. *Cleistogenes mutica* Keng. gramineae.

1. Area of distribution and environment: An important plant found in the gobis, plains in front of mountains, and stabilized sand lands in Pa-yen-cho-erh League, it grows sometimes in swamps, and by the side of small ditches.

2. Effectiveness in sand fixation and suitable areas for cultivation: A perennial herbal plant growing in bushes, it has some effect in sand fixation. It may be seeded on semi-stabilized sand lands in Pa-yen-cho-erh League and the Ho-hsi Corridor.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in the first decade of September, and may be gathered on the plains in the northern part of Alashan Banner and on stabilized sand land in the southern part of the banner.

4. Economic value: An excellent feed, much liked by sheep and horses. It is regarded as a body building fodder for the horses.

LXVIII. *Stipa glareosa* Smirn., gramineae.

1. Area of distribution and environment: A principal

vegetation on semi-stabilized sand lands in Ordos, Pa-yen-cho-erh League and the Ho-hai Corridor, it is widely found on plains in front of mountains, on dry riverbeds, and on gobis.

2. Effectiveness in sand fixation and suitable areas for cultivation: A small 20cm tall annual herbal plant, it may be seeded in rainy season for sand fixation.

3. Time of maturity of seeds: The seeds mature at the end of August.

4. Economic value: A first grade feed, it is much liked by domestic animals in spring, autumn, and summer. In winter, the starved animals may restore their stamina if they are put to graze on pastures with this plant.

LXIX. *Stipa gobica* Roshev., gramineae.

1. Area of distribution and environment: It grows on plains in front of mountains, in gobis, on dry riverbeds, and on petrified mountain slopes in Pa-yen-cho-erh League and in the Ho-hai Corridor.

2. Effectiveness in sand fixation and suitable areas for cultivation: Same as *Stipa glareosa* Smirn.

3. Time of maturity of seeds: Same as *Stipa glareosa* Smirn.

4. Economic value: Same as *Stipa glareosa* Smirn.

LXX. *Aneurolepidium dasystachys* (Trin.) Nevski,
gramineae.

1. Area of distribution and environment: It is widely distributed, but seldom appears in large quantities. It is often seen on slightly salinized meadow soil, on mountain slopes, and on gravel layers.

2. Effectiveness in sand fixation and suitable areas for cultivation: A perennial herbal plant with rhizoma, it seldom forms a big group, but it has a strong adaptability, and thrives on slightly salinized sandy soil. It may be seeded on semi-stabilized sand lands as a subsidiary sand fixation plant.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds ripen in August.

4. Economic value: An excellent feed with body-building effect.

LXXI. *Agropyron cristatum* (L.) Gaertn. gramineae.

1. Area of distribution and environment: Widely found in populations of *Artemisia ordosica* on the Ordos plateau, it also appears in the valleys of low rocky mountains in Pa-yen-cho-erh League.

2. Effectiveness in sand fixation and suitable areas for cultivation: A typical steppe plant, it stands aridity,

cold, and poor soil. It may be seeded as a sand fixation plant on stabilized sand dunes in Ikhobao League.

3. Time of maturity of seeds and places where seeds may be gathered: Its seeds mature in July, and may be gathered in Che-li-mu League and the eastern part of Liaoning Province.

4. Economic value: One of the excellent feeds, it is cultivated in north China and the Mongolia People's Republic.

LXXII. *Agropyron mongolicum* Keng., gramineae.

1. Area of distribution and environment: Found on sand lands of the Ikhobao plateau, it often grows together with *Artemisia ordosica*. It also appears in the valleys of Pa-yen-cho-erh League.

2. Effectiveness in sand fixation and suitable areas for cultivation: A 1 m tall perennial herbal plant, it stands weathering and aridity, and therefore is an excellent sand fixation plant for semi-stabilized sand lands.

3. Time of maturity of seeds: End of August.

4. Economic value: An excellent feed.

LXXIII. *Artemisia frigida* Killd., compositae.

1. Area of distribution and environment: It is found in loess piedmont areas, on stabilized sand lands on the Ordos plateau, and on stabilized sand lands in the Pa-yen-cho-erh League and the Ho-hsi Corridor.

2. Effectiveness in sand fixation and suitable areas for cultivation: A semi-shrub, it has short roots. New plants can easily grow out of adventitious roots on stabilized sand lands.

3. Time of maturity of seeds: September.

4. Economic value: A good feed, it should be cultivated in large quantities.

LXXIV. *Apocynum venetum* L., *Asclepiadaceae*.

1. Area of distribution and environment: Found in Min-ch'in in the Ho-hsi Corridor, and Chung-wei in Ninghsia Province, it grows on salinized sandy loam.

2. Effectiveness in sand fixation and suitable areas for cultivation: It may be planted on stabilized or semi-stabilized slightly salinized sand lands, and on the lake shores in the Alashan Banner.

3. Time of maturity of seeds: September.

4. Economic value: Its tissue may be used to make fabrics, and its tender leaves may be used as a substitute for tea.

LXXIV. *Gymnocarpus Przewalskii* Maxim., caryophyllaceae.

1. Area of distribution and environment: It grows on the Tung-hu Mountain in Pa-yen-cho-erh League, on the plains in front of the Pa-yen-wu-la Mountain, and sometimes on dry riverbeds.

2. Effectiveness in sand fixation and suitable areas for cultivation: A 50 cm tall shrub, it has numerous branches but very small leaves. It may be used as a sand fixation plant, but it is hard to gather the seeds. Seldom does it form a large patch on the ground.

3. Time of maturity of seeds: Early September.

4. Economic value: A much liked food of camels.

LXXVI. *Populus hopeiensis* Hu & Chow, salicaceae.

1. Area of distribution and environment: It is found in small quantities in the dry loess piedmont area in central Kansu, at Ku-lang, Wu-wei, and Chin-t'a in the Ho-hsi Corridor. It thrives on comparatively thick layers of sandy loam. Although it stands aridity, a certain amount of water is required for its growth.

2. Effectiveness in sand fixation and suitable areas for cultivation: A woody tree, it multiplies by tillering at the root. With good sand fixation effects, it can be planted in loess areas covered with sand where the moisture

condition is satisfactory.

3. Time of maturity of seeds and places where seeds may be gathered: It is rather hard to multiply this plant by cuttings or raising the seeds. In many places, the roots are used for growing new plants.

4. Economic value: Its timber may be used for construction and making furniture.

LXXVII. *Thalictrum squarrosus* Steph., ranunculaceae.

1. Area of distribution and environment: It grows on stabilized sand lands in western Liaoning, Che-li-mu League, and Ikhchao League.

2. Effectiveness in sand fixation and suitable areas for cultivation: A 50 cm tall perennial herbal plant, it has feathery leaves. Its branches are broken by wind in autumn, and hence it has little effect in sand fixation.

3. Time of maturity of seeds: August.

4. Economic value: A favorite food of camels.

LXXVIII. *Echinops Gmelini* Turcz., compositae.

1. Area of distribution and environment: Found in Pa-yen-cho-erh League, Ikhchao League, and the Ho-hsi Corridor, it is scattered along the perimeters of drifting sand or on semi-stabilized sand lands.

2. Effectiveness in sand fixation and suitable areas

for cultivation: A 30-30 cm tall annual herbal plant, it stands straight, and has thorns around its leaves. Since it covers only a small area of the sandy land, it has little significance in sand fixation.

3. Time of maturity of seeds: September.

4. Economic value: Its inflorescence may be used as a feed.

LXXIX. *Scorzonera divaricata* Turcz., compositae.

1. Area of distribution and environment: Found in Pa-yen-cho-erh League, Ikhohao League, and the Ho-hsi Corridor, it likes to grow by the side of dry riverbeds, on the sandy loams in shallow swamps, and occasionally on slightly salinized sand lands.

2. Effectiveness in sand fixation and suitable areas for cultivation: A 15-30 cm tall perennial herbal plant, it branches off from its basal parts, and forms a semi-spherical bush, but it has little significance in sand fixation.

3. Time of maturity of seeds: End of July.

4. Economic value: A feed.

LXXX. *Stellaria gypsophiloides* Fenzl., caryophyllaceae.

1. Area of distribution and environment: It grows on stabilized sand dunes in Ikhohao League and Pa-yen-cho-erh

League.

2. Effectiveness in sand fixation and suitable areas for cultivation: A 50 cm tall perennial herb, it has a big root system, and has many branches. The whole plant takes the shape of a ball. In August-September, its dry branches are blown away by wind. Hence, it is not a good sand fixation plant.

3. Time of maturity of seeds: August.

4. Economic value: Not liked by animals even in winter. When it is dried, it is reluctantly eaten by camels. Its root can be used as a medicine.

LXXXI. *Peucedanum rigidum* Bge., umbelliferae.

1. Area of distribution and environment: It is widely found on river alluvial sediments in the Fa-yen-cho-erh League, on big lattice-shaped sand dunes, and on mobile sand dunes in the Teng-ko-li desert.

2. Effectiveness in sand fixation and suitable areas for cultivation: A 30-50 cm tall perennial herb, its parts above the ground wither after the ripening of the seeds, and are then carried away by wind. Hence, it is insignificant as a sand fixing plant.

3. Time of maturity of seeds: End of August.

4. Economic value: A favorite food of camels.

LXXXII. *Hologeton arachnoides* Moq., chenopodiaceae.

1. Area of distribution and environment: Found in the west of Chin-t'a, it grows on flat gypsum gray brown desert soil, or on sand land with gravel. It thrives in ditches with running water. In dry environments, it is small and short, about 10 cm tall.

2. Effectiveness in sand fixation and suitable areas for cultivation: An annual plant, it stands aridity, but its branches and leaves are small. Insignificant as a sand fixing plant.

3. Time of maturity of seeds: It blooms at the end of July.

4. Economic value: It can be used as a feed in winter and early spring.

LXXXIII. *Peganum nigellastrum* Sge., zygophyllaceae.

1. Area of distribution and environment: It is widely found in Ikhchao League and Pa-yen-cho-erh League, seldom seen in the Ho-hsi Corridor, and widely found near the water wells, and cultivated wasteland covered by a thin layer of sand. Sometimes, it is also found on rocky slopes and alluvial fragmentary deposits in front of mountains.

2. Effectiveness in sand fixation and suitable areas

for cultivation: A perennial herb, it stands 15-20 cm tall, and has a strong tillering ability at the roots. It can stand aridity, but it has little sand fixation effect after the withering of its branches and leaves.

3. Time of maturity of seeds: It blooms in the middle of June, and bears fruit in July-August.

4. Economic value: It can be used as a feed and a green manure.

LXXXIV. *Cynanchum pubescens* Ege. asclepiadaceae.

1. Area of distribution and environment: It is found in large quantities in "sealing the sand and raising the grass" areas at Min-ch'in and Anhsi in the Ho-hsi Corridor. In the Teng-ko-li desert, it often grows on the ground between sand dunes on which *Nitraria schoberi* grows.

2. Effectiveness in sand fixation and suitable areas for cultivation: A perennial crawling herb, it grows fast, and covers a large area of sand in a short time. After it withers, it has no significance in sand fixation.

3. Time of maturity of seeds: August.

4. Economic value: Not liked by animals.

LXXXV. *Swainsonia salsa* Taub., leguminosae.

1. Area of distribution and environment: Found in the Ho-hsi Corridor, Ninghsia, Ikhobac League and

Pa-yen-cho-erh League, it is scattered on the salinised sand lands along rivers and around the lake basins.

2. Effectiveness in sand fixation and suitable areas for cultivation: A perennial herb, it has fine and weak branches and small leaves, and is, therefore, insignificant as a sand fixation plant.

3. Time of maturity of seeds: August-September.

4. Economic value: Disliked by domestic animals, it can be used to make green manure.

LXXXVI. *Dasiphora parvifolia* Jns, rosaceae.

1. Area of distribution and environment: It appears in small patches on gravel dunes or on stabilized sand lands in the valleys between the Yin Mountain and the Table Mountain.

2. Effectiveness in sand fixation and suitable areas for cultivation: A small shrub standing about 25 cm tall, it has numerous branches, and can stand aridity, but it can grow only on stabilized sand lands. It is insignificant as a sand fixation plant.

3. Economic value: Its tender branches can be used as a feed for sheep. A poor feed.

LXXXVII. *Caragana stenophylla* Pojark, leguminosae.

1. Area of distribution and environment: Found in

Chung-wei of Ninghsia, on the eastern and western slopes of the Ho-lan Mountain in Inner Mongolia, and in the Alashan Banner of Pa-yen-cho-erh League, it grows on mountain slopes, diluvial plains in front of mountains, and on the alluvial terraces of the Yellow River.

2. Effectiveness in sand fixation and suitable areas for cultivation: A small shrub, it can grow on diluvial deposits in front of mountains, on stabilized sand lands, and on monadnocks covered by drifting sand. However, it is too small to have any significance as a sand fixation plant.

3. Time of maturity of seeds: July

4. Economic value: A feed for camels.

LXXIVIII. *Lespedeza dahurica* Schind., leguminosae.

1. Area of distribution and environment: Found in Ikhchao League of Inner Mongolia, Shensi, Kansu, and Ninghsia, it grows on semi-stabilized and stabilized sand lands.

2. Effectiveness in sand fixation and suitable areas for cultivation: A short shrub with strong adaptability, it may be seeded on semi-stabilized and stabilized sand lands.

3. Time of maturity of seeds and places where seeds

may be gathered: The seeds may be gathered in the various banners of Ikhchac League.

4. Economic value: An excellent feed.

LXXXIX. *Allium mongolicum* Bge. Liliaceae.

1. Area of distribution and environment: Found in Ikhchac League, Pa-yen-cho-erh League, and the Ho-hsi Corridor, it grows in desert steppe area, and in slightly sandy soil, or soil covered by sand. It usually grows together with *Pipatanthus mongolicus* Maxim., *Zygophyllum*, *Xanthoxylon* Maxim., and *Artemisia sphaerocephala* Krasch.

2. Effectiveness in sand fixation and suitable areas for cultivation: A 10-20 cm tall perennial herb, it can stand extreme aridity. It may be planted on semi-stabilized and stabilized sand dunes as a sand fixation plant.

3. Time of maturity of seeds and places where seeds may be gathered: It blooms in July and August, and bears fruit in August-September, but the plant withers very fast in autumn.

4. Economic value: A good feed.

XC. *Tournefortia sibirica*, Boraginaceae.

1. Area of distribution and environment: Found in Chelien League, Ikhchac League, Pa-yen-cho-erh League, and Ho-hsi-Corridor, it grows on salinized lowland between

sand dunes, or on level semi-stabilized sand lands.

2. Effectiveness in sand fixation and suitable areas for cultivation: A perennial herb with rhizoma, it multiplies through the tillering of roots. Seeds are also used for the raising of new plants. It may be planted on salinized semi-stabilized sand dunes, or on lowlands between sand dunes.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature at the end of August.

4. Economic value: A feed for animals.

XCI. *Convolvulus fruticosus* Pall., convolvulaceae.

1. Area of distribution and environment: It is found principally between the Yin Mountain and the Table Mountain in the Fa-yen-cho-erh League, and between the Ya-pu-lai salt lake and the Ya-pulai Mountain, but seldom seen in the Ho-hei Corridor. It usually grows on sandy or gravel soil.

2. Effectiveness in sand fixation and suitable areas for cultivation: A 40-50 cm tall thorny shrub, it looks like a cushion in shape, and can slow down the velocity of wind and sand.

3. Time of maturity and places where seeds may be gathered: The seeds may be gathered in the Fa-yen-cho-erh

League between the Yin Mountain and the Table Mountain.

XCII. *Kalidium foliatum* (Pall.) Mong., chenopodiaceae.

1. Area of distribution and environment: Found in the Pa-ye-cho-erh League and the Ho-hsi Corridor, it grows on loose saline soil, on slightly salinized sand land, and on salinized lowland between the sand dunes. There are two more sub-species growing on the side of lakes, namely, *K. gracile* Fenzl, and *K. caspicum*. Their sand fixation effect is about the same as *K. foliatum*, but can stand salinity even better.

2. Effectiveness in sand fixation and suitable areas for cultivation: A semi-shrub, it stands 20-50 cm tall, and forms bushes. Its leaves are juicy. In the outer perimeter of drifting sand in the Ho-hsi Corridor and the Alashan Banner, it may be planted as a sand fixation plant.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in August-September, and may be gathered at Chin-t'a and Min-ch'in.

4. Economic value: Its seeds are edible, and the plant itself may be used as a feed for camels in winter and spring.

XCIII. *Clematis fruticosa* Turcz., ranunculaceae.

1. Area of distribution and environment: Found in the

gobis, and on low mountains in the Pa-yen-cho-erh League, it grows along the water ditches, and on dry riverbeds.

2. Effectiveness in sand fixation and suitable areas for cultivation: A 0.5 m tall shrub, it stands aridity and may be used as a sand fixation plant. But its seeds are hard to gather, nor can this plant grow into big patches.

3. Time of maturity of seeds: August.

4. Economic value: A feed for camels.

XCIV. *Buddleia alternifolia*, loganiaceae.

1. Area of distribution and environment: Found on alluvial sediments in Shensi and Kansu, it grows well on the Yellow River terrace at Chung-wei in Ninghsia.

2. Effectiveness in sand fixation and suitable areas for cultivation: A 1 m woody plant, it stands either erect or slanted. It has the effect of protecting the banks of the Yellow River.

3. Economic value: Its flower is beautiful and fragrant, and can be used for decoration.

XCV. *Asterothamnus centrali-asiaticus* Novopokr.,
compositae.

1. Area of distribution and environment: Found in the Ikhobao League, the Pa-yen-cho-erh League and the Ho-hsi Corridor, it likes to grow on gravel-sandy alluvial soil,

on gravel layer, or on gravel sand land.

2. Effectiveness in sand fixation and suitable areas for cultivation: A 50-60 cm high semi-shrub, it has numerous branches, and can stand aridity. Its leaves are hairy and gray in color. It may be seeded on alluvial sandy land.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds ripen in August-September, and may be gathered on dry gravel-sandy riverbeds, and in the gobis in the Ho-hsi Corridor.

4. Economic value: A good feed for camels, but not for cattle and horses.

XCVI. *Salsola passerina* Bge., chenopodiaceae.

1. Area of distribution and environment: Found in Ordos and the Alashan Banner, it likes to grow on loam covered with a thin layer of sand. On soils covered by a thick layer of sand or a large quantity of broken rocks, it is replaced by *Hololachne songarica*.

2. Effectiveness in sand fixation and suitable areas for cultivation: A 20-30 cm tall small semi-shrub, its root system goes down to the soil to a depth of 30-40 cm. Its basal parts can stop a small amount of sand. With a low resistance against aridity, it may be seeded on

diluvial plains in front of mountains in eastern Ho-hsi, the Alashan Banner and the Ordos.

3. Time of maturity of seeds and places where seeds may be gathered: It blooms at the end of June, and bears fruit in August-September, and its seeds may be gathered on the plains in front of the Nan Mountain in the vicinity of Chia-ku-kuan.

4. Economic value: A feed.

XCVII. *Amygdalus mongolica* Maxim, rosaceae.

1. Area of distribution and environment: It is widely found on rocky mountains and piedmonts, in valleys and dry riverbeds in the Pa-yen-cho-erh League.

2. Effectiveness in sand fixation and suitable areas for cultivation: A 1-2 m tall woody plant, it spreads out like a cushion on the ground. With dense but thorny branches and leaves, it can stand aridity and poor soil. It may be seeded in the alluvial ditches or valleys in the Ikhokho League, the Pa-yen-cho-erh League and the Ho-hsi Corridor.

3. Time of maturity of seeds and places where seeds may be gathered: The fruits ripen in late July, and the seeds may be gathered in the vicinity of Ta-ch'ing Mountain in Inner Mongolia.

4. Economic value: Its kernels may be used to extract oil.

XCVIII. *Amygdalus pedunculata* Pall., rosaceae.

1. Area of distribution and environment: It grows on the brim of sandy land, on sandy steppes, and on rocky slopes in the Ikhchao League.

2. Effectiveness in sand fixation and suitable areas for cultivation: A 2-3 m tall shrub, it stands aridity, and may be seeded on comparatively stable sand lands in the Ikhchao League, or on arid and hard sandy ridges.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in August, and may be gathered in the vicinity of Yin-keng-sha-wo.

4. Economic value: Its seeds may be used for extracting oil.

XCIX. *Nitraria sphaerocarpa* Maxim. zygophyllaceae.

1. Area of distribution and environment: A typical desert plant, it is found in the Ho-hsi Corridor. It is found particularly in large quantities in gypsum gobis in the northwest of Yung-chang, Ya-pu-lai, and Chiu-ch'uan. It used to grow in gravel or gypsum gobis, on the rim of dry riverbeds, and on the gravel alluvial plains in front of mountains.

2. Effectiveness in sand fixation and suitable areas for cultivation: A 30-50 cm tall small shrub, it can stand high salinity, and slow down the movement of wind and sand in the gobis. Its branches are bent like arcs. However, its sand fixation effect is far from that of *Nitraria shoberi*, and *Nitraria tangutorum*. It can accumulate sand to form a small mound of about 50 cm high.

3. Time of maturity of seeds and places where seeds may be gathered: It blooms in September, and its seeds mature at the end of June or early July. The seeds may be gathered at the Yung-chang--Ya-pu-lai area, and at Tun-huang.

C. *Astragalus melilotoides* Pall., leguminosae.

1. Area of distribution and environment: Found in Manchuria, northwest China, and north China, it grows on the alluvial plains of the Yellow River, and on slightly salinized sandy land.

2. Effectiveness in sand fixation and suitable areas for cultivation: It may be planted near the drifting sand area or farmlands where the moisture condition is satisfactory.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in August-September.

4. Economic value: It can be used as a feed, and to make green manure.

CI. *Iris tenuifolia* Pail. iridaceae.

1. Area of distribution and environment: Found in the Ikhobac League and the Pa-yen-cho-erh League, it grows on sandy soil, and often appears on sand dunes.

2. Effectiveness in sand fixation and suitable areas for cultivation: A herbal plant, it looks like gramineous plants in appearance, with linear leaves and roots. It stands tramping by the animals. Since it covers only a small area of sand, its sand fixation effect is insignificant.

3. Time of maturity of seeds and places where seeds may be gathered: Its seeds mature in June.

4. Economic value: Its leaves may be used to make ropes.

CII. *Asparagus gobicus* N. Ivan., liliaceae.

1. Area of distribution and environment: It is found on the stabilized sand dunes, on rocky mountains, and on gobs in the Pa-yen-cho-erh League, and in the eastern part of the Ho-hsi Corridor. Although it is distributed in a wide area, it appears only in a single plant.

2. Effectiveness in sand fixation and suitable areas for cultivation: A 25-30 cm tall perennial herb, it has little sand fixation effect, because its branches and leaves are weak, and fall when they are withered.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in September.

4. Economic value: Doubtful as a feed for animals.

III. *Cynoglossum divaricatum*, borraginaceae.

1. Area of distribution and environment: It is distributed on the stabilized sand dunes in the Ikhchao League.

2. Effectiveness in sand fixation and suitable areas for cultivation: A perennial herbal plant, it stands 80 cm tall, with leaves as wide as that of spinach. Its buds come out early in spring, and withers in summer. Then its branches are blown away by the wind. Hence its sand fixation effect is insignificant.

3. Time of maturity of seeds: June.

4. Economic value: Not a valuable feed for animals.

IV. *Cleistogenes squarrosa* Keng. gramineae.

1. Area of distribution and environment: It is found on stabilized and semi-stabilized sand lands in the various leagues of eastern Inner Mongolia, Liaoning

Province, and the Ikhohao League. It usually grows together with *Artemisia ordosica*.

2. Effectiveness in sand fixation and suitable areas for cultivation: A 10-20 cm tall perennial herbal plant, it stands aridity, but cannot stand salinity. After it withers, its stems are broken and then carried away by wind. Hence, it has little effect in sand fixation.

3. Time of maturity of seeds: September

4. Economic value: A good body-building fodder for horses.

OV. *Artemisia anethifolia* Keb. compositae.

1. Area of distribution and environment: Very widely distributed in the desert steppe area in the Pa-yen-cho-erh League and the Ho-hai Corridor, it is also found by the sides of ditches and roads.

2. Effectiveness in sand fixation and suitable areas for cultivation: A biennial plant, it is often seen in large areas in desert steppe areas covered by a thin layer of sand. During the years when the precipitation is scarce, it is very small and short, but during the years when the precipitation is plentiful, it grows fast. It has an effect in stopping the movement of drifting sand.

3. Time of maturity of seeds: September.

4. Economic value: It can be used as a reserve for animals during the winter.

OVI. *Medicago sativa* L. Leguminosae.

1. Area of distribution and environment: Cultivated in Manchuria, northwest China and north China, it grows well on sandy soil.

2. Effectiveness in sand fixation and suitable areas for cultivation: An excellent perennial grazing grass, it can prevent the movement of sand. It may be planted in loam, sandy soil, and slightly acidic alkaline soil.

3. Time of maturity of seeds and places where the seeds may be gathered: The seeds mature in July, and may be gathered when three-fourths of the pods are ripe.

4. Economic value: A top grade green fodder, it can also be used to make green manure.

OVII. *Pappophorum boreale* Griseb., Gramineae.

1. Area of distribution and environment: Although it is widely distributed on sandy lands, gravel lands, and gobis, it covers a small area in one place. It often appears in population of *Artemisia ordosica*, in swamps, or in alluvial ditches.

2. Effectiveness in sand fixation and suitable areas for cultivation: An approximately 5-20 cm high annual

herbal plant, its effectiveness in sand fixation is the same as that of hu-wei-ts'ao.

3. Time of maturity of seeds and places where seeds may be gathered: The seeds mature in September.

4. Economic value: A body-building fodder, it has a high nutritive value when the caryopses are ripe.

OVIII. *Tragus ramosus* Desf., gramineae.

1. Area of distribution and environment: It is found in the ditches of gobis, on the plains in front of mountains, in intermontane valleys, and on sand lands in the Ikhchao League, Pa-yen-cho-erh League and the Ho-hsi Corridor.

2. Effectiveness in sand fixation and suitable areas for cultivation: A small annual herbal plant, it stands less than 10 cm high. Its sand fixation effect is the same as that of *Pappophorum boreale* Griseb.

3. Time of maturity of seeds: August.

4. Economic value: A good feed for sheep.

OIX. *Chloris virgata* Swartz., gramineae.

1. Area of distribution and environment: It grows on dry river ditches and weathered ditches in Ho-hsi and the Pa-yen-cho-erh League. It grows in patches on the sand dunes in Ikhchao League.

2. Effectiveness in sand fixation and suitable areas for cultivation: An annual herbal plant, it stands 10-40 cm high. It grows fast in places where rain water converges, or during years when rainfall is plentiful. It can be seeded during the rainy season, but it cannot be used as a principal sand fixation plant.

3. Time of maturity of seeds: Early September.

4. Economic value: A feed of medium value.

CX. *Artemisia capillaris* Tb. *compositae*.

1. Area of distribution and environment: It is distributed in Inner Mongolia, Kansu, and Ninghsia. Constituting the principal population in the loess area, it is also found in large quantities on desert steppes. In addition, it is a kind of weed on farmlands.

2. Effectiveness in sand fixation and suitable areas for cultivation: It is found in larger quantities on desert steppes covered with a thin layer of sand. Although it has some effect upon the movement of sand, it is not a principal sand fixation plant.

3. Time of maturity of seeds: September

4. Economic value: It is said that it can be used as a medicine to cure dismenorrhia.

CXI. *Calligonum caput-medusae*, *polygonaceae*.

1. Area of distribution and environment: Distributed in the Central Asia drifting sand area of the Soviet Union, it is most widely found on the Hasak crescent drifting sand.

2. Effectiveness in sand fixation and suitable areas for cultivation: A big and tall shrub, it grows fast with a well developed root system. But the seeds must be preserved a long time before they can germinate. Seedlings of this plant are being nursed in Chung-wei, and the prospect of introducing this plant to the deserts in northwest China is good.

3. Time of maturity of seeds: Its seeds mature in central Asia during May-June.

4. Economic value: It is very effective in sand fixation.

CXII. *Calligonum arborescens*, polygonaceae.

1. Area of distribution and environment: Distributed in Soviet central Asia, it is more widely found on the big crescent shaped sand dunes in Hasakstan.

2. Effectiveness in sand fixation and suitable areas for cultivation: A big and tall shrub, it can survive under the pressure of sand. With a well developed root system, it grows fast. But the seeds must be preserved a

long time before they can germinate. Seedlings of this plant are being nursed in Chung-wei, and the prospect of introducing this plant to the deserts in northwestern China is very good.

3. Time of maturity of seeds: May-June in central Asia.

4. Economic value: Very effective in sand fixation.

CXIII. *Salsola Richteri*, chenopodiaceae.

1. Area of distribution and environment: It is found on semi-stabilized sand land in Soviet central Asia.

2. Effectiveness in sand fixation and suitable areas for cultivation: A shrub with roots as deep as 8-10 m, it is being nursed at Chung-wei. The prospect of transplanting to China's northwest is very good.

3. Time of maturity of seeds: September-October in central Asia.

CXIV. *Salsola paletskiana*, chenopodiaceae.

1. Area of distribution and environment: It is found on exposed loose sandy lands in Soviet central Asia.

2. Effectiveness in sand fixation and suitable areas for cultivation: A shrub with well developed root systems, it stands the pressure of sand and weathering. Its

seeds are easy to obtain, but their germination ability is very easily lost. It is an intermediate plant in the process of evolution of the plants in the deserts. The seedlings of this plant are being nursed at Chung-wei, and the prospect of introducing this plant to the deserts in northwestern China is good.

3. Time of maturity of seeds: September-October in central Asia.

OXV. *Haloxylon persicum* Bge. chenopodiaceae.

1. Area of distribution and environment: Found in the Tu-ku-man desert in Soviet central Asia, it can grow on 30-40 m high sand dunes.

2. Effectiveness in sand fixation and suitable areas for cultivation: A shrub without leaves, its photosynthesis is done by its small green branches. With strong branching power, it has a well developed root system. Capable of standing the pressure of sand and aeolian erosion, it is a typical plant growing in drifting sands. The seedlings of this plant are being nursed at Chung-wei, and the prospect of transplanting to China's northwest is good.

3. Time of maturity of seeds: October-November in central Asia.

4. Economic value: A good feed for animals and a good fuel.

CXVI. *Haloxylon aphyllum* Iljin., chenopodiaceae.

1. Area of distribution and environment: It grows on clayey soil in the central Asia desert area of the Soviet Union.

2. Effectiveness in sand fixation and suitable areas for cultivation: A shrub, without leaves, the photosynthesis is done by its small green branches. With a well developed root system, it can stand aridity and salinity, and adapts to sandy land in swamps. The seedlings nursed in Chung-wei are growing well.

3. Economic value: A good feed for animals and a good fuel.

[Available photos not suitable for reproduction]

- Fig. 1 *Calligonum mongolicum* Turcz on Sand Dunes
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- Fig. 3 *Zygophyllum Xanthoxylon* Mad. (Zygophyllaceae) Thrives on Sand Land
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EXPERIENCE OF FORESTATION BY THE MASSES
FOR SAND FIXATION AT TENG-K'OU HSIEN,
ALASHAN BANNER, AND HO-HSI CORRIDOR

In 1958 the desert survey team of Academia Sinica made a survey in the Inner Mongolia Autonomous Region and the Ho-hsi Corridor in Kansu Province. The area under survey included Teng-k'ou Hsien of the Pa-yeh-cho-erh League in the Inner Mongolia Autonomous Region, the Alashan Banner, Chung-wei of the Ninghsia Hui Autonomous Region, and Min-ch'in, Chin-t'a, Chang-i, Kao-t'ai and Tun-huang Hsien of Kansu Province. These hsien and banners are more or less under the threat of sand.

Teng-k'ou Hsien is located at a 100 km-long gap between the Lang Mountain and the Ho-lan Mountain. The drifting sand from the Alashan plateau moves eastward through the gap, and Teng-k'ou Hsien bears the brunt. Under the strong northwesterly wind, the sand buries farms and pastures, and leaves Teng-k'ou Hsien only a narrow strip of land 5 km wide and 208 km long free from sand. At the back of the hsien is the Yellow River; in front of it is the drifting sand which is incessantly advancing. Along the 98 km distance from San-sheng-kung to Pai-tzu-ti, there is an endless chain of sand dunes,

which constitute the source of sand for the Ku-pu-ch'i desert in the Ikhobao League. The windward slopes of the Cho-tzu (Table) Mountain are fully covered by loess, but there is no accumulation of loess at all in places shielded by the Ho-lan Mountain. The Pao-t'ou--Lan-chou Railway, which passes Wang-yuan-ti on the eastern bank of the Yellow River, is already under the threat of the drifting sand. The sand did little damage to the area in the south of Shih-tsui Mountain from Hui-nung and P'ing-lo to Yin-ch'uan because of the shielding effect of the Ho-lan Mountain. The area is densely populated, and well developed in agriculture, constituting the most prosperous area in the Ninghsia Autonomous Region. From Yin-ch'uan to the east of Chung-wei, there is gradually an accumulation of drifting sand, which has already reached the Pao-t'ou--Lan-chou Railway. From Chung-wei to Yin-p'en-shui is a big gap between the Ho-lan Mountain and the Ching-t'ai Mountain of Kansu Province. Through this gap the T'eng-ko-li desert of the Alashan Banner extends southward until it reaches the Hei-shan Gorges and Chung-wei. At Sha-po-t'ou, which is located on the Yellow River terrace, big mounds of sand as high as 300 m above the Yellow River pour into the Yellow River, forming numerous oases in the middle

of the river channel and causing serious obstructions to navigation. The loess is blown by wind to the windward slopes of the Ching-t'ai Mountain. In the vicinity of Chung-wei, the drifting sand has already crossed the Great Wall, and reached a point less than 10 li from the city. The Hsien History of Chung-wei said that "the big sand hill is located 70 li west of the city." This shows that the drifting sand had advanced considerably toward the southeast. The Pao-t'ou--Lan-chou Railway, which links northwest China and north China, must pass through the desert because it has to avoid the earthquake area from Shui-ch'uan on the south bank of the Yellow River to Ta-ying. This railway crosses the T'eng-ko-li desert six times, and traverses a total of 40 km in the desert, the longest section in the desert being 16 km from Oh'ang-liu-shui to Ying-shui-ch'iao. The railway is already built, but how to stabilize the drifting sand along the line, and how to safeguard the traffic call for continued study. The area from Chung-wei to Min-ch'in is on the outer perimeter of the T'eng-ko-li desert. Min-ch'in itself is surrounded by the T'eng-ko-li desert in the east, west, and south. Sand dunes are scattered in the desert. For instance, sand dunes

are located in the north, west, and east of Chin-t'a. The sand dunes on the left bank of the Hei River 15 km west of Chag-i threatens the farmland, while sand dunes are found in both east and west sides of An-hsi. At Tun-huang sand dunes rise as high as 130 m. However, the distribution of sand dunes in counties west of Min-ch'in is related to river deltas and ancient river valleys. For instance, at Min-ch'in there is the Shih-yang River; at Chin-t'a there is the Hei River. All ancient rivers and their deltas have a large amount of sedimentary sand; hence drifting sand is widely distributed in this area.

This narrow and long strip of land under the jurisdiction of Teng-k'ou, and the Alashan Banner belong to the dry desert region. The principal factor that hinders the development of this area is the scarcity of precipitation, although at Teng-k'ou Hsien and in the Ninghsia Autonomous Region, the water of the Yellow River may be used for irrigation. The Ho-hsi Corridor is moistened by the melted snow from the Ch'i-lien Mountain all year round. At Ma-ch'ang-ching and Yuan-chuang-tzu (both located on the outer perimeter of T'eng-ko-li desert), the underground water level is as deep as 26-56 m, but the local people use the flood water from the Ch'i-lien Mountain to grow

Elaeagnus angustifolia, and *Populus simonii* Carr. The former stands about 5 m tall and the latter 6 m tall. The Shih-yang River flows from Wu-wei to Min-ch'in where the underground water level ranges from 1.5 to 5 m deep, a favorable factor for this area.

The sand storm threat to the area east of Min-ch'in originates from the Alashan Banner. Located in the hinterland of northwestern China, the Alashan Banner is a part of the Mongolia Plateau. Climatically, it is greatly affected by the high pressure of Mongolia, and is constantly swept by the severe northwesterly wind. Topographically, the banner is shielded by the Ch'in-ling Range, the Yun-pen Mountain, and the Ch'i-lien Mountain in the southeast, and the Ho-lan Mountain in the east. The moist air from the sea can hardly blow in. Hence the climate is cold, dry, and windy. At Pa-yen-boo-t'e Municipality, the highest temperature is 34.8°C , the lowest temperature is 31.3°C , the precipitation was 58 mm in 1957, and the number of consecutive rainy days has never exceeded five. The Alashan Banner was afflicted by a serious drought in 1956 and 1957. The amount of evaporation in the banner is 14-39 times that of precipitation, while the average yearly relative humidity is 40 percent, the lowest being

10 percent. The northwesterly wind is the predominant wind, and southeasterly wind is also frequent. The highest wind velocities are graded 10-12. According to the records of Sha-po-t'ou, 74 sandstorm days were registered in 1957. The windy season is in late spring or early summer when plants are growing. The temperature on the sand surface may reach as high as 74° C. Thus the plants are often hit by arid wind. The loose sandy rock which constitutes the major mother rock of Alashan is very easily weathered in such a climate. At the same time, the river and lacustrine alluvial deposits are scores of meters thick. In the south of Alashan, there are no surface flows at all; in the north there are many gobis. This accounts for the fact that there are 200 m high sand dunes in the T'eng-ko-li desert, and 400 m high sand dunes in the Pa-che-chi-lin desert. Under the incessant effect of the northwest wind, the desert is expanding southeastward toward the eastern half of the Ho-hsi Corridor.

Such a vast expanse of drifting sand is not only the result of natural conditions, but also the result of human factors under the irrational social system in the past.

Originally, Teng-k'ou Hsien had a large area of *Tamarix ramosissima*, and the sand dunes there were covered

by *Artemisia sasaoides* Willd, *Piptanthus mongolicus* Maxim, and *Nitraria schoberi*. Hence, the sand dunes moved slowly. In 1875, a Catholic church was established here. It reclaimed the land indiscriminately, and seriously damaged the vegetation covering. The local people used the plants in the desert as fuel, cutting at least 30 million chin of *Artemisia* a year, resulting in the denudation of a 50 li wide sand land, and thus quickening the destruction of farms, pastures, villages and canals by the drifting sand.

Through generations, numerous rows of shrubs were planted in the desert near Min-ch'uan to protect the farms against the encroachment of sand. But during the rule of Ma Pu-ch'ing (7456 2975 7230), his cohorts let the camels graze indiscriminately in the shrub area, and imposed a "faggot tax" on the local people. As a result, all the shrubs grown over generations were thoroughly destroyed.

As no timely and effective measures have been taken in the Alashan pastoral area, which includes the T'eng-ko-li desert, a part of the natural vegetation is still in the process of destruction. The reason for this is threefold: (1) Many peasants from other hsien go to the shrub area for fuel. (2) The pastoral and mining organizations use *Haloxylon ammodendron* as fuel. (3) As

a result of excessive grazing, the pastures are degenerated. Furthermore, in the 50-li wide and 20,000 li long sand area, encompassing the Tu-ma-yang Lake, Pa-wang-tao, Pai-chu-li-hai-tzu and Shih-t'ou-hai in the Tu-lan-t'ai-su-mu of Alashan Banner adjacent to Min-ch'in of Kansu province, all the *Artemisia salsoloide*, *Salsola Richteri*, and *Lasiogrostis splendens* (Trin.) Kunth were all uprooted by the peasants of Min-ch'in.

The destruction of the vegetation on the sand dunes has brought about untold disasters to the people.

According to a survey at Teng-k'ou Hsien, the drifting sand moves an average of 5-10 m a year from the northwest to the southeast. During March and May, the movement is particularly fast. At Min-ch'in, the drifting sand is estimated to move 3 m a year. The sand belt between Chu-erh-ko-le-san-han-su-mu and Wen-te-erh-tu-su-mu in the Alashan Banner moved 10 li to the east, 10 li to the west, and 30 li forward in the direction of southeast in the last 30 years. The desert 20 li to the northeast of Alashan was more than 10 li away from the Yellow River 20 years ago, but now it is only 1 or 2 li away from the river bank.

Damage to farms, pastures, irrigation canals, and

forests: At Teng-k'ou Hsien, 1,000 mou of farmland is buried by drifting sand every year, and the crop yield is reduced on 50,000 mou of farmland close to the drifting sand. At Lung-sheng Hsiang, 3,000 mou of farmland was buried during the ten years before the liberation. Of the 150 mou farmland at Sze-pa-wang-te-mou near Teng-k'ou, 145 mou was buried by drifting sand during the last 10 years.

The Shen-chia River at Teng-k'ou changed its course seven times in 30 years. When the sand is blown up by the wind, the river channel is filled up by sand. Countless effort has been spent for dredging the river in the years past. Traces of abandoned courses of small streams are seen everywhere.

The Lo-tzu-shan-ching area in the Alashan Banner was originally fully grown with *Achnatherum splendens* Ohwi, but now it has become a vast expanse of drifting sand.

At Cha-han-en-t'e-kao-erh in the O-lung-pu-lu-ko-su-mu of the Alashan Banner, there was originally a 20-li long and 15-li wide forest of *Haloxylon ammodendron*, but now it has been buried by sand.

Damage to mankind and animals: Nan-lo-pao was a city built earlier than Min-ch'in, but now it is buried by sand.

The 20 villages, 2,300 households, and 2 million mou farmland at Oh'ing-mu-pao near Nan-lo-pao have been almost entirely gulped up by sand in the last two centuries; only 340 households, and 3,000 mou of farmland are left at Hsueh-pai-kou and Hua-yin-kou. The Hsueh-pai Ts'un originally had about 100 households, but by the time of liberation, there were only 9 households left. At Teng-k'ou Hsien, eight villages have been ruined by sand. It is quite common that the sheep shelters, water wells, and houses are buried by sand, and the farmers and herdsmen have to move their homes frequently. For instance, the herdsmen living in the Ha-t'eng-t'ao-hai-su-mu of the Alashan Banner had to move about once every ten years. A big wind on the 9th day of the third lunar month in 1957 plus a cold wave caused a village in the Alashan Banner to lose 100 head of cattle. In some places, the local people live in poorly built houses. When the wind comes, sand gets into pots and pans, and even rice bowls. Houses may be barricaded by sand over night. It is very frequent that travelers, herdsmen, and animals lose their direction in a sand storm and die in the desert.

Damage to communications: About 30 years ago, buses can go from Shih-tsui-shan to San-sheng-kung on the

Pao-t'ou--Yin-ch'uan Highway, but now this section is blocked by 3-5 m high sand dunes in four places totaling 25 km. The highway from Ya-pu-lai salt lake to So-so-men was open to traffic in 1956, but now it is blocked by drifting sand, which has advanced 10 meters.

Damage to industry and mining: The 10-li long salt lake in the Ou-lung-pu-lu-ko-su-mu in the Alashan Banner was good for salt gathering 30 years ago, but now it is entirely buried by sand. Even the famous Ya-pu-lai salt lake is half covered with 15-50 cm of drifting sand.

After the liberation, thanks to the concern of the Party and the diligent effort on the part of the masses under the direction of the Party, many sand fixation measures, such as forestation, "sealing the sand and raising the grass," and the erection of wind walls, were put into effect during the last nine years. Not only remarkable achievements were made, but valuable experiences were accumulated.

Min-ch'in Hsien adopted the three-step principle --"control-treatment-utilization." On the basis of the experience of the masses that "an inch of grass can shield a whole city from a big wind," the Hsien started sand control with the restoration of the forests. During

the last nine years, the hsien planted 1,240,000 mou of trees, raised 3,530,000 mou of grass, levelled 4,776 mou of sand dunes, and erected 3,000 li of wind walls. On the average, each household has 30 mou of forest. In addition, it reclaimed 280,000 mou of farmland, which increased food production by 85 million chin, with per-mou yield increased from 90 chin in 1949 to 223 chin in 1957. Although the increase of food production is inseparable from the adoption of various agro-technological measures, forestation is one of the principal factors that made the food production increase possible. As a result of the growth of protective forests, the river embankments are strengthened, and a large amount of water can be used to irrigate an estimated 360,000 mou of farmland. Prior to the liberation, the irrigation canals should be repaired three times a year at a cost of 640,000 worker-days, and 6,680,000 chin of grass. Now the canals are repaired only once a year at the cost of 170,000 worker-days and 280,000 chin of grass, saving 470,000 worker-days and 6,400,000 chin of grass. In the past, it used to take 72 hours for the water to flow through the irrigation canals to the farmland of the Ksush-pai rural commune, and each irrigation took 48 hours. But now, it takes only

24 hours for the water to reach the commune, and each irrigation takes only 24 hours. The firewood produced by the newly built forests can last a year for 2,370 persons. The timber produced by *Populus diversifolia* and *Elaeagnus angustifolia* can already be used for house construction. The grass produced each year can feed 1,300 head of livestock. The yearly production of green manure made of *Sophora alopecuroides* totals 600,000 chin. The Kao-lai-wang commune planted 16.6 mou of grape, 33.3 mou of apple, 16 mou of apricot, and 9 mou of peach.

At Teng-k'ou, the Party secretaries personally take part in sand control work. The people are mobilized to make wind walls, to "seal the sand and raise the grass," and to build forests on the basis of the experience that "sand likes wind and aridity, and fears water, grass, and trees." In eight years, the masses built 54,000 mou of forest (190 li long and 50 m wide), which furnishes protection to 50,000 mou of farmland (the farmland under production may be expanded to 100,000 mou). The crop yield per unit area has been increased from 70-90 chin during the pre-liberation years to 270 chin. The trees planted at Teng-k'ou in 1953 are now 5-7 m high, with an average circumference of 1-13 cm. The five-year old

Elaeagnus angustifolia can now bear fruits. The trimmings and feed grass gathered from the deserts total 9 million chin, which can be used as the spring feed for the livestock.

The eight-year struggle waged by the 20,000 people of Teng-k'ou has resulted in the elimination of sand dunes, and of the burial of farmlands and canals by sand. The people no longer have to move frequently, nor do the highways have to re-route from time to time.

At Min-ch'in and Teng-k'ou, the passive measures of sand prevention have changed to active measures of sand fixation.

The sand fixation and forestation work of Min-ch'in and Teng-k'ou has not only won recognition in the province and the whole country, but also won the unanimous praise of Soviet experts.

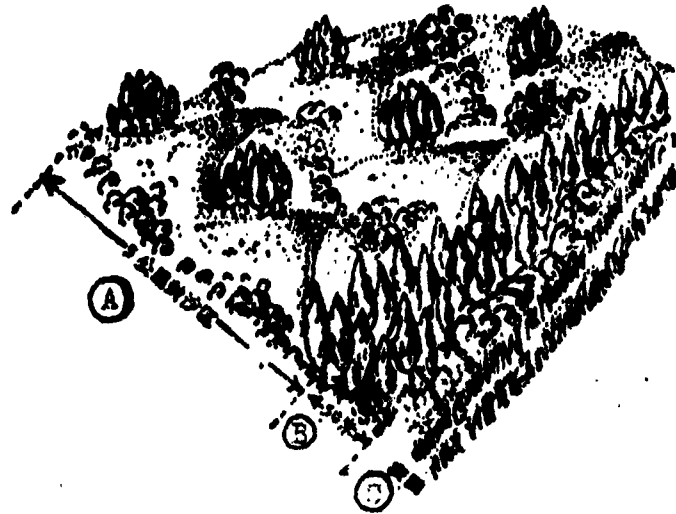
I. Sand Fixation and Forestation

The most economic method of sand prevention and fixation is to cover the sand land with herbal and woody plants. Such a vegetation covering can not only prevent the sand land from weathering, but can change the loose sand into fertile soil in the sense that the withered

branches and fallen leaves can increase the organic matter in the sand and change the physical and chemical properties of the sand.

1. Sand prevention forests. In the boundary region between the deserts and oases, protective forests can intercept the sand. For instance, Teng-k'ou Hsien built a 154 km long and 50 m wide forest in 1951 along the outer rim of the drifting sand from San-sheng-kung to Ssepa, and stabilized 90,000 mou of drifting sand. The method is to irrigate the lowlying land between the sand dunes first, and then plant the cuttings or sow the seeds. The plants are 1 m apart from each other, and the rows are also 1 m apart from each other. On saline lands, *Tamarix chinensis* and *Elaeagnus angustifolia* are planted. On sand lands where moisture is plentiful, willow and *Elaeagnus angustifolia* are planted. The five-year old *Elaeagnus angustifolia* is already 5-7 m high, with circumference measuring 10-13 cm. It can already bear fruit, and its timber can be used for house construction. Then more trees are planted on the lowlying lands between the sand dunes and behind the forests. A 5 km wide belt on the outer perimeter of the the drifting sand is used to plant grass. In this way, a total of 50,000 mou of farmland is protected

from the encroachment of sand, and the wheat yield on such farmlands is increased from the pre-liberation 70-90 chin per mou to 270 chin per mou in 1957.



Legend

- A. 5-km "sand sealing" area B. 50 m
C. Farmland

At Teng-k'ou, the trees are not trimmed during the first two years, and the trees in the 8th-10th rows are not trimmed at all in order not to reduce their wind prevention effect.

2. Plant woody trees on the lowland between the sand dunes. Willow trees are planted on lowlands between

1-2 m high crescent sand dune chains near Lung-kung Lake in Chung-wei. The trees are 1 m apart from each other, and the rows are also 1 m apart from each other. The *Populus simonii* Carr. planted during 1952-1953 are now 6 m high, and measure 7-10 cm in circumference. The willow trees stand 3 m high, and measure 3.3 cm in circumference. During the last six years, the sand dunes moved 5-8 m -- approximately the distance between two sand dunes. This year trees are widely planted on weathered lowlands between the sand dunes.

By this method of forestation, adventitious roots are obtained when the tree branches are buried by sand on the lowland between the sand dunes. But as soon as the sand moves away, the adventitious roots are exposed and finally the plant itself dies. This phenomenon is seen at the Sparrow Flat in Min-ch'in. As to the seedlings planted at the base of the sand dunes, they often die because of the exposure of their roots when the 30 cm thick sand is blown away by wind from March to July. In the natural *Populus diversifolia* Schrenk forest in the T'eng-ko-li desert, there is a 7 m thick layer of sand, which even covers up many big trees. This explains that the trees have a poor effect in sand fixation, and are in danger

of being buried. Suppose we wait till the sand dunes move forward, and then plant the trees on the ground between the sand dunes, the following defects will show: (1) Before the forest is stabilized, the sand dunes continue to move forward, and the trees are still in danger of being buried. (2) It takes too long to wait till the sand dunes move forward. (3) The soil on the ground between the sand dunes are usually hardened, unfavorable for forestation. Therefore, woody trees should be planted together with shrubs and grass. If the sand condition is bad, more shrubs should be planted; if the sand condition is good, more woody trees should be planted.



Legend

A. Year 1952

B. Year 1958

3. Farm protection forests. The building of farm protection forests is an advanced measure of sand fixation and wind prevention. According to the original

design of a survey team of the Ministry of Forestry, the main forest belt was to be 17-20 m wide with rows 1.5 m apart. But in conformity with the suggestions of the masses, the forest belt through the farmland was revised to 10-12 m wide, the distance between the rows was changed to 1 m, but still 9-11 rows were planted. In this way, the originally designed number of trees was maintained, and the forest belts occupied only 902 mou of farmland as compared with 1,841 mou of farmland envisaged in the original plan. The distance between the main belts is 400 m, while that between the subsidiary belts is 1,500 m.

The arrangement of the species of trees at Hsueh-pai Hsiang is as follows:

Elaeagnus angustifolia (E. a.) -- E. a. -- E. a. --
Populus simonii (P. s.) -- E. a. -- P. s. -- E. a. --
P. s. -- E. a. -- E. a. -- E. a.

In the space between the trees 1-3 rows of soy bean, lucerne, cotton, and vegetables are planted. (At Tang-k'ou Hsien half of the space between the trees is used to grow red beans, green beans, or black beans.) At Hsueh-pai Hsiang and San-lei Hsiang, yearly dividends are paid to peasants who contribute their labor to build the forests.

Each mou of forest requires an average of 4.5 worker-days a year. Part of the forest has been watered 1-2 times after it was planted. Special personnel has been assigned to protect the forest.

Min-ch'in Hsien is ready to extend the forest belt into the sand in the north. For expanding the farming area, reclamation is preceded by forestation.

Min-ch'in Hsien was correct in revising the original plan approved by the Ministry of Forestry. It has saved a lot of farmland without reducing the effect of wind and sand control. At Hsueh-pai Hsiang, four kinds of crops --soy bean, lucerne, linseed, and wheat--are planted on 200 mou of forest land. The soy bean harvest is the best, about 200 chin per mou. Although there was no harvest for lucerne during the first year, it grew as tall as 30 cm, and 97 percent of the seedlings survived. The wheat harvest is comparable to that on regular farmlands, but wheat affects the growth of trees, and only 80 percent of the seedlings can survive.

The Hsueh-pai Hsiang calculated that if two rows of crops are planted between the trees during the first year, the harvest is as good as that on regular farmlands. During the second year, only one row of crops can be

planted, and the harvest is not as good as that of the first year. During the third year, no crop can be planted in the forest. But at this time, the forest itself can yield 2,000 chin of firewood per mou, each mou of *Elaeagnus angustifolia* can yield 42 yuan worth of fruits (each mou of wheat can yield only 300 chin of wheat which can be sold for only around 30 yuan). Thus the yield from the forest makes up the losses of the second year. As the years go by and when the trees grow bigger, the forest will bring more income.

Elaeagnus angustifolia is not as big as *Populus simonii*. The latter should be used as the principal tree in the forest belt. However, there are eight rows of *Elaeagnus angustifolia* and only three rows of *Populus simonii*. Evidently, insufficient consideration was given in this respect during the forest building. Quite obviously, *Populus simonii* should be increased, and *Elaeagnus angustifolia* should be decreased. First of all, the State-operated nurseries should nurse less *Elaeagnus angustifolia* seedlings, and at the same time nurse more *Populus simonii* seedlings.

As mentioned above, *Elaeagnus angustifolia* is planted together with *Populus simonii* at Hsueh-pai Hsiang. At Min-ch'in and Teng-k'ou, there are four types of forests: (1) Pure *Elaeagnus angustifolia* forests; (2) forests with *Elaeagnus angustifolia* and elm; (3) forests with *Elaeagnus angustifolia* and willow mixed in same rows; and (4) forests with *Elaeagnus angustifolia* planted in alternate rows.

The pure *Elaeagnus angustifolia* forest grows well at Teng-k'ou Hsien, but the same forest on the Su-wu Mountain at Min-ch'in has been entirely destroyed by insects (one species of such insects is *Aphis mali*. Fabr.). The pure *Elaeagnus angustifolia* forest planted in 1951, now at an average height of 3 m, is not growing very well, and all the old trees fail to bear fruit because of pestilence caused by insects. (Failure to cultivate and weed is also a reason that accounts for the poor condition of the *Elaeagnus angustifolia* forest.)

The result of mixing *Elaeagnus angustifolia* and elm is also not satisfactory because the former grows fast during its early stage, while the latter grows slow. In addition, both species are easily destroyed by *Aphis mali*, Fabr., and cross breeding between the two cannot alleviate the insect pestilence. On the contrary, the insect on

one may easily spread to the other.

In the forests with *Elaeagnus angustifolia* and willow mixed together, the willow trees, although big and tall, grow here and there, and cannot form a contiguous forest. Thus the effectiveness in sand and wind control is not improved at all.

In places where *Elaeagnus angustifolia* and willow trees are planted in alternate rows, the willow trees are taller than *Elaeagnus angustifolia*. According to comrades at Teng-k'ou, this is the best type for sand and wind control.

4. Forestation on pebble river flats. In the past it was inconceivable to build a forest on riverbeds full of pebble. But in 1956, Wu-wei built a forest on pebble flats by the side of a river, and another on an abandoned riverbed full of pebbles in the northwestern corner of the city. Both forests are growing well.

The method of planting trees on pebble flats is as follows: First, dig ditches 3 shih ch'ih deep and 2.5 shih ch'ih wide. The seedlings are then planted in the ditch 3 shih ch'ih apart. The distance between the ditches is 4 shih ch'ih. The ditch is then covered by fertile soil around the seedlings. On top of the fertile

soil is a layer of sieved fine sand. In riverbeds with running water, trees are planted on dry pebble flats. Eighty percent of the *Elaeagnus angustifolia* planted on the pebble flat in the northwestern corner of the city survived, and they are now 3 m high.

5. Forestation by using flood water. At Ma-chang-ching and Yuan-chuang-tzu on the outer perimeter of T'eng-ko-li desert, the underground water is at 26-56 m deep, and cannot be used. At the same time, the precipitation is only 100 mm a year. The flood water from the Ch'i-lien Mountain constitutes a good water supply for forestation and vegetable gardening purposes. The local people dig the land 2-3 shih oh'ih deep, and then channel the flood water from the Ch'i-lien Mountain to the sunken area for planting trees and vegetables. The *Populus simonii* so planted is now 6 m high, and the *Elaeagnus angustifolia* is 5 m high.

In the vicinity of Ta-ching, the masses plant their trees in the ditches along the highways. Unfortunately, they piled the earth in a windward area. As the earth was blown back to the ditches, all the tree seedlings were buried and killed. In the Ta-ching area, the soil consists of diluvial deposits, and trees can grow

normally even at a depth of 2-3 shih ch'ih from the ground. But in northern Kansu, the rate of survival of tree seedlings is very low.

II. "Sealing the Sand and Raising the Grass"

The so-called "sealing the sand and raising the grass" is to stabilize sand dunes by recovering the original vegetation and raising grass on such dunes. This method is used at Min-ch'in, Chin-t'a, Ts'ao-hu, and Teng-k'ou.

A long time ago, Min-ch'in Hsien planted rows and rows of plants along the outer perimeter of the desert to protect the farms from sand and wind. But during the rule of the feudalist warlords, the plants were cut down as fuel, and the drifting sand gradually moved southward. By the time of liberation, only 200,000 mou of grass was left. After the liberation, the Party immediately proposed to restore and enlarge the vegetation area. In eight years, the area has reached 2 million mou. The largest vegetation area at Ta-pa in Min-ch'in is 80 li long and 20 li wide. The Hsueh-pai Hsiang at Min-ch'in originally had a 5 li long vegetation area, but by the time of liberation, the area had dwindled to 1 li long and 0.5 li wide. After restoration and expansion, the

vegetation area is now 20-li long and 10-li wide. In the area, *Populus diversifolia* and *Elaeagnus angustifolia* are planted.

The Kao-lai-wang agricultural commune at Min-ch'in built a forest of *Tamarix ramosissima* Ldb. In 1956, 1,300 carts of tree branches were gathered, and these branches were used to buttress the walls of 145 water wells. The commune also gathered 360 carts of *Glycyrrhiza uralensis* which were used as one month's feed for 180 sheep, 180 carts of *Sophora alopecuroides* which were used as a fertilizer for 250 mou of farmland, and 500 carts of *Corispermum patelliforme* which were used as fuel for 150 persons.

From San-sheng-kung to Sze-pa (a distance of 150 li) in Teng-k'ou Hsien, the area selected for "sealing the sand and raising the grass" totals 525,000 mou, among which 360,000 mou of drifting sand has been either stabilized or semi-stabilized. The Hsi-cha commune "sealed" 3,000 mou of drifting sand in less than three years. Since 1952, the commune has gathered 250,000 chin of hay to feed its domestic animals.

As to the formulation of concrete methods of "sealing the sand and raising the grass," a sand prevention and forest protection committee is organized in each hsiang.

Each commune is responsible for the protection of a section of the forest or bush; special guards are posted to watch that no livestock is grazing in the vegetation area without permission; a Sand Prevention and Forest Protection Convention is written; and a penalty and award system is established. At Teng-k'ou Hsien, each production brigade appoints a forest guard, and five households to inspect the forests by turn. When the livestock is put to graze, it is always accompanied by a herdsman. The Hsien-fu commune at Teng-k'ou Hsien organized seven forest protection groups to watch the livestock. The August 1 commune at Tien-ping Hsiang in Min-ch'in details one of its members to inspect the forest every day.

The main purpose of sealing the sand and raising the grass is to solve the fuel problem. Teng-k'ou Hsien organized the masses to build 13 boats for shipping coal. Min-ch'in made a fixed schedule for gathering weed from the lakes. Under the leadership of the chu and hsiang authorities, the masses are permitted to dig a limited amount of *Glycyrrhiza uralensis* in places where the threat of sand is not too serious. Since these measures were taken after giving full consideration to people's immediate as well as long-range interests, they are

voluntarily accepted by the people.

The forests at Teng-k'ou are often destroyed because of the fact that the hsien is a melting pot of racial groups, and the fact that agriculture is mixed with animal husbandry. The hsien has called more than 15 meetings with a view to eliminating the racial differences between the Mongols, the Hans, and the Huis, and to promoting cooperation for the protection of forests. As a result, the Mongol herders help the Han farmers solve the fodder shortage problem by permitting the latter's livestock graze on the steppes. At the same time, the government grants loans to the Mongols for digging water wells, and Yin-ch'uan supplies Teng-k'ou with a large amount of firewood and seeds.

The San-lei Hsiang of Min-ch'in Hsien has the strongest forest protection organization. It has a forest production and construction committee, headed by the chief of the hsiang. In addition, there is one full-time forest cadre. The commune has a forest section under which there is a 30-50 member forest production team responsible for the verdancy work. The team is headed by a chief and a deputy chief. The duties of the team are as follows:

- (1) Verdancy work;
- (2) Management of seedling nurseries, and the gathering of tree seeds;
- (3) Protection of young trees; and
- (4) Giving publicity to forest policies, learning forestry technology, and offering technological guidance.

When the forestation work is heavy, the farmers help the forest workers, and when the farm work is heavy, the forest workers help the farmers. A unified method of counting the labor points is devised for both farmers and forest workers. The forest guard is given an extra 0.5 labor point a day so that he can be on his post all year round.

III. Sand Fixation By Planting Grass

For quickening the stabilization of sand, grass seeds are sowed manually after the rain in places where natural seeding is difficult. During the rainy season, *Artemisia saissolcida* can germinate in two or three days. Since the seeds are often blown away from the sand dunes to lower places, it is necessary to sow the seeds several times and over a number of years before the sand dunes are

fully covered by vegetation. The seeds may be either broadcast, or sowed along the ditches.

Sowing along the ditches. When the sand is fully moistened by rain water, the seeds are sowed in ditches 1 m wide and 2 m apart. The sowing team consists of three persons. One person digs the ditch, the second person puts the seeds in the ditch, and the third person covers the ditch with soil. One chin of *Artemisia salsoloide* seeds is used for each mou. The ditches are perpendicular to the direction of the predominant wind so that the plant will have the maximum effect of preventing the wind when it grows up.

Broadcasting. The seeds are evenly sowed on the sand dunes. After broadcasting, we may either let the sheep tramp on the sand dunes, or rake the surface of the dune so that the seeds will go into the sand. At Min-ch'in, *Artemisia salsoloide* can grow to a height of 30 cm in the same year it is sowed.

Sowing of *Nitraria schoberi* and planting the slips. In the moist sandy area, the entire fruit of *Nitraria schoberi* may be used as the seed. If the seeds of *Nitraria schoberi* are to be sowed next spring, they must be soaked in warm water for 72 hours, and then preserved in a

45 cm deep pit before the time of sowing. When the seeds show sign of germination, sow them after the spring thawing and cover them with 3 cm of soil.

Planting the slips. Bury the cuttings from one or two year old plants in early spring or during the rainy season; new plants will grow out of the cuttings.

IV. Erection of Wind Walls

At Min-ch'in the northwesterly wind is most frequent, and the desert shifts southeastward. There are two types of wind walls; one is dead and the other is live. The so-called dead wind walls are mechanical wind screens which will be discussed in the next section. The so-called live wind walls refer to the *Salix chetlophylla* Schneid forests. Such forests are usually 4-5 m wide and their length depends upon the length of the drifting sand. After a number of years, the *Salix chetlophylla* will grow to a height of 2-3 m, and will be able to stop the advance of the drifting sand.

V. Mechanical Sand Screens

The local people call the mechanical sand screen

dead wind wall. The idea is to put different kinds of obstacles on the sand dunes to slow down the speed of wind. The sand screens made of different kinds of materials can last only two or three years. It is therefore necessary to change dead sand screens to live sand screens.

1. Square lattice type sand screens. In 1957 the Railway Sand Control Experimental Station at Sha-po-t'ou in Chung-wei used the square lattice type sand screens on both sides of the railway. The straw screen is made in the following way: First, the straw or hay is laid flat on the ground in squares measuring 1 X 1 m, or 2 X 2 m. Then use an iron pick to thrust the middle of the grass into the sand, resulting in the erection of both ends of the straw to a height of 10-20 cm. Then grass or trees are planted in the space among the squares. It is preferable that the trees or grass are planted on the windside of the space. The top of the sand dune is too high, and cannot be used to plant the grass. During the initial stage, one-third of the sand dune near the peak is left open, to be levelled off by the wind. During the second stage, trees are planted. In the case of woody trees, 10-15 cm of the seedling should be left above the ground and 45 cm buried in the sand. In the case of

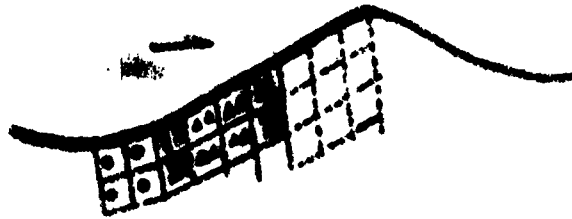
slips, 1-2 cm should be left above the ground and no less than 35 cm should be buried in the sand. Generally, an ordinary pick is used for planting the seedlings, and a Kuo-lieh-so-fu pick is used to plant the slips or cuttings.

[Available photo is not suitable for reproduction]

Square Lattice Type Sand Screen By The
Side of the Fao-t'ou Lan-chou
Railway at Sha-po-t'ou, Chung-
wei Hsien

At Chung-wei, 300 shih chin of straw is used per mou to make a 2 x 2 m square lattice sand screen.

In 1958, Chung-wei built two railway protection sand screens: one is 100 m wide and the other is 100 m wide. The 100 m wide 1 x 1 m lattice sand screen was built all over the sand dunes, while the 200 m wide 1 x 2 m rectangular lattice sand screen was built up to two-thirds of the height of the sand dunes.



Legend

- O Trees 1 x 1.33 m
- △ Shrubs 1 x 0.5 m
- × Semi-shrubs 0.5 x 0.5 m

According to the suggestion of Soviet expert Professor Petrov, it is better to erect sand screens before forestation because the sand screens can be built at any time of the year.

Square lattice type sand screen built at Min-ch'in. First erect a row of sand screen on top of the sand dunes with bundles (about 15 cm in diameter) of faggot and straw perpendicular to the predominant wind so as to stop the movement of sand dune tops. On the windward slope of the sand dune, rows of wind walls are erected perpendicular to the direction of the predominant wind at a distance of 1.5-2 m from each other. At the same time, rows of wind walls are also built on the windward slopes

along the direction of the wind at a distance of 7-10 m apart from each other to form a rectangular network. Then *Artemisia salsoloide* and *Agriophyllum arenarium* are planted on both windward and leeward slopes. The square lattice sand screen used at Min-ch'in is basically the same as the lattice sand screen built by the Railway Sand Control Experimental Station at Chung-wei, except that the top of the sand dune is not levelled off, because the moisture condition at Min-ch'in is not so good as that at Chung-wei.

Lattice type sand screen used at An-hsi. This type of sand screen is basically similar to the square lattice type sand screen of Min-ch'in, except that it does not have a row on the top of the sand dune. Furthermore, the screens erected at the two tips of the crescent are perpendicular to the direction of the wind caused by the local terrain so as to obtain the maximum effect of sand and wind control. The sand screen is made of branches of *Nitraria schoberi*. Within the lattice, clay bricks are used to cover the sand.



2. Horizontal sand screens. After the seedlings are planted in areas under strong aeolian effect, the seedlings are covered by wheat stalks or hay for protection. About 7,500 shih chin of wheat stalks or hay is needed for each mou of seedlings.



3. Vertical sand screens. The vertical sand screens are used at Sha-po-t'ou of Chung-wei. Such sand screens are made of *Achnatherum splendens* mats, or bamboo mats, or *phragmites communis* mats nailed to wooden frames 2 m wide and 1 m high. The frames are erected on the ridge of the sand dune at a 120° angle with each other. The frame may be lifted higher when the sand is accumulated to a certain height. This type of sand screen can last 2-3 years, and the cost of making a wooden frame is 10 yuan.

Generally, the masses use willow strips, *Achnatherum splendens*, and *Artemisia salsoloide* to build a 1 m high screen along the ridge of the sand dune.

On the leeward side of this type of sand screen, the sand piles up higher and higher. As a result, the screens

must be strengthened every year. On account of this reason, it can be used only temporarily along railways and highways.

[Available photo is not suitable for reproduction]

Vertical Sand Screens By the Side
of the Pao-t'ou--Lau-chou Railway
at Sha-po-t'ou, Chung-wei



4. Multi-row belt-shaped horizontal sand screen.

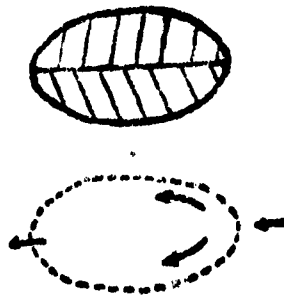
On the windward slopes, bundles of *Artemisia salsoloides*, *Nitraria schoberi*, and *Achnatherum splendens* branches are planted in rows on the sand dunes with 60 cm above the ground and 30 cm in the sand. The rows are parallel to each other at a distance of 3-5 m. About 100 shih chin of material is needed to build a 3 m long and 15-25 cm thick screen of this type.



5. Ring shaped sand screens. On round or oval sand dunes, sand screens made of *Artemisia salsoloides*, *Nitraria schoberi*, and *Achnatherum splendens* bundles are erected along the contour lines of the sand dune. The base of the upper ring should be at the same level with the top of the lower ring so that the sand particles between the rings will not be blown up by the wind. No screen is erected at the top of the dune, and the peak is expected to level off by itself.



6. \wedge -shaped sand screens. This type of sand screen is used generally for low, round or oval sand dunes, and the materials used are the same as the foregoing types. First of all, erect a basic wind wall from bottom up through the middle of the dune with bundles of the same materials used for other types of sand screens, with each bundle measuring 10-20 cm in diameter. Then insert the bundles at an angle perpendicular to the base line on both sides after the pattern of a feather. The wind walls are 1 m apart from each other.



7. Sand prevention walls.



VI. Covering Sand Dunes

Utilizing the erosion-resistant property of soil, the people in Ho-hsi use clay to cover isolated sand dunes that threaten the safety of villages.

1. Cover the sand with wet soil. In using the wet soil to cover the sand dunes, the people in Min-ch'in and Chin-t'a use two different methods. The method used at Min-ch'in is as follows:

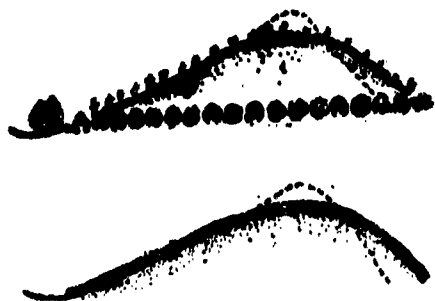
(1) First rake the peak of the sand dune in order to reduce the height and the gradient of the dune.

(2) Gather loam, which contains less than 20 percent of sand, in the vicinity of the sand dunes. If the loam is too dry, wet it with water. After the loam gets drier, spread it over the sand dune from the top down. The loam layer is about 12 cm thick, and it may be made thicker in places where the wind is strong.

(3) Then the seeds of *Artemisia salsoloide* are spread over the sand dune.

(4) Finally a few rows of trees are planted around the sand dunes in order to stabilize them permanently. Sometimes ditches are dug around the sand dunes. When the seeds of shrubs or herbs are carried by the wind to the ditches, a natural vegetation covering is formed by itself after the rain.

By using this method, Min-ch'in has covered more than 200 sand dunes, totaling 1,911 mou in area, and protected a large area of farmland and many villages.



At Chin-t'a Hsien, the method is to mix clay with water and chopped straw, and then smear the mixture over the sand dune to a thickness of 9-12 cm. After it is dry, it forms a hard, shining crust, on which no vegetation can

grow.

By using this method, Chin-t'a has covered 8,417 mou of sand dunes, and protected 25,064 mou of farmland, 31 irrigation canals, and 34 houses during the last eight years.

The method used in Min-oh'in can eventually attain the purpose of sand fixation because shrubs and trees are planted on the sand dunes after they are covered by wet soil. It is evidently a better method than that used at Chin-t'a. But the climatic conditions in the two places are different. Chin-t'a has an average annual precipitation of only 38 mm, while Min-oh'in has 113 mm. At Min-oh'in, wet sand is found 10-20 cm under the sand dunes, but at Chin-t'a wet sand is found 1-2 m under the sand dunes. These conditions prevent Chin-t'a from employing the method of Min-oh'in.

The method of covering the sand dunes with wet soil can achieve fast results, and can stop the movement of sand dunes completely. However, Professor Petrov pointed out the following shortcomings of this method: (1) It is too costly. At Min-oh'in, each square meter of sand dune requires one cart of soil, and each mou of sand dune

requires 100 work days. (2) After the sand dunes are covered by soil, the moisture condition of sand dunes becomes worse because the dry sand layer at the top is thickened to 40 cm as compared with the original 16 cm. As a result, *Artemisia salsoloides* can grow only at the lower part of the sand dunes and the upper part remains nude. (3) This method is applicable only for isolated sand dunes and only in places where clay is available. (4) The benefit is limited. (5) The soil coating can be very easily washed away by rain. (6) The sand dunes covered by soil should be constantly watched and repaired. Hence Professor Petrov suggested that in the neighborhood of population centers, square lattice type sand screens be used for crescent sand dunes instead of covering the sand dunes with wet soil. His suggestion is introduced as follows:



Remarks: This plan is applicable to sand dunes on alluvial sediments, under which the underground water level is high, and the underground water is fresh, not (or slightly) mineralized.

Legend

- Populus simonii Carr.
- X Apricot
- △ Elaeagnus angustifolia L.
- :: Artemisia salsoloide
- Haloxylon ammodendron

X-X 2 m

The above figure shows the vertical section of a crescent shaped sand dune. The area marked 1958 indicates the area where the sand screens are erected and the trees are planted during the first year. The area marked 1959 indicated the area where the sand screens are erected and

trees are planted during the second year after the peak of the sand dune is levelled off. At first, manual labor is used to erect the sand screens. Later on, the sand control work is taken over by the vegetation on the sand dune. The symbols in the squares of the above figure indicate the different species of trees. While *Achnatherum splendens* may be used to make the sand screens, apricot and *Populus simonii* may be planted at the lower part of the sand dune.

2. Cover the sand by clay bricks. First cover the surface of sand dunes with clay bricks made of clay brought down by flood to the neighborhood of sand dunes. Then use wet soil to seal the gaps between the bricks. Instead of using clay bricks, a special kind of brick called "kang-mien" is used to cover the sand dunes. The "kang-mien" is made in the following way: First, put a thin layer of soil mixed with straw in a 5-7 cm thick wooden box. Above the mixture put some chopped branches, and then pour a layer of mud over the branches. Thus a tree branch reinforced clay brick is made.



3. Cover the sand with straw mats. Use ready-made straw mats to cover the sand, with the edges of the mats buried in the sand so that they will not be blown away by the wind.



4. Cover the sand with pebbles. By the side of roadbeds of railways and highways, where pebbles are available use pebbles to cover sand dunes. At the same time, pebbles can reinforce the roadbeds. In the case of highways, as the asphalt road surface is smooth, little sand will accumulate on the road.



VII. Irrigate the Desert

In places where irrigation facilities are available, the sand may be irrigated according to plan. In Ho-hsi,

for example, the useless winter water in the canals may be channeled to the desert to help the germination of shrub or tree seeds blown to the desert by wind. At the same time, water helps the coagulation of sand particles. In addition, the irrigation water from the river contains a large amount of fine silt. After the water seeps down, a coat of silt and clay is left over the sand, and such a coat will help the germination of seeds.

The results of irrigating the desert at Sheng-ti-wan in Hsi-t'ou Hsiang, Chin-t'a Hsien in November 1953 were as follows: (1) On sand dunes which originally had no *Tamarix ramosissima*, a large amount of *Tamarix ramosissima* seedlings appeared. On the average, there were 141 plants of *Tamarix ramosissima* per square meter. (2) In areas where there had been no grass, a large amount of grass appeared. (3) Because of the growth of plants and the stabilization of sand dunes, 38,488 mou of farmland of 200 households at Sheng-ti-wan became free from the threat of sand, the dredging of irrigation canals was reduced from four times in 1954 to twice in 1956, the production of hay was increased three times, and the 22,500 chin of *Typha minima* (Funk.) Hoppe seedlings gathered in 1956 brought an additional income of 1,300 yuan.

The experience of promoting the natural multiplication of *Tamarix ramosissima* by irrigation at Hsi-t'ou Hsiang, Chin-t'a Hsien, is as follows: (1) In places where rain is scarce but irrigation facilities are available, grass or shrub seeds mixed in fertile soil may be sowed in July or August; then rake the ground with willow branches before irrigation. (2) In places where the annual precipitation is about 100 mm, seeds may be sowed on the leeward slopes of sand dunes, or on the banks of canals, and then irrigate the forest area frequently during the next two years. (3) In places where precipitation is above 300 mm a year, *Tamarix ramosissima* may be planted at the middle or lower parts of the windward slopes of sand dunes. (4) To help the germination of seeds, it is only necessary to irrigate once. If the seeds fail to germinate, another irrigation is called for. (5) Seedlings which grow too close to one another should be separated, and transplanted to irrigated sand flats. After the transplantation, the sand flats are irrigated once again.

This method is not generally feasible because of the lack of source of water. Furthermore, if irrigation water is available, it is better and more profitable to grow woody trees than shrubs or herbal plants.

VIII. Agrotechnological Experience In Sand Fixation and Forestation

(1) At Teng-k'ou Hsien, trees are planted 1 m apart from each other, and the distance between rows is 1.5 m. The ground is plowed 5-6 times in order to avoid aeolian erosion.

(2) In places where irrigation is feasible, the deserts are irrigated in July or August, and then the land is plowed in order to turn the weeds into the sand and at the same time reduce the salinity.

(3) At Teng-k'ou Hsien, when two-year-old cuttings are used for forestation, the cuttings are hammered into the sand with a wooden hammer wrapped with rubber. The cuttings should go deep and straight into the sand with a short section left above the ground, and the sand should be pressed compact around the newly planted cuttings.

(4) The forestation time should be in early spring or late fall. Seedlings should be planted in spring, and cuttings should be planted in fall.

(5) According to the experience of Teng-k'ou Hsien, which has a population of only 20,000 and built 308 li forest in seven years, efforts should be concentrated on building forests in one area, because scattered

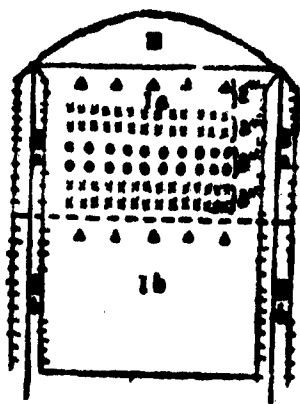
and small forests here and there have little effect in sand control in such a sparsely populated region under the serious threat of sand.

(6) In swamps or on river sand flats, willow should be planted. At Chung-wei, 91.82 percent of the trees planted survived. On fertile clayey soil, elm trees should be planted. On dry and slightly salinized soil *Elaeagnus angustifolia* should be planted, and on heavily salinized soil, *Tamarix ramosissima* should be planted. On mobile sand dunes, the rate of survival of *Artemisia salsoloide* is 92.51 percent. *Haloxylon ammodendron* should be planted on dry, high, and inclined sandy areas. At Min-ch'in, the rate of survival of *Populus simonii* planted in 1958 was 31.50 percent, and about 5-22 new branches on each plant partly withered. This shows that *Populus simonii* cannot stand the heat of sand. Also at Min-ch'in, the rate of survival of the seedlings of *Elaeagnus angustifolia* was 50.85 percent, and each plant had 5-20 new branches. The rate of survival of *Salix cheilophylla* slips was 8 percent, and each plant had 3-9 new branches; that of *Tamarix chinensis* was 3.3 percent; that of *sophora japonica* was 13.8 percent; and that of elm was 7 percent. The average rate of survival of trees

planted in the fall of 1957 and the spring of 1958 on crescent-shaped sand dunes was 82.55 percent, while the average rate of survival of trees planted along the crescent sand dune chains by the side of lakes was 92.81 percent. The average of the two was 84.08 percent.

(7) Concerning the proportion between the woody trees and shrubs, the sand fixation forest at Chung-wei, for example, consists of one-third of woody trees, one-third of shrubs, and one-third of semi-shrubs. The density is one woody tree per square meter, two plants of shrub per square meter, and four plants of semi-shrub per square meter. The trees include *Populus simonii*, *Elaeagnus angustifolia*, *Amorpha fruticosa*, *Salix flavida*, *Hedysarum mongolicum*, and *Artemisia salsoloide*. In 1957, on the basis of the suggestion of Professor Petrov, the proportion was changed to 50 percent of woody trees, 25 percent of shrubs, and 25 percent of semi-shrubs. At the same time, the density was changed to one woody tree every two square meter, one plant of shrub per square meter, and two plants of semi-shrub per square meter. As to the species of trees. Professor Petrov suggested that *Haloxylon ammodendron*, *Tamarix chinensis*, and *Caragana*

microphylla should be increased. The forest built in the fall of 1957 and the spring of 1958 was built according to Professor Petrov's suggestions.



- ▲ 乔木 1×2 米
- 灌木 1×1 米
- X 半灌木 1×0.5 米
- 草墙

Legend

- ▲ Woody trees 1 x 2 m
- Shrub 1 x 1 m
- X Semi-shrub 1 x 0.5 m
- Straw wall

In the above figure, I indicates the low area in the desert, II indicates the elevated area in the desert, and III indicates the "falling sand slope." Area I can be afforested immediately. Area II may be afforested during the second stage when the elevated area is levelled off by "straw walls." No tree is planted in area III

because the sand is too thick, and the gradient is too great. In area I, the section close to area III has more moisture than the section close to the top of the sand dune. Hence area I is divided into Ia and Ib. The arrangement of trees in the two sub-areas is as follows:

| Ⓐ 立地条件点型 | Ⓑ 树种 | Ⓒ 株行距(米) | Ⓐ 立地条件点型 | Ⓑ 树种 | Ⓒ 株行距(米) |
|----------|-------|----------|----------|------|----------|
| Ia | ① 小叶杨 | 1×2 | Ib | ① 沙柳 | 1×2 |
| | ② 花柳 | 1×1 | | ② 黄柳 | 1×1 |
| | ③ 旱柳 | 1×1 | | ③ 黄柳 | 1×1 |
| | ④ 柳 | 1×1 | | ④ 柳 | 1×1 |
| | ⑤ 蒿 | 1×0.5 | | ⑤ 蒿 | 1×0.5 |

Legend

- A. Type of area where the trees or shrubs are planted
 - B. Species of plants
 - C. Distance between plants and distance between rows (m)
1. Populus simonii
 2. Hedysarum scoparium
 3. Salix flavida Skv. et Chang
 4. Haloxylon ammodendron (X. A. M.) Bge.
 5. Artemisia salsoloide, Willd.
 6. Alaeagnus angustifolia L.

7. *Tamarix chinensis*
8. *Salix flavida* Skv. et Chang
9. *Haloxylon ammodendron* (X. A. M.) Bge.
10. *Artemisia salsoloide*, Willd.

The elevated areas in the right and left are too high and have a thick accumulation of sand, and therefore cannot be used to plant trees during the first stage. A straw wall is erected around the area where no trees can be planted so that it may be used for forestation during the second stage when it is levelled off by wind. The straw wall is made of rice stalks or hay. First lay down the rice stalks on the ground. Then use a pick to thrust the middle of the stalk into the sand so that the two ends will stand up. Then tramp on the sand around the stalks so that they will stand erect. After the straw wall is built, cover the area with grass.

The forest built at Chung-wei in 1958 was designed by Soviet expert Comrade Ah-fu-ning. It consists of 50 percent of shrub and 50 percent of semi-shrub. The density is one plant of shrub per square meter, and 2 plants of semi-shrub per square meter. The plants used are *Caragana microphylla* var. *tomentosa*, *Calligonum mongolicum* Turcz, and *Caragana microphyllum*.

The problem of the ratio between the woody trees and the shrubs, and the problem of the density of plants call for further study and experimentation.

(8) Forestation with cuttings. According to the experience of Hsueh-pai Hsiang in Min-ch'in Hsien, the average rate of survival of the cuttings of poplar, willow, and *Elaeagnus angustifolia* is 97 percent. The new plants are 60 cm high, and the diameters of their roots are around 1.14 cm.

(9) Deep planting. The characteristics of sandy lands are the lack of water and the presence of a thick layer of sand. At Sha-po-t'ou, for instance, the sand was 30 cm thick in 1957. In order to attain a high rate of survival of the plants, Chung-wei has adopted the following measures: 1) The holes for the seedlings must be 50 cm deep. 2) Cuttings must be soaked in water before planting. 3) Wet sand must be used to cover the holes after the seedlings or cuttings are planted, then tramp around the seedlings to make the ground compact.

(10) Forestation with short cuttings. The experience of Shui-yuan Hsiang, Yung-ch'ang Hsien, shows that when long cuttings are used, the rate of survival was only 42.3 percent, but when short cuttings are used (with 15 cm

above the ground), the rate of survival was 92 percent. The long cuttings are undesirable because of the following reasons:

1) The long cuttings are 5-6 ch'ih long, while the short cuttings are 2-3 ch'ih long. If the long cuttings are chopped into two, they may be used to afforest twice as big an area as would have been if long cuttings were used.

2) In the case of long cuttings, the above-ground portion is long, and sways too much in the wind. In addition, as the long cutting evaporates a larger amount of water, its root system has a slower development. In the case of the short cuttings, there is none of these undesirable phenomena. Hence the one-year-old plant grown out of short cuttings may reach a maximum height of 2 m, while the one-year-old plant grown out of long cuttings can reach a maximum height of only 50 cm.

(11) In both Fo-hsi and T'eng-ko-li desert, the salinized area, especially by the lake side, has a plentiful supply of water. Hence a large track of land on the shores of lakes in the T'eng-ko-li desert was afforested in the spring of 1958, but a large number of the seedlings died because no proper measures were taken to reduce the

salinity. However, in the Ho-hsi Corridor, the lake shores were first paved with sand before forestation. As a result, the rate of survival of the seedlings was high. On the shores of the Pa-yen-nor (Pa-yen Lake) and the Ping Lake in the Alashan Banner, there are five different rates of survival for seedlings:

| | Rate of Survival |
|--|------------------|
| 1) On slightly salinized soil | 28% |
| 2) On heavily salinized soil | 17% |
| 3) On soil with white saline spots | 7% |
| 4) In places covered with aeolian sand | 60% |
| 5) On sand dunes grown with <i>Nitraria schoberi</i> | 60% |

To build forests on lake shores with saline crusts, we must first dig the pits, and expose them for 2-3 days. Then plant the seedlings or cuttings in the pits and fill the pits with fertile soil. Finally, the soil is covered with sand and rocks in order to prevent the rise of saline. If saline crust appears in the forest area, wash the ground with water, or get rid of the crust by sweeping.

On lake shores with saline crusts, the soil should be turned or made loose after rain or watering in order to

prevent the rotting of the roots. The shrubs should not be watered in summer. As a result of applying these methods, the rate of survival of the trees planted by the tax bureau at Chiu-ch'uan reached 99 percent. On the west San-p'ing-k'ou saline flat in Min-ch'in Hsien, 85 percent of the trees planted and managed in the same way survived.

(12) At Cha-han-pu-lo-ko in the Alashan Banner, the masses let the elm and *Xlaeagnus angustifolia* grow without weeding, because the weeds serve to protect young plants from wind, sand, and hot sunshine. According to a survey made in August 1958, the seedlings entirely surrounded by weeds were weak and small, while those half-surrounded by the weeds were tall and strong. As compared with the seedlings not surrounded by any weed at all, the seedlings under the protection of weeds definitely grow better. The rate of survival of elm trees planted on the open ground in front of the Shuang-hei Mountain in the T'eng-ko-li desert was only 40 percent, while that of elm trees planted together with millet was 72 percent. This shows that farm crops, especially leguminous crops, can serve as a live screen to protect the forest. At San-p'ing-k'ou, Min-ch'in, the space

between the rows of trees or shrubs has been widened to 5 m for the cultivation of farm crops. The competition between forestation and farming is thus avoided as far as land utilization is concerned.

(13) Experience of nursing the seedlings of *Alseagnus angustifolia*. Most widely found in the area under survey, *Alseagnus angustifolia* is adaptable to any place. The timber used for houses at San-p'ing-k'ou, Min-ch'in, 50 years ago is still as strong as new. Although the timber of *Alseagnus angustifolia* is not straight, it can be used to make furniture. Its tender branches and leaves are the best feeds for sheep. In 1956, Teng-k'ou trimmed a large amount of branches and leaves from the *Alseagnus angustifolia* trees and sent it to the pastoral area as an over-winter fodder for the animals. With high resistance against aridity and salinity, it grows fast and can quickly bring income to the peasants. When it is blooming, the whole forest smells fragrant. Hence it is most welcomed by the masses. In Ho-pei, all the seedlings cultivated by the nurseries are thriving. In 1953, the seedlings nursed at Min-ch'in had to stay two years in the nurseries before they can be transplanted, the yield was only 1,805 seedlings per acre, and

the cost per seedling was 0.005 yuan. In 1953, the seedlings were kept in the nurseries for one year, the yield was increased to 30,000 seedlings per mou, and the cost was reduced to 0.0049 yuan. In 1956, the per mou production was increased to a maximum of 40,000 seedlings, and the cost was brought down to 0.0025 yuan per seedling. The sand fixation forest at Chung-wei created a record of producing 78,000 seedlings per mou. A survey made at a nursery at San-p'ing-k'ou, Min-ch'in, in August 1958 showed that an average of 200 seedlings grow on each square meter. It is estimated that the highest yield will reach 100,000 seedlings per mou. This shows that the technology of nursing the *Elaeagnus angustifolia* seedlings is steadily improving. The experience of *Elaeagnus angustifolia* seedling nursing may be summarized as follows:

- 1) "Level the ground and cover the saline with soil." This is an experience acquired by the San-p'ing-k'ou nursery at Min-ch'in. The so-called "level the ground" is to level off the high land, and raise the lowland until the whole area is level, and to scrap the saline crust. The reclaimed land is not used until the next year. If a piece of land is reclaimed in spring, it will be "cultivated in spring, exposed to sunshine in summer, plowed in

autumn, irrigated in winter, and raked in the next spring" before the seeds are sowed. In other words, before a piece of reclaimed land is put into production, it will be cultivated, plowed, and raked five to seven times. At the Tengcha seedling nursery, Min-ch'in, the land is first levelled, raked, and irrigated. Before thawing, the land is pressed by roller 10-13 times, and raked six times.

Cover the saline land with sand. On the basis of the experience of the masses that "sand is like fertilizer to saline soil," the San-p'ing-k'ou nursery of Min-ch'in used 1,005 carts of sand to cover 28 mou of heavily salinized soil in 1955 and 1956, and thus prevented the rise of saline.

2) Generous application of fertilizer and improvement of the method of fertilizer application. Using *Sophora alopecuroides* as a green manure, and stable manure as an organic fertilizer, Min-ch'in applies more than 1,400 chin of fertilizer per mou. At the seedling nursery in San-p'ing-k'ou, the procedure is to apply the green manure made of *Sophora alopecuroides* first at the time of levelling the ground, and then to apply the stable manure before the winter irrigation. The mixed use of these two kinds of fertilizers will help improve the quality of seedling.

3) Big field belt sowing. Borrowing the experience of the Soviet Union, Ho-hsi has changed "bed sowing" to "big field belt sowing." The seedling nurseries at Min-ch'in are using the following three variations of "big field belt sowing":

Three-row style: 40-20-20-40 Belt distance 40cm
(or 50cm), row distance 20cm.

Four-row style: 40-20-20-20-40 Belt distance 40cm
(or 50 cm), row distance 20cm.

Six-row style: Belt distance 30cm.

The "big field belt sowing" has the following advantages:

1) The spaces between the rows are used in alternate years for cultivation.

2) The seeds are neatly sowed, and the congestion of seedlings is avoided. The one-year-old seedlings are as high as 120 cm.

3) Modern farm machinery may be used for medium cultivation and weeding.

Each sowing team consists of nine persons: three persons dig the ditches; three persons sow the seeds; and three persons cover the ditches with sand. At San-p'ing-k'ou nursery, if 32 shih chin of seeds are sowed on each mou in the four-row style, it ^{is} expected to yield 55,000 seedlings

per mou; if 48 shih chin of seeds are used, it is expected to yield 50,000 seedlings per mou. At nurseries in San-lei, if 60 shih chin of seeds are sowed in the six-row style, it is expected to yield 84,000 seedlings per mou.

4) Early sowing and early germination. In Ho-hsi, the nursing grounds for seedlings are generally irrigated in winter. If the ground is irrigated too late, the thawing will be late next spring, and the growing period of the seedlings will be shortened. If the ground is irrigated earlier in winter, the time of sowing will be earlier. Generally, the seeds of *Elaeagnus angustifolia* are sowed on 15 March. The seeds of elm trees are stored first, and sowed in early spring of the next year.

5) Storage of *Elaeagnus angustifolia* seeds and their germination. The seeds of *Elaeagnus angustifolia* may be stored in a pit, and the method of storage will help the seeds germinate.

Before storing, the seeds are washed clean. The pit is located in a dry place with loose soil, measuring 1 m deep, 60 cm wide, and 1-3 m long. Put a 15 cm thick layer of sand at the bottom of the pit, and then put a 6-10 cm thick layer of seeds above the sand. So

goes on--a layer of sand alternates with a layer of seeds --until they reach a level 30 cm from the ground. The seeds are then covered by a layer of fine sand, and a layer of grass (approximately 15 cm thick). Then pour enough clean water over the pit to wet the seeds. A 3 cm thick ice is then formed over the grass. Finally, shovel 30 cm of wet soil over the ice to form a small mound. After the elapse of 90-150 days, the pit may be opened for inspection, and the seeds will be found showing signs of sprouting. The seeds may then be taken out of the pit, washed, and then sowed with grass ash.

To help the seeds of *Elaeagnus angustifolia* germinate in spring, the nurseries may soak the seeds in water for three days, and then bury them in a rectangular pit 50 cm deep. Or the seeds may be piled up against a wall facing the sun, and then covered up by a 2 cm layer of hay. The pile is watered every day. Under normal conditions, the seeds will show signs of sprouting in three days. When 50 percent of the seeds show signs of sprouting, they may all be taken out of the pit and sowed.

ANIMAL HUSBANDRY IN ORDOS, HO-HSI,
ALASHAN, AND T'ENG-KO-LI

I. Ordos

In the Ikhchao League, sandy pastoral area constitutes 40 percent, terraced pastoral area in front of the mountains constitutes 40 percent, meadow pastoral area with low mounds constitutes 15 percent, and farmland constitutes 5 percent of the total area. The farmland is located only in the northeastern part of the League, while the rest almost entirely belongs to pastoral areas. The meadow pastoral area is the principal pastoral region.

Among the areas under survey, Ordos has the best natural conditions. The Mongols call this area Po-erh-to-hai, which means "good grass." Since the conditions are favorable for reclamation and animal husbandry, the phenomena of indiscriminate reclamation and indiscriminate use of pastures are so serious that more drifting sand areas are found in Ordos than in Alashan. As soon as the vegetation on the drifting sand is restored, it is destroyed. (For instance, in 1917 the Mongols and the Hans burned all the vegetation and forests in Ordos in an attempt

to clear the ground for reclamation. About 60 years ago during the Ch'ing Dynasty, the vegetation was seriously destroyed by the immigrants.) The drifting sand caused by indiscriminate grazing is extremely serious. In the central and northern parts of the pastoral region, the sand dunes are covering over organic black soil. This means that these places were originally grasslands.

The ratio between grass production and grass consumption at the Wu-sheng Banner, the Otok Banner and the Hangchin Banner is about the same. Goat consumes 32-34 percent, sheep consumes 14.4-25.5 percent, cattle consumes 12.5-29.8 percent, horse consumes 17-22.3 percent, mule consumes 2.2-4.5 percent, camel consumes 0.4-2 percent, and pig consumes 1-3.4 percent. Most of the grass produced in Ordos is therefore consumed by goat and sheep. (The ratio among the number of domestic animals is as follows: Sheep : goat : donkey : cattle : horse : mule : camel = 1 : 1 : 4 : 5 : 5 : 5 : 7). The sheep and goat are concentrated near populations of weeds and small shrubs on the terraced lands in front of the mountains and in the meadow areas. Because of heavy grazing, the pastures are degeneralized and dwindling in size, with patches of

drifting sand appearing here and there. The following is a description of the different areas in Ordos:

Farmland. With the exception of some farmland along the rivers where irrigation is feasible, most of the farmland is dry. In the transitional area from the terraced land to the brim of the loess area, erosion ditches are clearly seen on the piedmonts. In the Mao-wu-su desert area, the farmland is very small in area. The pastures in the farming area are exceedingly small, located mostly on low, swampy, and salinized lands. The farmlands in this area are often hit by natural calamities, and the crop yields are unstable. More perennial herbal plants should be planted, crop rotation should be practised, and protective forests should be built.

Meadow pastoral area with low mounds. This area includes the lacustrine meadows in the northwest of the Wu-sheng Banner and the southeast of the Otok Banner. Populations of *Achnatherum splendens* Ohwi are found on meadow saline soil; populations of *Artemisia salsoloide* and weeds are found on chestnut soil; and populations of *Artemisia salsoloide* and *Caragana stenophyllia* pojark are found on primitive brown soil in stabilized or semi-stabilized deserts. There are no pastures which lack water.

Drifting sand areas are found in the north and south of the T'ao-yuan Mound, the Pa-yen Lake, the Chao-huang Flat, and the Hsin-miao District. The vegetation over higher places already show signs of degeneration because of heavy grazing. Furthermore, the meadow soil area is already infested with poisonous grass and parasites. The famous horses from the Wu-sheng Banner and the Otok Banner are no longer as good as they were because of the degeneration of the pastures.

The death rate among the animals is high because the load on each pasture is already over the saturation point. In the spring of 1957, 200,000 domestic animals died in a drought, and only 500,000 head of domestic animals survived (the total number of domestic animals in the early years after the liberation was 300,000). There are few trees in the area, except for some willow and elm trees found here and there near the population centers. There is no protective forest at all. Twenty years ago, the *Achnatherum splendens* flats were fully grown with *Salix chei*, *Lophila* and *Caragana microphylla* var. *tomentosa* as high as a man, but now all these flats have become areas of drifting sand. The degeneration of the pastures is very fast. It was only in 1956 that the

Mongols began to cultivate fodder crops, such as millet, black beans, corn, buck wheat and sorghum, and such crops quickly caused the formation of drifting sand.

In this area, efforts should be made to eliminate poisonous plants (such as tsui-na-ts'ao) and parasites, build protective forests, plant leguminous and gramineous feed grass, and raise grass for sand fixation. As the number of domestic animals on each pasture is already over the saturation point, domestic animals should not be allowed to multiply without a limit. However, more draft animals for the farms should be bred and sent to the farms of loess piedmont areas. Enough green fodder should be planted and stored for emergency use in drought years or years hit by natural calamities. In order to establish the bases for cultivating fodders, it is imperative to have irrigation facilities. Both Pa-t'u-wan Hsiang and Na-liu-ho Hsiang are good sites for the construction of irrigation projects. In planning the projects, overall consideration should be given to forestation, and animal husbandry as well as the cultivation of fodders.

Terraced pastoral area in front of mountains. This area refers to the high land in the northeast of the Otok Banner adjacent to the piedmont of the Table Mountain.

The vegetation changes gradually from the cushion-shaped populations of small shrubs on piedmont diluvial sediments in the east of Ordos to the small shrub herbal plants on the sandy and rocky soil in the west. A thin layer of floury, sandy brown soil is found throughout the area. As an important small shrub feed, *Artemisia frigida* Willd is found in populations of *Reaumuria soongorica* (Fall.) Maxim. + *Caragana stenophylla* pejark + *Zygophyllum xanthoxylon* Maxim + *Salsola passerina* Bge. + *Stipa gobica* Roshev, and the *Artemisia frigida* Willd-*Dianthus chinensis* L. population. During the drought of last year, some of the *Artemisia* species withered, and the animals had to be moved to the meadow pastoral area in the southwest for grazing. From time to time, the animals are also herded to this area for grazing from the meadow pastoral area when the latter is infested with parasites and poisonous plants. Hence, in the terraced pastoral area in front of the mountains, one can find both nomads and settled herdsmen.

Shortage of water is a serious problem in this area. In the water shortage area, some of the water wells are as deep as 20-30 chang, and water has to be transported from places 20-30 li away. Private water wells are often locked

as a precaution against water stealing. The activity of animals is limited to the area surrounding the water well. For big animals, their activity area is limited to 20-30 li from the water well. For sheep or goat, their activity area is limited to 10-15 li from the water well. As a consequence, large areas of grass cannot be utilized. Almost all the pastures in the terraced pastoral area of the Ordos lack water. In addition, all the pastures are over used, resulting in degeneration during drought years.

The death rate of sheep and goat in this area is lower than that in the meadow pastoral area. For other animals, the death rate fluctuates greatly. For instance, the number of horses in 1955 was 259.66 percent of that in 1949, 89.16 percent of that in 1954, and 97.28 percent of that in 1955. This shows that the irrational utilization of pastures constitutes a very serious problem in the Otok Banner.

In regard to the shortage of water, more sources of water should be explored, and the tools for water lifting should be improved. The pastures should be used by rotation, and water should be shipped by cart to places outside of the pastures to quench the thirst of the animals.

Fodders should be stored, and a plan should be made for the utilization of water wells, fountains, and rivers.

The Yen-hai-tzu Ku-pu-ch'i desert area. This area falls within the Hang-chin Banner. Of the 30,000 square kilometers of this banner, 50 percent is pastoral area, one-third is desert, 1.5 percent is farmland, 0.35 percent is forest, and the rest is non-productive salinized land. The pastures of this area are found on the highland south of the Ku-pu-ch'i desert, in the sand dune area, and the area between sand dunes. The vegetation in the highland area is distributed on the ancient eluvial soil over the cretaceous bedrock. On sand dunes and on the ground between sand dunes, graminaceous plants and weeds are found. *Penisetum flaccidum* Griseb and *Lasiogrostis splendens* (Trin.) Kunth are widely distributed. *Artemisia saissoloide*, *Psammochloa villosa* Bor., *Allium mongolicum* Ege., *Shragmites communis* Trin., tsui-ma-ts'ao (poisonous), and ts'un-ts'ao are found here and there. In comparatively heavily salinized places, *Kalidium gracile* Fenzl, and *Nitraria schoberi* are seen. In this area there are many dry ditches, which are more than 100 li long. Such ditches include the En-keng ditch, the Mao-kung-tai ditch, the

Yen-hai-tzu dry ditch, and the Mo-lin ditch. These dry ditches can be used to store water during the rainy season. The pastures on the ground between sand dunes are already degeneralized because of indiscriminate use for grazing. Some of these areas are turning from semi-stabilized deserts into drifting sand areas.

There are many water-scarce pastures in the northeast of Yen-hai-tzu and in the west of the Hang-chin Banner. The underground water level in the northeast of Yen-hai-tzu is as deep as 7-10 chang, while that in the west of Hang-chin Banner is often at 20-30 chang below the ground. Furthermore, underground water cannot be used for drinking because it is heavily mineralized.

In the Ku-pu-ch'i desert, the annual precipitation ranges from 150 mm in the west to 300 mm in the east, and fresh underground water is found under the sand layer. Hence *Bassia dasyphrilla*, cha-ming-ko, and other feeding grass can grow. *Artemisia salsoloide* and *Caragana tragacanthoides* are also widely distributed. In some places,

fresh rain water is absorbed by big sand dunes, and seeps down into the ground to form a fresh water layer which can be used for growing sand-fixation plants.

In the desert, 30 percent of the residents are

settled herdsmen, and 70 percent are nomads. Living in yurts, the Mongols lead a primitive nomad life, and increase the threat of drifting sand.

II. The Ho-hsi Corridor Basin

In the Ho-hsi Corridor, the grassland totals 90,000 square kilometers, constituting 31.11 percent of the entire area. In the farming area, there are 2,181,340 head of big and small domestic animals, constituting 68.52 percent of the total number of animals. The pastoral area in the corridor is so small that the animals have to be grazed on the Ch'i-lien Mountain. The natural pastures become all the more insufficient as a result of the expansion of irrigated farmland. Therefore, the lack of pastures becomes a serious problem.

Wasteland in the basin consists of pastoral land, gobi, deserted mountains, sandy and heavily salinized land, and idle farmland. The first three kinds of waste land are caused by aeolian erosion. The last two kinds are good for grazing. As a matter of fact, the sandy and heavily salinized land in the west of the corridor constitutes the principal natural pastoral area in the

entire region.

The gobis at the middle and the lower reaches of the Su-lu River constitutes 70 percent of the total area of the river valley. The major plants growing on the gobis include *Ephedra Przewalskii* Stapf., *Calligonum mongolicum* Turcz., *Hololachne scougarica* Ehrenb., *Nitraria schoberi*, *Zygophyllum xanthoxylon* Maxim., and *Asterothamnus centrali-asiaticus*. The gobis are poor pastures for camels because the grass is scarce, and the underground water level is deep. For instance, the gobi in Tun-huang is large in area, it has only enough grass to feed 71 camels. The camel caravan stations in the central part of the basin serve essentially fine fodders such as beans and husks of grain. The camels not used for transportation are grazed in the mountain area. However, grazing should be forbidden in the heavily eroded Pai-lung-tui area, where vegetation is scarce. The piedmont area in front of the Nan Mountain may be turned into a pasture by using water from the Ch'i-lien Mountain for irrigation. The desert area, where irrigation is impossible, should be used to grow medicinal herbs and plants with long fibers, and no grazing should be allowed. The Pai (North) Mountain and the Ma-chung Mountain should

be used as a natural pasture to raise sheep, goat, and camels.

The sandy saline land consists essentially of saline soil unsuitable for reclamation. At present, forestation projects aimed at "sealing the sand and raising the grass" are going on in many places, and thus the limited number of pastures are over-used. Because of the degeneration of pastures and the wanton destruction of vegetation, animals have little resistance against disease, and their death rate is high. Take the saline soil pasture at Tun-huang as an example. The number of animals died there constitutes 95 percent of the total number of animals died in the whole hsien. Since such pastures have a low productivity, the local people suggest that they should be used to grow wild hemp, *Achnatherum splendens* Chwi, and *Iris ensata* L. which can be used as raw materials for making fiber. Although such suggestions are worthy of consideration, attention should also be given to the potentiality of developing animal husbandry. Whereas these pastures (on which *Phragmites communis*, or *Alhagi pseudoalhagi* Desv. is the predominant plant) are still used for pastoral purposes, they should be used to raise superior species of grass for hay-making.

During the low water level period, all the withered grass and inferior species of grass should be burned and replaced by better species. At the thawing time or when the water level rises, no grazing should be permitted in low and swampy areas so as to give the grass a chance to grow. In places at a higher altitude, the pastures should be used by rotation. Locations should be selected to build silos to store grass for use in winter and early spring. *Phragmites communis* may be cut once a year. At Chin-t'a, for instance, it may be cut in July, and then dried, and stored away. In higher places, more *Glycyrrhiza uralensis* Fisch, *Lycium chinense*, and *Sophora alopecuroides* L. are found because of lighter salinity. In places where the water level is not too high, the quality of *Phragmites communis* is better, and there are more better species of gramineous plants. Because of the higher altitude of this area, the soil is more sandy in property, and many places are exposed because of heavy grazing. Hence protective forests should be built, feeding grass should be cultivated, and rotation should be put into effect for grazing. In the Yin-pen-shui area near Chin-t'a, where the water is bitter, and cannot be used by animals, deep

underground water should be tapped. The pastures with saline crusts should be either washed or scraped. Since this area is well equipped with conditions for raising animals of higher value, consideration should be given not only to investment, but also to the improvement of animal species; we shall never succeed if we give only one-sided consideration. The animals here have a low rate of multiplication. At present, in the farming area, mules are born by donkeys. However, very few animals can meet the standard required of draft animals except for a small number of cattle and mules. Among the animals here, a large number of them are either too young, or too old, or too weak. Such a backward situation exists not only in the pastoral area, but also in the farming area. According to statistics compiled at Ta-tan and Shang-juk Hsiang in Min-ch'in Hsien, of all the number of draft animals, 27 percent are cattle (one-fourth of them are strong), 4 percent are mules (54 percent of them are strong), and 66 percent are donkeys (28 percent of them are strong). In other words, 44 percent of mules, 41 percent of donkeys, 38 percent of horses, and 36 percent of cattle are old, weak, or crippled. Donkeys -- the most used animals in the farming area--are too small

and too weak to meet the requirements on the farms. The mules born by the weak donkeys also cannot satisfy the requirements during the great leap forward in agriculture. At present, foreign breeds are being introduced into this area for improving the animal species.

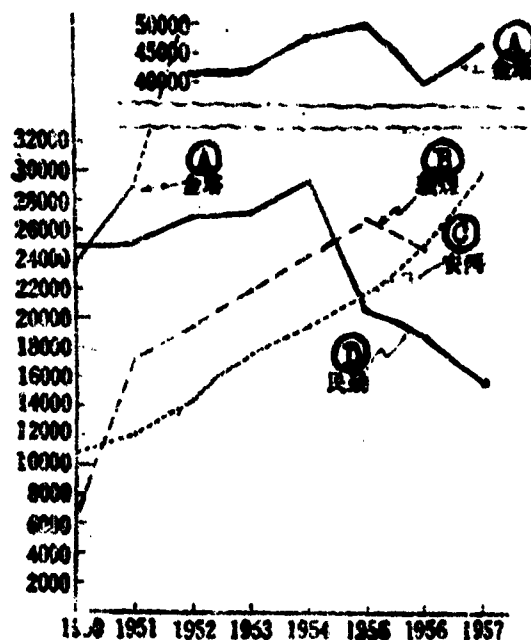
It is therefore suggested that an animal breeding station be established. As a first step, collect all animal species, and turn them over to the animal breeding station for selection. Then cross the breeds by artificial fertilization so as to obtain the best species.

In farming area of the corridor, there is a shortage of fertilizer. One of the main purposes of raising sheep is to accumulate fertilizer. In An-hsi and Tun-huang, sheep consume 16.5 percent of grass. In Tun-huang and Chin-t'a, goat consume 15.8-19 percent of the total amount of grass. In the future, for improving the pastures, and for ensuring the supply of fodders, sheep raising should be changed to hog raising because the manure produced by sheep is not as much as that produced by the pig. After a plentiful supply of fodder is ensured efforts should be devoted to the development of meat and dairy products so as to meet the demands of urban residents in the area.

Domestic animals (camels and sheep) in the basin are closely related to the pastoral areas in the nearby deserts. Several tens of thousands of camels now raised in the Alashan Banner belong to Kansu Province. The camels are essentially used for carrying salt. On their journeys from one place to another, the camels are freely grazed on pastures along the road. Large areas of drifting sand have already appeared on pastures near the Ya-pu-lai salt lake and the Chi-lan-t'ai salt lake, because of the excessive grazing by camels in winter and spring when the transportation work is heavy. Min-ch'in has the largest number of camels, while Chin-t'a has the largest number of goat. At Min-ch'in, sand dunes occupy 52.73 percent of the total area of the hsien. At Chin-t'a, deserts and mountains occupy 86.7 percent of the total area of the hsien. Since many pastures in these two hsien are under the project of "sealing the sand and raising the grass," the camels and sheep have to be grazed in nearby deserts, thus causing the destruction of large areas of vegetation and the formation of drifting sand. As these areas are close to the agricultural, industrial, and mining centers in the Ho-hsi Corridor, immediate measures must be taken to

remedy the situation. Basically, the number of domestic animals in the Ho-hsi Corridor has been on the increase during recent years, but there has been an obvious decrease of camels, sheep, and goat in Min-ch'in (see Tables 1, 2, and 3). Therefore, the selection of species and feeding of camels, and the sand fixation work should be considered in conjunction with the improvement of pastures.

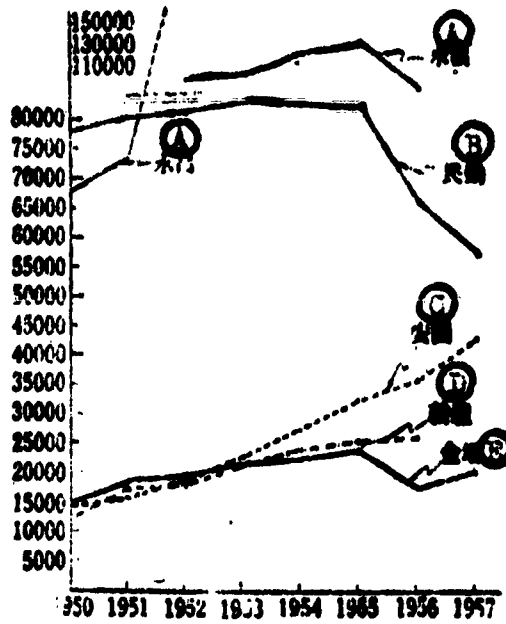
Table 1 Number of Goat in Ho-hsi Corridor in Recent Years



Legend

- | | |
|-------------|--------------|
| A. Chin-t'a | B. Tun-huang |
| C. An-hsi | D. Min-ch'in |

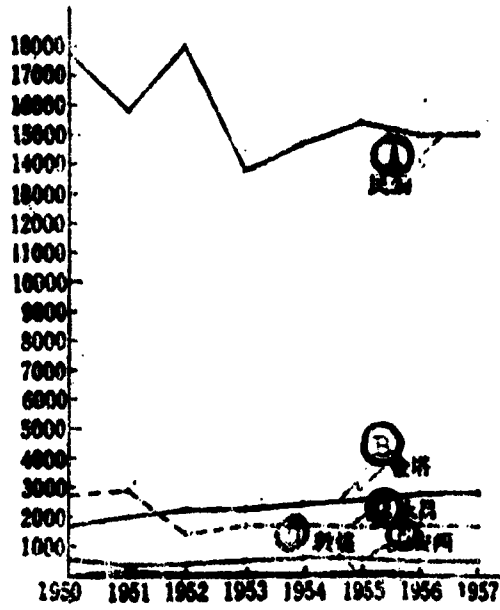
Table 2 Number of Sheep in Ho-hsi Corridor in Recent Years



Legend

- | | |
|----------------|--------------|
| A. Yung-ch'ang | B. Min-ch'in |
| C. An-hsi | D. Tun-huang |
| E. Chin-t'a | |

Table 3 Number of Camel in Ho-hsi Corridor in Recent Years



Legend

- | | |
|----------------|--------------|
| A. Min-ch'in | B. Chin-t'a |
| C. Yung-ch'ang | D. Tun-huang |
| E. An-hsi | |

III. Alashan

The Alashan district includes the Alashan Banner and the Otok Banner, with a total area of 230,000 square kilometers, a population of 73,274 persons (of whom 25,935 persons are herdsmen), and an animal population of 1,053,472. During the last decade, there has been no noticeable increase in population, but there has been an increase in the number of animals since the liberation. Because of the vast area, there are only 1.2 person and 4.5 head of animals on each square meter of land. The Alashan Banner has a total population of 23,792 persons, and on the average each person has 13.1 head of goat, 12.2 head of sheep, 3.7 head of camel, 1.3 head of cattle, 0.6 head of horse, and 0.42 head of donkey.

The vegetation in Alashan is scarce, and a large area of soil is exposed even in ordinary years. In drought years, domestic animals wander over a large area in search for grass, and tramp on the weathered pebbles, thus causing the formation of drifting sand. The casualty of domestic animals is high in years when grass is lacking. In one out of every three years, there is a grass shortage. In the past when the pastures were

out of grass, the animals moved to the pastures on lake shores or on the Ho-lan Mountain.

As the climate is getting drier and drier, the vegetation is slowly changing to the desert type. In the last few years, the number of animals has been increased by several times, but the situation of the pasture has not been improved. In the years to come, the shortage of grass will become more serious, and the threat of sand will become greater. It is, therefore, imperative to take measures for the improvement of pastures.

Statistics show that the number of animals decrease sharply in years of drought. Take goat in the Alashan Banner as example: 102,851 head in 1936; 55,406 head in 1948; 105,530 head in 1950; 332,376 head in 1955; and 369,758 head in 1957. Take camel as example: 46,325 head in 1936; 54,271 head in 1946; 49,078 head in 1948; 53,936 head in 1950; 89,775 head in 1955; and 104,304 head in 1957.

During the years 1955, 1956, and 1957, Alashan suffered the worst drought in 60 years (in some places there was no drought in 1956). Although some animals dies because of the drought, the total number of animals

increased instead of decreased. This shows that people took a passive attitude toward the drought in the past. But during the serious drought of recent years, the government and the people took active measures to fight the drought. In the Fifth Su-mu, for instance, the domestic animals were sent out to the Ho-lan Mountain and the Otok Banner for grazing. In 1957 when all the good feeding grass was eaten up, the camels had to eat *Nitraria schoberi* to fill their stomach. The work of protecting the young and female animals was particularly important during the drought. According to statistics of the Alashan Banner in 1955 (a year during which the drought situation was less serious), the number of female cattle and cattle less than one year old constitutes 63 percent of the total number of cattle; the number of female sheep and goat and sheep and goat less than one year old constitutes 65 percent of the total number of sheep and goat; the number of female camels and camels less than one year old constitutes 52 percent of the total number of camels; the number of female horses and donkeys and horses and donkeys less than one year old constitutes 43 percent of the total number of horses and donkeys. Natural calamities

accounted for 43 percent of the total losses of camels, 14-16 percent of the total losses of sheep and goat, 30 percent of the total losses of cattle, 27 percent of the total losses of horses, and 27.4 percent of the total losses of donkeys. The number of animals sold in relation to the total number of decrease was 20 percent in the case of camels, 41 percent in the case of sheep and goat, and 40 percent in the case of horses.

During the drought, sheep and goat are often slaughtered for meat, but camels are never slaughtered. In the Alashan Banner, camels eat about 50 percent of the grass, and goat and sheep eat about 40 percent of the grass. It is therefore important to watch the grazing camels, sheep and goat, because they can accelerate the destruction of the vegetation covering.

Therefore, during the drought season the following measures should be taken: forbid grazing in places where vegetation is scarce; move animals (especially young and female animals) to pastures outside of the region for grazing; sell or slaughter the old and weak animals; and prepare enough over-winter fodder.

Under the effect of high aridity and frequent drought, the pastures in Alashan are typical desert pastures

covered essentially by thin semi-shrubs. The vegetation here depends heavily on rainfall and atmospheric moisture for growth. The strong aeolian erosive effect turns pebbles into sandy, primitive soil. In many places such primitive soil has a high mobility. Many monadnocks and piedmonts are found in the Fourth and Fifth Su-mu in the Alashan Banner. The animals are unevenly distributed because the vegetation covering on pastures is thin, and the capacity of pastures in accommodating animals is low. The camels produced in Alashan are renowned in the whole country. For the improvement of animal husbandry in this area, more grass should be planted near the water wells or at the sources of water, the area within a radius of 5 li from the population center should be reserved for cultivating winter and spring fodders, breeding stations should be set up in the vicinity of population centers, and grown-up and strong animals should be put to graze on pastures in more remote regions.

Underground water often converges and gushes to the surface in the low basins in the desert where *Phragmites communis*, *Achnatherum splendens* Ohwi., *Nitraria schoberi* L., *Kalidium gracile* Fenzl., etc., thrive over a wide area, and form an important pastoral region in the desert. This

region not only enables the local domestic animals from the threat of drought, but also provides an asylum for animals migrated from other areas during drought years. In this region, the animals are evenly distributed, and the pastures have a high rate of utilization and can accommodate a larger number of animals per unit area. As the principal pastures for cattle, these grasslands are located in lacustrine basins in the Second and Third Su-mu of the Alashan Banner. In respect to measures of improvement, the low swampy areas should be reserved for hay-making, the higher pastures should be rotated for grazing in summer and autumn, protective forests should be built around the brim of the pastures, and tall trees should be planted here and there to provide shelter for wandering animals.

On the alluvial plains in front of the Ho-lan Mountain, and the Ch'ang-ling Mountain near the Yellow River, the water supply is satisfactory, the soil is fertile, the aeolian erosion is slight, and the vegetation consists of populations of small shrubs and gramineous plants. There is a lack of rainfall between spring and summer, as most of the rainfall occurs in August and September. During years with plentiful of

precipitation, numerous species of gramineous plants and weeds appear and cover a large area of this region. As better sheep, cattle, and horses are raised in the area, fur is produced in large quantities on the alluvial plains in front of the Ho-lan Mountain. The quality of the grass is at its best in autumn. Hence the nearby pastures should be used for grazing in winter and spring, and more remote pastures should be used for grazing in summer and autumn. In some places, fodder raising bases may be established by utilizing the sources of water in front of the mountains for irrigation.

The pastures on the Ho-lan Mountain belong to the forest steppe region. The mountain itself is partly covered by a natural forest. In the past, there was a serious conflict between forestry and animal husbandry in respect to land utilization, but now grazing is only permitted in the piedmont area, where 100,000 head of sheep and goat of the First Su-mu feed on gramineous plants and weeds. Strictly speaking, the pastures on the mountains should be provided with irrigation facilities, and solely reserved for hay-making and raising fodders to be used in winter or drought seasons.

The principal pastures in the O-chi-na Banner are located along the O-chi-na River. Because of the high underground water level, *Tamarix ramosissima* Ldb., *Elaeagnus angustifolia*, *Achmatherum splendens* Ohwi, *Phragmites communis*, and *Sophora alopecuroides* L. appear on such pastures. The leaves of *Elaeagnus angustifolia* can be used as a feed. In the gobi area,

vegetation is scarce, underground water level is deep, and the human and animal population is small. The salt lake region cannot be used for animal husbandry because of high salinity. In addition, the grassland on the Ma-chung Mountain also constitutes one of the principal pastoral grounds in the O-chi-na Banner, but the lack of water supply makes it less valuable. The main domestic animals in the O-chi-na Banner consists of camels, sheep, and goat.

The Pa-yen-cho-erh League has a total of 115,000 square kilometers of grassland (constituting about one-half of the total area of the League), distributed mainly on alluvial plains in front of mountains, on hilly sandy lands, and in lacustrine basins. The rest of the league is a vast expanse of desert filled with gravel, broken rocks, and shifting sand dunes, undesirable

for animal husbandry.

The whole Alashan Banner lacks water. The total area of grasslands, which cannot be utilized because of the lack of water, constitutes one-fourth of the entire area of the Alashan Banner. No aquifer is seen even at the depth of 20 chang below the surface. The vegetation in the northwest of Pa-yen-hao-t'e consists of populations of *Artemisia ordosica* Krasch. + *Corispermum patelliforme* Iljin., and individual plants of yu-lo-li, ah-kai-hao, *Stipa gobica* Roshev., yin-ch'eng-hao, and *Salsola passerina* Ege. Other plants include Pa-yin-lao-erh-kung of Pa-pai-kao-erh, Han-tao-erh-tun of Ta-ching, Pa-yin-ko-tai of Ai-lieh-pu-kai, and Hei-ma-kang and Wu-lan-kung of T'u-lan-t'ai. After the rainy season, a great variety of herbal plants emerge. The lower depressed areas may be utilized to accumulate drinking water for animals.

There are about 40 water fountains in the Alashan Banner. For establishing bases for raising foddors, a water conservancy project is designed for the Ha-la-wu ditch in the north and south of the Ho-lan Mountain, and a water reservoir is designed for T'a-erh-lin.

IV. The Utilization and Improvement of Pastures in the T'eng-ko-li Desert

On the basis of our observation, we may first of all say that although T'eng-ko-li is a desert, it is not a dreary, dreadful, and useless land. On the contrary, it is a treasury of numerous resources such as salt, alkali, water, and grass. From the viewpoint of animal husbandry, it is fully equipped with conditions to be turned into a base for the development of animal husbandry.

The T'eng-ko-li desert is situated in the south of the Alashan Banner, with a total area of 30,000 square kilometers. About 52 percent of the total area is occupied by a vast expanse of drifting sand, and the rest, 48 percent (that is, 14,000 square kilometers) can be used as pastures. The population is 6,000, most of whom are engaged in animal husbandry, and a small number of them are salt mine workers. They raise about 244,000 head of big and small animals (according to the 1958 statistics of Alashan Banner). The human beings and animals live in low, and warm lacustrine basins (cases in deserts) with plenty of water and grass.

Although a typical desert, T'eng-ko-li is endowed with better natural conditions than the gobis in the O-chi-na Banner and to the west of Chia-ku-kuan. According to the climatic data gathered at Min-ck'in, Sha-po-t'ou, Pa-yin-hao-t'e, and Ya-pu-lai, the annual precipitation in the T'eng-ko-li desert is around 120 mm (50-70 mm in gobi area), and most of the rainfall occurs in July, August, and September. The frost-free period lasts 190-200 days (one month longer than that in the Hu-lun League). The duration of sunshine totals 3,000 hours. Although a desert may have 101 disadvantages, it has one advantage; that is, the evaporation is slow on account of the weak capillary effect. Most of the rainfall seeps down through the sand, and is preserved under the ground between the sand dunes. With the exception of some individual places where the underground water level is low, the underground water level in places between the sand dunes and in lacustrine basins is generally at 1-5 m below the surface. It is not true to say that there is no water in the desert. Because of good aeration, the sand land has only a thin layer of ice in winter, or it may remain entirely unfrozen. In early spring, the terrestrial temperature in the desert is high, and there is

plenty of moisture in the air. In winter and spring, the O-chi-na Banner is not so cold, and the snow is not so heavy. Evidently, these natural conditions are favorable to the germination and growth of feeding grass, and the utilization of green plants. There are hundreds of big and small lakes, around which grass is abundant. These lake basins are not only the main pastures at present, but are potential bases for raising cultivated fodders. In addition, there are large areas of pastures not yet utilized because of the lack of water supply. According to an estimate made after this preliminary survey, the total amount of grass produced by the present pastures is more than enough to feed the current number of domestic animals. (In fact, the present number of domestic animals can be increased by 50-60 percent.) This serves to explain that T'eng-ko-li has a great potential for the development of animal husbandry.

The superiority of socialism is also unexceptionably shown here. Thanks to the support and concern of the party and government leadership, and through a series of policies and measures, the animal husbandry industry in the T'eng-ko-li has advanced from regeneration to stability and is forging ahead in the direction of development.

As compared with the pre-liberation figure, the number of big animals was increased by 100 percent, and the number of small animals was increased by 200 percent in 1958. In pace with the increase of the number of animals, the standard of living of the herdsmen has been raised to an unprecedented high. Now on the average each person has 41 head of animals, in addition to his income derived from subsidiary productive activities, such as transporting salt and gathering medicinal herb. Experienced in waging battles against nature, the herdsmen show ardent love for communism, and respond quickly to the call of the party and Chairman Mao. They have gradually changed their nomadic habit of chasing the water and grass and depending entirely on nature for a living. Under the superior condition of cooperativization (communalization is currently underway), they are considering such problems as the improvement of the management of their livestock, and the rational utilization of pastures. During the last 1-2 years, they acquired considerable experience in planting feeding grass and planting seedlings.

These favorable natural and social conditions are forceful guarantees for the further development of animal

husbandry in the T'eng-ko-li desert.

Now let us analyze the proportion of animals in order to see the direction of development of animal husbandry in the area. Of the 244,000 head of big and small animals, 16,583 head are cattle, 6,112 head are horses, 261 head are mules, 3,967 head are donkeys, 61,906 head are goat, 129,826 head are sheep, and 24,913 head are camels. The number of camels constitutes more than 10 percent of the total number of animals. In terms of the consumption of grass, camels consume about 36 percent of the total amount of grass. T'eng-ko-li has the largest number of double-hump camels in the country. The high percentage of camels among the animals is closely related to the natural conditions in the desert and the needs of the local people. As everybody knows, camels can feed on shrubs, semi-shrubs, and weeds on the desert steppes, and have a high adaptability to aridity, severe cold, wind, and sand. During the three consecutive years of drought from 1955 to 1957, many animals were starved to death, but the number of camels was increased by 64.66 percent. Bigger than other animals, the camel is born with the perseverance and stamina to make long journeys in the desert. Producing 8-9 chin of hair each, the

camel is an indispensable and irreplaceable beast for transportation in the desert. After some training, the camel can pull carts, and work on the farm (in Ho-hsi the camel is already so used). No wonder camel is raised by every household! In the future sand control work in the desert, camels will all the more needed. It can be said therefore that camel is one of the desert animals that will be greatly multiplied in the future. Since the vast grassland in the lake basin is flat in terrain, and well equipped with water and soil conditions, it may be used for the development of dairy industry once a large amount of superior grazing grass is planted. Furthermore, the dairy products may be processed not only to meet the demand of local herdsmen, but also for export.

Needless to say, the severe desert climate with high wind, shifting sand, and extreme aridity is mercilessly threatening animal husbandry. It is not uncommon that a severe dry wind in spring withers all the sprouting grass, and creates thereby a famine for the rest of the year. The pastures are dwindling in area because many of them are incessantly buried by sand. Drought occurs in nine out of every ten years, and the growth of grazing grass is severely inhibited. Good grazing grass is decreasing

quickly and in large quantities, or even disappears entirely. The instability in the production of grazing grass on the pastures accounts for the weakness and instability of animal husbandry in the T'eng-ko-li desert.

The lack of labor power and communications facilities is also a factor that prevents animal husbandry from further development. The flocks are generally left along on the pasture without any attendant; the hay is made too late and too little; the pastures are not used at the proper time; most of the pastures, where there is no supply of drinking water, are not utilized at all. On the other hand, the grasslands in the lake basin show signs of degeneration and salinization because of over-use. The appearance of drifting sand and aeolian, or alluvial, erosion caused by improper grazing or firewood cutting happens almost everywhere.

The crucial problem for the development of animal husbandry in the T'eng-ko-li desert lies in the control of sand and the transformation of desert climate. Evidently, if we leave the currently existing and solvable problems unsolved, the future prospect of sand control and the development of animal husbandry is very dim indeed.

In order to utilize the pastures rationally and to improve the pastures, we must first of all understand the pastures.

(2) The Natural and Economic Characteristics of Different Kinds of Pastures.

Since T'eng-ko-li is a typical desert area, the different pastures in the desert inevitably assume the characteristics of desert steppes to some extent. First of all, the vegetation on the pastures consists of a small number of species of plants. The whole T'eng-ko-li district has about 180 species of plants, belonging to 40 families. Among the families, the compositae, gramineae, chenopodiaceae, and leguminosae are the largest, and each family has about 20 species. The vegetation consists mostly of semi-shrubs and shrubs, followed by perennial herbal plants, and annual herbal plants. The plants can be divided into two "levels." Those at the lower "level" consist of annual or perennial short herbal plants, which are called by the masses as "base grass." The "base grass" includes *Cleistogenes squarrosa* Keng., *Stipa glareosa* Smirn., *Penisetum flaccidum* Griseb., and *Allium mongolicum* Bge. The growth of the base grass depends upon the situation of rainfall, and its coverage over the ground ranges from 10 to 30 percent. The "upper level" consists of semi-shrubs, or tall shrubs. The soil consists

of salinized soil and gray brown desert soil, which shows alkaline reaction. The soil is sandy, loose, and dry, easily subject to aeolian erosion. The grass yield on the pasture is low and unstable, on the average 1,200-2,000 km per hectare. The more widely distributed grazing grass and plants include *Phragmites*, *Achnatherum splendens* Ohwi, *Oleistogenes squarrosa* Keng., *Stipa glareosa* Smirn., *Penisetum flaccidium* Griseb., *Aneurolepidium dasystachys* (Trin.) Nevski, *Psammochoa villosa* Bor., fu-tzu-mao, *Hedysarum mongolicum*, *Lespedeza dahurica* Schind., *Hololachne soongarica* Ehrenb., *Agriophyllum arenarium* (M. B. A.) Ege., *Pugionum cornutum* Gaertn., *Salsola collina*, *S. loricifolia* Turcz. et Litw., *Allium mongolicum* Ege., *Artemisia frigida* Killd., *Eurotia ceratoides* (L.) C.A.M., *Calligonum mongolicum* Turcz., *Asterothamnus centrali-asiaticus* Novopokr., *Tetraena mongolica* Maxim., and *Taraxacum officinale*. Most of these plants have a sand-fixation effect.

The classification of pastures is a complicated problem for which there is not yet a definite standard in our country. We are trying to classify the pastures in the T'eng-ko-li desert into seven types according to their terrain, soil, water condition, and predominant

plants. Each type has a different economic significance. The following is a description of the different types of pastures:

1. Lake basin grasslands

Situated in low, depressed areas, such grasslands are surrounded by drifting sand. There are about 100 such grasslands scattered in the T'eng-ko-li desert (very few in the southwestern part), the big ones being 10,000 hectares, and the small ones being 800 hectares. Their total area is estimated at 540,000 hectares, representing 18 percent of the area of the entire T'eng-ko-li desert. In the center of most of the lake basins, there is a fresh water or salt lake. (Fresh water lakes are few.) The salinity of the soil gradually decreases from the center of the lake basin toward the outer perimeters, and at the same time the underground water level is getting deeper and deeper, ranging from 0.3 to 1 m. Hence different kinds of plant populations are distributed on different kinds of grass meadows. For instance, meadows of *Salsola Paletziana*, t'ai ts'ao, *Phragmites*, and *Achnatherum splendens* Ohwi are the major constituent parts of lake basin grasslands. In some of the lake basins, there are meadows of yen-chueh ts'ao and *Iris ensata*.

1) T'ai-ts'ao meadows. The underground water level under the meadow is 0.3-0.6 m, and the surface of the meadow is always wet. The grass is dense and low, about 10-17 cm. The coverage is 90-100 percent. The principal plants include t'ai-ts'ao, *Taraxacum officinale*, shui-mei-tung, ni-hu-ts'ai, and chin-tai-tai. The output of grass is 4,000 kg per hectare. At present, such meadows are mainly used for horses and sheep in the summer. The masses attach great importance to this kind of meadow, because it has a tendency of expansion. It is quite possible that originally the t'ai-ts'ao meadow was a meadow with tall grasses such as *Phragmites communis*, and later on it was tramped down by animals to become a meadow with low grass.

2) *Aneurolepidium chinensis* meadows. Underground water level for this type of meadow is at 0.3-0.8 m. The soil is extremely salinized, and the surface is covered by a crust. This kind of meadow occupies a considerably large area in the lake basin. *Aneurolepidium chinensis* is a typical semi-shrub halophyte, 30-45 cm high and covering generally 30-40 percent of the ground. Lushy green in color, it, unfortunately, is not a good grazing grass. Containing about 90 percent of water and a ^{high} percentage of saline, it is reserved as a supplementary fodder in winter

and spring. It is also used as a fuel by the herdsmen.

3) *Phragmites communis* meadow. *Phragmites communis* is one of the tall perennial grazing grasses in the desert. It is more liked by the animals than *Achnatherum splendens*; hence it is quickly consumed. According to the masses: "In the past, there was always a large area of *Phragmites communis* in each lake basin, but now after long periods of excessive grazing, the tall *Phragmites communis* has degenerated to crawling *Phragmites communis*. If excessive grazing is continued, it is quite possible that such meadows will gradually change to swampy t'ai-ts'ao meadows." This is entirely in conformity with the rule of change of vegetation under grazing. At present there are still large areas of tall *Phragmites communis* growing in swamps, and on water-filled lowlands. The reason why they are still preserved is that they are inaccessible to animals. The production of tall *Phragmites communis* on such meadows is 5,000-8,000 kg per hectare. The meadows with low *Phragmites communis* by the side of Hsi-t'ou-t'ao Lake and the Pa-yin Lake are principal summer grazing grounds for horses, sheep, and cattle, but they are in the process of degeneration. Measures should be taken to restore the tall *Phragmites communis* by forbidding grazing on such

meadows.

4) *Achnatherum splendens* meadows. Such meadows occupy a considerably large area in many lake basins. The underground water level is generally at 0.6-1 m. The soil is compact, salinized, and covered by white frosts of salt. *Achnatherum splendens* is a tall, perennial, gramineous plant. It is an excellent saline-resisting grazing grass most widely distributed in the T'eng-ko-li desert. The bush of *Achnatherum splendens* is about 120 cm high, and the average diameter is 1-1.5 m. However, the center of the bush is thin or even empty, showing signs of degeneration. In the bush, there are numerous withered branches. This fully shows that it is imperative to improve the utilization of *Achnatherum splendens*. The output of *Achnatherum splendens* on the meadow is 10,000 kg per hectare, the highest as compared with the output of grazing grass on other meadows. Evidently, if such meadows are put to more rational use, they can accommodate more animals per unit area. Aside from being a good feed, *Achnatherum splendens* can be used to make sand screens and paper.

2. *Nitraria schoberi* pastures on sand dunes.

Sand dunes covered by *Nitraria schoberi* are found

along the outer perimeter of lake basin grasslands. Occupying a total area of about 210,000 hectares, they are topographically a part of the lake basin. The predominant plant on the sand dunes is *Nitraria schoberi*. Between the dunes, there is a small amount of *Phragmites communis* and *Achnatherum splendens*, mixed with such annual plants as *Tribulis terrestris* L., *Salsola collina*, hua-mei-ta'ao, and *Setaria viriolis*. The grazing value of *Nitraria schoberi* is low; only its tender leaves and branches in early spring and its fruits in summer are liked by the animals. Its fruit is sweet and delicious, a rare product in the desert. Nicknamed "cherry of the desert," it can be used for brewing. *Nitraria schoberi* multiplies by its adventitious roots, and it grows both vertically and horizontally. But when the sand dune grows higher than 2 m, its roots cannot get the moisture from the ground, and the plant gradually withers. In places where *Nitraria schoberi* is found, the underground water level is at 2-3 m, and the soil belongs to the primitive loose gray brown desert soil type. In such places, the herdsmen settle down, and build their homes and shelters for their animals. They also raise in a small scale different kinds of grazing grasses, tree seedlings, melons, fruits, vegetables and

some farm crops, such as lucerne, barley, wheat, corn, carrots, millet, tsui-melon, *Elaeagnus angustifolia*, and sugar beets. This shows that the *Nitraria schoberi* area can be used to cultivate fodders and plant protective forests.

3. *Artemisia ordosica* pasture

Such pastures are found on sandy lands stabilized by *Artemisia ordosica* Krasch. Scattered in the drifting sand, such pastures are contiguous to lake basins as if they were a part of the lake basin, except that they are covered by sand. The total area of such pastures is about 180,000 hectares. The soil is primitive sandy gray brown desert soil. The underground water level varies from place to place. In some places, small ponds are found. Aside from *Artemisia ordosica*, there is a small amount of *Phragmites*^{communis}, *Achnatherum splendens*, *Artemisia frigida*, *Hedysarum mongolicum*, and *Calligonum mongolicum*. Close to the ground there are *hua-aei-ts'ao*, *Setaria viridifolia*, *Allium mongolicum*, and young seedlings of *Artemisia ordosica*. Most of the *Artemisia ordosica* plants show signs of withering and degeneration. In the bush, lots of dead plants and branches are found. The vegetation on the pasture is transforming to arid plant populations.

Such pastures produce 1,900 kg of *Artemisia ordosica* per hectare. Unfortunately, the plant has little grazing value, because it has a volatile fatty oil smelling, which is disliked by the animals. But after the winter, the withered branches and leaves and ripe fruits are liked by the animals. At present, camels are grazed on these pastures in autumn, winter and spring, while sheep and cattle are grazed in the nearby area. A large part of these pastures is still not utilized, and some of them are already covered by drifting sand because of tramping by animals and excessive digging for fuel.

4. Sandy pastures (semi-stabilized sandy land)

Sandy pastures are semi-stabilized sandy lands with 5-35 percent covered by grass. They are located on the leeward slopes of crescent-shaped sand dunes, and on the ground between sand dunes. Because of the sway and forward movement of sand dunes, the plants are either buried by the sand or uprooted by wind. Although such pastures are large in area, estimated at 240,000 hectares, and have good moisture conditions, they are extremely unstable. In the summer these pastures are used as grazing grounds for camels and sheep, and the vegetation is seriously destroyed. Strictly speaking, such pastures should be used for

hay-making rather than grazing. Better still, grazing should be entirely forbidden.

5. Ma-kang semi-shrub pasture

The ma-kang semi-shrub pasture is a type of pasture where water is scarce. The word "ma-kang" implies gobi, but actually this type of pasture is not gravel gobi. Located in the southwest of T'ang-ko-li, such pastures seem to be an extension of the alluvial plain in front of the Ch'ang-ling Mountain. Generally in the shape of a wide belt, these pastures are oriented parallel to the ridges of drifting sand, occupying a total area of 120,000 hectares. The soil is sandy gray brown desert soil, and underground water level is at 20-35 m. The principal plants include *Hololachne scougarica* Ehrenb., *Artemisia frigida*, and *Eurotia ceratoides* (L.) G. A. M. Herbal plants include *Cleistogenes squarrosa* Keng., *Allium mongolicum* Bge., *S. laricifolia* Turcz et Litw., yin-ch'ien-hao, and *Ephedra Przewalskii* Stapf. With the exception of the last two, all the plants have a high grazing value. According to the experience of the local people, animals grazed on ma-kang pastures are well groomed and have no problem in surviving the winter. Rich in phosphorus, sulfur, and protein, *Allium mongolicum* Bge. is a good appetizer for the animals, and has a germicidal effect.

Cleistogenes squarrosa Kang has a high content of carbohydrate, and is a favorite food of the animals. No wonder the local people are saying: "ma-kang has three treasures: *Hololachne songarica* Ehrenb., *Allium mongolicum* Bge., and *Cleistogenes squarrosa*." At present, the ma-kang pastures are used as grazing grounds for camels and sheep in summer and autumn, but they are not fully utilized because of the lack of water. The grass output on the ma-kang pastures varies greatly from year to year, depending upon the precipitation. During years when rainfall is plentiful, the output of superior grazing grass amounts of 1,800 kg per hectare. During the three consecutive years of drought from 1955 to 1957, *Allium mongolicum* and *Cleistogenes squarrosa* withered, and *Hololachne songarica* was weak. At the Ta-hung-sha-t'ang ma-kang pasture, which is famous for its lack of water, water is found in a 30 m deep well. In the future, more water wells should be dug in order to make better use of pastures where water is scarce.

6. Shrub pastures on plains in front of mountains

Such pastures are called "t'ian-tao" by the local people. In the T'ang-ko-li desert, the largest t'ian-tao are located on the plains in front of the Shuang-bei Mountain and the Tung-hu Mountain. Some of the t'ian-tao

are already buried by sand. Occupying a total area of 120,000 hectares, they are water scarce pastures, where the underground water level is very deep below the surface. The soil is sandy or slightly gravel gray brown desert soil. There are more species of vegetation on such pastures as compared with the ma-kang pastures. The principal plants include *Piptanthus mongolicus*, *Zygophyllum xanthoxylon*, *Caragana microphylla*, *Oxytropis*, *Nitraria schoberi*, and *Hololachne soongarica*. Herbal plants include *Cleistogenes squarrosa*, *Stipa gobicus*, *Penistum flaccidum*, *Allium mongolicum*, *Convolvulus fruticosus*, and some leguminous weeds. The yield of *Allium mongolicum* is 400-600 kg per hectare. In places where *Penistum flaccidum* is found, the soil is sandy and loose. Other species of plants are seldom seen. *Penistum flaccidum* is often eaten up by the animals before it reaches the stage of ^{spike} emergence. The economic value and the manner of utilization of this type of pasture are similar to those of ma-kang pastures.

7. Low mountain and monadnock pastures

These pastures refer to the pastures on the T'ac-sheng Mountain, Shuang-hei Mountain and the Cha-la-ko-erh monadnock. They occupy a small area, estimated at 30,000

hectares. The predominant plants are semi-shrubs, shrubs, and herbal plants such as *Hololachne soongarica*, *hei-tsai*, *meng-ku-hu*, *Caragana microphylla*, *ai-kai-ts'ao*, and *Oxytropis psammocharis*. The herbal plants include *kuan-mang-ts'ai*, *Phragmites communis*, *Stipa gobica*, and a small amount of *tsui-ma-ts'ao*. The vegetation covering is thin, and aeolian and alluvial erosion is severe. The grass output is low, and most of the grass has little value for grazing. The pastures should be closed to animals in order to prevent them from degenerating into deserts.

On the basis of the foregoing, we may make an evaluation of the grazing value and the potentials of development of the various pastures. First of all, the lake basin pastures are largest in area, and are equipped with the best natural conditions. On such pastures, gramineous grass constitutes the predominant plant; the grazing grass output is the highest and the most steady. After some slight improvement, they can accommodate twice as many animals as they are accommodating now. They can be used both as grazing grounds and as hay-making fields, and can be developed into bases for the cultivation of fodders. *Nitraria schoberi* pastures have little value at the present time, but their soil has a low content of saline,

and their water condition is satisfactory. They can be developed as bases for the cultivation of fodders, or used to build protective forests. Some individual lacustrine basins, like those of the T'u-lan-t'ai Lake, and the Cha-han Lake are large in area, and can be developed into mechanized high-yield pastures, or centers of dairy production. The ma-kang pastures should be closed to animals in order to prevent them from degenerating into deserts. At the same time, more water wells should be dug before they can be used as basic summer and autumn grazing grounds. The *Artemisia ordosica* pastures have little significance as grazing grounds. In pace with the development of animal husbandry, they can be developed into subsidiary grazing grounds. The degenerated *Artemisia ordosica* pastures and the sandy pastures should be entirely closed. During the next 3-5 years, they should not be listed as grazing grounds for animals.

(3) Rational utilization and improvement of various pastures

Transformation of desert is a means of attaining the end of utilizing the desert. The development of animal husbandry is an effective way of exploring and utilizing the resources in the desert. Large areas of stable

natural and cultivated fodder fields are the most important pre-requisite material basis for the development of large scale animal husbandry. The crucial problems for the development of animal husbandry in the desert consist of the control and utilization of the desert, and the improvement of the pastures. The improvement and utilization of the T'ang-ko-li desert should be considered together with the control of the desert. At present, the communalization has provided many favorable conditions for the development of animal husbandry, and the improvement of pastures in the T'ang-ko-li desert.

It should be pointed out that we are developing animal husbandry, while we are trying to conquer our enemy --the desert. Hence we must follow the principles of sand control in the utilization and improvement of the pastures. Our tasks are to protect and expand the vegetation covering, to increase the productivity and the rate of utilization of the pastures, and to quickly change the unstable situation and the state of dependency of animal husbandry. We make the following suggestions for the rational utilization and improvement of the pastures in the T'ang-ko-li desert in the spirit of the four dicta--more, faster, better, and more economical--of the

general line for socialist construction.

The sandy pastures should be entirely closed for forestation. The *Artemisia ordosica* pastures should be used as subsidiary grazing grounds and hay-making fields. The lake basin pastures and *Nitraria shoberi* pastures should be developed into bases for the cultivation of fodders. At present, however, they are population centers and should be used as hay-making fields as well as grazing grounds for animals in winter and spring. The water-scarce pastures should be developed into grazing grounds.

1. Rational utilization and improvement of lake basin pastures

(1) Lake basin ponds. These ponds may be used to raise fish. Since there are large flocks of wild ducks in the area, there is no doubt that these ponds can be used to raise ducks. Surveys should be made about the fluctuation of the water level, the quality of the water, and the method of pumping and transporting water for irrigating the pastures and forests.

(2) Salinized sections where there is no grass. To reduce the salinity, such sections may be covered by sand or soil. Saline-resisting plants such as *Tamarix chinensis*, and *Elaeagnus angustifolia* may be planted.

(3) *Aneurolepidium chinensis* meadows. *Aneurolepidium* may be gathered by rotation for fuel. However, after it is dug out, the meadow should be re-planted with other grass. It is preferable to cover the ground with sand and apply organic manure and green manure generously before replanting.

(4) T'ai-ts'ao meadows. Such meadows may be used as grazing grounds for horses in summer. Since it is wet all the time, sheep may contract parasitic diseases on such meadows. The salinity of the meadow is not too high; in fact, sugar beet may be tried after the grass is entirely uprooted from the meadow. The meadow can be kept dry by establishing a good drainage system.

(5) *Phragmites communis* meadows. The meadows with low *Phragmites communis* may be divided into two sections for restoring the tall *Phragmites communis*. In early spring, rake the ground, then remove the grass, but leave the rhizoma, and then close the pasture to the animals. At the time of the emergence of the spikes, cut down the *Phragmites communis* from section I for hay. The regenerated *Phragmites communis* may be used for grazing in winter and spring. As to section II, when the *Phragmites communis* is 30-45 cm tall and has not yet reached the stage of spike emergence, the section may be opened to animals for

light grazing. In places where the *Phragmites communis* is thin, the seeds of Ts'ao-mu-chi and *Medicago sativa* may be sowed. If the seeds do germinate and grow, use the plants for hay rather than for grazing during the first year. The pastures with tall *Phragmites communis* had better be used for hay-making only.

Phragmites communis is a principal source of hay. At present, the hay-making time (usually in September and October) is too late. During those months, the stalks are coarse and tough and the tissues of the leaves are hardened. The result is that half of the hay is eaten up by the animals, and the other half is wasted. The hay, therefore, should be made during the early stage of spike emergence, properly bundled, and then piled up compactly. At the time of feeding, the hay should be chopped up into short sections in order to avoid waste.

(6) *Achnatherum splendens* meadows. In early spring when *Achnatherum splendens* is budding, the meadow should be closed to the animals in order to avoid tramping. After the emergence of the spikes, the stalks and leaves of *Achnatherum splendens* become tough, and their nutritive value is lowered. And no animal would like to eat them. If such tall and dense *A. splendens* bushes are kept to summer,

they will become good breeding grounds for mosquitoes, where no animal would like to go. Furthermore, the remains of a large amount of withered stalks will not only cause inconvenience to hay-making, but also prevent the budding of new plants. At present, the *Achnatherum splendens* meadows are very poorly utilized. The masses are complaining about *Achnatherum splendens*, but actually, it is not utilized timely and rationally. The following suggestions are made for increasing the rate of utilization of the *Achnatherum splendens* meadows:

1) Grazing after hay-making. Make hay by the end of June when *Achnatherum splendens* has not yet reached the stage of spike emergence. By August and September, the regenerated *Achnatherum splendens* will reach 30-45 cm high, with plenty of tender leaves. Better than the original plants, the regenerated *Achnatherum* can be used for grazing in winter and next spring. By utilizing *Achnatherum* both as a hay and a fresh grazing grass, the rate of utilization may be increased by two times. Furthermore, there will be no hard, withered stalks left in the bush.

2) Artificial regeneration. For degenerated *Achnatherum splendens*, artificial method may be used for regeneration.

a. Agro-technical method. After thawing in spring, use a horse-drawn or motored bulldozer to crush the withered

and tough stalks, then chop the crushed stalks, and rake the ground. Finally use a machine to winnow out the chopped stalks from the soil. Then the meadow may be seeded with superior species of grazing grass, such as *Medicago sativa*. During the first year, the grass should be used as hay. During the second year, part of the grass may be used as hay and part for grazing. If the *Medicago sativa* grows well, the *Achnatherum splendens* bushes should be entirely removed, and turn the meadow into a field for cultivating fodders.

b. Burning method. Before the snow or immediately after thawing, burn the *Achnatherum splendens* bushes. The ash left on the meadow will help the budding of new plants. It will be most desirable that the above described agrotechnical method is used immediately after burning. It must be pointed out, however, that the burning method can be tried only in a small area, and precautions must be taken against the spread of the fire.

After these measures are taken, the grass output will be noticeably increased by several times, and the increased yield during the first year will make up the losses resulting from the closure of the pasture.

2. Utilization and Improvement of *Nitraria schoberi*

meadows.

The *Nitraria schoberi* meadows may be divided into two sections:

(1) The outside section. The outside section, consisting of semi-mobile sand dunes covered by *Nitraria schoberi*, *Artemisia salsoleide* and *Pennisetum villosa*, should be closed to animals for forestation. Seeds of grass may be sowed by airplane for large areas, or by camels for small areas. The seeding should be done in early spring after thawing, or in July during the rainy season.

(2) The inside section. The inside section should be used for cultivating fodders. In establishing fodder bases in the *Nitraria schoberi* section, precaution should be taken against the rise of sand because the soil is sandy and loose. Thus the following procedure must be followed.

First of all, the area to be cultivated for raising fodders must be determined by the availability of manpower, animal power, and seeds. Once the land is seeded, it should be constantly cultivated.

In the area selected for cultivating fodders, the underground water level should be at 3-6 m, and the sand dunes should not be more than 1 m high. The sand dunes should be levelled off, and more water wells should be dug.

It is more economic to dig the water wells deep, because the deeper the well, the greater is the amount of water it can provide.

The ground should be made as level as possible in order to facilitate irrigation. The field, if too dry, should be irrigated before seeding. The perennial plants such as *Medicago sativa*, *Aegilops*, *wu-mang-ts'ao*, and *ta-nei-ts'ao* may be sowed in summer, but not later than July. Annual plants such as *su-tan-ts'ao*, barley, oats, millet, corn, *ts'ao-mu-chi* (biennial), wild peas, *hu-lu-pa*, sugar beet, carrot, potato, sun flower, and pumpkin may be sowed in spring or late spring.

Perennial plants such as *Medicago sativa* may be planted in large amounts because they can improve the structure and fertility of the soil, and prevent the aeolian erosion of the top soil. Once such plants are sowed, they can last 3-5 years. Thus a large amount of labor and seeds is saved.

Medicago sativa has a large amount of yield and is one of the best grazing grasses. During its second year of growth, it develops a resistance against aridity and salinity, and can survive without much irrigation. Such merits are not found in other perennial plants. After a large area of *Medicago sativa* is grown, some annual plants may be

planted in the same field.

Protection should be given to young seedlings of *Medicago sativa* because they grow slowly and liable to destruction by wind and sand. Usually, barley and oats are planted in alternate rows with *Medicago sativa* to protect the young seedlings of the latter because they grow faster and can serve as a shield against wind, sand, and torrid sunshine. But the protective crops should not be excessive in amount. Once they are found inhibiting the growth of *Medicago sativa*, they should be immediately removed no matter whether they have grown up or not. On sandy or saline lands, *Medicago sativa* should be frequently watered, but no excessive amount of water should be used during each irrigation. When the soil is found too compact, it should be made loose by raking. Generous portions of organic fertilizers and green manures should be applied, because the nutrients can very easily seep down, and saline crusts are easy to form over the top soil. Sand screens should be installed if the sandstorm is too harsh.

During the last 1-2 years, the area devoted to the cultivation of grazing grass was small, and is merely for producing some superior hay or high-quality fodders for feeding female animals, young animals, and breeding animals. A part of the pasture should be set aside for the

Production of seeds, but large amounts of seeds should be ordered in advance from Min-ch'in and Chung-wei. The most ideal case is, of course, to be self-sufficient as far as the production of seeds is concerned.

The development of large areas of fine fodder production fields and the regeneration of natural pastures by human efforts will require a large number of farm machines such as tractors, bulldozers, ground-leveling machines, power plows and rakes, seeding machines, water-well drills, water pumps, and hoeing machines. At present, camels, horses and cattle are trained to pull the renovated farm implements in small areas.

The final aim of establishing large fields for cultivating crops and fodders in lake basins and *Nitraria schoberi* section is not merely to produce more and better grazing grass, but also to produce food grains, vegetables, melons, and fruits for the pasture workers.

On the basis of the foregoing suggestions, the cross-section of the lake basin and *Nitraria schoberi* pastures should look like this after the improvement:



Legend

- I. Ponds for raising ducks.
- II. Cultivated land for grass to be used for hay and grazing.
- III. Cultivated fodder-raising base, residential area, animal shelter and hay storage area, and fruit tree and seedling area.
- IV. Protective forest consisting of woody trees.
- V. Area reserved for raising grass.
- VI. Sand control forest consisting of shrubs.
- VII. Verdancy area.

3. Improvement and utilization of water-scarce pastures (ma-kang pastures and pastures on plains in front of mountains).

(1) Utilize underground water by digging wells. It is possible to make artificial rain and to channel the water from the Yellow River for irrigation, but such measures are not feasible at the present moment to meet the immediate needs. To dig water wells is the most effective

feasible way of solving the problem of drinking water shortage. Ta-hung-sha-t'ang has already succeeded in digging a 30 m deep water well which can provide enough drinking water for 600-1,000 head of sheep every other day. At Kung-hu-t'u on the plain in front of the Shuang-hei Mountain, water is provided by a 5 m deep well, where the "liberation" style water wheel is used. This shows that there is water underground, and wells can be dug. In order to avoid waste of effort and money because of failure, it is better to detect the source of water by scientific instruments before digging. For expanding the area of utilization of water-scarce pastures, water wells should be properly distributed. If the water wells are concentrated in one place, the pastures in the area will be destroyed by the frequent tramping of animals. The distance between the water wells should be determined by the amount of water available, by the capacity of the pastures, and by the distance the animals can travel.

On the basis of the grass yield (on the average 1,200 kg per hectare) on the water-scarce ma-kang pastures and pastures on plains in front of the mountains, each sheep needs 2-3 hectares of pasture, and 1,000 sheep will need 3,000 hectares. On such a large area of pasture, the sheep

will have to walk about 6 km a day. If each sheep needs 5 liters (about 5,000 cc) of drinking water a day, 1,000 sheep will need 5,000 liters, and each water well will have to provide so much water a day. At present, there are about 240,000 hectares of water-scarce pastures. If we dig a water well for each 3,000 hectares, we will have to dig a total of 80 wells.

Since these water wells will have to be very deep, we must study the method of lifting the water, because the time allowed for drinking the sheep should not be too long, otherwise the day's schedule will be upset. Of course, we can divide the 1,000 sheep into two groups of 500 each to drink water by turn. Nevertheless, wind wheels should be utilized to lift the water. Furthermore, the water containers from which the animals drink should be sturdy, clean and leak proof.

(2) Utilization of surface water by storing flood water. On plains in front of the Shuang-hei Mountain, there are many ditches caused by floods. About 5 km from the mountain, natural fresh water ponds are formed when the flood water is intercepted by sand dunes. According to local people, these ponds never dry up during years when rainfall is plentiful. We suggest that a reservoir

be built in the mountain as a source of drinking water for human beings and animals. It is said that fountain water is found on the T'ao-sheng Mountain. We think it should be stored in water reservoirs in the same way.

(3) Rotation of pastures. Many valuable perennial and annual grazing plants, such as *Oleistogenes squarrosa*, *Allium mongolica*, *Stipa glareosa*, *S. laricifolia*, and *Salsola collina*, depend greatly on rainfall for their growth and multiplication. If the animals are allowed to graze on pastures too frequently, the grass will never have a chance to grow to maturity, nor will they be able to bear fruits. Therefore, the pastures should be rotated, and given a chance to regenerate. The water-scarce pastures should be closed to animals as soon as they are found destroyed by aeolian erosion.

(4) The utilization and improvement of water-scarce pastures is a long-term project. If conditions permit, vegetables and trees should be planted near the water wells so that centers of population may be gradually established.

(5) Cattle and horses should be grazed near water wells, and camels and sheep may be grazed in places far away from water wells.

4. Utilization and improvement of *Artemisia salsoloide* and sandy pastures

As mentioned before, sandy pastures are semi-stabilized sand lands. They should be strictly closed after they are seeded with sand fixation plants. When the vegetation coverage expands to 60 percent of the ground, the grass may be cut to make hay.

Tall *Phragmites communis* grown in ponds should be used for hay-making. Pastures covered with *Hedysarum mongolicum* and *Calligonum mongolicum* should be reserved for seed gathering. The *Artemisia salsoloide* pastures with good "base grass" may be used for light grazing during the rainy season, in late autumn, and in early winter. When the camel and sheep eat the seeds of *Artemisia salsoloide*, they drop some on the ground, and tramp them down into the earth, thus helping the natural regeneration of the plant.

5. The attendance of animals by shepherds is a prerequisite to the rational utilization of pastures, animal protection, and rational grazing. It is also an effective way of solving the contradiction between farming and animal husbandry, of enforcing the rotation, and closure of the pastures, and of restoring the productivity of the pastures.

In the past, many animals were killed by wind, flood, and wild animals, or even died of starvation because they were unattended. After the communalization, animals are divided into smaller groups and attended by special persons. The grouping of animals is done according to their species, age, and sex. Generally, each group of cattle consists of 50-80 female cattle and 50 male cattle; each group of horse consists of 50 female horses and 60 male horses; each group of goat consists of 400 female goat and 500 male goat; and each group of camel consists of 30 female camels and 40 male camels.

6. Large-scale hay-making in summer is a hard task in the sparsely populated F'eng-ko-li. It must be done by a shock force within a short time. Hay-making is as important as water well digging, because a sufficient amount of hay can reduce the death of animals over the winter, put off the time for out-door grazing in early spring, and give the grass a chance to grow taller.

After the grass is cut, it must be properly dried and stored, otherwise the loss will be great if it is allowed to rot.

7. As long as the fuel and construction material problems are not solved, the closure of pastures, fores-

tation, and the measures of vegetation protection can hardly be carried out. The following measures may be taken in T'eng-ko-li to solve these problems.

(1) Promote the use of "solar kitchen" and marsh gas.

(2) Utilize the stalks and roots of *Nitraria schoberi* as a fuel after it is dug from grounds which will be developed into fodder bases.

(3) Change dead wind walls to live wind walls.

(4) Use clay, loam, and red soil to make bricks.

(5) Save bricks in building animal shelters.

(6) *Aneurolepidium chinensis* may be dug out and used as a fuel, because the *Aneurolepidium chinensis* meadows are heavily salinized where drifting sand is not easy to accumulate. However, the meadow must be re-seeded with other plants as soon as the *Aneurolepidium chinensis* is dug out.

(7) Fuel may be gathered from stabilized *Artemisia salsoloide* pastures during the rainy season, but these pastures must be re-seeded after the old plants are dug out.

(8) The trimmings from the forests may be used as fuel.

(9) Fuel and construction materials may be obtained from neighboring farms, forests, and mining areas.

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