UNITED NATIONS ENVIRONMENT PROGRAMME (UNEP)

USSR COMMISSION FOR UNEP (UNEPCOM)

ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC (ESCAP)

RANGELAND IMPROVEMENT IN ARID AND SEMI-ARID ZONES AND ITS ENVIRONMENTAL AND SOCIO-ECONOMIC ASPECTS

P r o c e e d i n g s

CENTRE FOR INTERNATIONAL PROJECTS

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RANGELAND IMPROVEMENT IN ARID AND SEMI-ARID ZONES AND ITS ENVIRONMENTAL AND SOCIO-ECONOMIC ASPECTS

P r o c e e d i n g s
of the International Seminar held in the USSR
under UNEP/USSR/ESCAP Project FP/6201-86-03

May 17 - June 4, 1987

CENTRE FOR INTERNATIONAL PROJECTS
USSR STATE COMMITTEE FOR ENVIRONMENTAL PROTECTION
M O S C O W

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INTRODUCTION

The international seminar on "Rangeland Improvement in the Arid and Semi-Arid Zones and its Environmental and Socio-Economic Aspects" was held in accordance with project document FP/6201-86-03 "Assistance for Establishment of Research and Training Centres for Desertification Control in the ESCAP Region" by the Centre for International Projects in Moscow, Samarkand and Ashkhabad within the period of May 17 - June 4, 1987.

The main purposes of the seminar were:

- To improve the skills of experts from developing countries of South East Asia and the Pacific in the field of desertification control, ecologically-sound management of rangelands in arid zones;
- To inform foreign experts of the ecological and socio-economic aspects of range improvement; of methods to counter soil degradation: of the main principles of rangeland management in the arid zones of the USSR for their possible application in developing countries:
- To expand information exchange on the advanced methods and techniques of range improvement, of controlling the negative impact of animal breeding on the environment:
- To further promote international cooperation on the problems of range improvement in arid zones and soil protection.

At the recommendation of ESCAP and in consultation with UNEP concerning the list of participants, the seminar was attended by 13 experts from South East Asia and two lecturers from Australia and UNEP.

The programme of the seminar consisted of two interrelated parts: theoretical and practical. The theoretical part was conducted in Moscow, the practical one - in Uzbekistan and Turkmenia. This form of organization ensured the logical sequence of lectures informing the participants of the main problems of the subject discussed, of different studies on it and the recommendations on the sound management of the natural resources. At the second stage the participants used the knowledge they acquired during the theoretical course to study practical ways and methods of rangeland management in conformity with scientifically justified techniques and recommendations.

The programme of the seminar was fully completed. Lectures were delivered by some leading Soviet scientists and experts. The seminar included two workshop classes allowing for disscution and information exchange of participants on range improvement issues in their countries.

The reporters dwelt upon topics of range degradation mapping feasibility, means of desertification control and necessity of direct participation of peasants in the process of range improvement. Representatives of tropical countries discussed the issues of productivity improvement under specific tropical environments, where the problems of deforestation gain prime importance as well as matter of ground water level reduction and intensification of water erosion processes. Problems of orientation towards optimum productivity, of water desalination in deserts, of the need to introduce nitrogen-accumulating brushes and legumes were also discussed. Great attention was paid to the socio-economic aspects of rangeland development.

During the final stage of the course, the participants had a briefing at the Agro-Industrial Committee of the USSR and were informed on the present stage and prospects of range development in the USSR.

The practical part of the seminar took place in the Central Asia and was sponsored by the National Research Institute of Astrakhan Sheep Breeding, Samarkand, Uzbek SSR, and the Institute of Deserts of the Turkmen SSR Academy of Sciences, Ashkhabad. The participants visited the above institutes and their field stations where the practical classes were held.

The participants displayed special interest in the techniques of range vegetation improvement, in the development of long-duration autumn/winter ranges. They were also interested in the nutrient value of arid forage plants introduced on the rangelands, asked about their content of various micro-elements, about possibilities for different grasses, shrubs and trees ecologycal coexistence. They also raised an issue of their impact on range productivity and of creation of specific microclimate. Problems of introduction of exotic or genetically improved plants; accumulation and conservation of moisture, practical utilization of of the institutes' recommendations were also discussed.

It should be noted that the composition of the participants in the seminar was quite heterogenious as regards their range of interests. Suffice it to say that the seminar was attended by experts from some humid tropical countries (Vietnam, Indonesia, the Philippines, and Sri Lanka). Nevertheless, in summing up the outcome of the practical course, they all noted the usefulness of the information gained and emphasized that all countries represented at the seminar can successfully apply the methodologies of range improvement, if not the practical methods in use in the USSR.

In conformity with the programme of the seminar almost all the participants made reports on rangeland problems in their countries.

In their free time the participants visited historical and architectural monuments of Moscow, Ashkhabad and Samarcand, the Exhibition of Economic Achivements of the USSR and the Turkmen SSR, the Moscow circus, etc.

Upon the completion of the seminar, all participants were handed certificates of completion. Foreign participants unanimously adopted the Final Communiqué praising the organizational and scientific level of the seminar and pointed out the desirability to continue events like that in future.

The present report includes the summary of selected lectures given at the seminar by the Soviet scientists as well as by foreign participants.

LIST OF PARTICIPANTS

of the international seminar "Rangeland improvement in the Arid and Semi-Arid Zones and its Environmental and Socio--Economic Aspects" under the Project FP/6201-86-03

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1.	Shafoor Karanday		Afganistan
2.	Cong Zili		China
3.	Yibulayin Sulaman		China
4.	Sounthone Leuammalaysy		Lao
5.	Chai Somsain		Lao
6.	Tudevin Baasan		Mongolia
7.	Hirevin Tulgaa		Mongolia
8.	Joey Austria		Philippines
9.	Millawalage Sandasiri Wickremarachchi		Sri Lanka
10.	Singh Kalicharan		India
11.	Sutaryo Suriamiharja		Indonesia
12.	Nguen Van Quang		Vietnam
13.	To Anh Tuan		Vietnam
14.	Mabbutt Jack	(lecturer)	Australia
15.	Skoupy Jil	(lecturer)	UNEP

The Rotation of the Pasture and Pasture Control Principles

N.T. Nechaeva, Institute of Deserts, Academy of Sciences of the USSR, Ashkhabad.

The deserts are the territories with rather high potential biological productivity despite the pronounced extreme terms.

To know the interaction between the animales, vegetation and soil is very important for the pasture control. Long observations of the state of pasture territory used in economy and specially conducted experiments make it possible to draw the conclusion, that moderate, well-organized pasturage is favourable for pastures. Undesirable changes in their plant cover and the decrease of productivity take place as a result of overpasturage or its long absence as well.

The influence of the pasturage's mechanism differ. The estrangement of the above-ground organs' parts (vegetative and generative) ruins different functions of growth and developement, changes the morphological structure, physiological functions of above-ground organs, and even underground ones, weakens the regenerative processes etc. The pasturage's influence on the seed regeneration of plants is also great. On the one hand, cattle bites generative shoots off, that ruins the renewal ability of plants, on the other - tramples seeds down, that facilitates their conservation and normal sprouting.

The influence of the grazing animales on the soil layer is as follows. If the pasturage slight or moderate, it is positive factor and shows itself in a certain loosening of the soil layer, if excessive - it's a factor of degradation.

Pasturage influences the processes of relief formation, especially in sandy deserts. Ruining of the turf layer gives the start to the process of sand blowing and hollow formation.

Desert plants, exposed to the influence of herbivorous animals for a long time, have formed a number of adaptations for pasturage in their structure. These adaptations show themselvs in the stucture of above-ground organs (curved, pricky in case of shrubs), in the arrangement of buds, in the ability of bited off shoots for quick regeneration, in the predominance of vegetative reproduction over seed one in case of perannial grasses etc.

The pasturage also influences all kinds of vegetation in different ways.

Unlike sheep, camels eat not only annual, but also rough, hardened brushes. That's why camels use 70% of saxaul branches, suitable for eating in the autumn and 80% in the winter, meanwhile sheep correspondingly 50% and 60%. During wide pasturage saxaul crown looks as if it was cut, vegetation receives the "pasture form". Strong crown biting off stimulates awakening of rest buds in the lower parts of bushes and intensifies the formation of shoots. As a result, the food mass does not goes down, and stunted bushes become get-at-able to sheep. The representatives of Chenopodiaceae family (Haloxylon persicum, H. aphyllum, Salsola richteri) are actively eaten only in the autumn-winter season after the end of the vegetation. Though the representatives of Calligonum genus are eaten when they are green, the curves of their branches prevent full eating of the shoots, considerable part of branches remains and secures the life of the plant. The Calligonum seeds have to be buried in sand, it takes place during pasturage.

Calligonum rubens develops better on the intensivly used pastures, gives more green shoots. adapts to the pasturage, forming stunted bushes. Calligonum rubens usually grows as a high bush (up to 2,5-3 m), its pasture form has flat short bushes 1,0-1,2 m high with crown's diameter about 3 m.

Wormwoods and saltworts (Artemisia, Salsola) are the most widespread and economically significant plants among suffrutexes. In the spring, autumn and winter sheep cosiderably eat vegetative shoots of wormwood in the lower part of the bush. Generative shoots are eaten much worse and mainly autumntime. In the summer Artrmisia is eaten badly, in the spring 30%, in the autumn and winter 40-50% of shoots, suitable for eating is used. If the pasture load is moderate, wormwood grows satisfactory and regenerates well, if strong - the wormmood is inhibited. Camels eat the upper parts of Artemisia, using 50% of annual increase springtime, 75% in the autumn and winter, during strong pasture load they eat even perannial soft shoots.

Suffruticose saltworts are eaten by cattle in the autumn and winter (Salsola gemmascens, Anabasis salsa) or all the year round (Salsola rigida). In the autumn and winter sheep use 35-50% of annual shoots, camels up to 75%. During strong pasture load camels bite off shoots compleatly, plants become short, practically do not seed and do not regenerate.

In the autumn - winter season moderate pasturage does not inhibit frutescent saltworts.

Their are two species of sedge, that are the most widespread and valuable among perannial plants: Carex physodes in sandy deserts and C.pachystylis in loess and clay deserts of foothills. Sheep eat the sedge all the year round. Springtime they use 85%, in other seasons 50-70% of shoots' yield. Camels eat Carex fewer, within 20-30% of the yield, but springtime Carex is the base of their ration. The sedge has high after-grass ability due to strong underground organs, that surpass above-ground shoots' mass in 15-20 times and successfully resist the pasturage in the spring. Moderate pasturage does not inhibit Carex, particularly when the season of pasturage changes every year. But systematical spring grazing or pasture load halves the yield within 4-5 years.

Well-eaten perannial plants, e.g. Astragalus, disappear from pastures even during moderate, but systematical spring pasturage because of absence of the strong root system.

There are two groups of annual plants, that have great pasture significance: ephemerals with winter-apring vegetation and annual saltworts. In the spring and summer 60-70% of spring grasses' yield is used, in other seasons - up to 60% of dead wood. Sheep eat all the shoots with generative organs.

Annual saltworts are eaten in different ways: 60% of some of them is used summertime and their number quickly falls during strong pasture load. 50-60% of lush saltworts' yield is eaten after the end of the vegetation in the autumn and winter. They are fewer damaged by pasturage, because they have time to seed.

When pasturage is absent, plants seed gradually, within long period of time from ripening in the spring up to the late autumn. But only a small part of seeds goes down the soil, the rest stay on the layer, where rodents, insects and birds eat them. So the possibility of normal grass regeneration diminishes next year.

During the pasturage ripe seeds are widespreaded by cattle, that's why the pastures are seeded simultaneously, within a short period of time. Depending on the pasture load the depth of the penetration differs. When the load is low (9 hectare per capita) or moderate (6 hectare) most of seeds reaches the depth, favourable for sprouting (0,5-2 cm) and only a small part of them (3-8%) reaches the depth of 5 cm. If the pasture is overloaded (3 hectare per capita) up to 26% of seeds gets into the depth unfavourable for sprouting (from 3 up to 5 cm) and has no chance to sprout, as a rule. The largest number of shoots grows in the areas of moderate pasture load (264 shoots per 1 m^2), than of the low (204 per 1 m^2) and at last the strong one (128). The shoots number on the protected areas is the least (70 per 1 m^2), there was no pasturage, and seeds were not trampled down .

During pasturage on desert pastures a certain part of food inevtably gets spoild (broken off or trampled down). The amount of the food losses depends on the composition of plants' vital forms, the soil layer, the load of pastures. The losses of the frutescent and suffruticose fodder does not exceed 1% of their amount in all the seasons. During the spring pasturage soft grasses are trampled down most of all. Being bent down or trodden in the sand, green grasses are able to rise (sedge in particular) and their losses are very small.

Depending on the intensity of the pasturage 3-7% of spring yield of dead wood is lost summertime. Frail shoots of annual saltworts are considerably trampled down (about 15% of the yield in the damp weather). In sandy deserts on large frutescent Haloxylon-Carex pastures sheep's ration consists of grasses in all the seasons. Shrabs' share spring and summertime is small - 13-25%, in other seasons is considerable - 33-48%. Springtime sheep eat the representatives of Calligonum, Astragalus generis, in the autumn and winter - the representatives of Haloxylon, Salsola generis.

Table 1.

Composition and nutritiousness of the pasture ration on the wormwood pastures

Season	Vegetable species amount in the ration		The nutritiousness of fodder weighting 100 kg (food unit)	
	in the first days of pasturage	in the following days	in the first days of pasturage	in the following days
Spring	42	34	74	63
Summer	18	17	52	49
Autumn-Winter	12	12	34	30

Eating of plants changes as grazing goes on. First of all animals eat the most attractive, though not numerous plants. But this variety does not last for a long time. The ration of the following days is less nutrious and more typical for pastures (Table 1). The nutritiousness of pasture ration diminishes from spring to winter on all the pastures: on the Artemisia pastures halves, on the Haláxylon- Carex ones reduces in 3,5 times,

During spring grazing biting off inhibits plants on early phases of vegetation. Perannial plants (Carex physodes in particular) have no time to accumulate enough plastical substances in their underground organs, that ensure high vitality of perannial plants and normal growth of shoots next season.

Well-eaten perannial plants are usually eaten before their seeds get ripe, that's why small, ill-eaten and even harmful plants gradually take their place. Lots of short grasses with low degree of use appear after the twice-repeated spring grazing. As a result, though the number of Carex shoots does not decrease for a while, their mass halves in 4 years. The number of annual plants sharply increases and the productivity falls.

During summer pasturage, shortly after the annual plants have sown, their seeds are trodden in the soil and then simultaneously sprout. In principle it's a positive thing, but for some cereals, e.g. for Bromus tectorum, which is very drought-resistant, summer pasturage is so favourable, that it ousts more valuable annual grasses and even perannial sedge (Carex physodes), inhibited by the pasturage. Bromus tectorum itself is a bad sort of food, because it's stunted and grows too thickly. Though the total amount of food does not diminish and sometimes even grows, its quality decreases, because in comparison with sedge the cereals are less nutrious and kept worse among dead wood.

During autumn and particularly winter pasturage late treading down of seeds and breaking of shoots decrease the amount of annual plants. It shows itself in the damp mild (vegetative) winters, when cattle pastures on the shoots. Nevertheless, the main foodplant - sedge, grows well, because it is always grazed after the end of the vegetation and grows among not numerous annual plants. The monotony of herbage, where Carex physodes predominates, is a negative consequence of systematical winter grazing. Pasture territory with salt wells constantly used wintertime is characterized by Carex in a good condition, but insipid annual spring grasses.

Grazing, repeated twice in the same period - in the first and in the second half of the spring or spring and autumntime in the same year - inhibits the vegetation. In 4 years of systematical twice-repeated grazing the amount of grass food sharply falls even on the well-fixed sands.

Using of the rotation of the pasture, i.e. annual change of the season, when the pasture is used, is favourable for the development of vegetation and the improvement of soils. The rotation of the pasture with the alternation of grazing in all the seasons successivly is the best one (Table 2). It's difficult to realize this most racional scheme in practice, because not all the pastures can be used all the year round. In this case the rotation of the pasture may consist of certain seasons' alternation, e.g. spring-winter or summer - autumn (Table 2), or cover just a part of the pasture territory (it also promotes keeping of pastures).

The schemes of the rotation of the pasture differ. The difference of the pasture reaction on the pasturage, that depends on the character of the vegetation and soil layer is to be taken into consideration as well. The season of using changes more often on sandy pastures than on solid ones.

Table 2.

The examples of the rotation of the pasture
(According to V.N. Nicolayev and others)

Year of using	The numbers of pasture areas 1	2	3	4
	Grazing all the year round:			
1-2	spring	summer	autumn	winter
3-4	summer	autumn	winter	spring
5-6	autumn	winter	spring	summer
7-8	winter	spring	summer	autumn

The alternation of spring-winter and summer-autumn grazing				
1	spring	winter	summer	autumn
2	-"-	-"-	-"-	-"-
3	winter	spring	autumn	sammer
4	-"-	-"-	-"-	-"-

They are comparativly large areas near wells within an average radius of pasturage, not small ones, that must be the basis of the rotation of the pasture.

Only incipid pastures where the yield has fallen, but the reorganisation of the vegetation has not gone too far need rest. In this case pasture productivity restores within 6-7 years. If pastures are broken to a great extent - these changes are inevitable. The territories need radical improvement.

Systematically grazed spring pastures also need rest. But, in practice, it's very difficult; the rotation of the pasture may be used here: annual change of the season of using.

Long absence of pasturage on the pastures with satisfactory state of the vegetation negativly influences the soil and vegetative cover. 4 years of rest caused the fall of the productivity (20%) in the South-East Kara-Kumes. Longer rest causes the disappearance of some plants, excessive soil compression, formation of surface crust (with moss, lichen, aquatic plants etc.), blocking of normal plant regeneration. Long absence of pasturage is unfavourable for all types of pastures, it causes decrepitude and low productivity.

Right, scientific, well-organized pasturage preserves ecological systems of arid territories. Racional using of pastures is capable to provide high level of productivity and prevent the formation of deserts in arid areas.

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FODDER ASSESSMENT AND DESERT PASTURE VALUATION

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Desert pastures in the Soviet Middle Asia occupy enormous territory extending for about 20° from south to north and 36° from west to east.

Vegetation of this vast region accounts for over 5.5 thousand different types and forms of plants. Mountain areas are characterized by the largest differentiation in species. However, in spite of the paucity of vegetation in the desert part of the region, a significant part of meat, wool, sheepskin and 100% of karakul astrakhan is produced here.

Desert pastures as distinct from grazing grounds of other geographical zones ordinarily are used for grazing purposes all year round and only at winter time, after snow falls and ice-covering, indoor maintenance of sheep is practiced. Low harvest yield and its changeability at different seasons of the year is a characteristic feature of desert pastures. Different types of pastures have their respective dynamism in season fodder amassing. Apart from the plants that are being consumed around the year, desert is rich in vegetation that is eaten by animals at definite seasons of the year.

For fodder assessment of pastures it is especially important to take into account nutrition value of pasture herbage. Feeding of agricultural animals according to the norms based on strict calculation of their needs in organic and mineral ingredients of food-stuffs compared with their actual presence in pasture vegetation is the final and desirable objective in rational pasture cattle-breeding.

It is rather difficult to make assessment of the nutrition value of pasture fodder. From the start the nutrition value of separate types of plants should be defined, then - correlation of these types should be established, which always varies depending on the pasture type. And only after that, one can pass over to assessing nutrition values of pasture types, groups of types and classes. Obviously, it is necessary to know fodder nutrition value at different seasons in the situation when cattle-breeding on pastures takes place around the year.

In the USSR, the nutrition unit and quantity of digested protein is taken as an indicator of fodder nutritiousness. To the extent that the new data is accumulated, a gradual passover to fodder assessment in energy units is being practiced. As distinct from the Scandinavian fodder unit which is calculated on the nutrition value of barley, the Soviet fodder unit is calculated on nutrition value of oats. In this case, the fodder assessment is based on a system of starch equivalent, worked out by Kelner. Just as in the case of starch equivalent, assessment in feed units suggests constant and invariable productive action of all fodder nutrition elements irrespective of balanced rationing for animals in accordance with macro- and microelements, vitamins and other biologically active substances.

At present time the preference in the overwhelming majority of the countries in Vestern Europe, the USA, Arab East is given to the system of assessing nutrition value of fodder and rations according to pure energy derived on the basis of exchange energy content in fodder. Apart from the fodder assessment according to pure energy, there exists in these countries an evaluation of total sum of nutrition substances, as well as of the quantity of digested protein,

In the GDR over the last years a new system to assess fodder nutritiousness was developed according to which fodder productive effect is sized up by pure energy fat accumulation.

Pasture rationing of sheep and camels grasing in desert zone is quite varied and represented by different live forms of plants - starting from large shrubs and trees up to small annual ephemers.

Practice of desert pasture cattle-breeding has shown that the most important in terms of fodder for pasture cattle-breeding are a few dozens of plant species, while the remaining part of plant types is to be found in small numbers and, thus, their role in feed balance is insignificant.

To feed correctly animals it is not enough to know botanical composition of plants growing on pastures. One should know also in what way this fodder is digested in animal stomack, whether it is eatable and what is its nutrition value. In this connection in the USSR the emphasis has been put lately on studying feed advantages not of separate plants, but of pasture rationing, since eatability and especially digestion of fodder from this or other plant varies greatly depending on the collection of associated pasture plants.

A comprehensive cycle of research studies on chemical content of seasonal pasture vegetation in Turkmenistan was carried out over a number of years by the Institute of deserts, the Academy of sciences, Turkmen SSR. Data on fodder digestion received in the course of the special balance tests with animals was used to assess nutritiousness of desert pasture fodder. To make this data comparable the assessment results of fodder nutritiousness was expressed in schematical feed units balanced according to digested protein contents.

Shrubs play a significant role in fodder rationing of sheep and camels during different seasons of the year. They form on pastures the upper and middle layers of vegetation. The height of shrubs reaches 0.8-3 m.

Among bushes dominate different kind of Ghenopodiaceae family: Aellenia subaphylla, Haloxilon aphyllum, H. persicum, Salsola richteri, S. arbuscula. Ordinarily vegetation begins in the early spring, flowering - in April, fruit-bearing - in autumn. Annual shoots and fruit-bearing sprouts are used as fodder mass. Sheep are eating them only in autumn and winter, camels - the whole year round.

Another, also representative group of bushes are species of Polygonaceae family: Galligonum alatum, G. elatum, G. setosum and others. Species of Galligonum family are widely spread on pastures of sand desert. Bushes are 1,2-3 m high. Short vegetation cycle is characteristic for these species of plants, usually it begins in March, flowering - in April, fruit bearing - in Mai-June. Annual shoots and fruits which fall to the fround rather early and are picked up by animals from the ground serve as a feed mass.

Table 1. Nourishing seasonal dynamics of desert pasture fodder

Name of the plant	Nutritiousness of 100 kg of fodder (s.f.u.) counted in absolutely dry weight			
	spring	summer	autumn	winter
Bushes				
Aellenia subaphylla	78	59	47	36
Galligonum alatum	90	68	20	15
G. densum	57	42	16	-
G. elatum	74	68	21	11
G. setosum	100	68	23	16
Ephedra strobilacea	149	142	118	72
Haloxylon aphyllum	151	87	50	50
H. persicum	99	76	52	26
Salsola arbuscula	90	66	55	41
Semi-bushes and semi-shrubs				
Anabasis ramosissima	139	88	80	37
Astragalus longipetiolatus	182	67	47	36
A. unifoliolatus	178	67	51	36
Geratoides ewersmanniana	95	70	45	40
Gonvolvulus divaricatus	89	46	25	16
G. korolkovii	74	44	25	20
G. subhirsutus	98	75	43	16
Kochia prostrata	85	70	49	30
Mausolea eriocarpa	108	87	35	17
Oligosporus scoparius	75	72	50	39
Salsola gemmascens	109	79	64	59
S. orientales	90	71	53	46
Seriphidium badhysi	82	70	56	28
S. kemrudicum	72	68	54	33
S. kopetdaghense	77	45	47	35
S. maritium	63	51	42	32
S. santolinum	90	67	54	27
S. scotinum	128	90	41	24
S. sogdisnum	106	43	43	35
S. sublessingianum	132	95	48	22
S. terraealbae	117	74	58	38

Continued Table 1

Name of the plant	Nutritiousness of 100 kg of fodder (s.f.u.) counted in absolutely dry weight			
	spring	summer	autumn	winter
S. turanicum	82	71	56	55
Smirnovia turkestanica	212	137	87	43
Perennial herbs of summer vegetation				
Agropyron sibiricum	129	75	47	22
Reluropus repens	110	69	56	26
Alhagi canescens	85	58	52	25
A. persarum	59	44	29	17
Aristida karelinii	21	15	12	10
A. pennata	78	65	16	15
Astragalus agameticus	178	80	-	-
Elymus racemosus	85	61	31	-
Heliotropium arguzioides	180	86	28	16
Stipa hohenackeriana	136	53	28	15
Perennial herbs of spring vegetation				
Astragalus maximowiczi	245	110	-	-
Carex pachystylis	149	90	47	39
C. physodes	118	62	37	23
Cousinia shistoptera	62	49	44	41
Dorema aitchixonii	110	63	-	-
Ferula assa-foetida	163	127	46	36
F. Badrakema	150	105	-	-
Poa bulbosa	85	50	48	23
Rheum turkestanicum	111	75	-	-
Annual herbs of summer vegetation*				
Agriophyllum latifolium	-	109	98	52
Atriplex lasiantha	-	85	28	22
Chrosophora gracilias	-	73	59	53
Ceratocarpus utriculosus	-	111	46	46
Climacoptera lanata	-	77	64	45
C. transoxana	-	91	51	29

Continued Table 1

Name of the plant	Nutritiousness of 100 kg of fodder (s.f.u.) counted in absolutely dry weight			
	spring	summer	atumn	winter
G. turcomanica	-	43	37	23
Gamanthus gamocarpus	-	61	40	32
Girgensohnia oppositoflora	-	104	72	40
Halimocnemis karelinii	-	48	42	41
Halocharis hispida	-	51	43	30
Salsola leptoclada	-	72	44	44
S. paulscnii	-	53	42	16
Annual herbs of spring vegetation (ephemers)				
Aegilops sguarrosa	66	36	26	-
Bromus tectorum	112	67	35	24
Eremopyrum buonapartis	153	84	60	36
E. distans	146	99	64	51
E. orientale	132	97	72	47
Gutandia memphitica	101	75	-	-
Acantholepis orientalis	156	82	27	-
Alyssum desertorum	112	-	-	-
Arnebia decumbens	188	142	-	-
Delphinium camptocarpum	183	66	32	-
Isatis violascens	172	116	40	-
Koelpinia linearis	152	85	-	-
Leptaleum filifolium	177	85	-	-
Senecio subdentatus	151	112	49	-
Strigosella africana	150	91	27	-
S. gandiflora	119	68	44	-
S. turkestanica	146	83	21	-
Satragalus filicaulis	150	122	-	-
Cnobrychis pulchella	200	128	-	-
Trigonella grandiflora	153	80	-	-

*Nutrition values of summer annual plants during spring period was not calculated since animals are practically not eating them

Data given in Table 1 shows that the maximum nutritiousness of all plant species is observed in the spring period. Then it falls abruptly and reaches the minimum in the winter time.

Among bushes the largest nutrition values demonstrate in the spring time Ephedra strobilacea and Haloxylon aphyllum, which is explained by significant accumulation of protein. However sheep is consuming both of these types reluctantly in the spring time, That is why their nutritiousness should be taken into account in feed rationing of camels.

Semi-bushes and semi-shrubs - rather numerous set of plants which play a noticeable and in some cases predominant role in feed rationing of cattle. Plants of this group usually make the middle, and when the bushes are non existant, the upper level of vegetation especially in gypseous and clayey deserts. Plants height is usually of 30-60 sm and with some species comes to 100-120 sm.

In floral sence the largest diversity of types represent Ghenopodiaceae and Compositae families. Species and Leguminosae and Gonvolvulaceae families are also rather common. In the spring time Leguminosae species demonstrate the highest nutritiousness. They are Astragalus unifoliolatus, A. longipetiolatus and especially Smirnovia turkestanica.

Perennial herbs of summer vegetation is relatively small group of plants though it plays a significant role in feed rationing of sheep and camels. Summer perennial herbs are characterized by rather prolonged cycle of the vegetation period. Gramineae family has the largest representation in this group. The majority of plants increase their fodder mass to the maximum extent in the summer time. Astragalus agamrticus and Heliotropium argusioides possess very high nutritiousness in the spring time though it does not give effect since animals do not consume these plants.

Perennial herbs of spring vegetation (ephemers) is relatively small in terms of species composition group of plants, but extraordinary widely distributed over desert pastures. It differs from summer perennial plants only by shortened vegetation cycle. The majority of plants represented here makes the basis of feed rationing for sheep in different types of pastures and has paramount importance for desert pasture cattle-breeding. Plants of this group build up their feeding mass in the spring period. Then the plants dry out.

Two types of Gyperaceas - Garex physodes and G. pachystylis are the most valuable plants in terms of feeding effect, they are distributed everywhere, the first - on sand soils, the second - in loess and foothill regions. Poa bulbosa (Gramineas family) is also widely distributed in foothill regions and provides for the main harvest mass on pastures.

Annual herbs of summer vegetation have great importance in vegetation coverage, especially in gypseous and clayey deserts. Here belongs a numerous group of annual herbs of Ghenopodiaceae family with vegetation period extended from spring to autumn. The majority of types related to this group of plants is characterized by the development of relatively deep stern root system which enables to get moisture and nourishing substances out of soil even in summer, the most difficult period for plants vital growing. Maximum build up of fodder mass of this group takes place in the summer-autumn period. In the spring and summer cattle is consuming the majority of plants in small quantities, but the amount is increased substantially in autumn and winter, the period of fruit-bearing of Ghenopodiaceae, which serves as a fat producing feed for sheep and camels.

Annual herbs of spring vegetation (ephemers) are extremely important on pastures of southern desert subzone, which is characterized by strictly seasonal winter-spring distribution of atmospheric precipitation. Within the boundaries of the Soviet Middle Asia the plants of this group are widely distributed in pastures of sand and loess deserts. Shortened period of vegetation is generally characteristic feature of this plants group especially rich in species number. The maximum build up of feeding mass falls on the spring period. The plants consumption by the cattle is very high during the whole year.

Pasture rationing of animals within the limits of the same type of pastures remains a constant quantity and is changed substantially by season. However even within the limits of one year, at the beginning animals are eating more attractive, tender parts of a plant, which are very appetizing. If the catle population is moved to another ground when the most appetising and nourishing pasture plants are consumed, animal rationing will be gradually supplemented with more coarse and less nourishing fodder plants. That is why while defining the degree of pasture plants consumption by cattle in pastures it is desirable to proceed from average seasonal indicators.

Nourishment differentiated evaluated of various pasture types (Table 2) in conjunction with their harvest yields and fodder consumption by different kind of cattle is used in pasture valuation and ensuing economic assessment in all-state system of land cadastre.

Table 2. Seasonal dynamics of fodder nourishment in the main types of desert pastures, Turkmen SSR

Types of desert pastures	Nutritiousness of 100 kg of fodder (s.f.u.) counted in air dried weight			
	spring	summer	autumn	winter
Sand deserts	112	68	44	28
Gypseous deserts	111	63	52	35
Glayey deserts	115	70	50	32
Loess deserts	118	76	54	30
Flood-lands terraces	130	78	49	21

Land constitutes the main and indispensable means of production in agriculture. Unfortunately, not always and not everywhere necessary care is taken of its rational utilization and improvement of soil fertility.

All-union land cadastre has been worked out and is periodically renewed so as to make land users more responsable for its cultivation, as well as to ensure scientifically sound planning and organization of agricultural production.

Land valuation as one of the elements of land cadastre envisages identification of its natural fertility.

While preparing pasture valuation one encounters the greatest difficulty in working out valuation scale. The majority of scientists suggest to take as its basis fodder productivity. However, there is no unanimity of opinion in this matter at the present time with regard to evaluation of pasture productivity: according to its harvest yield, according to the size of physical fodder mass consumed by cattle, or the size of the consumed feed mass expressed in feed units, or schematic feed units, balanced on the basis of the most important indicator of nutritiousness - protein consumption. That evaluation of feed productivity of pastures in schematic feed units adjusted according to digested protein, is the most objective criterion for valuation of pasture territories. At the present time there is no uniform all-union valuation scale anabling to assess all pasture territory of the USSR. To have an approximate idea of it is necessary to know the fodder productivity of natural pastures in all the main natural zones of the country.

Proceeding from the closed 100-points evaluation scale it is sufficient to determine the highest indications of fodder productivity with the aid of which high limits may be found, as well as to establish the price for one point in schematic feed units.

The analysis of data according to fodder productivity of natural and cultivated pastures in various natural zones of the USSR provides the possibility to determine the upper limit of feed productivity which is equal to 10 thousand s.f.u. from 1 ha.

To make pasture valuation of desert zone, a separate regional 100-points scale is being worked out provided that it can eventually be transformed in the all-union scale. Since the maximum productivity of desert pastures is equal to 1 thousand s.f.u. from 1 ha, ratio of regional and all-union valuation scales might be as follows (Table 3).

Table 3. Approximate regional and all-union valuation scales to assess pastures according to fodder productivity

Valuation class	Regional scale		All-union scale	
	Fodder content, s.f.u./ha	Assess-ment in points	Fodder content, s.f.u./ha	Assess-ment in points
Rich pastures	1000-810	100-81	10000-8100	100-81
Medium pastures	800-610	80-61	8000-6100	80-61
Impoverished pastures	600-410	60-41	6000-4100	60-41
Poor pastures	400-210	40-21	4000-2100	40-21
Poorest pastures	200- 20	20- 2	2000- 20	20-0.2
Useless pastures	-	-	-	-
Inconvenient lands	20	2	20	0.2

Comparison of two suggested valuation scales demonstrates their good correlation. The value of one point on regional scale corresponds to 10 s.f.u., but on all-union scale - 100 s.f.u., i.e. 10 times higher. In this case the ratio of converting of the regional scale into all-union is equal to 0.1. Thus, tracts of desert pastures with fodder productivity of 900 s.f.u./ha according to the regional valuation scale for desert zone will be assessed in 90 points and put into rich pastures category. The same pastures will be assessed if we use all-union scale in 9 points and will be placed into the class of poorest pastures.

If we make pasture valuation in the USSR in accordance with the suggested principle, the territory of the desert zone falls completely into the class of poorest pastures, which is in conformity with the real state of affairs.

Apparently, the most controversial matter in the process of elaborating all-union valuation scale is the lower limit the poorest pasture class gradation. Following logical correlation of two scales under consideration it would be more reasonable to determine the lower limit of all-union scale in the same way as regional - in 2 points. But in this case, while making all-union assessment of lands fit for pastures, the class of inconvenient lands will include many millions of hectares of Karakum and Kizilkum pastures, fodder yield of which constitutes less than 200 s.f.u./ha. At the same time it is well known that millions of karakul sheep are grazing the whole year round on these poor pastures. Taking this into account it is advisable (at least while making assessment of desert pastures on an all-union scale) to combine the lower limit of all-union and regional evaluation scales not according to points, but rather according to absolute figures. Medium scale pasture map was used in the Turkmen SSR as the basis for departure in pasture valuating, according to each contour of which spring-summer, autumn-winter fodder reserves were calculated. Valuating indications were taken into account in preparing three schematic cadastre maps: for spring-summer, autumn-winter periods and average annual indices (Fig.1).

Examining the schematic map of pastures valuation in the Turkmen SSR as a whole it is possible to establish vividly expressed dependence between natural factors (climate, relief, soil) on the one hand, and the size of evaluating point on the other. The most highly productive fodder areas are situated in river flood-lands with elevated norms of moisture in surface soil layer. Then mountain regions follow with larger quantity of precipitation and grey type of soils. For huge areas of desert regions a definite regularity can be traced - reduction in pasture fodder productivity in the direction from south-east to north along with the reduction in precipitation from 170 mm in south-east to 100-80 mm in north of the Republic.

Pasture valuation maps should be used as the main material of departure for subsequent economic land assessment as the means of production in agriculture.

Economic assessment of desert pastures, as well as other land categories, is the next stage in preparing and implementing a state land cadastre and is a matter for separate consideration.

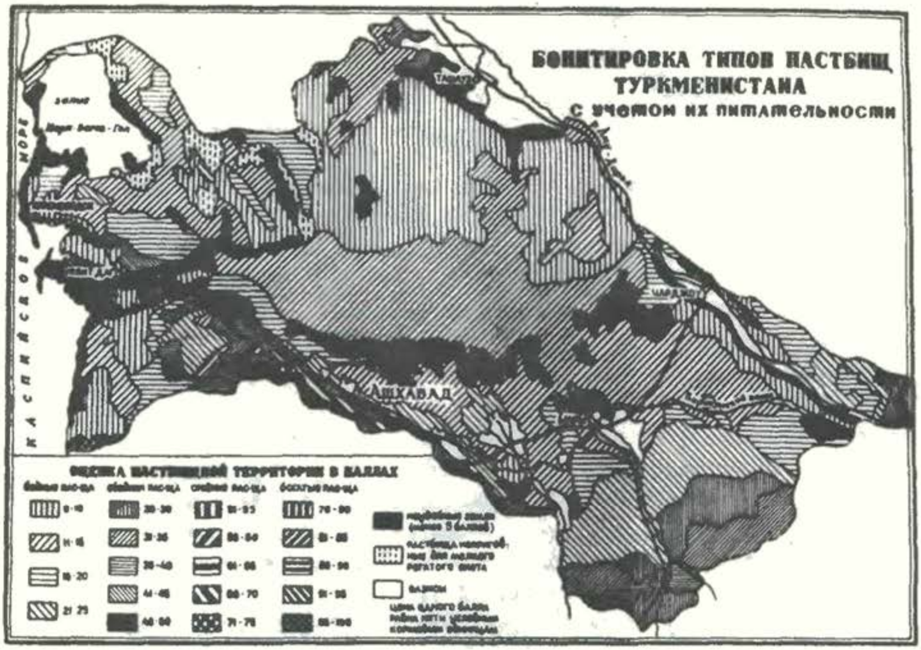

Figure 1

1. Valuation of pasture types in Turkmenistan, taking into account their nutritiousness. 2. Assessment of the pasture territory in points. Poor pastures. Impoverished pastures. Medium pastures Rich pastures. 3. Inconvenient lands (less than 5 points). 4. Pastures not suitable for small cattle. 5. Oases. 6. Value of one point is equal to five schematic units.

THE METHODOLOGICAL BASIS OF THE DESERT PASTURE MONITORING

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The desert-pasture monitoring is a system of scientifically substantiated regular actions designed to give comprehensive and timely information about the condition of desert pastures. Such information may be used by industrial enterprises as a basis for adoption necessary administrative decisions aimed at preservation of the environmental balance in the desert ecosystem.

The system of the desert-pasture monitoring consists of the following major elements: the regular inventory of pastures, the geobotanical map-making, the setting of medium long-term indicators of fodder productivity, the integrated fodder evaluation of pastures in the system of the State Land cadastre, the identification of the annual and seasonal dynamics of the fodder productivity of pastures,

The inventory of desert pastures is carried out periodically, each 12-15 years. During this period great changes are expected to take place in the plant cover of the desert as a result of the integrated effect of natural and anthropogenic factors. They should be considered in detail.

The inventory of desert pastures is made in the process of the integrated detailed geobotanical examination of the pasture territory. A new map of pastures is drawn up in the course of it. Besides the composition of the major map of pastures, the inventory of water sources, industrial facilities is carried out, the experience of the application of the pasture territory in the system of the pasture rotation is studied and analyzed.

The data received serves as a basis for a number of detailed topical maps and diagrams. The results of the inventory are used to give a comprehensive description of the condition of the pasture territory, the recommendations are worked out to improve its application.

A composition of the pasture map is the most important task that is solved during the geobotanical examination of pastures. Remote techniques of studies with the employment of the materials of aerial and space photography play a great role in the improvement of the quality of map-making and the increase of the amount information that contain pasture maps, whereas the volume of field works goes down.

The schale of aerial photographs is very important for effective identification under the conditions of the desert zone. On the large-scale aerial photopictures (1:100000 and more) it is easy to identify separate bushes under the conditions of the sand desert with big bush vegetation, each of the bush specimen has its own image due to the peculiarity of its structure.

With the decrease of the scale of photopictures up to 1:25000, the character of the placement of separate plants in the vegetation community starts to play a more important role. Such categories as thickness of stand, closing, spacing between separate bushes and etc. become very important.

With the further decrease of the scale of aerial photographing the mosaic structure of the plant cover identified by the tone of the photopicture begins to play the role of the identification signs. In case of the small- scale aerial photographing (1:4000 - 1:7000) different combinations of the vegetation that belong to the particular types of landscape are identified on the photopictures. Therefore the process of identification in general boils down to the singling out landscape categories such as communities, localities, areas and etc. and not to the usage of the signs of vegetation images.

The application of one of the scales of photoinformation is determined by the character of the geobotanical examination and concrete tasks of the researchers.

The character and technique of photopictures varies greatly depending on the type of work done and the scale of the final version of the pasture map.

Various scales of space photographing have their own purpose allowing to identify the larger units of landscape and pasture classification.

The photopicture identification always has an integrated nature and is based on the environmental information. The character of the relief and soil is easily identified as the major component of the vegetation environment on the large-scale photopictures in this case. The location of plant associations on the definite type of relief and soil serves as an additional sign, that allows to determine the boundaries of the allocated pasture.

Various signs are used to identify different specimen of bush vegetation: ratio of the chrome green to the height of the plant, height of the placement of the largest diameter, form, sharpness and contrast range of the magnified photopicture, nature of the bush shadow. Furthermore the conditions of plant habitat serve as indirect additional signs: elements of relief and soil, nature of humidification.

The culture landscape is clearly identified on the small-scale space photopictures. In this case the comparison of space photopictures of the same territory made in different years allows to determine the dynamics of the expansion of the areas with anthropogenic landscapes.

The researchers receive two basic advantages with the application of space photographing: impartial and operational character of the information allowing to study the dynamics of nature processes at large areas.

The last years have seen the great interest towards the integrated, multistep application of the data received by remote techniques for scientific and practical purposes in different fields. During the examination of the pasture vegetation the synchronized three step investigation of pasture territory plays important role. Land (field) examination of the key areas, medium-scale examination based on the materials of aerial photographing, small- scale examination based on the materials of space photographing. This time it really becomes possible to use an integrated approach during the examination of desert territories at different levels simultaneously and in various directions.

While determining the fodder productivity of desert pastures it is necessary to take into account their total yield and the volume of the consumed reserve. The total yield of pastures is an amount of the total fodder mass of the pasture vegetation (calculated for its air-dry condition) not considering the extent and nature of its consumption by the animals. In fact the consumed reserve is only a part of the eaten fodder mass.

Under the conditions of the desert zone, in the course of the cattle keeping at the pastures all the year round the dynamics of the total and eaten reserve in different seasons is very important.

Starting the evaluation of the fodder reserves at the pastures the right choice of the area typical for its vegetation and the nature of relief becomes significant. To determine the fodder reserves one should prevent the pasture of the cattle at the area chosen for this purpose. In case of necessity to carry out the work at the pastures with partially consumed vegetation, the correction factors should be developed for various species of plants because their consumption by the cattle is different.

Under the conditions of the desert with thin vegetation a narrow long strip-transect is considered to be the most suitable ground for the determination of the amount of feed reserves. It allows to take into consideration the constant changes of the plant cover thickness on different elements of relief.

The size of the transect varies depending on the nature of the plant cover. For many years the transect up to 4 m wide and up to 400 m long was used for geobotanical examination that covered the area from 800 to 1600 m.

The recent comprehensive study of the optimal area of the yield accounting of desert pastures and frequency of areas during the composition of pasture maps in the scale 1:100000 (the basic scale of the geobotanical map-making under these conditions) made it possible to realize important corrections.

The results of the fractional yield accounting of pastures according to plant associations give us an opportunity to recommend the optimum length of transect up to 100 m. It is possible to estimate the fodder productivity of each of the plant groups separately all over its length. The shorter length of the transect is not desirable mainly because of the difficulty to account objectively small rare plant associations. The transect 500 m long may be applied only in masses with homogenous, hardly changing plant cover at the large area.

The laying-out of the transect strip and the ecological profile takes place at the same time. The direction of the profile and the transect is chosen in such a way that they cross the maximum number of plant groups in this area.

The large-scale field test of kilometers long transect laid-out for the estimation of the fodder reserves at different types of desert pastures enables to recommend the laying-out of the meter long grounds with 50 m spacing along the line of the transect to evaluate the reserves of low grass vegetation.

The plant mass collected from the meter grounds and divided according to basic production groups then makes it possible to calculate the yield of each plant group, identified at the ecological profile and the transect separately.

While drawing the diagram of the ecological profile it is necessary to make corrections and precisions in the field itself. The special attention is paid to the correct matching of the boundaries of plant groups, relief and soil elements it gives us an opportunity to posses correctly matched diagrams of landscape that are used, if necessary, to make additional corrections of the geobotanical area boundaries on the pasture map with extrapolation of the content of aerial photographing reference materials for key areas.

As a result of the calculation of the extent of plant groups, relief and soil elements at the profile, their ratio within the limits of the given terrain is being determined.

The processing of field materials begins with the determination of areas that belong to different plant groups at the transect by means of the summation of strips with the same plant groups. If there are bare ground all over the transect, they are included into the total estimates.

The number of specimen of bushes, small bushes and tall grass is calculated all over the transect according to the specimen and classes of size for each of the plant group and is written separately in special blanks. The number of these plants per one hectare is estimated by means of established factors.

The processing of field material on the accounting of grass vegetation collected in the course of laying-out of the transect meter grounds has its own peculiarities. First of all the number of meter grounds laid-out for each of the plant group is estimated. Then the air-dry mass of specimen is determined for each of the plant groups, it is calculated in kilograms per hectare.

The adjustment of the data according to the results of the average yield year is one of the important moments in the estimation of the fodder reserves at the desert pastures. There is a very complicated interdependence between the pasture yield and weather conditions of the year because numerous specimen of the plants at the pastures that belong to various life forms react in different ways to the weather conditions.

The following gradation is used for the meteorological evaluation of each year for the geobotanical examination of desert pastures: very high-yielding year, high-yielding year, average-yielding year, low-yielding year, bad year. The special indicators calculated for different biological plant groups on the basis of the long-term observations are applied for the impartial evaluation of the amount of fodder reserves at desert pastures under different weather conditions of the year.

The calculation of the total and eaten fodder reserve with the help of the seasonal coefficients is binding for all the seasons of the year. The calculation of the average year eaten fodder reserve is made taking into account the duration of seasons in the corresponding natural area.

On the whole to estimate the yield of pastures on the basis of the key ground the calculation of all the indicators is made taking into consideration the percent ratio of the available plant groups.

The estimation of the seasonal dynamics of total eaten fodder reserve fluctuations at production grounds identified on the pasture map is carried out by means of averaging of the values of the total yield of pastures for each of plant groups.

The data of the estimation for each of the production ground is laid down in the consolidated register of the seasonal fluctuation dynamics of the fodder reserves. The consolidated register contains all the geobotanical grounds with the legend of the pasture map, the area of pastures, total and eaten fodder reserves according to different seasons and their average amount for the whole year.

To feed the animals properly it is necessary to know how the animals eat the fodder in various seasons and its nutritiousness in particular.

In the research on the nutritiousness of the pasture fodder much attention is paid to the study of the seasonal fluctuation dynamics of the factual rations of different specimen of cattle during their pasture at various types of desert grounds. The original method called "simulation" was worked out in the USSR for the estimation of pasture rations of the different specimen of cattle. The gist of this method lies in the determination of the ration content and eaten amount of the fodder at the pasture with the help of the direct calculation of the number of bites of the animals of various specimen of plants with the further simulation of biting. This method gives good results under the conditions of desert pastures with bare grass stand.

The materials that characterize the nutritiousness of the pasture fodder, the data about its content and amount of pasture ration for the different specimen and groups of the animals are widely used during the composition of feed balances in the pasture stock breeding.

The approximate feed balance of the nutritional substances under the conditions of keeping of Karakul cheeps at Saxaul and sedge pasture (Haloxylon persicum-Carex physodes) in the Central Karakum desert serves as an example (see Table 1).

The composition of such feed balances makes it possible for the workers of desert-pasture stockbreeding to find rapidly a solution of the questions of the balanced feeding of the agricultural animals covering the deficit of the nutritional substances by means of the additional feeding.

The working out of the pasture land cadastre is considered to be one of the important actions designed to axamine in detail the desert pastures for further development of the stockbreeding.

The basic elements of the pasture land cadastre are valuation and economic estimation of the pasture territory.

The valuation of lands provides for identification of their natural fertility based on the quality signs. The materials of the large-scale geobotanical examination of pastures adjusted according to the average long-term indicators are used as a starting point for the valuation of the desert pastures.

With the development of the remote methods of research it became really possible to make a rapid annual evaluation of the fodder productivity of pastures at the large territory at the same time. The methods of evaluation are based on the correlation interdependence between the plant productivity and the value of coefficients of spectra brightness. The data received is adjusted taking into consideration the peculiarities of natural conditions of different pasture regions, the structure of the plant cover, nature and extent of consummation of various specimen of plants by the animals.

The Institute of the desert studies of AS TSSR has developed a principal, methodological scheme that provides for integrated application of remote and ground techniques of the evaluation of fodder productivity of desert pastures with composition of multipurpose operational pasture maps. These are the major elements of this scheme: zoning of the pasture territory; preparation of the materials on the seasonal dynamics of the increase of the fodder mass according to classes, type groups and types of pastures; composition of multipurpose operational pasture maps.

Despite all the advantages of the remote techniques of the evaluation of the fodder productivity of the desert pastures over the traditional ground method of the geobotanical examination, they have one major shortcoming: comparatively low accuracy, that sharply limits their range of application. The accuracy of the calculation of the parameters of the plant cover with the help of remote aerial and space photographing methods is influenced by the objective factors: the distorted effect of the atmosphere, bare nature and multilevel character of the plant cover, different timing of the vegetation development in various natural pasture regions. It is clear that remote photometric techniques of examination do not allow to identify the structure of the plant cover that complicates the avaluation of the fodder reserves in all the seasons of the year.

Such great number of the drawbacks makes it necessary to run obligatory ground synchronized monitoring to make correction and precision of the data received by means of the remote methods.

The permanent key grounds that cover all the multiple vegetation of the pasture territory under consideration should be indispensable. Different categories of the key grounds may be laid-out at the pastures: review, summary, detail and auxiliary. The first three categories of the key grounds are used depending on the production purpose of the operational pasture maps. The auxiliary key grounds, that cover the whole pasture territory are used only once in 10-15 years during the regular inventory of the natural fodder areas.

The main objective of the composition of the annual operational pasture maps is to provide the specialists with the necessary objective information as a result of the comparison of the evaluation of the present year fodder productivity with the average long-term indicators received in the course of regular detailed inventory of the pasture territories. Therefore during the composition of the operational pasture maps it is necessary to have all the results of the geobotanical examination including the productivity values on the basis of the average yield year.

Table 1. Approximate food balance under the conditions of the keeping of Karakul sheeps at the saxaul and sedge pasture (The Central Karakum desert)

Season	Indicators	Air-dry fodder (kg)	Basic nutrition elements								
			Feed units (kg)	Digested protein (kg)	Critical amino acids				Microelements		
					Lisin (g)	Methionine and cistin	Triptophane (g)	Carotene (mg)	Copper (mg)	Molybdenum (mg)	Cobalt (mg)
Spring	Demand	190	91	9.1	1056	646	152	1520	1520	150	80
	Fodder availability	190	163	24.0	1590	424	371	42182	1561	146	70
	Balance	0	+72	+14,9	+534	-222	+219	+40662	+41	-4	-10
Summer	Demand	245	123	12,3	1624	298	209	2460	2220	220	110
	Fodder availability	245	128	9,0	556	142	168	2580	1470	128	93
	Balance	0	+5	-3.3	-1068	-756	-41	+120	-750	-92	-17
Autumn	Demand	135	76	6.7	806	494	122	1520	1290	130	60
	Fodder availability	135	73	5.5	278	87	78	6443	1109	71	36
	Balance	0	-3	-2.1	-528	-407	-44	+4923	-181	-59	-24
Winter	Demand	150	100	10.0	891	549	126	1800	1440	140	60
	Fodder availability	150	61	6.1	465	169	83	811	774	80	44
	Balance	0	-39	-3.9	-426	-380	-43	-989	-666	-60	-16

Rangeland mapping by remote sensor techniques

B.V.Vinogradov

Aerospace surveying is one of prinsipal methods for desert rangeland monitoring. The use of remote sensor indication is essential in studying of environmental conditions, classification and mapping of rangeland systems, monitoring of phenological development and biomass dynamics, etc.

The main task of remote sensor indication is studying of the structure and mapping of rangelands. At first, the use of aerial photography in rangeland mapping was limited by contour interpretation when only boundaries of rangelands were mapped, while their content was determined in the field. Later on, establishment of reliable interpreting indicators for rangeland vegetation permitted to develop methods of combined interpretation techniques based on investigation of key areas and extrapolation. This enabled to apply the landscape approach to mapping, and to perform a multi-stage generalization of rangeland ecosystems, thus significantly increasing (by 2-3 times) efficiency of work.

The second task of aerospace rangeland monitoring is determination of productivity by optical indicators. The theoretical basis of this method were studies on relationship b tween reflectivity of vegetation and its biomass. At present, this task is achieved mostly by using multi-spectral images from Earth satellites, as well as by aerial spectrophotometric surveying of rangelands.

The third task is remote sensor phenology or aerospace monitoring of rhythmics in rangeland vegetation composition and biomass. An annual, especially in springtime, aerospace inspection of rangeland vegetation seasonal development is used in Central Asia, Kazakhstan and US Western states. Remote sensor measuring of biomass growth rates in the beginning of the vegetative period permits to predict rangeland yields, deviations in vegetation time and composition of ecobiomorths.

The fourth task of monitoring is indication of rangeland economic modifications, recording of their many-year dynamics and forecasting of future changes. Aerospace images are used to identify dynamic stages of such modification or degradation of rangelands, interprete their changes related to grass burns, water management construction etc. The most correct method of rangeland remote sensor monitoring is comparison of repeated aerospace images of the same areas obtained with large time intervals (3-5 years). Such a comparison permits an accurate measurement of the scope and rate of rangeland transformation. Optical and radiation effects of man-made succession of rangeland vegetation permit to forecast desertification processes.

Among technical questions of rangeland aerospace monitoring, the following two are of special importance. One is studying of rangeland vegetation optical properties, determination of natural and technical conditions for surveying. An important achievement in this field was the above-mentioned model of relationship between brightness and biomass on the exponential basis and selection of optimal brightness indices in the red and near-IR spectral bands. Another problem is automated processing of remote sensor data. Unfortunately, the level of automation is still very far from that of detailing achieved by visual interpretation. Nevertheless, it was possible to automate some important auxiliary operations, in particular, comparison of images in different spectral intervals, differentiation of oejects by the level of optic density for classification purposes, seasonal comparison of images etc.

At present, there are no commonly accepted notions of rangeland mapping. This is due to complexity of spatial structure of rangelands, multifactorial character of their classification, uncertainty in the term "type of rangeland" and difficulty to generalize differently scaled rangeland units. The existing classifications of rangelands (geobotanic, ecological, topological and physionomic) are inconsistent and do not reflect their complex spatial structure. In the most often used classifications the type of rangeland - lowest taxonomic unit - is characterized by uniformity of ecological conditions and similarity of the vegetation botanic composition; the group of types - medium taxonomic unit - is identified by properties of the vegetation cover and ecological conditions having an economic value, and the class - highest taxonomic unit - is identified by most important, having a great economic value, ecological indicators (climate, relief, hydrology, soil). However, there is no uniformity in the use of this classification, since the same levels are interpreted differently. For instance, in the work by Nechaeva and Nikolaev the type is identified by a list of dominating forage plants, group of types - by soil factors, and class - by landscape types of deserts/3/. In the work by Vinogradov and Popov /2/ groupe of forage lands are identified on I:10000-I:20000 aerial photographs by predominating associaations of forage plants, topography, difference of soils and sand stability in wet conditions, while classes - on I:30000-I:50000 aerial photographs - by landscape indicators with certain combinations of classes, associations and formations of plants.

There is a need in such classification of rangelands which would take into account combinations of geobotanic, ecological and landscape indicators at all hierarchic levels. Moreover, the identified units should be sufficiently physionomic and easily recognizable on images, just as types of land use /4/.

According to most authors, the lowest unit of rangeland classification is range site, which corresponds by territory to a vegetation association site with one soil difference on one relief pixel, and with a single type of economic use. The size of range site would correspond to the minimum area of vegetation association or elementary complex. In arid zones it varies from 0.I to 5 ha (average I ha), depending on the topography. Range sites are mapped in I:I0000 detailed scale.

Mapping of rangelands in smaller scales (I:30000 and less) may be complicated due to the necessity of generalizing in two ways - typological and territorial.

Typological classification of range sites is done through generalizing characteristics of plant composition. Forage lands are subdivided into species, genera, classes, families.

A species of forage lands is typological grouping (association) of range sites with a certain composition of grazed and non-grazed plants, certain specific yields, seasonal production, soil difference and one type of economic use.

A genus of forage lands is the second stage of typological generalization, where groups and classes of plant associations are qualified by indicators pointing to similarity of edificators, sub-edificators and structure of associations.

A class is determined by plant formation or group of formations united by a generic similarity of edificators.

A family is characterized by type of vegetation having similar ecobiomorths of edificators, which determine the type of economic use.

The above typological units do not cover all possible versions of generalization. Therefore, in some cases it is necessary to distinguish sub-species and sub-classes of forage lands etc.

The main problem of rangeland mapping is the difficulty of classifying their spatial parameters. The chorologic territorial classification is made on a landscape basis. The principal advantage of maps using the chorologic classification is their specific and detailed character, reliability and timeliness.

The most developed landscape classification of rangelands exists in Australia. From 1946, it uses the national system of four key scales for land mapping. . A land site - principal chorologic unit which is uniform as to topography, vegetation and soils - is mapped in 1:10000 scale. A land unit is a combination of geographically related land sites, characterized by uniformity of the parent rock and conditions of internal drain which are reflected in the soil and vegetation cover, but not in the form of relief. Land units are mapped in 1:50000 scale. A land system presents a combination of geographically related land units, whose boundaries normally coincide with clear geomorphological lines. This level is mapped 1:200000.

A land region and landscape are distinguished by morphogenetics of the geological structure, and are shown on I:I000000 and I:3000000 maps.

Soviet landscape studies use 4-5-stage classification. A facies serves as an elementary unit with one indigenous plant association, one series of derivatives united by one epiassociation, one soil difference, uniform conditions of moisture and drain, and microclimate. Urochishche is a complex of facies united by one form of relief on a uniform substrate (simple urochshche), or a changing substrate (combined urochishche). Then goes locality, presenting a regular combination of morphologically, geophysically and geochemically integrated urochishches with repeated forms of relief. The principal unit is landscape which also represents a regular combination of localities united by one genesis and geological and geomorphological structure.

Canada adopted a staged classification. A land type in it is determined as territory with absolutely uniform combination of soils of one soil series, and successional series of vegetation. This is close to our simple urochishche. A land system is territory with repeated indicators of relief, soils and vegetation. It corresponds to our locality or combined urochishche. A land district is characterized by specific relief, geology, geomorphology and corresponding vegetation. This is our landscape. Finally, a land region is territory with a distinct regional climate reflected in the vegetation cover. It corresponds to our understanding of a province.

In francophone countries the lowest unit is "parcelle écologique" characterized by specifics of microclimate and microedaphon, and shown only on maps of super-large scale. "Station écologique" is defined on large-scale maps by microrelief, soil cover and effects produced by man and animals. "Secteur écologique" is shown on medium-scale maps by topographic situation, local climate and type of surface sedimentation. "Région écologique" is mapped in small scale by general relief, regional climate and large geomorphological units. The highest unit - "zone écologique" is characterized by zonal climate and is shown on very small-scale maps.

In the above-mentioned landscape classifications of levels (excluding the Australian classification), neither scale intervals, nor the levels themselves are not strictly predetermined, making it difficult to accept them unconditionally. On the basis of frequency-spatial characteristics of geosystems we succeeded to calculate a single step of approximately three-fold increase of the scale denominator when passing from a lower to higher level, and logarithmic distribution of unit scales /I/. Such classification is universal, more detailed and covers the whole range of scales. Definitions of units in this classification are composed of two parts - stem "choros" (site, territory) and prefix pointing to the scale. In our classification the elementary unit is "monochora" which covers one element of the relief with one plant association and one soil difference. Units at higher levels are combinations of lower units.

In principle, it would be more simple to introduce landscape taxons in rangeland classification. For instance, this is practiced by Australian scientists who use landscape units in rangeland mapping. However, in this case the typology of rangeland units is not taken into account. Therefore, it would be more preferable to have a two-dimensional classification.

The principle of the proposed classification is clearly seen on the graph, where typological units are plotted on one coordinate, and chorological - on the other (Fig.1). In the cross-point we have the required two-dimensional units for mapping rangelands in various scales. Naturally, in various geographic conditions and depending on territorial complexity this proportion can change. Table I gives a list of major rangeland systems in surveying scales which are shown on small- medium- and large-scale maps.

It would be interesting to introduce in classification the third parameter - economic modification of rangelands related to overgrazing. However, the level of degradation can be clearly shown only for range sites. In complex rangeland systems various elements may have various levels of degradation under the same load, depending on capability of single range sites to resist overgrazing. At the level of range sites, the most adequately studied are modifications in ilak white saksaul sand-desert soils.

The first degree of rangeland modification (degradation) is reflected in change of vegetation at the level of association groups. The vegetation composition changes insignificantly, phytocenosic links get weaker and transition to semi-associations is evident, though the changes are easily reversible. Spots of non-consolidated sands amount to 4-10% of the area.

The second degree of degradation is reflected in changes of association classes and transition to agglomerations, which are difficult to reverse. The volume of grazed phytomass is decreased two-fold. Spots of non-consolidated sands reach I5% of the area.

The third degree is characterized by practically irreversible changes at the level of plant formations. Rangelands become practically unsuitable for use. The area of non-consolidated sands exceeds 25%.

The fourth degree are badlands, completely excluded from rangeland rotation and practically devoid of any vegetation.

An important advantage of desert rangeland monitoring with the help of aerospace techniques is the possibility of quantitative evaluation of rangeland many-year dynamics. This is illustrated by the following example.

To investigate changes in the status of rangelands on black earths of the Caspian Plains for the last 30 years we analyzed aerial photographs of I:20000-I:30000 scales obtained in I954, I963, I970, I979, I98I and I985, and space photographs from "Salyut-4,6 and 7" orbital stations taken in I976, I978 and I982 with spatial resolution 50-80 m. Field studies were carried out in I954, I958, I98I and I98I-I984. To evaluate desertification trends a testing ground of 2I6,000 ha had been selected.

Due to a high optical contrast of barren sands compared to semi-desert rangelands, all desertification foci are well interpreted on panchromatic photographs with a relative error I-2% (the same error occurs as a result of geometric distortion of images, inaccurate carrying over of contours from images to a map etc.).

The method of instrumental interpretation with prior classification followed by comparison of results (Post Classification Method) is used to compare to compare repeated images of various scales and quality. First, indication and classification of desertification foci (eolocumulative, deflation-cumulative and deflation facies) was performed visually by aerial photographs and instrumentally by space images using display-type IMA processor and a single legend. Then, the interpretation results were corrected and converted into the single data presentation scale I:300000. The detected desertification trends are shown in Fig.2.

The 1954 images reveal a stable status of ecosystems. At that time there were predominantly (83.3%) grass-wormwood ranges and hay-lands on sandy brown soils with forage yields 3-8 centners/ha, and on meadow-brown soils with yields 8-I2 centners/ha. The former appeared on aerial photographs in grey tones with diffused transition of shades, and the latter - in dark grey tone with visible signs of hay harvesting. By I970, the pressure upon rangelands reached critical values. As a result of overgrazing, yields from grass-wormwood ranges and their area were reduced two-fold. Their images had also changed: they became more light, and the texture of complexes - less contrasted. In I974-I98I, the degradation of Black Earth natural ecosystems reached catastrophic proportions. The previously dominating grass-wormwood ranges disappeared altogether. Serious degradation affected not less than 75% of rangeland area. Average yields dropped to 2-3 centners/ha.

For mathematical expression of desertification trends on the Black Earth we used aerospace data to calculate the area of drift sands and deflated surfaces.

Most conveniently, desertification processes are described by the expression:

$$S(t_i) = a \exp (k(t_i - t_o)), \qquad (I)$$

where: S – relative area of desertification foci in t_i year; a – relative area of drift sands and deflated surfaces in the state of ecosystem stability (a = 2±I%); t_o – conditional year when the desertification processes started, whose intensity is described by exponent k. This function was computer-solved by three points of the linear regression equation:

$$\ln S = kt_i - kt_o \qquad (2)$$

Analysis of equation (2) gave coefficients of equation (I): a=2.3; t_o=I954, k=0.I. Thus the equation appeared as:

$$S(t_i)=2.3 \exp(0.I(t_i-I954)) \qquad (3)$$

Here the correlation factor is 0.9599, and the residual dispersion – 0.087. According to the obtained expression (3), the area of desertification foci increases every year by approximately I0% from the area of the preceeding year.

Analysis of equation (3) leads to following conclusions. In I950s, desertification foci covered only 3-4% of the ecoregion area, and the rangelands were not overpressed. In I960s, the desertification reached the maximum admissible value – I0% of the region area, i.e. the level of reversible ecosystem changes, and, accordingly, pressure upon the rangelands sharply increased. In I970s, the desertification processes became critical – they affected over 20% of the area. This was already the stage when changes in the ecosystem were difficult to reverse, and the pressure on the rangelands exceeded the normal one by 2-3 times. In I980s, the desertification dynamics adopted an exponential character.

The uantitative expression of the present desertification trends permits their extrapolation forecasting. It is assumed that a present trend can be extrapolated at least by one-third of the time investigated. In our case, forecasting can be made by 10 years ahead, i.e. up to 1994. According to equation (3), the desertification foci will reach 84% in 1990, and cover the whole area by 1992 (Fig.3).

The above data present a predictive model for the ecoregion. However, alternatives are possible, depending on changes in the predictive background, i.e. environmental conditions significant for prediction purposes. Corrections are made on the basis of additional studies, first of all taking into account spatial irregularity of the territory. For instance, considering that the badlands (clay and brown soils, salinized and other soils resistant to eolic processes) account for about 10% of the testing ground, the form of the trend should change: after reaching 70-80% of the area in 1989-1990, the desertification foci will slow down their growth to the logistic curve. Phytoreclamation of sands, started in 1980, will also slow down the desertification process. If the scope and efficiency of phytoreclamation is maintained at the present level (about 1% of sand area per year), parameter "k" in equation (3) will be reduced to 0.08. By the corrected prediction, expansion of desertification foci should also be slower, reaching the maximum in 1995, after which the foci area will begin to shrink. Other factors may also be used to correct predictions.

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FIG. 1 TWO-DIMENSIONAL CLASSIFICATION OF RANGE SYSTEMS

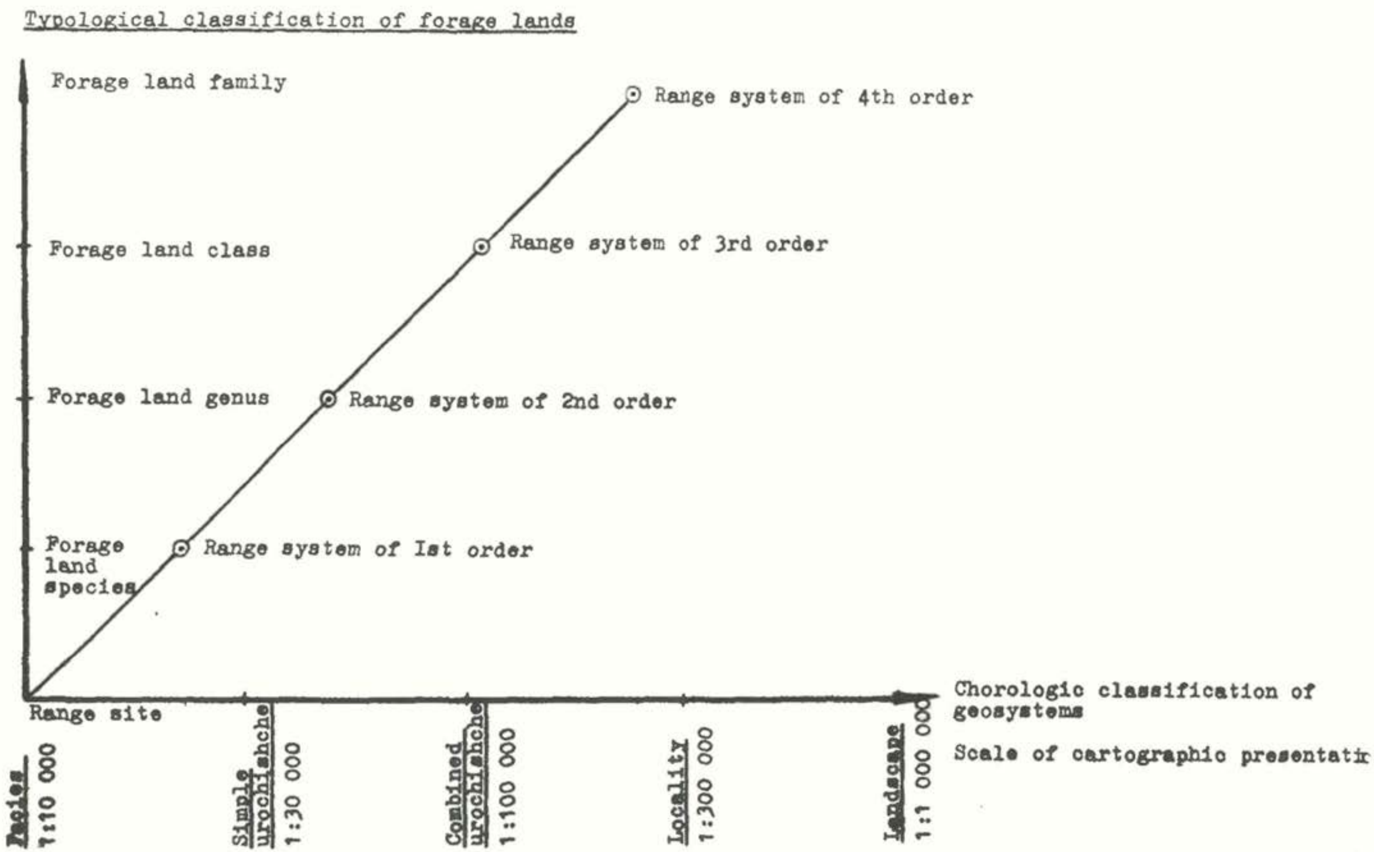
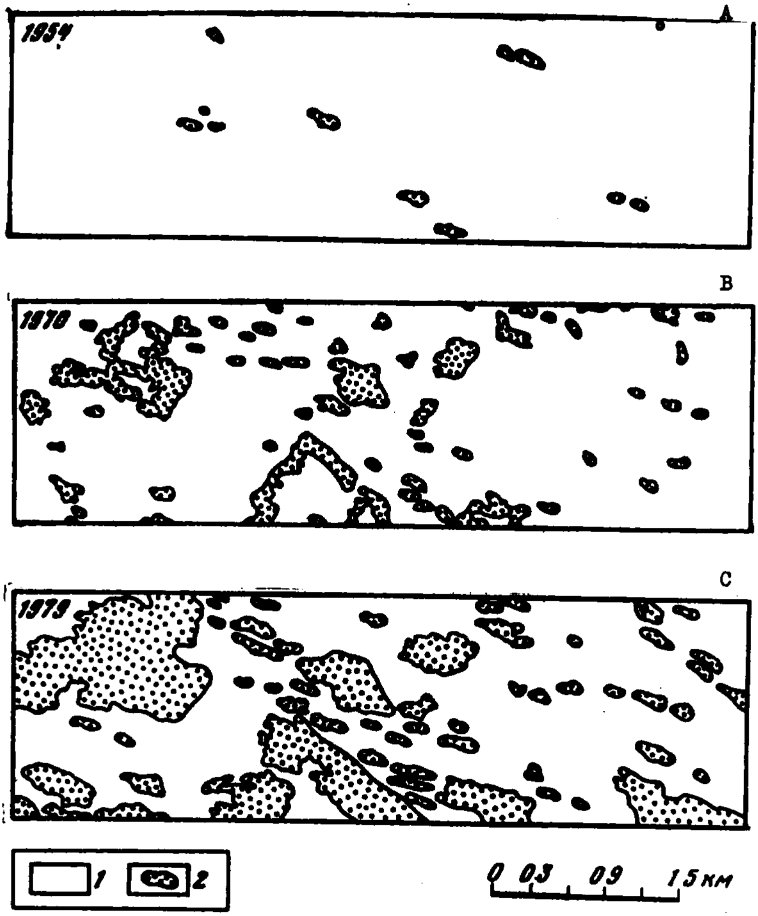


FIG.2 DEVELOPMENT OF DESERTIFICATION PROCESSES ON THE BLACK EARTH ON THE BASIS OF AEROSPACE DATA

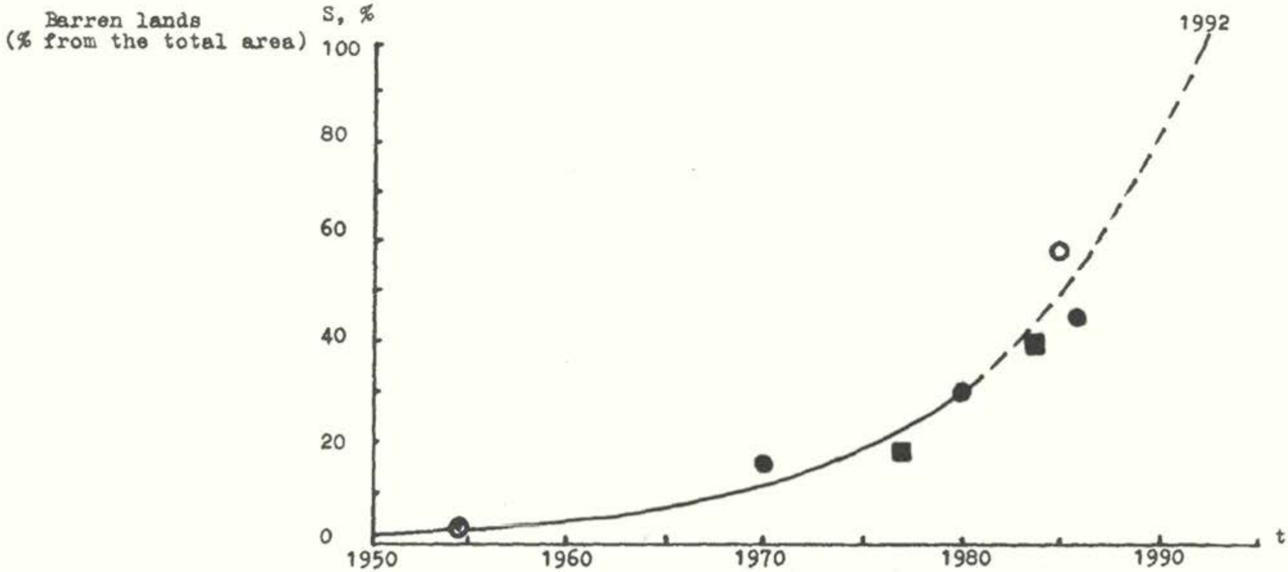


A - 1954; B - 1970; C - 1979/1981

1 - variously tramped rangelands

2 - barren drift sands and deflatory depressions

FIG. 3 DESERTIFICATION TRENDS ON THE BLACK EARTHS



Development of desertification processes by:
- ● repeated aerial photographing
- ○ aerovisual monitoring
- ■ space images
- — prediction of desertification trends

Table 1.

Main rangeland systems

Definitions, synonyms	Unit scale of mapping, scale intervals	Specification
Range site, facies, monochora, land site	I:I0000 (I:8000-I:I5000)	Elementary range portion, with one plant association or elementary complex of fragments of associations, with one soil difference or their elementary complex on one element of the relief
Range system of Ist order, simple urochishche, nannochora, land unit	I:30000 (I:I8000-I:50000)	Combination of elementary range portions of one or various types of forage lands, united by one form of the relief and one continuous topo-ecological series, including portions with different optimal regimen of use
Range system of 2nd order, combined urochishche, microchora, land system	I:I00000(I:60000 I:I50000)	Combination of range systems of Ist order of one or various groups of forage lands, united by a regular combination of relief forms and one complex topo-ecological profile
Range system of 3rd order, locality, mezochora, land system	I:300000(I:I60000-I:500000)	Combination of range systems of 2nd order of one or various classes of forage lands, united by one genetic type of the relief, locality of one genesis and one hydrological regimen
Range system of 4th order, macrochora, landscape	I:I000000(I:600000- I:I500000)	Combination of range systems of 3rd order of one or various families of forage lands, united by one genetic type of landscape and one type of geologo-geomorphologic structure

FROM EXPERIENCE OF DESERT PASTURES IRRIGATION
(The USSR, Mongolia and Syria are taken as examples)

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The problem of providing foodstuffs for world population envisages intensification of agricultural production on the basis of utilization of achievements in scientific and technical domain. In this connection the experience of optimal measures in irrigation of natural pastures as an important means of raising the effectiveness in cattle-breeding is of significant interest.

In the Soviet Union the natural pastures occupy 332 million ha, which is 1.5 times larger than cultivated arable land.

The main areas of pasture cattle-breeding is to be found in Kazakhstan, where its territory is equal to 180 million ha and in the republics of the Middle Asia - 70 million ha. About 80% of sheep live-stock, over half of horse and goat population, the fourth part of cattle and the whole population of camels are grazing on natural pastures.

The creation over the years of the Soviet power of big cattle-breeding farms made it possible to pass over to organization of the planned use of natural pastures territiries. However, pasture irrigation is still one of the main issues of further cultivation of the arid zone.

Subterranean waters is the most dependable and widely used source for desert pasture irrigation. It allows to solve the problem of water supply in cattle-breeding and to establish stable fodder base. Research studies undertaken by the Soviet hydrogeologists have indicated the existence of significant reserves of underground waters in the USSR arid zone. Estimated reserves of subterranian waters only in the Kazakh SSR are assessed in the figure of 1960 m^3.

The largest part of quality underground waters in Kazakhstan is situated in the south of the Republic. In the sand desert tracts of Mujunkum, Kizilkum, near Arak Karakum subterranian waters are located at the depth of 3-10 to 30 m. Production capacity of wells is estimated to be 200 to 430 m^3/day. At the depth of 100-150 m. artesian basins have been located, which contain primarily fresh water (of high pressure and selfflowing). Wells capacity is 300-8,000 m^3/day. 100 million ha of pastures received water and 40 thousand of arable land was irrigated in Kazakhstan with the use of underground waters.

In the Turkmen SSR about 80% of the territory falls on a vast desert - Karakum, which plays an important role in cattle-breeding of the Republic.

Waters of profound layers in Karakum as a rule can not be used in agriculture due to high content in them of mineral substances - up to 15-30 g/l.

Fresh and slightly salted underground waters are to be found in the form of lens of various origins and volumes. The largest lenses have been formed in the zone of formation of hilly-ridge sands. 8 big under the sand lenses with the total statistical deposit of 80 km^3 have been studied in Karakum. On the basis of the subterranean waters of the Yaskhan lens it became possible to arrange for water supplies of industrial and agricultural enterprises including pastures. Water drain has an enormous importance. Reserves of the drain flowing in Karakum are estimated in 332 million m^3/yearly (of all the deserts of the Middle Asia and Kazakhstan - 703 million m^3/yearly). This provides for the possibility to have distant pasture cattle-breeding and small oasis irrigated agriculture. Drain water flowing provides for 20% of water supply in desert pastures of Turkmenistan.

The total water consumption of underground waters in the USSR for pasture irrigation reaches 0.33 km^3 during the year. To get the water to pastures 50 thousand chinks, 51 thousand slit wells were bored, over 101 thousand ponds were constructed. The level of water up-take mechanization is equal to 85%. Building of water-pipes and water channels is going on a wide scale. Pumping, cleaning and water refreshing stations are also being built up. So, for instance, in the Kazakh SSR combined water-pipes in Ishim and Bulaevsk with the total length of 3.5 thousand km are presently in use. Drinking water for over 600 thousand people is supplied through them, as well as water is supplied for cattle-breeding farms. The length of Presnovsk combined water-pipe, for example, which runs along the territory of the RSFSR and the Kazakh SSR, is over 3.3 thousand km.

The general sketch of agricultural water supply development in the USSR for the period until the year 2,000 includes a programme of undertaking further prospecting, research studies, projects of construction works to get water to natural pastures. An analysis of the present state of natural pastures in different parts of the country is given in the general sketch, which defines at the same time a variety of measures to enhance the effectiveness of their use. A great number of measures is to be carried out so as to solve such problems in the period up to the year 2,000. In particular, it is contemplated to supply all natural pastures with water and to carry out reconstruction of water supply systems in previously irrigated land areas equal to 170 million ha. It is planned to improve the mechanized water supply, to further clean watering points e.t.c.

The reconstruction of pasture water-pipes envisages provision of means of automatization and communication, which regulate the processes of water supply and water elevation. It is planned to raise significantly the level of industrialized construction of water intake and watering points at the expence of larger utilization of the system of construction modules and blocks of technical equipment. Type projects of buildings with the high ratio of prefabricated elements were worked out and are put to practice in the framework of this system.

The ratio of pastures with water supply from the underground sources will reach in the year 2,000 95%. It is planned to undertake water refreshening of waters polluted with minerals at heliorefreshing, electrodialysis and reciprocal-osmotic plants.

It is planned to drill 700 thousand exploitation holes to get water to new territories and to restore the systems that have broken down.

Other necessary technical measures for pasture watering are also envisaged.

Great experience of the common work to ensure stable development of cattle-breeding has been accumulated by the Soviet and Mongolian water supply organizations.

As is known, the leading place in agricultural production of Mongolia belongs to cattle-breeding, when the cattle is grazing on pastures the whole year round. It gives about 4/5 of gross agricultural productiin. Pastures account for about 85% of country's surface area or 132.7 million ha. The richest tracts of pastures are situated in the north of the country, where main reserves of surface waters are concentrated.

The MPR is characterized by sharply continental climate with small amount of precipitation, sizable annual and daily fluctuations in air temperature, with cold windy winter and short summer. Severe natural conditions cause significant difficulties in organization of cattle watering during the cold period of the year. In winter time a significant part of springs and wells is frozen, at the same time water demand according to consumption norms is reduced only 1/3 or 1/2 times. Thus, the regions which are well supplied with water in summer time become poorly provided for in winter time. During severe snowy winters the situation worsens by the fact that the cattle has to get its fodder from under the snow. Its additional feeding with mixed foodstuffs and hay raises the norms of water consumption otherwise the animals may perish due to water deficiency in their bodies. It is explained by the fact that in pasture cattle-breeding the animals are eating grass together with snow and, thus, get additional moisture.

At the beginning of the 60-s mass construction of watering points began in Mongolia with the USSR technical assistance. Average annual construction rate in the MPR is 1.5 thousand watering points and around 2.5 million ha of pastures receive water. At the beginning of 1986 the total of 74 million ha got water and 30 thousand watering points were constructed. About 80% of them are pit wells and holes 30 m deep, 20% - holes with the depth of 150-200 m. It is planned to finalize watering of natural pastures in the MPR before the year 2,000.

A pit well is the most widely used type of water intake installation in the MPR not only for pasture watering, but for water supply of small settlements. Its construction and exploitation are not expensive. It is put into operation within short period of time and is compensated very fast. Boring wells with rotor and shock-rope type machines are constructed on pastures, where underground water is located on a sizable depth. Wells are equipped with filters and pumps.

The following measures are envisaged for further development of pasture watering:

- reconstruction of watering points, which will include spring manipulation, modernization of outmoded wells that will increase production capacity of watering points, improve their sanitary state and ensure the year round exploitation;
- construction of new wells and holes to use the waters of Quaternary accumulations and surface jointings in the zones of rocky grounds, as well as abyssal subterranean waters;
- irrigation of forage crops to create buffer fodder stocks.

Soviet and Mongolian water management organizations conduct scientific research and test constructive studies to create special water elevating equipment to utilize in the MPR wind energy installations and to solve other questions of great practical significance for further development of distant pasture cattle-breeding.

"A scheme of exploitation of Syrian desert water resources" is under consideration in the Syrian Arab Republic in conformity with signed contracts and with the participation of the Soviet water management organizations. A great number of prospecting and research studies was performed in the area of 4.97 million ha, including hydrological, hydrogeological, soil, geobotanical and other studies to substantiate project decisions.

The cattle-breeding (primarily, sheep-breeding) in the SAR accounts for 20-40% of the total value of agricultural production in the country. Natural pastures in the Syrian desert is the main fodder base of the cattle-breeding.

Increase in cattle population, lack in pasture watering, not regulated grazing, distruction of vegetation (including by means of transportation) lead to overexploitation and degradation of pasture lands.

Pasture watering in the SAR has its century-old history, Some ancient water-falls are in use till present day. Underground waters, river flows and during precipitation period - rain water accumulated in natural relief hollows and artificial ditches is being used for cattle watering practically the whole year round. The total of 1,000 water sources (holes, wells, storage lakes e.t.c.) are in use. They are situated at the distance of 10 to 40 km and even at greater distance, which obviously has a limiting effect on the proper use of pasture lands.

Subterranian waters of the Syrian desert is the most reliable source of pasture watering. The underground waters depth location in Quaternary accumulations in vadi plains ordinarily do not exceed 1-2 m but in Palaeogene-Neogene accumulations they reach 70-90 m.Waters do not have pressure. Arid climate leads to mineralization of underground waters in this area and only in river basins the mineralization does not exceed 1 g/l. Relatively low deposits of water layers make them accessible for extensive exploitation despite considerable salt content in water. Yearly water intake is about 13.1 million m^3. Jointing rocks and carbonates of surface chalk, where the main water accumulation can be found, are the most plentiful in water reserves. Water content in rocky ground is not uniform. Specific capacity of wells is 2-5 l/s. Mineralization of subterranean waters - from 0.4 to 3-4 g/l. The deposit depth is measured within the limits of 200-300 m. Yearly water intake - 11.9 million m^3.

The Euphrates is the permanent source of pasture watering. In pasture zone adjacent to the Euphrates, canal water supply is in wide use (average distance to pastures is up to 30 km). Water intake from the river and irrigation canals is done by portative pumps and manually. Natural closed hollows are used as temporary water reservoirs (feids - Gjub, El-Mey, Kasabdgit and others), where during rainy periods around 10-20 million m^3 of water is accumulated. After high-floods are over and river-beds and feids have dried out nomads cattle-breeders open small kopani - dug-outs of up to 5 m in depth and take subsoil waters.

According to the estimates of specialists, out of the total volume of surface flow about 12% of water is being accumulated in small reservoirs (around 3 million m^3) of seasonal regulation, which are designed to get 25% of their capacity intake from annual flow.

Scientifically proved recommendations for further development of cattle-breeding, raising fodder potential of pastures, production of fodder on irrigated lands and other matters are given in "The scheme of exploitation of Syrian desert water resources". It is expected, that to reach the desired level (the year 2015) for cattle watering, taking into account daily consumption in each season, it would be necessary to have 9.7 milliom m^3 of water. Proceeding from the maximum capacity of one watering point and seasonal distribution of live-stock it would be necessary to set up 4.2 thousand new watering points. According to estimates, water requirements for oasis irrigation will augment to 96.6 million m^3 annually (at present time the relevant figure is 22 million m^3). Accordingly the tracts of irrigated land will increase from 1.7 to 11.0 thousand ha.

The main source of pasture cultivation will remain underground waters. The use of surface water with the help of reconstructing existing reservoirs and construction of new barrages to develop estuary irrigation will grow. However, specific conditions of surface flow formation in a desert can not ensure stable production of fodder only at the expence of estuary irrigation. This problem is in need of further detailed study.

Improving of sand-desert rangelands

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Productivity of sand-desert rangelands is low, and in lean years it reaches only I.0-I.5 metric centners/ha. In average, 3 years out of I0 are lean years.

Improvement of rangelands is an important reserve to provide forage for animals. It can be achieved by creating artificial phytocenoses capable to produce high and stable yields. In this respect, the experience gained by the author in the Central Kara-Kum may present a certain interest.

The Central Kara-Kum is one of major rangelands in Turkmenia, stretching up to 800 km from east to west. The total area of the region is I2.7 mln. ha.

Most of the region is represented by high (I0-I5 m) ridged and hillock sands. The central part, within the ancient deltas of Murgab and Tejent rivers, is covered by ridge-and-takyr complexes, with 20-25 m high meridional ridges alternated by wide takyr-like surfaces and sors.

The ground waters are found very deeply (20-25 m) and are highly mineralized (25-30 mg/l). The vegetation lives exclusively on the atmospheric water.

The climate is continental. In winter, frosts can reach -30-35°C. An average annual precipitation is 80-I50 mm, with most high levels in winter and spring.

Plants of herbaceous and herbaceous-wormwood phytocenoses, which are characteristic of the region, have a superficial (up to

I20 cm) root system, and therefore they can not fully use moisture and nutrient reserves of the environment. As a result, the vegetation productivity is lower than possible.

At the same time, newly sown or added artificial phytocenoses have root systems located at various levels, down to 8 m and more, thus permitting a fuller utilization of environmental resources.

There are two ways for improving range- and haylands; simplificated and substantial. The simplificated improvement is achieved through adding seeds of woody and bushy plants to the already existing thinned vegetation cover without prior cultivation. The substantial one - by strip plowing of the community with adding to the culture of lacking forage plants.

The method of rangeland improvement is selected depending on natural and environmental conditions (see Table I).

Table I.

Methods for improvement of sandy rangelands

Relief	Sand stabilization	Vegetation	Improvement methods
High-ridged by-well sands, up to 30 m	Barchaned, unstabilized	Thinned selin	Simplificated: adding of white saksaul mixed with Paletzky chekez, red kandym and chogon
Ridged and hillock sands, up to I0 m	Low-stabilized	Selin, thinned kandym	Simplificated: adding of white and black saksauls mixed with other shrubs

I.	2.	3.	4.
Inter-ridged low-hillock sands up to 3 m	Medium-stabilized	Thinned semi-shrubbed grass cover	Substantial: harrowing and sowing of saksauls, other shrubs and semi-shrubs and perennial herbs
Inter-ridged low flattened sands, underlaid by takyrs, up to 0.5-I.5 m	Stabilized	Thinned shrubs and semi-shrubs. Ilak turf of medium height	Substantial: strip plowing, adding of saksauls, other shrubs and perennial herbs

According to L.G.Dobrin (1979), the area of by-well barchan massifs in Turkmenia is 35,000 ha, of which 70% are in the Central Kara-Kum. To restore vegetation in this area, it is necessary to sow white saksaul (at a seeding rate of I0 kg/ha). In mixture, it is possible to use chogon (sand form), Paletzky cherkez and red kandym. However, white saksaul should account for more than a half of seeds, thus ensuring an adequate number of shoots - 500-I200 per ha (depending on meteorological conditions).

On large areas ofdesert rangelands it is advisable to improve without mechanical protection, irrigation or fertilization, but with embedding the seeds. Such an embedding can be effected by running through a herd of sheep (Nechaeva, Prikhodko, 1988). Aerial sowing, used for several years, proved to be unprosuctive exactly because the seeds were not embedded. On by-well sands it is possible to add "granulated" seeds obtained by soaking them in a pulp-like solution comprising clay and sand in I:2 ratio. Additional sowing into a wet soil or through the snow also gives good results. The plants taking root in the first year enroot well later on, and their mortality rate in the following years is only about 30%. In 5 years a shrubbery with a grass cover is formed.

Formation of a stable phytocenosis of artificial hermaceous white saksaul on high-ridge sands takes place in the second year. Analysis of its floristic composition shows that the basis of grass cover are perennial herbs, such as Heliotropium arguzioides and Tournefortia sogdiana, and annual cereals Bromus tectorum and Cutandia memphitica. With development of a new phytocenosis, the role of Aristida karelinii is reduced to the minimum. The perennial Carex physodes - an important sand stabilizer - spreads only to the upper third of the slope and in by-shrub spots, without reaching the ridge top. In a I4-year community the number of species varies within IO-I3, instead of I-2 existed before the improvement. In most cases the number of hermaceous plants per I m^2 is not more than 20. An exception are by-shrub spots, where the number of Bromus tectorum and Cutandia memphitica cereals may reach 40-50. The inter-shrub space is occupied by Heliotropium arguzioides and Tournefortia sogdiana, while an insignificant number of Tetracme recurvata and Lappula caspia grows on the periphery of tamarix mounds, indicating to a weak stabilization of sands.

Dynamics of crown projection areas shows an increase of this parameter with age in cultivated Haloxylon persicum, and a decrease in wild plants which readily spread over low-stabilized sands - Smirnovia turkestana, Acanthophyllum elatius, Aristida karelinii.

Yields of annual forage herbs grows in 10-14 years from 3.5 to 5.6 metric centners per ha, and their nutritive qualities rise significantly. The annual/perennial plant ratio in the biomass tends to increase in favour of the latter (from 44 to 83%), thus making biomass yields more stable by years.

Productivity of rangelands on ridge-hillock low-stabilized sands can be increased using the above-mentioned simplificated improvement techniques. Taking into account good conditions for forestation and protection against the wind erosion, it is possible on these lands to increase the number of sown species, by including in the mixture black saksaul, Richter cherkez and borjok, in addition to the already mentioned chogon, kandym, Paletzky cherkez and white saksaul. Within 5 years after sowing the shrubs, a quite formed self-reproducing normal phytocenosis appears. It includes trees, shrubs, semi-shrubs, perennial and annual herbs, thus permitting an all-year grazing on the artificial pastures. The total phytomass of shrubs increases in 10 years from 24.5 to 82.2 metric centners per ha, and forage yields - from 3 to 9 metric centners per ha.

Sowing of shrub seeds with harrowing gives good results on low-stabilized small-hillock sands. This method is simpler than plowing which is not always possible because of relief conditiond, and sometimes is not feasible due to the danger of erosion. Harrowing before and after sowing facilitates embedding of the seeds, steady shooting and better enrooting. Harrowing does not eliminate the grass cover, and ripping creates favourable conditions for rooting and further growth of annual and perennial herbs. As a result, in the first 5 years produetivity of rangelands rises due to abundance of herbs, and later on - due to the sown shrubs.

To improve rangelands on small-hillock sands it is possible to use all types of plants with various life forms which are recommended for sand deserts. The seeding rate is 8 kg/ha, of which more than a half should be saksaul, and the rest - other shrubs in various combinations. The shooting rate reaches 3,000-5,000 per ha, with 31-50% rooting in the first 3 years (74% for white saksaul) when the sowing density is 2,000 shrubs per ha. The projective cover increases from 25 to 60% in 10 years. By that time, the shrubs reach their maximum size, and the community receives an undergrowth from seeded reproduction ensuring a long life for the new phytocenoses.

Undersowing of forage plants - saksaul, cherkez, chogon and other shrubs - on virgin lands with herb-stabilized (especially with ilak) sands does not give positive results because of competition on the part of the latter. On areas stabilizated by ilak, the most optimal agrotechnical method for introducing phytomeliorant is strip plowing. Plowing on stabilized sands should be effected at a depth of not less than 30 cm. In case of a lesser depth, ilak roots start growing again in the first year, preventing shooting and enrooting of the new plants. Plowing changes water-physical and chemical properties of the soil, reduces evaporation, eliminates competition for moisture on the part of root herbs, facilitates accumulation of moisture up to 4-10 mm even in summer, creating favourable conditions for new shoots, their enrooting, growth and development. The number of shrub shoots reaches 4,000-10,000 per ha, but within 3 years it decreases by 50-87%.

Plants sown on plowed lands are characterized by accelerated growth and development: in five year white saksaul becomes 100-150 cm high with the same diameter of the crown, and enters the generative phase. With age, the specific variety of the community expands, to gether with the projective cover. After five years, reproduction of ilak and other herbs begins (from roots and seeds remaining in the soil), permitting to use the artificial pasture for grazing.

In conclusion, our many-year studies show that at any level of sand rangeland degradation phyto-improvement measures lead to their reclamation and increase of forage yields.

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SYSTEM OF PASTURE IMPROVEMENT IN CLAYEY DESERT

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Vegetation of deserts and semi-deserts, which are used as pastures, presents by itself a rather fragile, easily vulnerable natural creation. Poor economic cultivation and exploitation of these ecosystems lead to disbalance, impoverishment of their structure and productivity and occasionally to their destruction.

Low productivity of desert pastures, sharp flactuations in harvest yields and in content of nutrition substances in pasture fodder depending on year or the season, as well as poor composition and structural simplicity of natural ecosystems make it necessary to work out effective technology to raise fodder productivity and stability of pasture ecosystems.

This article summerizes the results of activities in the All-Union Scientific and Research Institute of Karakul Production, USSR Ministry of Agriculture in elaborating scientific base and methods of radical improvement of desert and semi-desert pastures. Experimental studies were carried out in a foot-hill desert (Nishan station) with clear lightly loamy grey soils with the yearly precipitation rate of 220 mm., in wormwood-ephemer desert (Karnab station), in sub-sand clear grey soils with the yearly precipition rate of 160 mm and in South-Western Kizilkum (Ayak-Agitminsk station) in desert sand soils with the yearly precipitation volume of 110 mm.

The forming of contemporary flora composition and vegetation structure in arid regions of the Middle Asia and Kazakhstan, especially in foot-hill areas and plains adjacent to mountains is greatly affected by anthropological factors - grazing by animals, cutting of woods and bushes, as semi-shrub plants, ploughing and fires. Combined action by natural historical and anthropological factors resulted in dominating distribution of ephemeric and ephemers-wormwood vegetation and forcing out bushes and solanic semi-shrubs and later - the wormwoods.

Gonsidering various anthropological options of desert phynocenoses in the light of the understanding about their full composition it is worthwhile to mention that many present day vegetation communities of the USSR arid zone are not fully complemented in terms of flora and cenose since they do not include species capable to grow in given conditions when there is sufficient number of embryos. The lack of full composition in phynocenoses and the possibility to enrich them with new including more productive plants species is well supported by the results of research studies of sinusial structure of natural and artificial phytocenoses, conducted for the first time by N.T.Nechaeva.

The special research studies that we carried out while examining structure of natural ephemer Garex pachystylis + Poa bulbosa and wormwood ephemer Artemisia diffusa + Garex pachystylis + Boa bulbosa communities made it possible to determine the following: ephemeroidous communities of foothill desert occupy small layer of air enviorenment - 0-15 sm and of soil - 0-60 sm , ephemeroidous wormwood phytocenoses respectively 0-235 and 0-90 sm.

Artificial agrophytocenoses grown from bushes (Haloxylch aphyllum, Salsola paletzkiana, S. richteri, Ephedra atrobilacea,Rellenia subaphylla) and from semi-shrubs (Salsola rigida, Kochia prostrata) due to its strongly developed and deeply penetrating root system, located in soil, contribute in different ways to cultivation and atilization of new ecological niches.

In the zone of root growth of artificial phytocenoses, which were produced by means of sowing seed mixture of bushes, semishrubs and herbs, moisture reserves and nutrition substances are 3-5 times larger compared with the live conditions of natural ephemeroidous and ephemeroidous-wormwood vegetation.

Ephemers and ephemeroids if they are sown in their pure form can not serveas dependable means of raising harvest yield of pastures in a desert zone, at the same time fodder plants from the class of bushes and semi-shrubs are characterized under these conditions by relatively high productivity which is due to ecological and biological features.

Bushes and semi-shrubs are characterized in the cultivation process by rapid and development, early and steady entry into the reproductive phase, by plentiful fruit-bearing. N.T. Nechaeva places them in conformity with the ontogenetic character of their growth among rapidly maturing bushes, which enter generative phase at the age of 1-2 years and promptly developing their surface part - Aellenia subaphylla, Salsola, Kochia prostrata, Artemisia diffusa, A. furanica, A. halophila. Their life span is 7-25 years. Among the late maturing types which enter fruit-bearing phase after 4-5 years are Haloxylon aphyllum, Ephedra strodilacea, which live about 40-50 years.

Great importance in defining productivity and resistance of fodder plants to extreme conditions of desert ecological regime has the character of development and formation of root systems. Annual ephemers, ephemeroids and salt worts form surface and poorly developed root system mainly adapted to use soil moisture, accumulated ad a result of precipitation.

Cultivated semi-shrubs form relatively strong deeply penetrating root system. Aellenia subaphylla's roots penetrate the soil during the first year for 180-250 sm, the fifth year - 800 sm. Roots of Kochia prostrata and Salsola rigida in the first year of existance penetrade the earth to the depth of 80-150 sm, in the third and fifth - 500-700 sm.

Root system of Haloxylon aphyllum, which is cultivated in different soil climatic conditions of arid zone is also characterized by strength and deep soil penetration: in the first year - to 130-150 sm, at the age of 5 years - to 12-14 m, 10 years - to 16 m.

The plants consume not only moisture from atomospheric precipitation due to their deep root system, but condensated, elevated by capillaries soil moisture and subterranean wa-ters. At the same time, Haloxylon aphyllum, Salsola paletzkiana, S. rigida, Aellenia subaphylla, Kochia prostrata are characterized by the economical use of soil moisture for transpiration. The most intensively transpiring plants out of tested ones are Eurotia ewersmanniana - 673-1 105 mg/hour, ecotypes Konchia prostrata - a little less - 400-665, and others - the most economical users of moisture for transpiration - Salsola rigida - 337-364, Haloxylon aphyllum - 302-318, Aellenia subaphylla - 415-556 mg/hour.

Effective method of improving desert and semi-desert pastures was worked out on the basis of know-how of ecology and biology of fodder plants and field agrotechnical tests, In particular, the All-Union Scientific and Research Institute of Karakul Production has designed a method of creating pasture protective belts of black saksaul (Haloxylon aphyllum).

The role of pasture protective belts in a desert is of great importance. They reduce wind speed (1.5-2 times as compared with the open pasture), hold the snow and protect the soil from drying and blowing. Relative air humidity is higher in the belt itself and in adjacent places. As a result more favorable ecological conditions for growth and production of high harvests of ephemers and annual saltworts are created. Type composition of plants in a forest belt is more differentiated. Here we have substancially larger variation of types of ephemerous herbs while their density is lower (2-3 times) as compared with the open pasture. In pasture protected belt the harvest yield of fodder mass of ephemers is being increased 2-3 times, a new phytosenos with the features of community of herbs, cereals, ephemers, saltworts is formed. At the distance of 100 m on the leeward side of the belt the fodder harvest gets augmented by 25 %.

To choose a tract for pasture protection belts it is necessary to take into account soil-climatic, pasture-feeding conditions of each farm and biological peculiarities of black and other bushes that are used to improve fodder lands.

The most suitable places to set up pasture protection belts are sand, sandy and loamy soils. Soils with small or medium measure of salt in the form of sulphate or chloride-sulphate are also suitable. Accelerated growth and forming of high stem are secured for black saksaul on such types of soil with the optimal level of underground water deposits (5-30 m).

The effectiveness of creation of pasture protecting belts depends, apart from the right choice of pasture strip, from timely and exact fulfillment of the whole complex of agrotechnical methods designed to create favorable conditions for growth and development of cultivated plants.
In others than sandy deserts, the width of pasture protecting belts is made of 25 m. Between each pair of belts a natural pasture of 200-250 m of width is preserved. When the belts are distributed in such a way, then for each 100 ha of pastures one may have from 12.5 to 20 ha of protection belts.

Great effectiveness of pasture protecting belts may artise out of their position, when they are lined perpendicularly to the direction of prevailing winds. The proper preparation of soil for sowing plays an important role in the series of agrotechnical methods of establishing pasture protecting belts.

An attempt to introduce Haloxylon aphyllum by way simply additional sowing over the vegetation of the desert pastures the seeds of some types of Artemisia, Garex pachystilis, Poa bulbosa are usually of no avail: shoots are rather sparse, grow slowly and plants are dying out. Such character of bushes and semishrubs development is explained by high competitivness of Gare pachystylis and Poa bulbosa.

Ordinarily mould-board ploughing with complete overturn of the layer to the depth of 20-22 sm is practiced. Ploughing on poor, salted or strongly gypseous soils is done with a subsoil cultivator to the depth of 15-30 sm with simultaneous harrowing. If there is the need, the disk-rolling and fragmentation of ploughed strips are performed. Autumn-winter-spring period is considered to be the best time to prepare soil. It is better to begin the ploughing operation while the soil is still wet. This will allow to give the soil a good work over within desired depth norms.

Keeping to optimal sowing time limits is an agrotechnical method no less important for creation of forest belts, which ensures desired germination completeness. It was established during many years of research studies and in the course of production practice that the best sowing time limits for Haloxylon aphyllum, Salsola paletskian, S. richteri should be winter (from the middle of December to middle of January) and early spring (from mid-January to mid-February).

Among a number of agrotechnical measures an important part is given to optimal norms of seed per hectare and to the depth of seed placement in soil. Standard norm of seed sowing with the due account of its quality is 5 kg/ha for the first class, 8-9 kg/hafor the second class and 2.0-2.5 for the third class (without wings When pasture protecting belts are made of Salsola paletskiana and S. richteri seed sowing norm is equal to 7 kg/ha. In case of mixed sowing, sowing norm for Haloxylon aphyllum is 3.5 kg/ha and for Salsola paletzkiana, S. richteri - 2.0 kg/ha. The seed placement in soil to the depth of 0.5-1.0 sm is the most effective way of sowing of Haloxylon aphyllum, Salsola paletskiana, S. richteri. The seeds are covered by rolling.

In March-April appear shoots of Haloxylon aphyllum, Salsola paletskiana, S. richteri. Plants of the black saksaul and cherkes reach on clear sandy grey soils 45-60 and sometimes 70-80 sm in height at the end of the first year of vegetation. In the fourth and fifth year of vegetation the height of these trees gets to 2.5-3 m. At this time normal pasture protecting plantations have been already formed.

Optimal density of standing Haloxylon aphyllum during the formation of pasture protecting belts is 500-800 bushes per I ha. This standing density provides for good development of ephemerous and saltworts vegetation which ensures the highest pasture productivity. Excessive density of saksaul bushes leads to close of their crowns, complete black-out of ground and disappearance in the shade of the black saksaul of ephemers and saltworts plantations. The value of dense plantations with closed crowns in terms of fodder and phyto-land-reclamation is low. The thinning out has to be done in the second year of Haloxylon aphyllum exstance. With the standing density of 500-800 bushes per I ha and their uniform distribution, the nutrition area of each bush will come to 12.5-20 m^2. While thinning out over-dense plantations of 5-10 year of age, part of bushes is dug out, another part is transformed into pastures by cutting bushes at the height of 30-40 sm from ground surface.

Foot-hills of the Middle Asia covered with ephemeral and ephemeroid vegetation serve as splendid spring-summer pastures. The main drawback of these territories lies in absence of autumn-winter grazing. Grassy plants dry out at the end of the spring, are easily broken and carried away with the wind. Harvest yield and nutritiousness of fodder go down sharply. In winter time still intact low height herbs are covered with snow and become inaccessible for sheep. As a result, a very tense situation arises with respect to fodder balance of karakul producing farms located here.

Zootechnical considerations dictate the creation of autumnwinter pasture in foot-hill semi-desert. Selection of karakul sheep as species was taking place against the backgroung of fodder diversity under the conditions of sand desert. That is why the karakul sheep are in need of specific rationing - they consume 1.5-2 times larger amount of plant species than other animals.

The desirability of setting up bush and semi-shrub pastures comes not only out of zootechnical needs, but also out of the necessity to exploit favorable ecological conditions of foot-hill semi-desert (elevated atmospheric precipitation, more fertile soil). Almost half of the ground moisture in half a metre soil layer in a foot-hill semi-desert (Nishan steppe) in the amount of 800-1.500 t/ha is not taken by natural vegetation and uselessly evaporates during the summer and autumn.

All this set a task at one time - to establish in foot-hills of the Middle Asia autumn-winter pastures. The best fodder plants under these conditions turned to be Artemisia diffusa, R. turanica, A. halophila, Salsola rigida, Aellenia subaphylla, Kochia prostrata, Salsola lanata, Gamanthus gamocarpus, Halimochemis villosa. Follows the ratio of sown plants: bushes - 30 % semi-shrubs - 60 %, ephemeroids - 10 %. The ratio of sown land to pastures 30 - 35 %. Harvest yield on sown lands accounts for average figure of 1.5 t/ha of eatable dry mass. Thus, several tasks are solved simultaneously - raising of pasture fodder volume and overcoming the limitations in the periods of their use.

As distinct from foot-hill zone, the desert wormwood pastures are lacking juicy green fodder in the summer period. Sheep are getting green fodder in desert pastures mainly in spring. In this connection the creation of artificial summer pastures with high harvest yields acquires great practical significance.

The following plants are used to create summer pastures in this zone: Kochia prostrata var. canescens, K. prostrata var. villosissima, Eurptia ceratoides, types of Astragalus, Galligonum, Kochia scoparis, Garthamus tinctorius. Artificial pastures created in foot-hill wormwood ephemer desert accumulate during the summer period the maximum quantity of eatable phytomass, which is equal to 2.5.-5.0 t/ha from Kochia prostrata, 4.6 t/ha from Galligonum rubens, 2.5÷2.9 t/ha from Kochia scoparia, 2.5-3.0 t/ha from types of Astragalus, 3.0-5.9 t/ha from Garthamus tinctorius (in green mass). At the same time, fodder of these plants contains in summer from 10-12 to 16 % of protein, significant quantity of carotin and carbohydrat, as well as from 30 to 66 % of moisture. All this makes it in the summer period an important source of highly nutritious green vitaminic fodder against the background of natural pastures with their dry faded vegetation.

Summer artificial grazing ground made of Kochia scoparia, Garthamus tincordius is used already in the first year of sowing, while different types of Galligonum, Astragalus, Kochia prostrata - in the second year of vegitation.

In Uzbekistan, it was recognized phytocenosically proved and economically desirable to establish long-standing pastures of autumn-winter and around the year exploitation, which consist of bushes of Haloxylon aphyllum, Salsola richteri, Aellenia subaphylla - 25 %, semi-shrubs of Kochia prostrata, Salsola rigida and different types of Artemisia - 60 %, herbs Poa bulbosa and ephemers - 15 %. It is recommended to sow for spring-summer pastures semi-shrubs Kochia prostrata, Eurotia ceratoides, Gamphorosma iessingii - 70 % and herbs Poa bulbosa - 30 %.

It is preferable to conduct sowing works in the autumn-summer period, when conditions are more propicious for seed sprouting and their field germination is higher. During the autumn-winter sowing seeds are placed into wet surroundings and during prolonged winter time are in good watering conditions, are subject to alternate (positive and negative) temperature impact which ensures their atratification. This adds to favorable conditions of seed sprouting and development of fodder plants shoots. Seeds covering in soil elevates their field germination. Optimal coverage depth is 0.5-1.5 sm.

Stability of ecosystems is depending upon the complexity of structure, number of species composing senoses and interaction of these species. In this connection while constructing pasture agrophytosenoses, great importance acquires, besides correct definition of number of species and living forms, knowledge of biological and phytosenosic compatibility of fodder plants in concrete ecological conditions of an arid zone.

Pasture agrophytosenoses of around year utilisation, made of the mixture of different types and living forms of feed plants, are characterized by high productivity, which surpasses natural pasture lands 3-5 and more times, by steady harvests according to years and seasons, by diversity of fodder and long-standing productivity.

Long-term utility and economic desirability of introducing methods of land-reclaiming in desert and semi-desert pastures have been proved by actual work in the leading karakul producing farms of the Middle Asia.

SEED-GROWING AND SELECTION OF DESERT-PASTURE PLANTS

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Selection and introduction of new fodder crops has enormous significance for the solution of the problem of raising productive capacity of desert and semi-desert pastures. This problem is many-sided and complex: a selectioner deals in the desert zone not with cultured plants, but with wild-growing, not studied at all or studied superficially in genetic, biological and physiological sense. At the same time, conditions of deserts and semideserts are extremely different and are subject to stress preassures of abiotic factors.

Due to a number of causes the selection of arid feed plants is lagging behind in the system of agricultural crops selection. One of the causes is the fact that the development of methods to increase the harvest yields of desert pastures (in particular by introducing new feed plants in crops) has begum quite recently.

In the arid zone of the Soviet Middle Asia and Kazakhstan over 300 types of feed plants of natural flora belonging to 29 botanic families were tested. The largest part of tested types belongs to cereals families - Gramineae - 75 species, Chenopodiaceae - 40, Leguminosae - 29, Cruciterae - 25, Compositae - 17, Polygonaceae - 13, Umbralliferae - 10 and only 91 species belong to remaining 22 families.

The following species are the most adaptable for cultivation and use in the selection work

<u>Trees</u>

1. Calligonum arborescens
2. Haloxylon aphillum

<u>Shrubs</u>

3. Haloxylon persicum
4. Calligonum rubens
5. Calligonum caput-medusae
8. Ephedra strobilasea
9. Salsola paletzkiana
10. Salsola richteri

6. Calligonum microcarpum
7. Calligonum setosum
11. Aellenia subaphylla
12. Salsola arbusculiformis
13. Salsola laricifolia

Semi-shrubs

14. Kochia prostrata
15. Salsola rigida
16. Camphorosma lessingii
17. Eurotia ewersmanniana
18. Astragalus agameticus
19. Artemisia diffusa
20. Artemisia badhysi
21. Artemisia kemrudica
22. Artemisia Halophila

Perennial

23. Astragalus agameticus
24. Poa bulbosa

Annual

25. Salsola lanata
26. Gammanthus gemocarpus
27. Halimocnemis villosa
28. Eremopirum orientalis
29. Bromus tectorum
30. Malcolmia grandiflora

The following features are expected from the species selected for deserts and semi-deserts; high harvest yields in definite soil climatic conditions; annual harvest stability, especially during unfavorable years; ecological plasticity; high feeding capacity; preservation of the best feeding parts (leaves, assimilar sprouts); stability to systematic grazing; early plant growing on spring pastures and prolonged vegetation on summer pastures; drought-resistance, salt-resistance, frost-resistance; simultaneous ripening and fruits fall-resistance; relatively high field germinating ability of seeds; resistance to sickness and pests. Plants should have a root system, which anables to use moisture and nourishment reserves not only of the surface, but of the deep layers of soil. Until now 8 species of feed plants have been selected in the USSR and among them 6 species of Kochia prostrata and two species of Salsola rigida.

Types of Kochia prostrata - "Karnabsky" and "Pustinny" are characterized by relatively high harvest yields (1.2 - 1.5 t/ha of dry fodder in the regions with annual rain fall of 160-250 mm). They are adaptable to cultivation of perennial pastures and haymowing. The types of "Orgachersky early-matured" and "Orgachersky late-matured" are adapted for mountain pastures in Kirghizia (annual rain fall - 300-500 mm). These types yield 3.5-3.9 t/ha of dry fodder.

Salsola rigida species - "Pervenets Karnaba" and "Sunny" are characterized by extreme drought-resistance and significant salt-resistance, yield 1.5 - 2.0 of dry fodder in the regions of rain fall of 110-250 mm. If we take into account that average harvest yield in natural pastures is only 0.3 t/ha, and in unfavorable years even lower, one can easily figure out, what a great potential of raising pasture productivity may be found in selection of desert feed plants.

Arid regions are far from being uniform in soil-climatic and phytocenotical respects. Even within the framework of the same ecological type of desert selection of uniform species similarly adapted for cultivation under different conditions is hardly probable. Unfortunately, the above mentioned species of desert feed plants fit relatively favorable conditions - for foothills and mountain vallies. It makes approximately 30% of arid land in the USSR. One of essential drawbacks of desert pastures consists in sharp fluctuation of their productivity which adversely effects cattle-breeding. Under these conditions the priority attention is given to selection of crops species, which constantly yield high harvest irrespective of meteorological conditions. In the course of unfavorable years the harvest yield of such type should not be lower than 0.6 - 0.8 t/ha of dry fodder.

A serious problem of pasture cattle-breeding may be found in sharp changes in nourishing values of pasture feed plants in the course of the year. For example, 100 kg of dry pasture fodder in Kizilkum and Karakum contains 81 feeding units in spring, 49.5 - in summer, 54 - in autumn and 18.3 in winter. Protein content is being reduced from spring to summer from 20% to 5%, albumen - from 13% to 4%. Reduction of the general nutriton value and protein content in summer and especially, autumn and winter leads to disruption in normal cattle-feeding on pastures, to albumen hunger. This phenomenon provides basis for another, not less important direction in the selection work - improvement of feed quality. First biochemical studies of inner variability of desert feed plants have demonstrated that they are characterized by great polymorphism with respect to albumen content and other nutrition ingredients and this is an indication of sizable selection opportunities.

Selection work in desert feed plants is based on many-sided utilization of wild species as starting point. However, up till now introduction into cultivation of desert feed plants more often accidental material, collected at one place of the area of this or another species, was used, at the same time ecological-geographical types of plants, formed in the process of evolution, have different economic and ecological value.

Intraspecific differentiation of wild types of feed plants in deserts and semi-deserts can be observed, if the semi - shrub Kocnia prostrata is taken as an example. Its area is vast - from nothern temperate regions of Euro-Asia to north Africa. It is quite natural that within the boundaries of such a vast space species can not be uniform. In the research work of the selection centre of the Institute of the karakul production great diversity not only within one species, but also among acotypes and population was established. This diversity relates to morphological, biological, ecological-physiological features and economically valuable signes.

The indicator of plant survival turned to be the same for all tested types of Kochia prostrata in ephemeral desert of clear grey soil of light loamy mechanical composition. In the south of Kirghizia the survival of plants at the end of the fourth year of growth - Kochia prostrata var. canescens, K.p. var. virescens was equal to 66.0-68.2%, K.p. var. villosissima from Volgograd, K.p. var. virescens from Achikular - 29.9 - 36.4% and K.p. var. virescens from Stavropol - only 2.8%. Tested ecotypes turned to be differentiated according to economical value symptoms, in particular according to the size of the formed feed yield which varied from

2.24 - 2.27 t/ha of dry fodder, ecotypes from the south of Kirghizia, to 0.6 - 0.7 t/ha of dry fodder, ecotyped from Munkum and Volgograd.

Wild types of feed plants, the product of natural selection, are extremely adaptable to extreme correlation of factors of abiotic environment, have their own ecological shelters in deserts and semi-deserts, are characterized by high tolerance to prolonged soil and air drought, soil salinity and other environment limiting factors. Wild population of feed plants are very stable to pasture. As a rule they are more resistant to sickness and pest compared with cultivated feed plants. These features and symptoms of natural flora types help a great deal in implementation of regional selection programmes in arid areas.

The negative fectures of wild feed plants as original species for selection are the following; unevenness of seed maturing, low field germination, crestafalling, seed pollution (mechanical sowing becomes more difficult), rapid fall in seed germination (during the first year of storage), insufficient leaves coverage. Some types and forms of feed plants are thorny, contain much salt, volatile, oils, alkaloids e.t.c.

In spite of these drawbacks, the main task at the present stage of selection effort consists in identifying wild types of feed plants, which are promising for selection. At the same time, identification and study of promising types, variety of their species, changeability, economic features e.t.c. can not be made by one researcher or even organization. Comprehensive cooperation of all interested institutions is called for in this undertaking.

From the point of view of collecting original material for introduction into selection work the priority importance acquires variation centres similar in its ecological conditions with the region for which the collected material is destined. Mountain and foothill regions are noteworthy in this respect which are gathering grounds for types and forms of feed plants with valuable economically useful characteristics and ecologo-biological features. The questions of seed reproduction play an important role in organizing an introductory selection work with feed plants.

The need of rational organization in seed-growing for feed plants has set up a task of studying the biology of fruit formation, seed fertility and elaboration of seed production technology. Research studies show that desert feed plants are growing very fast in cultivated agrotechnical areas, maturing, already during the first year are entering generation phase and bear abundant fruits. In cultivated conditions seed fertility of semi-shrubs is growing constantly during five-year period and of shrubs over the period of 12-50 years.

Seed harvest yield of Kochia prostrata of different ecotypes is about 80-160 kg/ha, of Salsola rigida - 120-150 kg/ha, of Aellenia ceratoidea - 120-300 kg/ha, of Camphorosmal lessingii - 30-60 kg/ha, of Eurotia ceratoides - 70-80 kg/ha, of Haloxylon aphyllum - 200-450 kg/ha, Atemisia diffusa - 10-15 kg/ha, Salsola paletzkiana - 400-500 kg/ha. At the same time desert feed plants sown in cultivated agrotechnical areas produce seeds of better quality and larger weight.

Identification of fruit bearing characteristics of desert feed plants under the conditions of cultivation opens great vista for organization of accelerated seed production in quantities that satisfy cattle-breeding farms. Different types and species of desert feed plants envisage specific physico-chemical characteristics of soil and ground, measure of their moistening.

Seed plots of pasture feed plants should be founded on the best lands with even relief that allow to use agricultural equipment with a high production rate. Plots formation is made on clear fallow lands. To prepare fallow land it should be ploughed during the period of the highest accumulation of soil moisture. The soil is ploughed to depth of 20-22 sm with simultaneous harrowing. After the rains the soil is ploughed again to the depth of 12-16 sm with simultaneous rolling it up which provides for the coverage and better preservation of moisture. The soil is subject to disking and cultivation in case pests show up on it. The second tilling of fallow land depends upon the fact, whether pests have shown up.

Timely sowing is very important to get germination of full value while forming seed plots of desert feed plants. In the USSR the best sowing dates are considered to be November-January. Good results are obtained when the sowing is done just before the snowing or while it is snowing. To get optimal density of standing plants it is necessary to be within the following norms of seed sowing: for Kochia prostrata - 4/5 kg/ha, Salsola orientalis - 6, Aellenia sudaphylla - 8, Artemisia diffusa - 0.5, Camphorosma lessingii - 6, Holoxylon aphyllum - 5 kg/ha, taking into account 100% of economic (sowing) seed fitness.

Seeds of desert feed plants are as a rule polluted with a touch of different stuff, including twigs, leaves, dry buds e.t.c. which adversely affects its pouring. It makes it impossible to use regular seeding-machines, which have to be significantly modified.

While creating seed plots of Kochia prostrata, Salsola rigida, Camphorosma lessingii and Artemisia diffusa inter-row width is made equal to 60 sm, Aellenia subafylla - 75 sm. Optimal depth of seed coverage for Haloxylon aphyllum, Kochia prostata, Camphorosma lessingii is about 0.5-1.0 sm, for Salsola orientalis - 1.0-1.5, Aellema subaphylla - 1.0-2.0, Artemisia diffusa - 0.5 sm. Coverage is done by rolling with disk-ring roller immediately after sowing or still better simultaneously with it. The dates of maturing and harvesting of seeds of desert feed plants depend to a large extent on natural conditions of their growing and annual state of metereology. The sign of seed ripening is in their becoming brown, good development of sprouts, their easy separation from the stem if the bush is shaken. Species under consideration mature in October-November. Harvesting is done by combines and manually when 70% of seeds have already become ripe. During separate harvesting, for example, of Kochia prostata and K.p. var. villosissima stems are mown by a harvester into rolls when 30% of seeds are ripe. After rolls have been dried up over the period of 4-5 days and seed have completely ripened, the final harvesting is done by combines. Separate harvesting allows to begin field tilling 4-5 days earlier than usually, sharply reduces seed losses (from 50% to 15%), improves their quality. Reserves of nutrition substance in the seeds of desert feed plants is rapidly evaporating. That is why it is expecially important to see to it that seeds are dried on time and properly. To make the drying process uniform and rapid collected seeds (pile) are spread in a layer of 5-10 sm and are being shoveled permanently. It is recommended to proceed with the drying using open asphalted ground and if weather conditions deny it, then it might be done under light, well ventilated shelters. Seeds sowing qualities should be in confirmity with the following parameters: moisture content at the storage and during transportation - not to exceed 12%, quality for seed-growing purposes, for creation of cultivated pastures and hay-mowing.

Table 1. Seed sowing qualities of desert feed plants

Plant	Germination not less % Class 1 - 2 - 3	Seeds of main species not less %
Aellenia subaphylla	50 - 40 - 30	60
Haloxylon aphyllum	70 - 60 - 50	75
H. persicum	80 - 70 - 60	60
Kochia prostrata var. canescens	70 - 60 - 50	40
K.p. var. villosissima	70 - 60 - 50	30
K.p. var. virescens	70 - 60 - 50	40
Salsola paletzkiana	45 - 35 - 25	65
S.richteri	35 - 30 - 20	65
S.rigida	70 - 60 - 50	50

Developing rangeland resources in African drylands

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Introduction

Arid and semiarid regions constitute more than 50 per cent of tropical Africa and support more than 35 per cent (116 million) of its population. The drylands (Figure 1) of tropical Africa extend over an area of 24 countries 1/*).

(a) largely desert countries with more than 66 per cent arid areas: Botswana, Cape Verde, Chad, Djibouti, Kenya, Mali, Mauritania, Niger, Somalia;

(b) counties with over 30 per cent arid and semi arid areas: Burkina Faso, Ethiopia, Gambia, Mozambique, Senegal, Sudan, Tanzania, Zambia, Zimbabwe; and

(c) countries with below 30 per cent arid and semi arid area: Angola, Benin, Cameroon, Madagascar, Nigeria, Uganda.

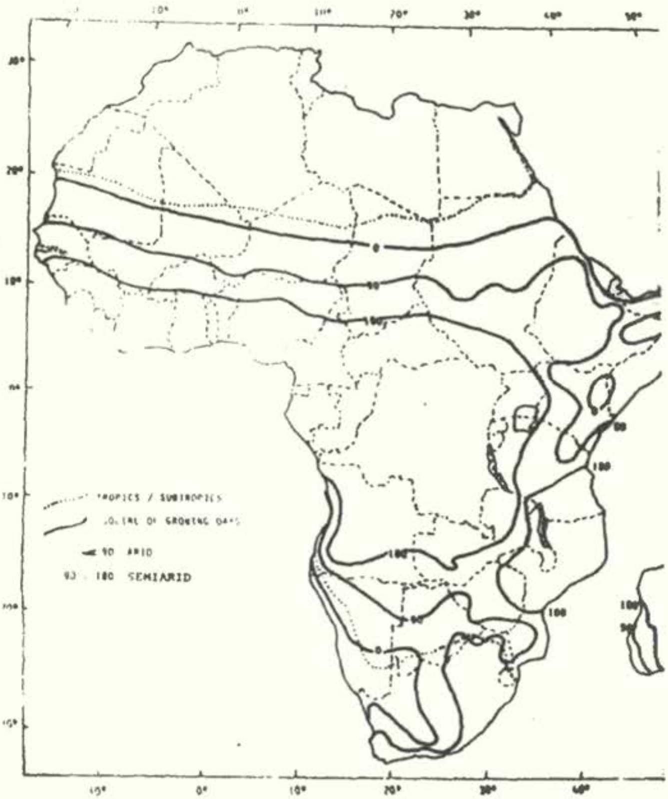
In arid lands, the dryland vegetation is a fundamental resource which transforms solar energy into food and which protects and stabilizes the surface of the ground. This vegetation survives by adapting to water deficit in ways which are important because they determine seasonal differences in the usefulness of dryland pastures.

Under natural conditions and through appropriate strategies the dryland ecosystems maintain a balanced exchange of water and energy. The equilibrium is readily disturbed when meagre vegetation is reduced by man's actions which expose the ground surface, humus will be mineralized and soil structure lost. Rain will fall directly on the soil and break it down. As the water budget deteriorates in the soil beneath, the level of groundwater in nearby wells may fall. The water lost to the soil store now contributes to over - rapid runoff. Where the surface has been loosened or disturbed, the top soil layer, with the best structure and the bulk of plant food, may be washed away,

*) See References

Fig. 1

Map: Drylands of Africa



Source: FAO (1978).

or blown away in dust storm. All these changes mean a more hostile environment for plants. Vegetation responds less well to rain, produces less biomass and many plants tend to die at an increasingly early stage of drought. Such changes are typical of desertification [2/].

Desertification is caused by overcultivation, overgrazing, deforestation and bad irrigation. Increased herd sizes and decreasing pasturelands lead to overgazing. New wells and improved veterinary services can mean more animals than rangelands can support. Woodlands are being cleared at the rate of four million hectares a year in the arid tropics [3/]. Such deforestation can cause water tables to fall, soils to erode and land to become dusty and arid. Tree planting - for fuel, for timber and to prevent desertification - is proceeding 50 times slower than the Sahel really needs. Expanding croplands are pushing herders onto ever more fragile land.

While traditional systems of Livestock management were generally well adjusted to local ecological conditions, now much rangeland has severely deteriorated. We know far less than we need to about the theory and data of a relevant human ecology to apply to rangeland management. A long histry of failed resources is part of a larger process by which local mechanisms to manage resources in good or bad years have been eroded by events beyond their control. However, one is for sure, developing of rangeland resources in African drylands must be done hand in hand in integrated manners with antidesertification measures.

Natural conditions

Tropical Africa, as defined by FAO (1978), lies between the northern and southern isolines of 18^{o}C as mean temperature in the coldest month. Table 1 shows climatic zonation of the tropical African drylands. Figure 2 shows rainfall zones in Africa.

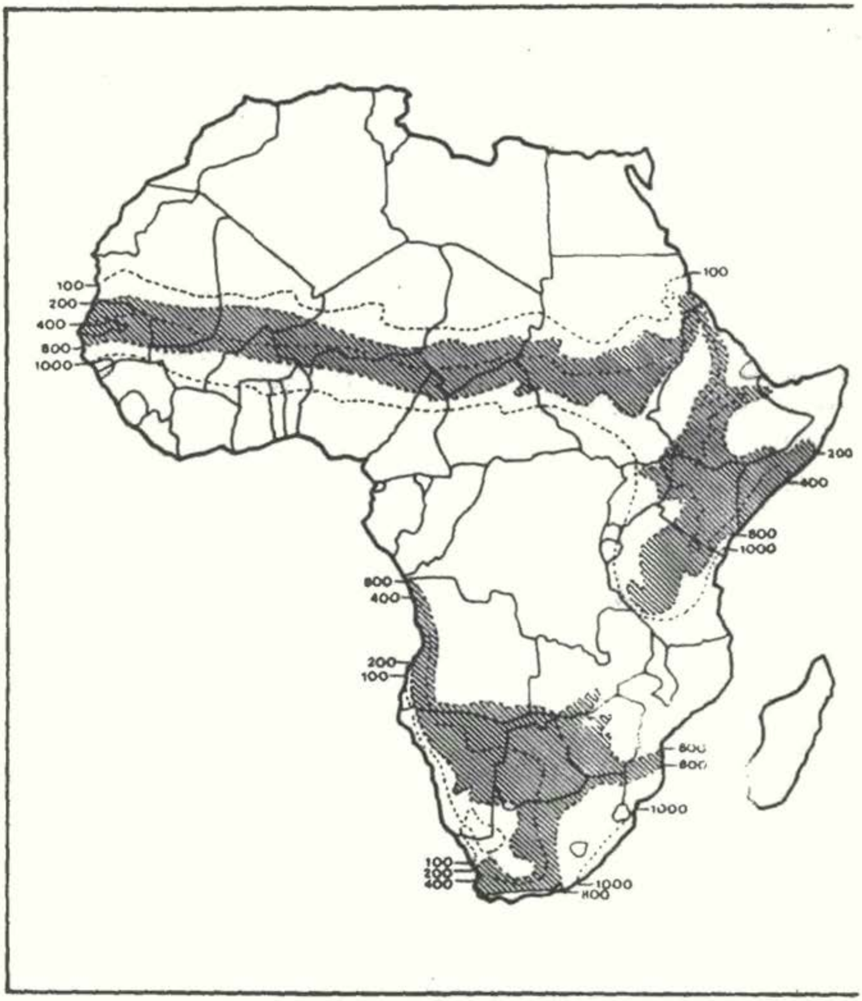


Figure 2. Africa rainfall: 200mm to 800mm rainfall zone (90 per cent isohyet probability)

Source: Adapted from Atlas for Afri[illegible] Editions Jeune Afrique, 1973

Table 1: Climatic zonation of the tropical African drylands

Zone designation Jahnke (1982)5/ FAO (1978)		Length of growing period FAO (1978)4/	Approx. mean annual rainfall (mm)a)	Approx. corresponding zone FAO (1976)	UNESCO (1977)
	I	0 days		Saharan b)	Hyperarid
			100 - 250 —	//////// ////////	/////////////
Arid	II	0 -74 days		Sahelo-Saharan b)	Arid
			350 - 600 —	///////////	/////////////
	III	75 - 89 days		Sahelian	
			500 - 800 --	/////////	
	IV	90 - 119 days	600 - 900 —	Sahelo-Sudanian	Semiarid
Semi arid	V	120-149 days	750 - 1000 —	//////	///////// /////////
	IV	150-149 days	800 - 1400 —	Sudanian /////////	Subhumid
				Sudano-Guinean	/////////

Source: Kotschi, J. (1986)

(a) Found by comparison of isolines.

(b) Saharan and Sahelo - Saheran zones overlap.

Soil fertility in arid and semi arid regions is determined primarily by water availability. Low nitrogen content is the next limiting factor for production, followed by phosphorus. Nutrient levels of potassium, calcium and magnesium are normally sufficient; pH is commonly neutral to slightly alkaline. Wind and water erosion are the most common problems.

Water conservation measures are of primary importance. Apart from large alluvial valleys (Niger River) water is generally scarce. In most cases, surface water is available only during and shortly after the rainy season, which last from zero to six months. Reduced annual rainfall during the last two decades, increased surface run-off on degraded lands and greater demands for water have led to a situation in which water use exceeds water intake rates. The ground water levels have dropped. In some areas natural vegetation is dying because root systems no longer reach ground water tables, and boreholes supplying drinking water for humans and animals must be continually deepened.

The natural vegetation is characterised by tree-shrub-grass savannas woodlands and sparse forests. The savannas range from grassland plains with a few scattered trees, through shrub and open woodlands, to dense and complex systems of trees, bushes and grasses. In many areas, the savanna merges into a true forest in which there are several levels of trees, oftern described as broad-leaved woodland or wooded grassland. With increasing aridity, the density of trees decreases and thorny, xerophile and drought - resistant species gain in importance. Most of these are slow-growing, and many are difficult to regenerate.

Human influence has fundamentally changed the natural vegetation. People have selected and maintained trees for many purposes: browse, firewood, charcoal, construction wood, etc. Increasing human and animal population have led to drastic reduction of natural vegetation and, in places, to complete devestation. The slow growth of indigenous species and the problems of revegetation make rehabilitation difficult.

Large areas of savanna woodland and dry tropical forest are being cleared every day to make way for cash crops. Domestic grazing animals can also destroy woodland. It is even more difficult to keep track of the destruction of trees outside the forests than in them. Yet the loss of such trees, rarely recorded in forestry statistics, may be more important to rangeland ecology than loss of forests. Growing stock and deforestation rates by country are given in Table 2.

The Sahel is a region of steppes with thorny species. The term "steppe" is applied here to "open grass vegetation, sometimes mixed with woody species, and generally not subject to fires. There are widely spaced perennial grasses, usually not reaching 80 cm. Annuals are often abundant" 8/. Thus the steppe is a vegetation consisting essentially of small, annual herbs (mainly grasses), interspersed with some perennial grasses and woody species. The cover of herbaceous stratum is small, the formation is open. The steppe exists in several forms: with trees and/or bushes, and with herbs and/or grasses only.

The spatial distribution of the vegetation is, however, extremely heterogenous; heterogeneity being associated with the topography, type of soil and the distribution of water. Both the sand dunes, with good infiltration but low water holding capacity, and the slopes - where run off is considerable - have an open vegetation. The ligneous stratum is less developed, while the herbaceous stratum on sand can be considerable. The herb layer consists mainly of annual grasses. The woody species sometimes form dense populations in the depressions; here the importance of the herb layer is inversely proportional to the development of woody plants, and perennial grasses are present.

The Sahel is crossed by great rivers, notably the Niger and the Senegal. In the rainy season, these rivers overflow and large areas are flooded. In these flood zone, aquatic rangelands develop. Southwards, in the Sudano-Sahelian and Sudanese zones, savanna replaces the steppe.

Table 2. Growing stock and deforestation rates by country

Country	Volume of forests and savannas mill. m³	Annual deforestation rate 1981-85		
		Total deforestation (1000 ha*)¹	Savannas % of savanna area	Forests % of forests area
A. Largely desert countries (over 66% of area arid)				
Botswana	229	30	0.1	n.a
Cape Verde	n.a	n.a	n.a	n.a
Chad	213-*)²	80-*)²	0.6	0.0
Djibouti	n.a	n.a	n.a	n.a
Kenya	116	39	1.6	1.7
Mali	102	40	0.5	n.a
Mauritania	n.a	n.a	n.a	n.a
Namibia	214	50	0.2	n.a
Niger	34	60	2.1	n.a
Somalia	156	13	0.1	0.2
B. Countries with over 30% of area in arid and semiarid zones				
Burkina Faso	85	60	0.8	n.a
Ethiopia	752	88-*²	0.4	0.2
Gambia	7	5	2.0	3.4
Mozambique	133	120	0.8	1.1
Senegal	145	49	0.5	n.a
Sudan	997	504	1.1	0.6
Tanzania	693	130	0.3	0.7
Zambia	629	70	0.1	1.3
Zimbabwe	222	70	0.4	n.a
C. Countries with below 30% of area in arid and semiarid zones				
Angola	1091	94	0.1	1.5
Benin	60	66	1.7	2.6
Cameroon	4861	100	0.3	0.4
Madagascar	1104	156	0.2	1.5
Nigeria	958	400	1.1	5.0
Uganda	165	50	0.8	1.3

Sources: FAO/UNEP (1982)[6] FAO (1984),[7] J. Kotschi (1986)
*)¹ Mean gross volume over bark
*)² J. Kotschi at all calculation
n.a. ....not available
Remark: The given wood volumes exclude shrubs and woody fallows.

Bush fires are most common in areas with a homogeneous biomass greater than 1 t .ha^{-1}. This explains why they hardly occur north of the 300 - 400 mm isohyet. South of the 700mm isohyet, the vegetation burns every year 8/. Bush fires influence the dynamics of the rangelands in two ways: directly, via the seed balance and indirectly, via the burning of the biomass.

The drought exarcerbate situation in African drylands. The 1968 - 73 Sahel drought killed between 50,000 and 250,000 people and some 3.5 million head cattle 3/. However, prolonged droughts are a "normal phenemenon" in the Sahel. Drought is a relative concept implying rainfall insufficient to support human and animal population. Drought has revealed, not caused, ecological imbalance, environmental degradation and mismanagement.

Production of rangelands

The production of rangelands is often expressed in the number of cattle, sheep, and goats per hecatre, or in kg of meat and milk per animal. Although this production (secondary production) is the ultimate goal, we must accept that plant production (primary production) is the basis for this secondary production 8/.

Primary production can be natural vegetation, cultivated forage or agricultural by-products. The quantity and quality of primary production determines secondary production. Likewise, secondary production influences primary production. Here we will merely mention overgrazing, deforestation bush fires and drought as factors which influence this primary production.

Primary production, in turn, depends on environment, although man can intervene by irrigating, fertilizing, reseeding, tree planting, etc. Climatic factors (rainfall, temperature, humidity radiation, evaporation, photoperiod) and edaphic ones (topography, physical and chemical characteristic of the soil, depth of the soil) determine the quantity and quality of forage.

Man has modified the primary production of African rangeland by agricultural and pastoral expansion, deforestation, fire and new settlements.

In may instances this has reduced biological diversity and productivity and caused serious breakdowns in essential ecological processes. We have to find ways out from present situation in order to develop rangeland resources on sustainable base both primary and secondary production.

<u>Investments in the rangeland of Africa and achievements</u>

In the last 15 years the equivant of 600 million US dollars in international development funds has been invested in the rangeland of Africa in an attempt to develop a strategy of resources exploitation that would be as efficient as traditional pastoralism but that would have a chance of coping adequately with the greatly changed conditions of late twentieth century African life 9/. There is, however, very little to show for that investment. Several reasons have been put forward for the failure of livestock and rangelands projects:

(a) Domestic livestock systems have undoubtedly been introduced into some areas which are ecologically unsuited to that from of land use;

(b) it has been difficult to design projects to the required geographic scope; pastoralists are highly mobile and their cultures and economics often transcend more than one political boundary;

(c) pastoralist systems and rangeland ecologies are unsufficiently respected to provide a basis for planning;

(d) projects intended to improve pastoralist conditions have frequently been poorly designed and executed; there are numerous examples where development and charitable institutions have attempted to assist rangeland peoples without adequately assessing or understanding the total system these people live and work within;

(e) projects have been imposed without an understanding of pastoralist societies, and imposed to achieve objectives which have little to do with the objectives of those societies 10/.

Inspite above facts, however, few efforts have been made to improve arid and semi arid rangelands in Africa.

Ways and means of developing rangeland resources and their problems

While there is no single fix or package for livestock and rangeland management, and little prospect of dramatic improvement, there are nevertheless a number of promising improvements and techniques which could provide benefits, particularly if used in combination. These include controlled extension of water points and any other forms of of water development, livestock population and, carrying capacity, pastoral grazing strategies, sedentarization, planting of multipurpose fodder trees and shrubs, afforestation, agroforestry, establishment of plantations, natural forest management, sand dune fixation, reseeding of range, soil conservation, antidesertification measures, energy, improving veterinary care, improving livestock marketing facilities, education, training, research, disaster prevention etc.

Controlled extension of water points

Much efforts has been put into trying to improve the infrastructure of pastoralism by the sinking of new wells, mainly in the Sahelian region of Senegal, Mauritania and Mali. The phonomenal growth in the number of watering points has concentrated herds in limited areas and causes desertification through grazing, browsing and tramping. Watering points tend to be over-used and often contribute more to degradation than to the opening of new ranges. Wells also tend to break down. In northeast Kenya only 14 to 54 boreholes drilled since 1969 were working in 1979. In Botswana 40 per cent of boreholes never function. In Tanzania most of the former permanent water supplies were either broken down, clogged up or in need of spare parts 10/.

However, in Botswana, water development increased available grazing area by 2.5 times, and in Somalia appears to have been technically successful and without negative ecological impacts, although limitations of access have increased inequalities between pastoralists 11/.

Evidence suggests that water development without careful planning, donor coordination and control over water use has considerably aggravated to severity of droughts. Today it is generally agreed that water development can play an important role in development of livestock production, but that it must be seen in the context of resource management as a whole if negative effects are to be avoided. In future, water development will continue to be an important means of opening up grazing areas which are presently under utilized or not used at all. For example, Mauritania has 55 million hectares usable rangelands, but only 39 million are used, largely because of water shortage 10/. However, capacity of wells or dams should be limited so that the number of animals which can be watered is not so great as to cause widespread overgrazing. The ideal situation with regard to water development in the Rendile area (Kenya) would be to have a watering point on every 25 km^2 12/. Not motor pumps but rather manuals or animal driving pumps should be used to draw water.

Livestock population and carrying capacity

Relative to area and human population, a higher percentage of total livestock population is found in arid and semiarid drylands of Africa than in other dry tropical areas, e.g. in South Africa and Australia. Table 3 shows that the drylands of Africa has a high stock density (6,4 TLU/km^2)*). The semiarid zone has the highest density of livestock and agriculturally active people of ecological zone in Africa apart from the highlands 5/.

Carrying capacity may be defined as the upper rate of stocking that can be supported on sustainable basis without damage to the habitat. With increased numbers of people and livestock, large parts of arid and semi-arid have been severely overgrazed, leading to gross modification of the natural vegetation and serious soil erosion. The productivity and therefore the

*) TLU ... Tropical Livestock Unit.

Table 3. Human and livestock population in African drylands

Zone	Arid	Semiarid	Drylands
Surface area (mill. km^2)	8.3	4.1	12.4
Agricultural population (million people)	24.8	65.7	90.5
Livestock population (mill. head) Cattle	31.5	45.5	77.0
Sheep	37.0	23.0	60.0
Goats	48.3	33.2	81.5
Camels	11.1	-	11.1
Total TLU*)[1]	41.7	37.4	79.1
People /km^2	3.0	16.0	7.3
TLU/km^2	5.0	9.1	6.4
TLU/Person	1.7	0.6	0.9

Source: Jahnke (1982), adapted.

*)[1] TLU ...Tropical livestock Unit: 1 camel = 1 TLU,
1 cattle = 0.7 TLU, 1 sheep/goat = 0.1 TLU.

carrying capacity of the African dryland range resources has declined. This is true of trees and bushes, both browse resources. It is also true of grazing resources, which are affected by a probable change in species composition of annual grasses. Moreover, carrying capacity depends not only on the plants but also on the water available to livestock. The carrying capacity also varies with local variations in average annual rainfall, seasonal distribution of rainfall, soils and inputs of energy and nutiriemts

What numbers of people and domestic animals can be sustained in dryland rangelands without destroying it? Estimating the sustainable carrying capacity of rangeland is fundamental to any long term effort to help the environment to recover. Moreover, it is difficult and often a completely academic exercise. FAO finds excess current population in terms of food [13/]. The World Bank study finds enough land to support a much larger population until the end of the century, with regional variations. [14/]. Both studies as above assume a continued low input for this case; both predict much higher carrying capacities with increased inputs, by which is meant more capital-intensive methods.

Many pastoralists are good stockmen but poor pasture managers. Few will notice or be able to take heed of the deterioration of food plants or the time lag between disappearance of food plants and their effects on stock numbers. Often stock losses are heaviest in dry years, when they are blamed on poor rainfall rather than on range deterioration. Recovery in such areas may appear rapid with good rains but this often misleading. Where there has been a loss of species or change in the structure of plant communities, recovery of vegetation will depend on plant succession and may take decades. Where top soil has been lost, the recovery will take substantially longer.

Demografic regulation would be effective in the medium and long term. Control of pasture use is particularly important in determining to sustainability of land use. In Sahel, access to pasture and browse, to form land and crop residues, and rights to water, salt licks, access to trees, and wild food plants are regulated by traditional mechanisms in the pastoral economies. Seasonal and annual variations in plant growth make collective use of pastures inevitable.

Calculations of carrying capacity should be treated with caution, particularly if the methodology is not stated. Instead of an overall figure, a production system approach indicating specific forage limitations would be more appropriate for estimates of carrying capacity 1/.

Pastoral grazing strategies

Pastoral grazing strategies involve herding as a means of animal control. A common strategy in mobile pastoral systems is herding splitting, e.g. milking animals are kept close to the homestead and the dry herd is taken on transhumance. In arid areas, splitting between species is also practised: the milking camel herd is kept close to the camp, the small reminents some distance away, and the dry camel herd still further away, so that different grazing areas are used for different production purposes.

The patchy and unreliable rainfall in arid areas demands high mobility of herds, and the more arid the area the more opportunistic land use must be to achieve any livestock production 11/. Transhumant cattle moving from wetter to drier areas, where raisers commence latter, have an advantage in being able to graze relatively young grass with high nutriative value than mature grass for a longer period than can sedentary cattle.

The effects of long - distance movements on animal production are often regarded as negative. However, if drowing is done carefully, animals can even gain weight en route 15/. Movement is more likely to disadvantage the people, especially for its access to health care, schooling and other social amenities. The hardship of movement on the pastoralists themselves is one reason why some decide to settle.

Sedentarization

The essential adaptive strategy of pastoral societies is movement. The policy of most countries is to settle the pastoralists in order to provide them with services such as education, health and veterinary services, and to better intergrate the pastoralists into the marketing system.

Development services to pastoral societies should, as much as possible, be based on training local members of a community in the fields needed, such as those mentioned above and providing them with all the infrastructures of services. Undoubtedly, of course, this trend heightentens the need for range monitoring and control in zones surrounding settlements, trading centres and waterpoints.

Since 1976, UNESCO and UNEP have been carrying out a programme in a 22,500 km^2 area of northern Kenya traditionally grazed by four groups of nomadic pastoralists. This Integrated Project in Arid Lands (IPAL) is an interdisciplinary research project to determine the process leading to desertification and to find solutions.

The project appeared to combine both the modern and the traditional. It included permanent settlements, as well as food aid and veterinary and well-digging services. The project found that desertification accompanied settlements around wells, shops, schools and famine relief centres, and has been exacerbated by a reduction in available grazing areas.

IPAL - KALRES (Kenya Arid Lands Research Station) has over the years produced an impressive quantity of published documentation, containing much valuable scientific information, including ecological studies, the composition and density of woodlands and shrublands, and monitoring trends in tree populations, human consumption of wood and browse production and consumption. The long term objectives are to develop a system of land use which will reserve the present trend towards rangeland degradation and to establish production at a level sufficient to provide for the needs of the growing and increasing sedentarized population. However, the mobility and dispersion of livestock can again be increased considerably, and overall numbers of livestock can be better controlled through a greatly improved marketing system [16/].

Resettlement and training in non-pastural occupations can reduce pressure on pastural land. Success in resettlement of pastoralists has been reported from Somalia, where some were trained as fisherman [17/]. Hogg suggests that, rather than resettling destitute pastoralists, after drought or similar disaster it may be economically more rational to help them to restock, at least in areas where widespread overgrazing is not an immediate problem [18/].

Planting trees and shrubs

Trees and shrubs serve a wide range of protective and productive functions. They have the potential to improve the supply of energy, raw materials and food and to improve sustained management of the environment and to promote socio-economic development. They not only control erosion, they improve water use and microclimate, and increase soil fertiflity. Tree planting can contribute substantially to control of desertification.

Few afforestation efforts have been made to improve arid/semiarid rangelands in Africa. Most of the present forestry programmes were launched in response to the 1969 - 1973 drought. Since 1975, commitments have been growing rapidly especially in the CILSS (Comité Permanent Inter-Etats de Lutte Contre la Sécheresse Dans le Sahel). The main efforts are concentrated in West Africa, followed by East Africa.

In the early years, forestry activities were aimed primarily at meeting domestic energy demand, e.g. fuelwood and charcoal. A slight change in approach can be observed within the last 3-4 years. FAO and some other organizations have tried to encourage the greater use of trees and shrubs for livestock fodder. Trees of the Prosopis genus and Acacia genus are highly resistant. The Prosopis genus bear pods which are up to 14 per cent protein and 45 - 55 per cent carbohydrate [3/]. The foliage of Prosopis juliflora and P. cineraria are lopped for fodder every winter in the arid and semiarid zones of India.

Acacia albida is also valuable fodder and often is the only remaining bit of greenery in the dry seasons. This leguminous, nitrogen-fixing trees has a deep taproot system that enables it to tap lower sources of water and nutrients inaccessible to agricultural plants. The leaf litter of the tree contribute nitrogen, other nutrients and much-needed organic matter to the soil. The wood is used for local construction and as a fuel. The thorny branches serves as fencing material.

Acacia albida is leafless during the agricultural season and therefore does not compete with crops for light. Crop yields under and around Acacia albida have been found to be equivalent to those in fertilized fields. Therefore, Acacia albida has been given high priority in agroforestry projects in suitable parts of the Sahel [19/]. The idea of agroforestry is to grow field crops/pastures with shrubs and trees intermixed in spatial and chronical combinations of the different vegetation components in such a way that there is a little competition as possible between them; instead their various requirements should be complementary. By this means, optimum productivity per unit area could be achieved. However, little technical knowledge exists yet about agroforestal practices on the extension levels.

Many tree and shrub species have already proved useful for forestry activities within Africa dry lands. Exotic tree species have been so favoured including Eucalyptus comaldulensis Azadirachta indica, Prosopis juliflora, Albizia lebbeck, Casuarina equisetifolia, Parkinsonia aculeata, Cassia siamea and others. The indigenous African species have been largely ignored inspite that it is very well known that they are fully adapted to the local conditions, are highly resistant to drought and serve a great variety of functions. Among those successfully planted are: Acacia senegal, A. albida and Khaya senegalensis.

In many cases, it would probably be preferable to plant shrubs rather than trees. Shrubs appear to have been largely neglected, yet, they could represent a valuable contribution of forestry to improved land use.

Based on even the more conservative projections of future population growth and food requirements, it is safe to say that the ability to prevent sand-blowing and even sand dune fixation and afforestation - will demand increased attention in the economic planning within the African drylands. Sand dune fixation is designed to present the movement of sand long enough to enable either natural or planted vegetation to become established. The technique of dune fixation is, therefore, based on the principle of reducing the threshold velocity of wind at the dune surface by establishing a pre-planting mechanical system.

In view of the actual process of desertification, particularly in the Sahelian region, and the need for expanding sand dune fixation activities, a new classification based on dynamic criteria is proposed [20/].

Good results with sand dune fixation were obtained in Senegal, Morocco, Mauritania, Mali, Somalia and Tunisia. Of all the forest species, the hardest and the most adaptable in the arid and Saharan regions is Tamarix aphylla. The next hardest, as far as the south of Tunisa is concerned are Calligonum, Acacia ligulata, Parkinsonia acculeata and the self-sown bushy species such as Nitraria retusa, Aristida pungens, Retama retam, and Lycium arabicum [21/].

Given the tremendeous fuelwood needs within the rangeland regions and the fact that national forestry departments are not able to match by present afforestation needs, the only long term answer seems social forestry, e.g. mobilizing the support and active participation of local people to plant and protect trees. Social forestry in African drylands is still at very modest level compared with Asia, notable in India and China. The most popular afforestation measures is the "green belt" a shelterbelt of hard, drought resistant trees which protects the settlement from sandstorms and encroaching sand dunes, and which can be harvested for fuelwood, fodder and poles. Such green belts of 500 hectare were established around Ouagadougou, capital of Upper Volta and 300 hectare green belt around Niamey, capital of Niger.

Fuel-saving cook stoves aim at reducing fuelwood consumption by replacing the traditional three-stone fire. Energy savings in the range of 30-40 per cent can be achieved [1/]. Many stove programmes has been quite successfull.

Reseeding of range

Determining whether a range can be restored by natural means or will require artificial seeding is a matter of judgement. However, the decision should be based on the kinds and amounts of plants remaining, the expected rate of naural recovery and the cost of alternative approaches, the climate, the supplementary treatments that may be used to accelerate natural restoration, stable soil conditions, and whether the site is adapted to prevent artificial seeding techniques[12/].

Reseeding of range with indigenous grass species has been attempted in many parts of Africa. However, in view of the high cost and low animal production yields per unit area reseeding is not likely to be economically viable. [1/]. Furthermore reseeded areas must be protected.

Education, training and research

People's knowledge should be the sharting point of rigorious scientific enquiries. This call for two-way channel of communication between scientist and local people in which both sides gain a better knowledge of animal husbandry practices and farming.

It is important that scientific and technological advances be communicated in a way which facilitates their adoption where they are seen to be both socially and economically benefial and ecologically sound.

Some of the recommendations to be proposed for acceptance will be quite new to local nomadic populations. To convince them that the recommendations made are workable and desirable, demonstrations are necessary. Two types of demonstrations should be expoited: active participatory demonstration and non-active participatory demonstration.

Suitable topics for the training included: afforestation programmes, construction of water points, soil rehabilitation, energy savings, the use of veterinary drugs, livestock breeding, antidesertification measures and health care.

Conclusions

Rangeland rehabilitation is a highly-specific process and must be based on a large number of community based ecodevelopment projects of manageable size. Many different action are necessary to solve the problem of environmental degradation in drought-affected regions of Africa. These are needed at all levels, from local to international, and from an enormous spectrum of individuals and organisations.

Environmental rehabilitation cannot be a purely technical process. African societies cannot resurret the past, nor can they be expected to adopt an environmental philosophy shaped largely by the concerns of western society. To achieve the balance between productivity, ecological sustainability and equity, African societies need to develop an ethic with corresponding attitudes and behaviour that reflect an appreciation of the harmony expected from ecodevelopment. Local people must be fully involved in the necessary and slow - search for and definition of a new ethical and behavioured attitude.

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LESSONS FROM COMBATING DESERTIFICATION OF RANGELANDS IN THE ESCAP REGION

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I. INTRODUCTION

The Plan of Action to Combat Desertification (PACD) formulated by the UN Conference on Desertification (UNCOD) and subsequently endorsed by the UN General Assembly contains the following definition of desertification: "the diminution or destruction of the biological potential of the land (which) can lead ultimately to desert-like conditions. It is an aspect of the widespread deterioration of ecosystems, and has diminished or destroyed the biological potential, i.e. plant and animal production, for multiple use purposes at a time when increased productivity is needed to support growing populations in quest of development" (United Nations, 1978).

Dregne (1983) has identified the following over lapping stages in the desertification of rangelands:

- replacement of perennial grasses by annuals and forbs;
- increase in the density of woody shrubs and trees;
- absolute decrease in plant cover of all types and exposure of the soil surface;
- soil crusting due to trampling by livestock;
- accelerated soil erosion by water and/or wind.

For Dregne, moderate desertification of rangelands involves partial deterioration in the pasture assemblage and incipient erosion, equivalent to fair range condition on the US scale.

Severe desertification is evidenced in the dominance of the pasture by forbs and woody shrubs, by significant reduction in plant cover, by significant soil losses through sheet and gully erosion or by deflation in areas subject to wind erosion, with drifting of sandy soils and growth of sand hummocks and small dunes. It equates with poor range condition on the US scale.

Very severe desertification is marked by large areas of barren land with erosion gullies or dunes, representing the extreme condition popularly thought of as desertification. It represents a virtually complete loss of economic productivity and a degree of deterioration at which reclamation becomes prohibitively expensive and where significant natural recovery may take many decades or even centuries. It equates with very poor range condition on the US scale.

On the basis of estimates made for UNCOD, Dregne (1983) estimated that of the 3750 million ha of rangeland in the arid and semi-arid zones, 82 per cent or 3072 million ha were at least moderately desertified. Degradation of rangelands is by far the most widespread form of desertification therefore, accounting for more than 90 per cent of the area affected by it. Rural populations dependent on pastoralism likely to have been seriously disadvantaged economically through desertification, with their livelihoods put at risk, were put at 17.5 millions, more than one third of whom were resident in Asia and the Pacific region.

The main causes of desertification in rangelands were listed at UNCOD as overgrazing, cutting of trees and shrubs for fuelwood and construction, unmanaged firing, and soil compaction linked with all the foregoing (UNCOD Secretariat, 1977).

Recommendations of the PACD directly related to combating desertification in the world's rangelands included:

- surveying and monitoring rangeland condition;
- assessment of productivity of range types, determination of the impact of grazing on them, and their requirements for regeneration;
- instituting measures to assist regeneration, including temporary exclosure, seeding or planting pasture plants and trees for shelter, fuelwood etc., physical and chemical treatment of denuded soils, water and soil conservation;
- developing improved grazing strategies, including determination of carrying capacities and stocking rates of range types for appropriate livestock management

systems, provision of watering points and fences, development of silvipastoralism and fire management;

- improving livestock management through selection and breeding and control of diseases;
- strengthening extension services in support of improved range and livestock management, supplemented by demonstration plots and projects;
- strategies to combat drought, including forage and grazing reserves, supplementary irrigation or water harvesting, provisions for moving stock from affected areas;
- measures to combat other climatic extremes, including shelters and wind breaks;
- strengthening the economic basis of the pastoral industry through improved marketing and transport facilities, and price support schemes and through integration with adjacent livelihood systems;
- measures to decrease pressure on rangelands such as promoting alternative livelihoods and improving land tenure;
- provision of health, social services, housing etc., compatible with dispersed and mobile populations.

The general objectives of such measures were to reverse the environmental processes of desertification, to establish ecologically appropriate and sustainable land use, and to improve the quality of life of people affected by desertification.

II. ASSESSMENT OF PROGRESS WITH THE IMPLEMENTATION OF THE PLAN OF ACTION TO COMBAT DESERTIFICATION

The PACD called for an assessment of progress with its implementation seven years after its inception in 1977. This General Assessment of Progress (GAP) was reported on by the Executive Director of the United Nations Environment Programme (UNEP), as the UN body entrusted with the co-ordination of activities under the Plan, to the Twelfth Session of his Governing Council in May 1984. The documents upon which the GAP was based included:

- a further global assessment of the status and trends of desertification;
- a review of actions under the PACD;
- a review of institutional and financial measures in support of the PACD.

A broad summary of these findings was published in Environmental Conservation, Vol. 11, 1/2, 1984.

This paper draws particularly on the first and second of the above sources, and also on an unpublished document "Assessment of the Implementation of the Plan of Action to Combat Desertification in the Asian and Pacific Region", prepared for the ESCAP Secretariat in support of an intergovernmental Meeting on the establishment of a regional network of research and training centres for desertification control (Mabbutt, 1986).

The CAP found that progress in combating desertification since 1977 had generally been disappointing in most countries little had been achieved in assessing and monitoring desertification and in drawing up co-ordinated action plans, or even in establishing the requisite machinery - all designated as priority areas for initial actions under the PACD. One consequence of this was a lack of detailed information on desertification status and trend, and it was necessary to rely for the most part on broad regional assessments. Among the actions undertaken relevant to desertification control, there appeared to have been greater emphasis on investment in general infrastructural development - such as road construction, for example - than on field projects to counter the processes of environmental degradation. With notable exceptions, the course of desertification appeared to have gone unchecked, particularly in the developing countries. The GAP also revealed that desertification was by no means confined to arid and semi-arid lands but was particularly serious in the subhumid tropics, with the result that the population at risk was considerably larger than in the 1977 estimates. In terms of area affected the rangelands posed the main desertification problem, and in most areas, including much of Asia, the trends remained negative.

III DESERTIFICATION IN RANGELANDS OF THE ASIAN AND PACIFIC REGION

a. Regional variety of pastoralism

Attention is drawn to the great extent of the region - an area of more than 30 million sq/km in 39 countries, with more than 20 million sq/km in the arid, semi-arid and subhumid zones. Livestock-based systems of land use include extensive shepterded open rangeland in lowland and upland deserts, including nomadic and transhumant systems, subject in some areas to state direction but still largely under traditional use, fenced commercial rangelands under private lease with year-round set stocking, grazing of village commons, woodlands and wastelands as an adjunct to rainfed cropping, grazing systems supported by forage production from irrigated agriculture, and animals kept by farmers practising swidden farming in tropical uplands. Each of these systems is threatened to some degree by desertification.

This variety of pastoral use reflects a wide range of environments in the drylands of the region. In the north and west, arid and hyperarid climates characteristic of much of Western Asia are extended eastwards through Central Asia by the barrier of the Himalayan and Tibetan ranges across the rain-bearing airstreams. To the south of this barrier, tropical monsoonal climates prevail in which a dry trade wind circulation is interrupted by the rain-bringing southwest monsoon of South Asia in June-October and by the northwest monsoon of northern Australia in December-March. These rains become lighter towards the continental interiors, as in Rajasthan and central Australia. Rangelands north of the mountain barrier experience severe climates with extreme winter and summer temperatures, a meagre precipitation mainly in the cold half of the year and including snowfalls, and strong winds in the transition seasons. In the far south of the region, the rangelands of southern Australia have rain in their temperate winters but also receive occasional drenching summer rains.

Socio-economic contrasts in the region are no less striking. It contains some of the world's least-developed economies, many developing countries, including the very large economies of India and China, and developed economies as in Australia. With more than 2.5 billion inhabitants this is the world's most populous major region. Populations are considerable even in parts of the drylands; for example in the Rajasthan Desert, where population density averages more than 50 per sq kilometre. In comparison, the drylands of Australia seem devoid of human settlement. The bulk of this large and rapidly increasing regional population remains rural and dependent on the land, with resulting intense and growing pressure on natural resources.

b. History of pastoral land use and desertification

In southwest Iran, the Iranian Plateau, the Indus valley and China the region includes areas with the longest histories of pastoralism in the world, as indeed also of tillage and irrigation. In such areas ecosystems were transformed and the processes now recognized as desertification set in many millenia ago; their progress has fluctuated through history, particularly with varying political and economic stability, but in the past the traditional systems generally maintained a degree of environmental stability or at worst of only slow deterioration, perhaps of periodic degradation and slow recovery. Since the beginning of this century however, and particularly since the mid-century, traditional pastoral economies have been increasingly disrupted or displaced by a number of developments, including population growth and rise in livestock numbers, growing urban markets for meat, technological changes such as the advent of motor transport, rising consumption levels with social and economic advancement, and the encroachment of mechanized cropping on the better grazing lands. These changes have resulted in localized overgrazing and an accelerating removal of woody vegetation for fuelwood and construction. At the same time, traditional migrations of pastoral nomads have been hindered in many areas by political restrictions on movement, by their own desire to benefit from education and social services, by government policies favouring sedentarisation, and by a response to economic opportunity offered by employment in cities or industrial and mining centres at home and abroad.

A comparable acceleration of desertification has occurred in areas where grazing of livestock forms an adjunct to rainfed cropping, as in Rajasthan. The main underlying factor here has been a doubling of population over the past 30 years, to more than 20 millions - a rate of increase greater than in India as a whole. Over the same period there has been a radical increase in livestock numbers, to a total of 24 millions in 1984. Yet the area available to grazing has diminished with the extension and intensification of cropping, particularly the loss of fallow lands. In most areas the impact of grazing has been compounded by the gathering of wood for fuel, and no more than 5 per cent of Rajasthan is now wooded. The consequences of overgrazing have included a decrease in palatable perennial pasture species, denudation and wind-drifting of sandy soils and mobilisation of formerly fixed dunes. There has been relatively little development of alternative sources of livelihood, leaving 80 per cent of the population dependent on the land. The benefits of large-scale irrigation through the extension of the Rajasthan Canal are restricted to the northwest corner and offer little relief to the general problem.

The Australian rangelands typify the shorter history of desertification characteristic of lands opened up in response to growing markets of the industrializing world of the mid-Nineteenth Century. Different parts were occupied at different times, generally in response to good seasonal rains and rising world prices for wool or meat. Each of the main pastoral districts shows an early exploitive phase in response to unwarranted expectations from pasture lands about which little was known, to the misapplication of imported technologies, to inappropriate land holdings, and to a lack of the infrastructure, such as fences, watering points and transport, necessary to combat the vagaries of rainfall. This inevitably led to rapid desertification in the first years of occupation.

c. Status and trend of desertification in rangelands of the ESCAP region

The status and trend of desertification in rangelands of the ESCAP region as estimated in the GAP and subsequent assessments (Mabbutt, 1986) are as follows (areas in millions of ha):

Subregion	Extent of Rangeland	Area Desertified	Percentage Desertified	Trend
South Asia	240	225	94	Deteriorating
China & Mongolia	335	250	75	Improving
Australia	375*	130	35	Stable overall
USSR in Asia	322	250	77	Improving
Combined	1 347	875	65	

* Area presently grazed of a potential rangeland area of almost 600 million ha

These figures do not take account smaller areas in South-East Asia, for example northeast Thailand, where livestock grazing have contributed to desertification associated generally with upland cultivation. The figures for "area desertified" should be interpreted as "areas within which at least moderate desertification is widespread", that is there has been significant reduction in the quality and amount of forage and some accelerated wind or water erosion.

The figures identify the serious situation in the drier areas of South Asia, from Iran to northwest India and Nepal, where the problem areas include shrub pastures in arid sandy desert lowlands and in semi-arid uplands and where the situation continues to deteriorate. Apart from lowered grazing capacity, associated problems in these desertified areas include accelerated water erosion in hilly terrain, with harmful consequences for water storages, including irrigation works, in adjacent lowlands, and wind erosion and the mobilisation of dunes in sandy deserts. Destruction of woody vegetation for fuelwood, notably in closer-settled areas, is a major contributing factor, particularly in non-oil producing countries. Encroachment of cropping on former rangelands has increase grazing pressure in lowlands and has contributed to deforestation, accelerated erosion and slope instability in the piedmonts. Despite local successes, as in dune fixation and range control in Iran for example, desertification trends are generally negative and the outlook remains unfavourable, as predictable from a continuing growth of rural populations and livestock numbers, the limited reserves of grazing land available for further exploitation, and slow rates of progress with rangeland rehabilitation or alternative ameliorative measures.

North of the Himalayan-Tibetan divide, the proportional extent of desertified rangeland remains high, embracing part-gypseous low shrub steppes on clay soils and stony plains in the northern areas, tall shrublands of the dunefields in the arid intermont basins, with areas of open low shrubland on takyr flats, low shrub-ephemeroid pastures on the piedmonts, and montane meadows and shrublands. Desertification has a long history in these areas but trends have been significantly reversed over the past two or three decades, notably in the Central Asian Republics of the USSR and in western China.

It is generally acknowledged that the rapid desertification which marked the early European occupation of Australian rangelands is no longer occurring, as a result of betterunderstanding of the productivity of the pastures and their response to grazing, improvements in infrastructure and operational methods, and through government intervention, including for example changes to land tenure, limitations on stocking levels and drought assistance. There is less agreement on how far the position has stabilised however, on where it continues to deteriorate and on the extent to which improvement is occurring. A relatively low percentage of desertified rangeland reflects the short history of pastoralism and generally low stocking pressures in these sparsely lands.

IV. PROGRESS IN CONTROLLING DESERTIFICATION IN RANGELANDS OF THE ESCAP REGION

It should be emphasized that actions to improve combat desertification in rangelands of the ESCAP region did not begin with the PACD, as shown by the presentation at UNCOD in 1977 of case studies in desertification control by Australia, the People's Republic of China, India, Iran and USSR (Mabbutt and Floret, 1980). Nevertheless the relevant recommendations of the PACD provide a useful framework for reviewing achievements in halting and reversing desertification in rangelands of the region, and for identifying constraints to progress as well as ingredients of success.

a. Establishing the machinery for desertification control

Recommendations for preparatory measures under the PACD included establishment of a national co-ordinating machinery for desertification control, recognizing the complexity of the problem and the wish to avoid overlapping, gaps or inconsistencies among the actions of the organizations operationally concerned. It was suggested that this machinery should be centrally placed, at a high level in the administration.

Of the countries of the region for which information exists, only Afghanistan established such a central co-ordinating machinery, and this arrangement subsequently lapsed. Already in China and the USSR there existed multidisciplinary institutions, in the Institute of Deserts in Ashkhabad and the Institute of Desert Research at Lanzhou, with a wide co-ordinating role in applied research. The basis of success in these two instances has been the integration of their scientific achievements into field projects in the framework of large-scale governmental projects. The Central Arid Zone Research Institute, in Jodhpur, India, also, has an impressive record of investigations into problems of the Indian arid regions over a quarter of a century, but still faces major problems in securing the adoption of its findings into local systems of land use.

In most countries of the region, responsibility for desertification control has been allocated to one or more existing departments concerned with the management of natural resources or to newer organisations with general responsibility for environmental concerns - a reflection in the developing countries of a shortage of resources and of professional staff. Similar arrangements have arisen in Australia because land and water resources are constitutionally the domain of separate State governments within a federal structure. Such dispersal of responsibility hinders the co-ordinated actions required for desertification control and is particularly disadvantageous in the area of range improvement, which tends to over lap traditional departmental concerns, for example those of forestry, soil and water conservation, agriculture and animal production, as well as aspects of social and economic administration.

These arrangements are reflected in a general absence of co-ordinated national plans or programmes of desertification control as called for under the PACD. To what extent this explains the commonly inadequate record of desertification control, or to what extent it is a reflection of more significant underlying constraints, needs to be considered further.

b. Monitoring and assessing desertification in rangelands

The PACD asked that standardized systems of surveying and monitoring desertification, including the human condition, be established or strengthened, and that meteorological and recording networks be improved, and stressed the need to monitor atmospheric processes, the state of vetetation and soil cover, dust transport and the shifting of sand dunes, and wildlife - all of them relevant to control of desertification in rangelands. The general response at national levels had however been so inadequate as to present major problems to the GAP.

This cannot be put down to technical shortcomings. Although the proposed international methodology for desertification assessment and monitoring remains in its provisional stage (FAO/UNEP, 1984), there have been considerable advances in the application of remote sensing for rangeland monitoring. Much understanding of the nature, progress and causes of desertification came initially from airphoto interpretation of rangelands (of Kharin, 1976; Vinagradov, 1976), and this has since been supplemented by the harnessing of satellite imagery with its capacity for repetitive monitoring, synoptic overview, multispectral analysis and digital interpretation linked with automated information systems (of Graetzetal, 1976; 1986). Furthermore the region is relatively well-served with stations for receiving satellite imagery, many capable of handling thematic mapping data, those in Australia, China, India, Pakistan, Republic of Iran and USSR being particularly relevant to rangeland monitoring.

Several countries of the region, notably Australia, India and USSR, helped to pioneer the use of remote sensing data in integrated surveys of land resources and capability, and with the exception of Afghanistan, countries of the region concerned with the desertification of rangelands have some facilities and experience in this area.

At national levels there has been significant strengthening of meteorological and hydrological recording networks, although stations are still sparsely scattered through the deserts and uplands within which the rangelands are mainly situated.

Despite all these developments however, and with the substantial exception of the USSR, progress has generally fallen short of the establishment of rangeland monitoring systems effectively serving management. Some technical problems in vegetation monitoring remain, such as spectral interference from ground reflection in areas of open low vegetation. More importantly, translating vegetation measurements into forage assessments requires supportive ground observations by trained technical personnel on a scale beyond the present resources of most countries of the region. But beyond all this there still remains for most countries the essential task of bringing the results of monitoring into service through improved range management by involving the land user, bringing us against the economic, cultural and political dimensions of the problem.

Monitoring desertification through the human condition, in rangeland societies as elsewhere, has so far provedelusive. There are first of all problems with relevant physiological, economic and social indicators, most of which are secondary or indirect reflections of desertification at best and which in any case present difficulties for surveys. More fundamentally however, the use of such criteria for assessing desertification requires that the problem itself be first recast in human as distinct from environmental terms, in relation both to cause and effect.

c. Assessing range productivity and the impact of grazing

Already by 1977 there had been considerable achievement in these fields, notably by the Commonwealth Scientific and Research Organisation (CSIRO) and State departments in Australia, by the Institute of Desert Research in China, by the Central Arid Zone Research Institute in India and notably by the Institute of Desert at Ashkhabad in the USSR. This work has since progressed further and its benefits have been shared internationally through training courses and seminars. In these countries lack of knowledge in these areas is no longer a major barrier to range improvement; the needs reside rather in the training of technical staff for survey and extension work and in the application of the findings in range rehabilitation and management. Other countries of the region however require substantial further assistance in training professional and technical staff to meet these objectives.

d. Measures to control erosion

Control of wind erosion and the stabilization of mobilised dunes through the use of shelter belts, bitumenous or organic mulches, and various methods of planting have been carried out on a considerable scale in western China (Walls, 1982), particularly on oasis perimeters, in other areas of threatened cropland and pasture lands, and along railways, in Iran by the

Forest and Range Organization on coastal and inland dunefields and on sandy steppes (Niknam and Ahranjani, 1976), in USSR as part of the reclamation of send deserts and the protection of installations (Babaev, 1980), and on a somewhat smaller scale in field projects in Rajasthan, India (Shankarnarayan and Sen, 1985). These techniques have now been widely tested in field programmes and, notably in USSR and China, have been incorporated into improved land use. Several international training courses on this topic in support of the PACD have already been held in USSR and China.

Nevertheless large areas subject to wind erosion and sand drifting remain untreated, threatening nearby productive lands. Major constraints in several countries are lack of resources, including trained personnel, and failure to accord priority for action. The measures required are closely related with afforestation programmes and other actions to ease the fuelwood crisis, particularly in South Asia, where afforestation projects outnumber other forms of response under the PACD. In these more densely settled sandy desert areas, where wind erosion of grazing lands is linked with pressure on agricultural lands, technical solutions to control wind erosion must be supported by broader economic and social measures to relieve pressure on the land and to secure community involvement in and support for protective management after completion of the projects.

Less prominence has been accorded to control of water erosion in rangelands. Watershed improvement and erosion control are however priority areas in densely populated Nepal, where three quarters of the country consists of steep, hilly terrain, where an area of 150,000 sq/km supports a human population of 15 million - 90 per cent rural - and a livestock population in excess of 22 million, and where less than 25 per cent of the original forest cover now remains. Considerable international assistance is being provided in the field of soil and water conservation, but so far little scientific work seems to have been carried out to improve the status of rangelands.

In the flattish rangelands of western New Youth Wales, Australia, areas known as "scalds", denuded by a combination of wind and water erosion, are being successfully revegetated through a combination of disc ploughing, shallow pitting or contour banks with seeding plus fertiliser application, and locally with the treatment of hard-setting soils with gypsum.

e. Measures to improve pastures

It is this category of actions which identifies the notably successful responses under the PACD in the USSR and China. In the USSR improvements include the planting of shelter belts of taller shrubs in the piedmont and loessic deserts, commonly involving strip ploughing and seeding, the regeneration of the mixed shrubland of the sandy deserts and the establishment of perennial components in ephemeral pastures, locally using aerial seeding. These improvements have been solidly based on studies of the ecology and productivity of the pasture communities. Labour-intensive reclamation programmes in Arid western China include the planting of shrubs and grasses in "kuluns", as part of dune stabilisation on oasis perimeters, whilst on the sandy semi-arid steppes of north-central China aerial seeding of shrubs and pasture grasses has assisted the stabilisation of sandy soils through as a counter to wind erosion (Zhu and Liu, 1983).

Actions to assist pasture regeneration in rangelands are commonly handicapped by cost in relation to productivity and the large areas involved, notably in Australia, where labour costs are high. Aerial seeding has been used to overcome these problems in some areas, notably in the Ord River catchment of Western Australia. Aircraft have also been used in the application of herbicides for woody shrub control in the southeastern rangelands. A growing optimism about the future of Australian rangelands (cf. Harringtonetal, 1984), reflects confidence about understanding the problems rather than actual achievement, but here have been considerable advances in pasture agronomy, in fire management of woodland pastures and in combating woody shrub invasion.

In India, CAZRI has identified valuable shrubs and perennial grasses as the basis of proposed methods of pasture improvement, in particular in association with water harvesting, but population pressure on communal grazing lands, lack of resources and traditional attitudes have hindered their application.

f. Development of improved grazing strategies and livestock management

Many countries in the region have introduced national programmes to control the use of rangelands. Afghanistan has formulated new grazing laws and measures to facilitate the seasonal movement of the nomadic pastoralists who comprise a quarter of its rural population. The Islamic Republic of Iran has sought to protect its rangelands by nationalizing them and by regulating pastoralism and fuel-gathering.

In the Central Asian Republics of the USSR, seasonal grazing systems have been introduced for new state ranches for karakul pelt production, based on some decades of ecological studies and supported by fencing, construction of shelters and the provision of rational networks of watering points. These innovations are an integral part of regional development supported by the extension and amelioration of irrigation and the exploitation of groundwater.

The effective adoption of improved grazing systems must in the last resort depend on the land manager. The state ranch is well-adapted to apply such improvements, but change is less easily brought about in traditional pastoral societies, or where livestock owned by peasant farmers are grazed on common lands. Nevertheless, since animal productivity in traditional pastoral systems may be only a quarter of that in improved commercial systems there is obvious scope here for reducing grazing pressure whilst maintaining output. It has so far proved to be a more direct and effective avenue of progress than that of pasture improvement, although meeting obstacles in traditional attitudes to livestock as wealth, or where livestock numbers are seen as part of risk-reduction, or where there are religious barriers to selection or control of breeding stock. Programmes for livestock improvement in traditional systems are commonly being helped by market forces in response to the growing urban consumption of meat and dairy products in many developing countries, and indeed the presence of marketing outlets has been an important ingredient of success.

The commercial system of Australia operates on pastoral leases which stipulate maximum levels of year-round set stocking to obtain "lenient" grazing pressures. So far, the main benefits of applied research have come from improved livestock quality and health rather than from grazing management, since deferred or rotational grazing generally shows no advantages.

g. Developing and managing water resources in rangelands

The provision of stock waters, irrigation supplies for forage production, and domestic supplies to raise living standards in pastoral communities have been important parts of regional improvement programmes, for example in the Karakum Desert in the Turkmen SSR and in Rajasthan in India. Conversely, the central role of range improvement in programmes of watershed management, with their implication for water supplies in adjacent areas, has also been recognized, as in Nepal. Most countries of the region have responded in some way to this recommendation of the PACD, but supplementation of existing supplies is not in itself enough, since such developments have implications for and need to be integrated with range management. Experience in Sahelian Africa has shown how the provision of additional stock watering points without such controls may accelerate rather than control desertification.

h. Reduction of drought risk

Preparing for drought is something which receives support in principle, but in practice responses are still generally of an emergency nature, and hence inefficient. Affected populations have time-tested procedures for coping with moderate droughts, with governments entering the picture only in severe droughts. Whilst food reserves have been established in many countries, communal customs, growing livestock numbers and pressure of immediate needs have militated against setting aside drought pasture or forage reserves. In India, successive Five year Plans introduced the Drought-Prone Area and Desert Development Programmes, which included establishing food and forage reserves and providing drought insurance. In most developing countries however, drought insurance is minimal or absent and any financial assistance is in the form of ad hoc payments. Australian governments assist pastoralists in drought-proclaimed areas by subsidizing transport of livestock and fodder, whilst marketing support schemes and low-interest loans help to reduce the impact of fluctuating production and prices.

Pastoralists are unlikely to be assisted by progress with long-term weather forecasting (1-6 months) in the near future. There have been widespread improvements in stock and domestic water storages and supplies, assisted by the availability of heavy construction machinery. Most important in the long term are increased operational flexibility through improved turnoff and marketing facilities, supplementary irrigation where appropriate, and general economic improvement in pastoral communities, including the provision of alternative forms of employment and income.

V. LESSONS FROM THE IMPLEMENTATION OF THE PACD

The general premise in the PACD that existing basic scientific knowledge was adequate to proceed with its implementation has been shown to be justified with respect to range improvement. What remains is to adapt that knowledge and experience to the range of environmental and socio-economic conditions in rangelands in the ESCAP region, and additionally to mobilise it in the development of relatively simple and rapid methods of desertification assessment to assist the formulation of desertification control programmes. Nevertheless there are wide differences between countries of the region in their resources of trained scientific and technical staff at all levels. This situation calls for regional co-operation in training for desertification control, and the network of research and training institutions recently initiated by ESCAP for this purpose should be widely and strongly supported, whilst international funds should be sought for establishing training institutions in countries that lack them.

The GAP did not find that lack of aid funds had been a major cause of the generally inadequate response to the PACD in the area of environmental improvement; rather that such activities had received low priority in the expenditure of the funds made available. Where investments have been made in primary production they have tended to be in irrigation or other forms of intensive production, leaving rainfed cropping and pastoralism relatively neglected. It has been suggested that this may because the true costs of allowing the continuing degradation of productive lands have not been made clear, nor the social benefits which may accrue from rehabilitation. This is particularly the case for rangelands, which tend to be the most remote and marginal areas, geographically, economically and politically.

Pastoralism, although dependent on the land, tends to be driven by the economic and cultural fabric of societies or by international commodity markets that are relatively insensitive to the state of the land. The fundamental need is to improve feedback between the natural and socio-economic systems, involving not only improvements in extension services and the provision of infrastructure, but the building of cultural bridges and the participation of pastoral communities in range improvement programmes.

The last few decades have seen a reassessment of traditional pastoral systems in many parts of the world, for example through work by institutions such as the International Livestock Centre for Africa (ILCA) and activities under the UNESCO/Man and Biosphere (MAB) Programme. There have been few such assessments in the ESCAP region, although the Turan Basin Programme under MAB is a valuable exception (Mabbutt and Floret, 1980). The findings of such studies have under lined the importance of traditional pastoral land use, including nomadic uses, in areas that might otherwise remain unproductive, the value of traditional skills and the need to create conditions which can preserve and reinforce them through new technology and allow them to operate whilst maintaining an ecological balance, and the social and cultural importance of such communities which goes far beyond their economic significance. The PACD stresses the importance of securing community participation in desertification control measures, not simply through the passage of information, but through involvement in decision-making, management and ownership. This approach has been exemplified in many programmes in social forestry in the ESCAP regions, but not so far in pastoralism, although the modernised systems of karakul sheep raising in the USSR exemplify some aspects of it.

Perhaps the final lesson in the PACD, and one which is exemplified in the two outstanding national exemples of rangeland improvement in the ESCAP region, is the importance of political will. Dryland rehabilitation projects tend to be long-term, with low initial returns on outlay, making them relatively unattractive by relatively short-term commercial criteria. Rangeland improvement projects particularly fall into this category, which is generally one for government initiatives. It is significant that the two main regional examples of national success in combating the desertification of rangelands come from planned economies, where the links between scientific research, planning and development are close and direct. Elsewhere, perhaps the main result of international concern with desertification since 1977 has been a growing awareness of the finite nature of land resources, including rangelands. This awareness however has not yet prevailed in the arena of public policy-making. It remains for the scientists to present the costs of rangeland degradation in compelling terms, and to provide convincing examples of the net benefits of rangeland improvement.

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FORAGE PRODUCTION FROM DESERT RANGELAND OF INDIA

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ABSTRACT

Field experiments were conducted at Central Arid Zone Research Institute, Jodhpur and its Range management and soil conservation areas to find out suitable techniques for increasing productivity of arid grasslands. Reseeding high yielding perennial forage grasses with appropriate agronomic practices increased forage production significantly. Strip-cropping of grasses and legumes and silvipastoral system proved beneficial under arid conditions of Rajasthan.

Animal husbandry plays an important role in the economy of western Rajasthan as there are risks involved in crop production because of erratic and low rainfall in this region. The livestock of arid region of Rajasthan are reputed for high production potentials and drought hardiness and get their sustenance from existing grasslands. But due to low carrying capacity and increased pressure of livestock on existing grasslands, these lands have reached to last stage of denudation.

In order to evolve scientific technology for speedy improvement of the grasslands of arid areas of Rajasthan, studies were initiated in 52 Range Management and Soil Conservation areas (each about 80 ha) to cover different land types namely rocky, semi-rocky and shallow soils, duny and deep sandy plains of the region. These areas were fenced and seeded with matching grass species. Later trials on soil and water conservation introduction of legumes and trees, controlled grazing, mixed grazing and grazing intensities were carried out. The results of these studies are discussed below.

Fencing: An efficient grassland management aims proper utilization of forage without undue interference with the growth and vigour of useful plant species. With adequate protection and grazing the grasslands according to their carrying capacity (aiming at 70% forage utilization level), the forage yield doubled within three years time. Increase of forage yield in 'poor', Fair and 'Good' condition class grassland was 148.3, 91.9 and 116.5 per cent respectively.

Amongst the different type of fencings tried, the angle iron posts and barbed wire fencing is the most efficacious and economical in the long run although the initial cost is high (Rs. 15/- per running metre).

Soil and soil moisture conservation

Adoption of appropriate moisture conservation measures on lands with shallow soils and rolling topography (2 per cent slope) led to significant increase in forage production. The average increased yields over control as a result of contour furrowing, contour bunding, and contour trenching were of the order of 638.7, 168.8 and 165.0 per cent, respectively. Contour furrows (60.96 cm wide and 22.86 cm deep) with a cross section of 929. sq. cm. at a distance of 8-10 metres across the slope proved superior to contour bunds and trenches. Contour furrowed plots were also found to contain more soil moisture than that of contour bunded or contour trenched plots.

In extremely dry area of Jaisalmer district, grassland with gravelly, barren shallow soil was protected with ditch and mound fencing (500 m apart) and in between these ditch and mound lines, contour furrows spaced 8-10 m apart were constructed. These soil conservation structures trapped the naturally blowing sand and led to natural regeneration of Lasiurus sindicus grass. The forage yield increased due to contour furrowing over control was highly significant and mean increase in yield was 632.5% over control (Table 1). Inter row water harvesting system gave better establishment and higher forage yield of pasture legumes than flat sowing. The increases in the yield of Clitoria ternatea and Stylosanthes hamata due to inter row water harvesting over flat were 35 and 124 per cent, respectively.

Performance of Stylosanthes hamata appeared to be promising in association with Dichanthium annulatum in rainfall zone more than 400 mm. The forage yield of S. hamata obtained from pure and mixed plots were 14.1 and 8.6 q/ha., respectively. The yield of D. annulatum from pure plot was 33.1 q/ha as against 31.4 q/ha from mixed plot with S. hamata. Thus total productivity of grass legume mixture of D. annulatum + S. hamata was highest of the order of 41.9 q/ha which was 26.9% higher over control. The crude protein content in S. hamata was the highest i.e. 12.53% in pure plot which was followed by 11.42% in mixed plot with grass. The crude protein content in D. annulatum was 4.18 per cent.

Reseeding: Natural succession of desired species is very slow process in arid region. Hence, reseeding the natural grassland with suitable perennial grass species is the only solution for quicker improvement of degraded pasture land. Reseeding involves proper soil working, sowing of appropriate grass species and after care of the grassland. The land should be properly prepared and all unwanted vegetation grubbed out and cleaned. The best time of sowing for grasses is last week of June or first fortnight of July. Seed rate of 4-6 kg/ha for Cenchrus species, 5-8 kg/ha for Lasiurus sindicus and 2-3 kg/ha for Dichanthium annulatum, is recommended.

Seed should be mixed with wet soil three to four times the volume of seed and drilled in furrows with minimum soil cover in lines 50-75 cm apart. Dry forage yield of such sown pasture of Cenchrus ciliaris (358) obtained at Central Research Farm, Jodhpur in 1982, 1983, 1984, 1985 and 1986 were 507, 1664, 2475, 1800 and 3280 kg/ha, respectively.

In order to have better establishment of Lasiurus sindicus, the seed if pelletted is most appropriate. Pellets are prepared by mixing seeds of grass, cowdung, clay and sand in proportion of 1:1:3:1 using sufficient quantity of water for preparing round pellets of the size of about 0.5 cm diameter, each pellet containing 2 to 3 spikelets. These pellets may be dried and stored. Sowing by this method is effective in the areas where soil working is not possible. The establishment of Lasiurus sindicus and Dichanthium annulatum is more sure with transplanting of rooted slips or seedlings as compared to seeding but transplanting is not practicable on large scale due to water scarcity conditions in dry areas and high labour requirement for transplanting. Sowing of seed of Cenchrus ciliaris (358) at Central Research Farm, Jodhpur in dry soil before the onset of monsoon gave 36 per cent higher forage yield over post monsoon sowing. The results concerning the increase in forage production due to reseeding under different condition classes of grasslands presented in Table 2 revealed that increase in forage yield due to reseeding was from 30 to 122 per cent in 'Poor' and 29 to 107 per cent in 'Fair' grasslands.

The direct seed sowing of Cenchrus ciliaris in heavy textured saline soil completely failed but transplanting of about 3 weeks old seedling established cent per cent. The dry forage yield obtained in 1983 during establishment year was 26.66 q/ha and it increase to 28.70 q/ha in 1985.

The Dichanthium annulatum was sown by pelletted seeds in heavy textured saline soil on mounds. The grass established well and dry forage yield in 1985 was 23.40 q/ha, while yield of native grass i.e. Sporobolus helvolus on this soil was 14.56 q/ha.

Improved grasses: Lasiurus sindicus gave high tonnage (upto 2.6 tonnes/ha) in grasslands on sandy soils with annual rainfall of 150 mm, and below, whereas Cenchrus ciliaris and Cenchrus setigerus were found suitable for light to medium soils with annual rainfall of 300 mm and above and gave yields upto 3 t/ha, while Dichanthium annulatum gave high forage yield (upto 6 t/ha) on heavy soils under annual rainfall above 400 mm. Panicum antidotale performed well on light textured soils with an annual rainfall of 250 mm and above whereas Sehima nervosum yielded good forage on the hilly terrain. Sporobolus helvolus performed well in grasslands with saline soils. The crude protein content of important forage grasses varied from 9.2 to 2.8 per cent in different seasons of the year. The protein content was maximum during rainy season and from October onwards it started decreasing and was least during April to June.

Fertilizer use in pasture grasses

The grasslands of western Rajasthan are highly depleted of soil nutrients and are subjected to erosion hazards. For optimised production, it is essential to provide adequate nutrients in the soil. Desert soils of Rajasthan are not deficient in potash but they are deficient in nitrogen. Studies on fertilizer use in range grasses revealed that increased yield of forage of the order of 50 to 70 per cent could be obtained by application of 20 kg N/ha. Application of nitrogen at the rate of 20 kg/ha in areas with annual rainfall of 300 mm and below and 40 kg N/ha in two split doses in areas with the annual rainfall above 400 mm, is recommended. The protein content of forage in fertilized pasture was higher than that of unfertilised.

Strip cropping

Studies on strip cropping of grasses and legumes were carried out from 1981 to 1985 at Central Research Farm Jodhpur and from 1982 to 1985 at Bikaner. Permanent strips 4 to 5 m wide and 40 to 50 m long of Cenchrus ciliaris at Jodhpur and Lasiurus sindicus at Bikaner were established at right angles to the general direction of the prevailing winds. In between grass strips cluster bean and moth bean for fodder were sown during kharif season. The mean data in respect of fodder yields of grasses and annual legumes are given below:

Mean dry fodder yield (q/ha) of grasses and annual legumes

	Jodhpur	Bikaner
Cenchrus ciliaris	12.26	-
Lasiurus sindicus	-	43.68
Moth bean	7.29	11.25
Clusterbean	11.40	21.08

The clusterbean gave higher fodder yield than mothbean at both the centres. Lasiurus sindicus yielded maximum forage at Bikaner than Cenchrus ciliaris at Jodhpur. The permanent strips of grasses helped in preventing soil loss caused by wind erosion. The loss of soil during summer season was 86 per cent higher in control plots than that in the plots having protected strips of grasses.

Choice of tree species for grassland

To improve productivity of grassland, it is essential to introduce some suitable tree species to provide shads for grazing animals and top feed during the lean periods. The selection of suitable tree species for a particular climate and soil should be given more importance which can provide continuous and economic supply of green fodder without any extra input.

Prosopis cineraria is important drought hardy forage tree which grows in grasslands without any detriment effect on grass grown in association with it. The tree is lopped for its protein rich (17.49 per cent) leaves. Zizyphus nummularia a bush provides very valuable nutritive leaf forage containing 14 to 16 per cent protein. It grows well in cultivated fields and grass lands. Acacia tortilis grows very well on light to medium textured soils even in low rainfall areas below 250 mm. It is both fast growing and frost hardy, its leaves and pods provide good top feed. In areas with annual rainfall above 400 mm Albizzia lebbek has given good performance. Calligonum polygonoides is a sand dune fixation plant. It leaves and tender stem provide a good top feed for camel, sheep and goats. Acacia senegal grows well on rocky sites and provides leaves and pods for animals. Salvadora parsica performs well on saline soils. Acacia nilotica grows well on heavy textured soils in low lying areas. It provides nutritive top feed through its leaves and pods. In extremely dry areas, animals eat the green shoots of Capparis aphylla. Colophospermum mopane recently introduced in rangelands is also growing well. Dichrostachys nutans has given good performance on different rangelands and provides palatable and nutritive leaves for sheep, goats and camel. A good pasture may have about 30 trees per hectare. Silvi-pastoral studies conducted with Acacia tortilis, Azadirachta indica, Albizzia lebbek and Holoptelia integrifolia and four grasses namely Cenchrus ciliaris, Cenchrus setigerus, Dichanthium annulatum and Panicum antidotale revealed non significant differences in the dry matter production under different tree species.

Growth of tree species during earlier years of growth is slow and may not interfere the growth of grasses. With the advancement of age, crown cover and root system of the tree develops progressively and it may affect the ground vegetation. Studies conducted on the contribution of the understory in afforested areas, with Prosopis cineraria, Albizzia lebbek, Tecomella undulata and Acacia senegal revealed that production of forage under first three species did not differ significantly but the yield under Acacia senegal was significantly lower than the other three species.

Forage yield (Table 3) of Cenchrus ciliaris upto 1 meter distance from Prosopis cineraria trees was significantly reduced. But yields under trees from 2 to 5 meter and in open area at 15 meters did not differ significantly. The grass seed yield was significantly low under tree canopy as compared to open land moisture content of soils under tree canopy was higher thus indicating beneficial effect of tree canopy by preventing evaporation losses.

Utilisation: - Utilisation of forage from grasslands can be through (a) harvesting, preserving and then feeding to the livestock. In reseeded pastures forage yields are fairly high, it is best to resume a portion (about 25%) of it to harvest at flowering stage to feed animals during lean periods. (b) Grazing: Best way to utilise the grassland is through grazing based on carrying capacity. Carrying capacity (on year long basis) of pastures under five different condition classes in arid zone of Rajasthan during normal years of rainfall is as under:

Condition class of pasture land	Forage production kg/ha during normal years	No. of adult cattle units (300 kg body weight per 100 ha
Excellent	1500 kg and above	25-30
Good	1000 and above	20
Fair	750 and above	17
Poor	500 kg and above	13
Very poor	200 kg or even less	1-6

Under abnormal years, grazing stress has to be increased or decreased depending on the availability of forage on the pasture lands.

Goats V/S Sheep Grazing:

Studies on the comparative performance of goats and sheep on sown pasture of Cenchrus species infested with *Zizyphus nummularia* bushes revealed 292 per cent increase in the body weight gains in male goat as compared to ram lamb with-in a period of one year under light intensities of grazing (3 animals/ha). The increase in gain of male goat over ram lamb was 178 and 75 per cent under medium (4 animals/ha) and heavy (6 animals/ha) intensities of grazing, respectively.

Mixed grazing:

Results of the studies on mixed grazing with cattle and sheep on *Lasiurus sindicus* rangeland in rainfall zone below 250 mm revealed that the growth of animals per unit area remained to be the highest when heifers grazed alone followed by mixed grazing with heifers and sheep and least when sheep grazed alone.

Stall feeding of hay:

Trials on performance of heifers in two systems viz., continuous controlled grazing and continuous controlled grazing with additional stall feeding of hay 4 kg/heifer/day from

January to June, each year were carried out in Lasiurus sindicus pasture at Lawan (Jaisalmer) and in Cenchrus species pasture at Pali. Hay conserved for stall feeding was harvested at preflowering stage of grass from half portion of the grazing paddock. Results revealed that stall feeding of hay to heifers during lean period resulted in higher body weight gains in all years at both the locations. The forage yield of grasses at both the locations was also higher under the treatment where grass was harvested preserved and fed to animals. (Table 4)

Palatability of different species of grasses and the grazing behaviour of animals

Among all grasses, Cenchrus ciliaris and Cenchrus setigerus the perennial species are most palatable to all species of farm animals during the entire year. The annual species such as Aristida funiculata and Cenchrus biflorus on maturity cause severe discomfort to sheep from the middle of August to the beginning of November, as their awns and burrs pierce through the mouth parts and the skin of the grazing animals. Such species are also trouble some to cattle. During this period perennial species, such as Dichanthium annulatum and Lasiurus sindicus are relished most. From November onwards, these perennial species become woody. Then they are not liked by cattle and cause discomfort to sheep by injuring their mouth parts with the sharp ends of the stems. Therefore annuals whose burrs and awns have been shed are relished. From March onwards, when the annual grasses get exhausted, the high perennials get broken down and are caten.

During the hot weather, animals, eat the green shoots of Calligonum polygonoides, Capparis aphylla, etc. Tussocky grasses e.g. Dichanthium annulatum and Lasiurus sindicus during maturity are unpalatable to sheep and goats, but are grazed upon by cattle. To have the best utilisation of grassland it is advisable that sheep and goats fallow cattle - the goats will eat up, thorny bushes which otherwise are trouble-some to cattle.

Preservation of forage:

Specially in the arid regions, there is an shortage of forage from November onwards when the grasslands get grazed and it becomes acute in drought years. To have a regular supply of good and nutrions forage it is essential to process and preserve it under proper condition. Forage can be preserved by making hay.

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Table 1: Dry forage yield (kg/ha) of <u>Lasiurus sindicus</u> under contour furrowed and control plots

Years	Contour furrowing	Control	% increase over control
1961	796.2	257.0	209.8
1962	2297.0	212.0	983.4
1963	647.6	65.5	888.7
1964	1951.0	110.0	1673.6
1965	2293.3	234.3	878.7
1966	2328.1	255.3	811.9
1967	1741.0	434.4	300.8
1968	371.8	27.6	1247.1
1969	1669.8	328.4	408.5
Mean	1566.2	213.8	632.5

Table 2: The average forage yield (air dried kg/ha) due to reseeding under different grasslands

Year	POOR			FAIR		
	Reseeded	Control	%Increase in yield	Reseeded	Control	& Increase in yield
1960	1066 (3)	750	42.1	1173 (2)	800	46.6
1961	1609 (5)	885	81.8	2002 (3)	1556	28.7
1962	990 (4)	692	30.1	1686 (7)	869	94.0
1963	1501 (2)	675	122.3	1741 (6)	964	80.6
1964	1552 (7)	715	117.1	2516 (8)	1213	107.4

Figures in parentheses indicate the number of trials.

Table 3: Effect of Prosopis cineraria canopy on the productivity of Cenchrus pasture

Distance from tree (meters)	Forage yield (Q/ha)		Seed Yield (kg/ha)
	Green	Dry	
1	26.6	11.6	38.0
2	58.5	28.8	46.9
3	51.0	24.8	88.7
4	54.0	26.5	112.3
5	60.6	30.9	115.8
15 open area	64.0	32.8	215.0
SEm$\pm$	5.3	3.2	16.7
CD 5%	15.6	9.4	49.1

Table 4: Gain in body weight (kg/heifer) under continuous grazing V/S Grazing with stall feeding of Hay during the lean period i.e. January to June

YEAR	Treatment	Lawan Lasiurus sindicus pasture		PALI Cenchrus species pasture	
		Body weight gain (kg/heifer)	Forage yield (q/ha)	Body weight gain (kg/heifer)	Forage yield (q/ha)
1978-79	T1(No.stall feeding)	59.8	7.04	34.4	18.99
	T_2(Stall feeding)	60.3	10.40	43.4	19.67
1979	T1(No.stall feeding)	28.3	3.48	59.5	21.25
	T_2(Stall feeding)	24.0	6.89	82.3	30.66
1980-81	T1(No.stall feeding)	24.9	7.01	26.8	2.04
	T_2(stall feeding)	29.1	11.35	27.2	1.98
1981-82	T1(No.stall feeding)	21.6	2.48	33.0	17.68
	T_2(stall feeding)	31.8	3.82	52.0	19.73

FOREST RESOURCES IN THE EAST NUSA TENGGARA (INDONESIA) : under the pressure of cattle grazing and swidden cultivation

Sutarjo Suriamihardja *)

INTRODUCTION

East Nusa Tenggara (Nusa Tenggara Timur; NTT) is the province in Indonesia located within latitudes $8^{o}5'$ to $11^{o}1'$ and longitudes $118^{o}56'$ to $125^{o}11'$ East. The total land area is approximately 4.74 million hectares divided into three major islands (Timor, Flores, and Sumba) with a total 566 islands. According to the census of 1983, the population was about 2.9 million and increasing at an annual rate of 2%. About 89% of the population make their living by farming in the upland hilly areas.

Practically all islands are mountainous (70%) with the slopes higher than 50%. Based on the land capability classification issued by Soepraptohardjo (1970), only about 35% of the land is suitable for agricultural purposes (1.7 million hectares), that are 3% suitable for irrigated agricultural lands and 32% for rainfed agriculture, while the remainder (65%) must be managed for the perenial vegetation or forests and grazing lands.

Generally, NTT's climate is arid monsoonal with the severest drought occuring on the eastern regions because of their proximity to the continent of Australia and its dry weather outflow winds which give NTT its dry season. The high mountainous region of West Sumba and West Flores receive rain in excess of 2,500 mm per year, while the eastern parts of these islands receive less than half of that. Rainfall decreased on islands further east, such as Timor, East Sumba, and East Flores, where precipitation drops below 1,000 mm per year. The dry period (rainfall less than 60 mm/month) extends to eight months.

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LIVESTOCK PRODUCTION

Livestock production is particularly important to NTT, which produce close to 30% of the nation's livestock , accounting for 85% of the province's yearly exports (Webster et al, 1977). This potential is supported by a large area of savannah as a major resource for livestock production; Conterius and Menafe (1985) stated that there is about three million hectares of savannah distributes mainly in Timor and Sumba. The area is classified by Bonnemaison (1973) into the Palm Savannah, Eucalyptus Savannah, Acacia Savannah, and Casuarina Savannah (Sherman, Rika, and Lore, 1977).

The most important livestock in NTT is catlle especially Bali cattle. Livestock shepherdings are generally conducted extensively without any management actions other than burning which often carried out twice a year (in June and later in October). It was estimated by Jones (1982) that the area of grassland burned each year probably exceeds one million hectares. It is not unusual to see single fires which have covered 20,000 to 30,000 hectares of grassland in East Sumba and Central Flores during the June-October period.

For the future, there is very little potential to extend the amount of grazing land as the result of the competition with food crops, poor species of grasses caused by fire, long dry season, and lack of water. The province, however, could increase production significantly through better range management, improved pastures, and better use of water (Sherman, Rika, and Lore, 1977).

FOOD CROP PRODUCTION

The economy of the region is based on the exploitation of natural resources, primarily of the soil for food and plantation crops; during 1975-1983 about 70% of NTT's gross domestic product was given by agricultural sector with an annual increment of about 3%. The great support of agricultural sector to the province's income, however, is followed by ever-decreasing land capability due to traditional - destructive farming system of the farmer.

Swidden cultivation (or shifting cultivation) is the agricultural farming system practised by most of the villagers. They live five months yearly on their swiddens (from clearance to harvest) and the rest of the time live a relatively settled in the villages. Aproximately 62% of the rural families in NTT are involved with swidden agriculture (Webster et al, 1977). More than 100,000 hectares of secondary forest is burned each year in order to grow maize (Jones, 1982).

Several problems associated with swidden agriculture has been noted by many study teams working for NTT. The EIRDS (East Indonesia Regional Development Study), a technical cooperation of the Government of Indonesia and the Government of Canada 1974-1977, classify the problems as follows :

a. The rate of destruction of primary forests in some areas of swidden cultivation is excessive and potentially dangerous.

b. The reduction of forest land coupled with ever-increasing area under yearly cultivation has resulted in a decline in water holding capacity of micro-environments and resultant fast run-offs. Thinning of topsoils has resulted, and serious downstream erosion is now observable in many locations.

c. The general decline in productivity of the land base. This could be directly related to a reduction in soil fertility coupled with the growing necessity to cultivate lands only marginally receptive to swidden agriculture.

FOREST RESOURCES

Appropriate forest area in NTT is highly needed by both local and central government due to the following reasons :

a. The whole area of NTT has been affected by relatively recent tectonic activity, and some area have been affected by recent volcanism, resulting an immature landscape whether it be in major mountain ranges or in recently uplifted coral reefs. This immaturity in the landscape tends to promote rapid land erosion (Webster et al, 1977). In combination with the seasonal shortages of surface water (due to climate condition, physiography, and the action of man), the immaturity of landscape make NTT more critical.

b. The increasing need for industrial wood and fuelwood. Wood consumption estimate indicates some 1,112,000 m^3(r) needed in 1985 and 1,376,000 m^3(r) in 1995 (Jones and Darsidi, 1976).

In 1985, about 35.2% of the land area was enacted as forest land. The forest land cosists of protection forest (677,601 ha), nature conservation forest (116,511 ha), recreation forest (15,379 ha), and production forest (858,471 ha). In fact, in 1976 only about 60,7% of the forest land is forest covered (Jones and Darsidi, 1976), which was made up of primary forest (292,300 ha) and secondary forest (720, 700 ha). By the fact that more than 100,000 ha of secondary forest is burned each year and, at the same time, more than 1,000,000 ha of grassland burned, one can make a rough estimation about the condition of forest now.

The primary forest remaining mostly at high altitudes and in other remote and inaccesible parts of the region. Pressure on the forest edge continues, however, from villagers seeking to extend grazing areas and shifting cultivation. In fact, the entire forestry situation in NTT is critical; the remaining forests are neither supplying local demands for wood nor are they providing adequate watershed protection. Roads and bridges continue to be washed away by floods, irrigation works are made useless by sediments from critical treeless watersheds. There is about 1,742,938 ha of critical lands in NTT (36% of the total land), that are 348,408 ha in the forest lands and 1,349,530 ha in the outside of forest lands.

FORESTRY AND AGRICULTURE STRATEGIES

In terms of the economic, environmental and climatic influences of forest on living standards of the people in NTT, the forests is now in a state of decline. The rate of forest destruction, chiefly by fire, continues at an alarming pace and appears to be increasing. For the best future of NTT, both national and provincial governments put their great attentions on the regreening movement, that is the establishment of fast growing species of trees, grasses, or legumes for the control and prevention of soil erosion, water basin recharge, and environmental protection.

The above strategy combines livestock production, food crops production, and forestry missions either in the forest lands or in the outside of forest lands. In principle, the core program of the strategy is to develop agroforestry-based agricultural systems in any kind of land utilization. A long time is needed to convert traditional-destructive farming system and uncontrolled grazing into an ecologically and economically usefull system. For NTT the time needed is probably shorter since there is an indigenous agroforestry model on Timor which has prospects of being developed in other parts of NTT and also in other arid or semiarid regions; the model is known as Amarasi Lamtoro (Leucaena) Model.

Jones (1982) give a brief description on the Amarasi Model as follows :

> The basic elements of Amarasi Model include the growing of maize in cleared and burned thickets of Lamtoro on a two or three year rotation and the concurrent use of the Lamtoro to fatten cattle.
>
> A single family, with two hectares of relatively poor limestone soil covered entirely by Lamtoro, can produce 1,000 kg of maize per year on 2/3 rds of a hectare (with possibly 700 kg for their own use and 300 kg for sale) and fatten 4 head of Bali cattle on the remaining one and a third hectares (with one for their own consumption and three for sale).
>
> The Lamtoro regrows from its burned roots making it unnecessary to reseed or replant the tree. Its new foliage is immediately available during the ensuing dry season for cattle fodder. During a three or four year fallow period the fallow area continues to provide fodder for livestock.
>
> The Amarasi Model is a settled system of agriculture involving a modified form of swidden cultivation and burning. The openings in which maize is cultivated seldom exceed three hectares and there is little soil loss in the system.

Amarasi Model has been identified as being a successful approach to stabilizing the agro-ecosystem in NTT and also in other arid parts of Indonesia. In the forestry sector, modification of the Amarasi should be developed in the establishment of community forestry and bufferzone or fuelwood plantations. Specifically for the purpose of cattle raising, however, actions will be required on several following points (Webster _et al_, 1977) :

a. Improved range management is essential. Presently some of the grassland is overgrazed while other areas are underutilized. The areas closest to the river tend to be overutilized, further inland, good grazing land is completely dormant.

b. A water development program needs to be undertaken. A study should be conducted to determine groundwater potential.

c. Accessibility to upland grazing flats must be improved. A considerable percentage of good grassland upland area is not utilized simply because it is unreachable.

d. A pasture improvement program should be introduced. Burning has resulted in erosion problems and in a poor quality of coarse grass.

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DESERT TYPES OF MONGOLIA

The Mongolian People's Republic is situated in the centre of Asia at the average altitude over fifteen hundred metres above the sea level and is surrounded on almost all the sides by large mountains that isolate it from the areas of both Atlantic and Pacific air mass circulation. The continental climate largely determines frequent occurence of deserts and semi-deserts.

The semi-desert and desert zones from an arch-like belt 480 km wide and 2000 km long, embracing the western, southern and south-eastern part of the country, in particular The Large basin, Lakes Lake Valley, Transaltai, East and South Gobi.

The total area of arid zones in Mongolia makes up 641,5 thousand km^2, i.e. some 41% of the country's territory.

The northern border of the semi-deserts is easily traced along the boundary of light chesnut soils and corresponds to the isohyet of 200 mm, and the northern boundary of the deserts - along the margin of brown stepped-desert soils and corresponds to the isohyet of 100 mm a year. It is interesting to note that the northern boarder of the arid territory nearly coincide with the line dividing the northern and southern geotechtonic megablocks of the Kaledonian and Gertsinsky periods.

There are quite a few works in the world literature on the classification of desert types. These classifications are based on different principles: climatic, soil, floristic, lithoedaphic. Of great interest is the desert classification as to lithoedaphic conditions, suggested by M.P. Petrov (1973 For Central Asia for instance the following types of deserts are found: sand deserts on loose deposits of ancient alluvial plains, sandy shingle and shingle deserts on gypsum tertiary and cretaceous structured plateaus; break-stone gypsum on tertiary plateaus; stone deserts on low-mountain and hummocky relief; loamy low-carbonate nappe loams; loess deserts on piedmont plains, clay takyr deserts on piedmont plains and in ancient river deltas, clay badland deserts on low-mountain relief, composed of salt-bearing marls and clays; sononchak deserts in saline depressions and along sea coasts.

A.G. Babaev, I.S. Zonn and others (1986) have analyse the existing concepts of desert classification and zonation in the world and suggested the following types independent in morphstructural and lithoedaphic respect.

1. sand
2. sand-break-stone
3. break-stone gypsum
4. stone
5. loess - clay
6. solonchak

Proceeding from the above-mentioned works and our own research of deserts and semi-deserts of Mongolian People's Republic we come up with our own classification:

I. sand
II. sand-shingle
III. shingle-break-stone
IV. stone-break-stone
V. clay
VI. solonchak
VII. rocky (mountain)

I. Sand deserts occupy 4,8% of the arid territories of Mongolia. The relief of sand deserts is varied. Widely occur fixed sand mounds, hillock sands, honeycomb.-hillock sand even cover sauls, shifting barchan and barchan-hillock sands, sand desert vegetation is richer than in other lithoedaph types. This is determined by more favorable water-retaining properties of sands, which absorb atmospheric precipitation and slow down their direct evaporation. The dominating type of vegetation are species of more xerophilous type and typical psammo phytes from Central Asian sand desert flora: Artemisia klementzea, A. xanthochroa, A. sphaerocephala, Hedysarum mongolicum, Psammochloa villosa, Calligonum mongolicum, Agropyron fragile, Stipa gobica, Nitraria sibirica, Haloxylon ammodendron, etc.

Sand deserts are subdivided into three subtypes:

1. Sand deserts on thick loose deposits of middle-upper Quarternary alluvial lacustrine plains. They are found in the Large Lakes basin and the Lake valley. The relief is mainly barchan-hillock and hillock-honeycomb. The soils are loamy sand light chestnur and bare sands occur. The contemporary geomorphological processes are deflation-accumulative.

2. Sand deserts of piedmont accumulation-denudation plains and intermountain depressions. They are widely found in the foothill areas of Gobi Altai. The relief is barchan and barchan-hillock, brown stepped-desert grey-brown and takyr - like soils are developed in depressions.

3. Sand deserts of the structural-denudation plains, hummocky terrain and bazalt plateuas. They are found in the south-east of the country. The relief is hillock barchan-hilloc and flat-rolling. The soils are brown stepped-desert and grey-brown.

II. Sand-shingle deserts take up 7,2% of the desert area in Mongolia. The surface layers are made up of sandy conglomerates and shingles the Vegetation is dwarf shrub and semi-shrub in combination with ephemeral borbs. Following subtypes are marked.

1. sand-shingle deserts on thick loose deposits of middle upper Quarternary and contemporary alluvial-lacustrine plains. They occur in the Large Lakes basin. The relief is plain intermitten with small hills of stabilised or drifting sands. The soils are brown desert-steppe.

2. Sand-shingle deserts of piedmont ancient alluvial-lacustrine plains and intermountain depressions (of Neogene and Pleistoceneage) are found in the Lake Valley. The relief is plain in combination with low mountains, hummocky terrain, lacustrine-solonchak depressions and sand areas. The soils are brown desert-steppe.

III. Shingle-break-stone account for 31 of arid lands in Mongolia. This type of desert occur on the Central Gobi peneplaing and in Eastern Gobi depression. A peculiar feature of this type of desert is that its surface is covered with shingle-break-stone elunum an wide occurence of solonchaks in closed basins. In terms of their morphostructural features shingle-break-stone deserts can be subdivided into:

1. shingle - break-stone deserts of denudation-horizontal and - stratum plains

2. shingle - break-stone deserts of denudation-sode plains, hummocky terrain, piedmonts and basaltic plateaus.

Brown desert steppe and brown steppe desert soils are typical of both subtypes, while light chestnut mealy carbonate soils are typical only of the latter subtype. The vegetation is dominated by Artimis Salsola sp., Stipa sp., Allium sp., etc.

IV. Rocky-break-stone deserts is the major desert type in Mongolia (43% of arid zone). The predominant relief is low land and hummocky. The desert surface is covered with break-stone (10-100 mm), sometimes with coarser fragments.

There are many rocky outcrops of bedrock material. Three subtypes are distinguished:

1. rocky-break-stone deserts of piedmont alluvial fan plains

2. rocky-break-stone deserts of piedmont trains and denudation plains

3. rocky-break-stone deserts of low lands hummocky terrain and denudation socle plains.

Flat interfluve surfaces of the rocky-break stone deserts are characterized by the preseace of a rocky-breakstone "armour" resulting from constant weathering and partly from washing out of dust particles and fine sand. The grey desert prevail soils - usually thin and weakly developed lime or gypsum. The main vegetation is of shrub-type spread along the dry riverbeds, very meagre and dispersed.

V. Clay deserts are not widely spread in the Gobi, they take up some 0,3% of the territory. Clay deserts are subdivided into clay takyr-like and clay badland types.

1.Clay takyr-like deserts formed on immature and often uncompacted clay deposits, are mostly typical of intermountain depressions of the Golbyn and Borzongiin Gobi. Small areas are found in Transaltai Gobi. Takyr and takyr-like soils have smooth solid surface broken into polygonal fragments by shallow fissures. Takyrs are usually devoid of vegetation, sometimes there occur annual seepweads.

2. Clay badland deserts of hummocky terrain and depression edges are made up of mottled clays of Meso-Kainozoic age. This subtype occurs in Harman and Nogoontsav, Haichiin uul, Transaltai Gobi, etc.

VI. Solonchak deserts account for some 5% of the Mongolian arid zone, and occur in small massives in other types of deserts. They are especially typical of shingle-break-stone deserts.

They most frequently spread on dry lake shores and basins without outflow.

Solonchak deserts are subdivided into hydromorphic and lithogenic depending on the solonchak type.

Hydromorphic solonchaks develop in the areas with high water tables, on foliated loam and clay lacustrine-alluvial and alluvial fan deposits. Their surface is covered with dispersed halophylous xerophilous and psammophyte - shrub vegetation. Among halophylous there are many succulents, most typical are various seepweads (Halocnemum Salsola, Anabasis, etc.). Hydromorphic solonchaks are divided into crust, plump and wet. Crust solonchaks are widely spread and occur in low areas. Plump solonchaks occur in combination with the crust ones, they occupy small areas and differ from the crust solonchaks by the presence of a 5-15 cm-thick cushion. Wet solonchaks are characterised by a higher water table and absence of vegetation.

Lithogenic solonchaks are found in the Transaltai Gobi. The pecularities of the nature and soils of the Transaltai Gobi are largely determined by a wide occurence of salt-bearing and gypsum-bearing Cretaceous-Palaeogene mottled deposits. On the major part of the area they are covered by a mantle of Quaternary deposits of various thickness, but in some regions they out crop directly to the surface thus becoming the source of salts, gypsum, silt and dust matter.

VII. Non-rocky mountain deserts account for 7.5% of deserts in Mongolia. This type includes pediment mountains of arch axes and inselber s i.e. mountain ridges of Arts Bogd, Gov Gurvan, Andreigiin Nuruu, etc. In terms of absolute heights there are high (over 2500 m), medium (1600-2500 m) and low (below 1600 m) mountains.

Desertification processes develop differently in various types of deserts. In rocky-break-stone deserts of piedmont train there prevails water erosion. Deflation process is typical of solonchaks and sand deserts.

In iunfavourable years with low precipitation and strong winds sand range lands are easily degraded. The area of shifting sands increases which results in a severe desertification of fertile soils. Our data available since 1940 to this date shows that the area of shifting sands on former rangeland areas has reached 3,8 thousands square kilometers. This process is undoubtably connected with prolonged drought period in registered in Central Asia.

As investigation shows, unsound and extensive use of territory for animal-breeding and transport facilities contributes to desertification, as well as uncontrolled deforestation for fuel needs.

In order to control desertification it is important to develop and implement scientifically based economic plans.

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RANGELANDS MANAGEMENT IN THE PHILIPPINES*

JOEY E. AUSTRIA**

I. INTRODUCTION

The Republic of the Philippines is a country in Southeast Asia composed of about 7,100 islands. It has a total land area of 30 million hectares, 15.3 million of which are forest lands.

The Philippines' rangelands are a vital natural resource because they serve as the cheapest source of feed for the country's livestock industry; they serve as watershed for important water systems; they serve as habitat of wildlife and a place for game hunting and recreation; and they serve as ecological niche beneficial to micro-organisms responsible for soil development and nutrient cycling.

Due to the ecological importance of rangelands, grazing therein is governed by specific rules and regulations to protect and preserve their productivity and ecological stability with the ultimate objective of optimum production.

The continuous demand for forest products, coupled with widespread slash-and-burn agriculture (also known as swidden farming) by forest occupants as well as by indigenous forest settlers, has helped increase the area of rangelands. Forest renewal could not always cope up with the rate of forest destruction. Hence, many forested areas have become grasslands and brushlands, making the management of rangelands an important forest activity in the country.

II. FEATURES OF PHILIPPINE RANGELANDS

Rangelands in the Philippines cover about 2.9 million hectares. Since grasses are the predominant vegetation, rangelands are generally classified into

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* Short report presented during the Seminar on Rangelands Improvement in the Arid and Semi-Arid Zones: USSR- 18 May to 06 June 1987.

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any of the following grassland community types: a) Imperata cylindrica type; b) Themeda triandra type; c) Capillepedium parviflorum type; and d) Chrysopogon aciculatus type. Many rangelands are also interspersed with patches of second-growth forests and brush/weed species such as Chromolaena odorata, Lantana camara, Mimosa indica, Solanum ferox and Pteridum aquilinum.

The soil in the rangelands are usually severely eroded and are very shallow. They have low nutrient content, particularly nitrogen and phosphorous, and many are highly acidic. This is due to the constant leaching of the soil surface brought about by poor vegetative cover.

There are two climatic seasons in the Philippines namely, rainy from May to October, and dry from November to April. This climatic pattern accounts for the dramatic changes in rangeland vegetation. During rainy seasons, rangelands have verdant vegetation while during summer, rangelands become parched and dry.

III. GRAZING IN RANGELANDS

In the Philippines, rangelands are part of the public domain and grazing therein is opened to private individuals under the leasing system practiced by the Government. Under this system, the Government and any qualified individual execute a lease agreement whereby the lessor (Government) allows the lessee (private individual) to conduct grazing activities and introduce improvements in a given area subject, however, to certain terms and conditions. Any violation of the terms and conditions will lead to the cancellation of the lease agreement and forfeiture in favor of the lessor of any improvement introduced by the lessee in the leased area. The term of the lease is for 25 years, renewable for another 25 years. The maximum area of any lease is 2,000 hectares and the minimum area is 50 hectares. Any grazing land below 50 hectares is subject to a pasture permit which is renewed annually.

Not all rangeland areas in the Philippines could be leased for grazing purposes due to the following reasons:

1) Grazing is allowed only in areas with slopes of less than 50% to prevent serious soil erosion; many of the rangelands have steep slopes, hence, they could not be opened for grazing.

2) Many rangelands are interspersed with patches of cultivation by forest occupants or with scattered settlements by ethnic groups.

3) Some rangelands have been established as reforestation projects or delimited for industrial tree plantations, agroforestry, or tree farms.

4) Some rangelands are within watershed reservations which have been closed to commercial grazing.

As of May 15, 1987, there are 1,022 grazing leases and 110 pasture permits in the Philippines. These have a total area of 434,688 hectares and 18,419 hectares, respectively.

IV. PROBLEMS

Rangeland development and management are affected by the following problems:

1) Many rangelands have been invaded by <u>Chromolaena odorata</u>, a poisonous weed species. This has resulted to the reduction of the carrying capacity of affected pasture areas. This weed species hinders the growth of palatable forage species, reduces the mobility of livestock, and, when eaten, causes diarrhea and eventual death of livestock. Many affected pasture areas have been abandoned as the eradication of this weed species has become next to impossible due to its prolific growth and regeneration habits.

2) Many rangelands have severe occupancy problems. Population pressure and lack of employment opportunities in the rural areas of the Philippines compel people to engage in marginal agriculture and in so doing, rangelands become the target for their activities.

3) Native grass species have low herbage yield which result to low carrying capacity of pasture areas. The stocking rate of native grasslands is roughly one (1) head of cattle per hectare. With this rate, the annual cattle production for the whole country will not exceed 500,000 heads of cattle. This livestock pro-

duction hardly meets the annual beef demand of 168,000,000 kilograms which is roughly equivalent to 672,000 heads of cattle.

4) Many grazing lessees depend on nature in the development and management of their pasture areas. They lack interest in developing or improving the natural soil cover to increase the grazing capacity.

5) Since many rangelands are located in remote areas, lessees and permittees are often harassed by lawless elements. This peace and order problem is one of the reasons why many pasture areas have been abandoned or left undeveloped.

V. PROGRAMS/PROJECTS

The management and development of rangelands is the responsibility of the Bureau of Forest Development, a line agency under the Department of Energy, Environment and Natural Resources. This function used to be directly under the Range Management Section of the said Bureau. Realizing the growing importance of the role of range management in forest conservation and livestock production, the Section was recently upgraded into a Division to have a larger manpower and a greater part in policy and decision making.

Further, the regulations and guidelines on the administration, management and disposition of rangelands for grazing purposes have also been updated with the following policies/regulations:

1) Zonification of grazing lands to provide stability of land use and security of tenure;

2) Deputation of ranch employees as forest officers;

3) Collection of inspection and survey fees;

4) Increase in the application fees and annual rental; and

5) Issuance of provisional pasture permits pending issuance of a regular lease agreement.

In 1976, the Forest Range Development Program was launched. This program has five components, namely: 1) manpower development; 2) survey and reclassification of areas covered by pasture leases and permits and potential grazing areas; 3) range improvements; 4) development of range management plans; and 5) continuous range condition analysis. The training component has so far, produced 184 graduates who have become well-versed in range management. Twenty-one (21) of them are at present full-time team leaders doing land capability surveys and reclassification of rangelands. So far, the teams have evaluated a total area of 1,263,559 hectares of existing and potential grazing lands.

The establishment of forage seed production areas and eradication of weed species are the two main activities under the range improvement component. Thus far, eight forage seed production areas have been established throughout the country to ensure a continuous supply of planting materials of high-yielding grasses and forage legumes for distribution to grazing lessees and permittees.

As far as eradication of weeds is concerned, a study on the eradication and control of Chromolaena odorata by means of biological, chemical and mechanical methods has been conducted. The results of said study have been disseminated to pasture lessees and permittees to serve as their guide in the control and eradication of this poisonous weed species. However, the chemical method, which is the most effective, could not be readily adopted in view of the prohibitive cost of herbicides.

A detailed guideline in the preparation of a grazing management plan has been developed to guide grazing lessees and permittees in the systematic development and management of their grazing areas to improve range productivity and prevent accelerated soil erosion. It is now mandatory for all grazing lessees and permittees to reforest steep portions (having a slope of 50% and over) of their areas, to plant trees within a strip along the pasture perimeter and along the banks of creeks, streams and/or rivers within their areas. Likewise, they are required to gradually improve the natural soil cover by introducing high-yielding grasses and forage legumes. In line with this requirement, pasture lessees and permittees have been urged to undertake range fertilization. However, many could not do so because of the prohibitive cost of chemical fertilizers. On the other hand, organic fertilization has not yet been extensively practised due to the lack of technology in the cheap and simple production of non-chemical fertilizers. These explain why the introduction of high-yielding forage species has been slow.

The last component of the program, range condition analysis, has not been carried out as yet due to financial constraints on the part of the Government.

Another program which contributes to the protection of rangelands is the Integrated Social Forestry Program. This is aimed at containing occupancy and cultivation within forest lands by farmers. In this program, deserving landless upland farmers who have been occupying portions of the forest lands as of December 31, 1981 and have developed the same as their primary sources of livelihood are considered by the Government as partners in the protection and development of forest resources. They are issued renewable 25-year stewardship certificates over their cultivations with the agreement not to expand their clearings and to help in the conservation and protection of their clearings and adjacent areas. Currently, the program is indirectly helping in the solution of peace and order problems in many areas of the Philippines. This is so because many peace and order problems are economic in nature and with this program, many upland farmers are given the chance to legally occupy and cultivate their own areas, thus providing them alternative sources of livelihood.

Related to this, the Government is at present doing its best to solve directly the nationwide problem on insurgency and lawless elements. With the solution of this problem, full development of rangelands is expected to follow.

VI. CONCLUSION

In the final analysis, rangeland management in the Philippines is relatively new considering that it has only been given emphasis during the last decade. Although appropriate programs have been formulated, these could not yet be fully implemented due to many constraints. It may be noted that the Philippines is at present still trying to get up on its knees after having been mismanaged for quite sometime.

With this seminar, I am optimistic that I could acquire additional knowledge and skills in rangeland management which could be helpful and applicable in my country.

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