International Cooperation to Combat Desertification
General Assembly Resolution 3337 (XXIX)

CASE STUDY ON DESERTIFICATION
IRAN: TURAN

May 1977

Prepared in the Department of the Environment, Tehran

SUMMARY 7

1. INTRODUCTION 10

BACKGROUND 10

IRANIAN CONSCIOUSNESS OF DESERTIFICATION 13

THE TURAN PROGRAMME 14

DESCRIPTION OF THE STUDY AREA 16

DESERTIFICATION PROBLEMS 17

CRITERIA OF RELEVANCE 17

BIASES 17

2. VEGETATION 18

POPULATION AND DISPERSION STUDIES OF DOMINANT SPECIES . . 20

DENDROCHRONOLOGICAL STUDIES 22

SUPPORT FOR HYPOTHESIS OF INTRA-SPECIFIC COMPETITION . . 22

STUDIES OF GERMINATION AND ESTABLISHMENT 22

PALYNOLOGICAL STUDIES 22

3. TECHNOLOGIES 23

PASTORALISM 23

TRANSHUMANT PASTORALISM 23

SEDENTARY PASTORALISM 24

ECOLOGY AND ETHOLOGY OF DOMESTICATED ANIMALS 25

AGRICULTURE 27

PRINCIPAL CROPS 27

IRRIGATION 27

DRY FARMING 28

BUND FARMING 28

FLEXIBILITY AND INTERDEPENDENCE 28

4. EVIDENCE OF DESERTIFICATION 29
DISTURBANCE VEGETATION 29
ARGUMENTS FROM THE DISTRIBUTION OF FAUNAL SPECIES . . . 33
GRAZING PRESSURE 34
5. HISTORICAL RECONSTRUCTION 34
ARCHAEOLOGICAL EVIDENCE OF SETTLEMENT 35
INDUSTRIAL ACTIVITY 36
HISTORICAL EVIDENCE 39
THE LAST YEARS OF KHAR 42
THE USE OF OUTLYING SETTLEMENTS 42
PREDATORS 43
NOMADIC PASTORALISTS 43
FORTIFIED VILLAGES 43
THE SAND 44
THE IMPACT OF CAMEL GRAZING 44
THE EFFECTS OF MOTORISATION 44
THE ESTABLISHMENT OF SECURITY 45
6. ECONOMICS 46
THE NATIONAL CONTEXT 46
PASTORALISM IN TURAN 50
THE TRANSHUMANT FLOCKS 51
SEDENTARY PASTORALISTS 52
AGRICULTURE 52
OBSTACLES TO THE DEVELOPMENT OF THE ECONOMY
OF TURAN 53

7. THE QUALITY OF LIFE 55

8. CONCLUSION 57

RECOMMENDATIONS 57

BIBLIOGRAPHY 59

APPENDICES

APPENDIX 1 Plants of the Turan Biosphere Reserve 61

APPENDIX 2A *Zygophyllum eurypterum* Dimension and Age Data 67

APPENDIX 2B *Zygophyllum eurypterum* Ring Analysis 68

APPENDIX 3 Mammals of the Turan Biosphere Reserve 70

APPENDIX 4 Climatological Data for Towns of the Northeast of the Iranian Plateau 72 (1961-1973)

APPENDIX 5 Population, Resources, Services of Central Tauran 1966 and 1973 Census 73

APPENDIX 6 Components of the Turan Programme 77

APPENDIX 7 Preliminary LANDSAT Analysis of Sand and Settled Areas—Turan Biosphere Reserve 78

APPENDIX 8 Expanded Legend for Preliminary Vegetation Map of Turan Biosphere Reserve. 86

APPENDIX 9 Ecology of *Gazella dorcas* (Jebeer) and *Gazella subgutturosa* (Goitered gazelle) in the Turan Biosphere Reserve - Preliminary Report . . 90

MAPS

1. Map of the Iranian Plateau

2. Topographic Map of Turan Biosphere Reserve and
   Preliminary Vegetation Map with legend

3. Map of Central Tauran

4. Map of Khar and Tauran

SUMMARY

Of Iran's 1,650,000 km^2 all but the Caspian littoral and parts of the northwest fall into Meigs' semi-arid, arid or extremely arid classification, and most of this area, outside the small proportion (5%) that is cultivated, is considered desert by Iranians. Despite harsh conditions—extremes of temperature, wind and aridity—this territory has been the scene of significant human activity since the end of the Pleistocene, and has lain at the centre of a culture area and a major civilisation since the first millennium B.C. This long history of human use has led to a situation where in most cases natural and cultural factors cannot be readily separated in the investigation of problems of desertification. No precise figures are available for the extent of desertification in Iran, partly because opinions differ on the definition, but all sources of information indicate that it is considerable and accelerating. Increased pressure from grazing and the spread of dryland farming is the most obvious factor. This case study looks beyond this factor in search of underlying social and natural causes.

Exploitation of arid lands is of great importance for Iran's future. The rate of population growth and economic expansion demands that Iran plan for maximum sustainable productivity throughout her total territory. Although the per hectare productivity of the deserts and their environs is low, their overall potential for production and for settlement is considerable. Recognising this the Department of the Environment formulated a comprehensive programme of ecological research, experimentation and management aimed at the improvement of land use in the central deserts. In order to prepare for the future, this programme seeks to protect and conserve the natural resources of Iran's arid lands and to combat processes that would lead to desertification.

The Iranian deserts are an excellent laboratory for the investigation and experimental treatment of general problems of desertification deriving from human activity and exploitation of resources in arid and semi-arid lands. They provide a range of examples of desertification, historical and current, in the decline and disruption of physical, biological and socio-cultural systems.

As the prototype of a general programme, an area of two million hectares on the northeastern margin of the central deserts was selected for intensive study and experimental management.

This area—known as Turan—was already a protected area and has since been formally designated a Biosphere Reserve. It was selected for its diversity, representativeness, and relative economic importance and accessibility. Processes of desertification that are presently evident include deforestation, decline of vegetative cover, soil erosion, and sand accumulation and movement. These processes are closely interrelated with others that are less evident, but equally adverse for the ecology of the area, including changes in population, and in the national social and economic context, such as the labour market, the meat market, communications, investment, and legislation. The causal relationships between these processes, though often taken for granted, are complex.

The present case study is taken from the Turan Programme. It focuses on an area of 1,000 km2 which constitutes a microcosm of the whole, and demonstrates in historical perspective several of the cultural, biological and physical processes that involve the increase and decrease of productivity and living standards. In this small area—an island of agricultural and pastoral production almost surrounded by unproductive sand and playa—both the vegetation and the land forms have been significantly modified by human activity in the form of traditional technologies of irrigation, dry farming and pastoralism. The case study discusses this modification and addresses the following questions:

a) to what extent is desertification due to human activity in vulnerable areas determined by economic and political events and processes in urban or less arid areas?

b) to what extent is it possible to generalise about the association of particular socio-economic conditions with desertification?

c) what effects—positive or negative—are particular traditional land use systems and value systems likely to have on ecological equilibrium?

Desertification is not new, but it is more critical than before. Old problems are now exacerbated by the increasing differentiation between rates of socio-economic change in city and desert, which leads to a growth in cultural prejudice that in turn reinforces neglect and abuse of the deserts and their margins.

In drawing conclusions from the case study, special emphasis is given to the role of exogenous factors. In order to counteract processes of desertification, large scale planning and long range management procedures are required that would include desert and related non-desert areas, and would apply the same ecological as well as economic standards to both. Within this general context, the case study argues that in processes of desertification in the history of Turan cultural, socio-economic and natural factors have been closely interrelated and should be treated together. At another level, the case study suggests that certain socio-economic and cultural conditions are more likely to be associated with degradation of resources than others.

In the light of these conclusions, the case study recommends that the struggle against desertification should be conducted through management programmes based on the reconstruction and evaluation of the ecological history of vulnerable areas. Such programmes should be fully comprehensive and integrated on three levels. They should integrate:

a) the theoretical and field orientations of the physical, biological and social sciences

b) the functions of research, experimentation and management

c) the participation of the research team, the local population and relevant decision makers

Careful attention should be given to building on existing technologies, supporting innovation within existing traditions, and introducing modern or exotic technologies only where the payoff and the risk are well defined. Emphasis should always be given to increasing the interdependence and range of interlocking systems, and to encourage livelihood diversification and flexibility. In more specific terms, in order to prepare for and plan human exploitation of vulnerable areas in the future, and reduce the risk of desertification to the minimum, it is necessary to monitor natural resources, prepare for the effects of predictable desertification processes, and finally by provision of facilities, including public education, and communications, to seek generally to reduce the basis of cultural discrimination between urban and rural living in arid zones.

1. INTRODUCTION

BACKGROUND The Iranian Plateau exhibits a long and varied history of desertification. Comprising over one and a half million square kilometres of high arid country, it includes most of Iran and extends into southwestern Afghanistan and western Pakistan. It lies between the major river systems of the Oxus and the Indus on the east and the Tigris and Euphrates on the west, and has functioned historically as a crossroads for population movements between central Asia and northeast Africa and Arabia, and between the Indo-Pakistan subcontinent and Europe. These movements have given rise to relationships and affinities that are obvious both in the flora and fauna and in cultural features. Some ten millennia of human activity since the domestication of plants and animals have in generally accepted opinion led to serious reduction in the productivity of the Plateau's natural resources, specifically in soil and vegetative cover. However, though the decline may have been continual, it has not been uniform and much can be learned from reconstruction of the ecological history of the Iranian Plateau that will be of value in the treatment of desertification problems elsewhere.

Although the Plateau is in many senses an ecological unit, many of its human use systems extend beyond the high mountain ranges that define it and its history is closely interrelated with that of the surrounding lowlands. It is not yet possible to produce a synthesis of the earliest land use patterns on the Plateau or to find complete agreement on its pristine natural ecology, but there is evidence of human activity for at least 100,000 years, and of agriculture and pastoralism for the past 10,000 years. The development of irrigation systems on the major rivers around the outside of the Plateau, starting with Mesopotamia in the late fourth millennium, gave rise to a qualitative differentiation between life in the denser populations and more complex social systems of the lowland cities, and the sparser, simpler structures of the Plateau, where no such technology that would allow the development of large dense populations was yet feasible.

This type of ecological differentiation provides one of the themes of this study, since it illustrates the role of exogenous factors in processes of desertification. In many cases, and on smaller scales, it can be shown to lead to cultural discrimination by large dense populations against the relatively small and scattered populations of arid and semi-arid lands.

Changes in this ecological relationship between the Plateau and the Mesopotamian lowlands is not perceptible until over two millennia later when evidence appears of urban developments on the relatively meagre, largely seasonal rivers on the inside rim of the Plateau. These cities do not appear to have flourished until the period of economic and political expansion of the Achaemenian empire (6th - 4th centuries B.C.) which coincided with the introduction of a new irrigation technology: the *qanat*.

The *qanat*—known east of Iran as *kariz*, and in North Africa as *foggara*—is an underground channel which brings ground water out onto the surface, where it is required for irrigation, by means of gravity flow. It is built and maintained by means of wells which give access to the channel every 10 to 50 metres along its course. Qanats require considerable and long term investment. Construction takes years, even generations, and regular maintenance is required to maintain the flow. Investment on this scale is not within the means of small sparse populations with simple economies. The investment required for the construction of major qanats could only be managed from within the economies of larger settlements. Qanat building was thus a major means of colonising new areas, and constitutes a specific exogenous factor in the ecological history of many localities on the Plateau. It led to a new cultural differentiation—in this case, between the more fertile and better watered alluvial fans around the inside edge of the Plateau and the more arid interior.

The introduction of qanat technology revolutionised the settlement and land use patterns of the Plateau. The next comparable technological innovation was mechanisation. During the long period of technological stability and consequent stability of land use patterns between these two processes—which may be dated arbitrarily at 750 B.C. and 1960 A.D. respectively—the surface water available from rivers and springs was probably constant except for variation between wet and dry years, and the quantity, quality and distribution of water sources on the Plateau could vary only along a single parameter: the varying ability at different times and in different places to make the investment necessary for the construction and maintenance of qanats and other largely ancillary irrigation works.

The greatest period of investment appears to have been under the Sassanian empire from the third to the seventh centuries A.D. The Arab conquest in the 7th century seems not to have had any permanent effect on investment, which began to deteriorate noticeably only in the period immediately preceding the invasion of the Mongols and then dropped significantly as a result of their invasion in the 13th century.

Investment is used here in the sense of the expenditure of labour and in some cases materials for the modification of the environment in order to increase the productivity of natural resources. Various forms of irrigation engineering require the most investment, dry farming requires relatively little, and pastoralism may require none at all unless it is necessary, for example, to increase the number of watering points by digging wells. It is possible to generalise that the greater the investment required by a particular technology the less likelihood of desertification because the population, having more at stake, monitors productivity more carefully.

There is also a sense in which pastoralists may be considered to have made and be maintaining an investment in their rangeland (beyond increasing the number of watering points)—if grazing has modified the vegetation, or maintains it in a subclimax condition, in such a way as to increase long term pastoral productivity. The significance of fluctuation in levels of investment for understanding desertification is a second important theme in this study. It is important to note that this also is generally an exogenous factor, depending on the interest of urban populations.

The ability and readiness to make such investments varied according to larger political and demographic conditions. Qanats went out of use; villages moved. The total number of villages and towns fluctuated. Variations in investment corresponded with variations in the degree of pastoral activity compared to agricultural activity. But the introduction of qanat technology had opened up the Plateau to a set of human use systems based on a specific range of agricultural and pastoral technologies which scarcely changed until very recently. The background to the present desertification problems in Iran was formed cumulatively through that period of nearly three millennia.

During the 1960's the situation changed. The change in technology brought with it a change in investment patterns. The most obvious cause for the change was mechanisation, though the role of other factors such as population growth should not be ignored. Mechanisation allowed the use of ground water for irrigation by means of motorised pumps. Since it is cheaper to buy a pump than build a qanat, but to keep the pump operating requires continuous expenditure for fuel and maintenance, people tended to move from qanats to pumps and in so doing, to involve themselves much more intimately in the larger economic system. Thus, the economic dependence of marginal lands was increased by mechanisation, which led in certain areas to intensified use with lower investment. Increased desertification was associated with this process.

The history of the areas vulnerable to desertification on the Iranian Plateau, and probably elsewhere, since the "urban revolution" in Mesopotamia 3000 B.C. should be studied in the context of larger social, economic and political developments, the economic and administrative dependence of sparsely populated areas on the populations of more densely settled land, and resultant cultural discrimination. However, it is also necessary to bear in mind that this dependence is one aspect of a symbiotic relationship. The intimacy of the relationship between the arid center and the fertile margins of the Iranian Plateau has increased considerably as the result of the mechanisation of transport and communications. The use of arid rangelands by transhumant pastoralists who summer in the high mountain pastures on the periphery has been greatly facilitated. The use of these rangelands is now directly related to the urban meat and dairy markets. The compensation of shepherds is now determined through competition with urban labour markets.

Of Iran's total territory of 165 million hectares, 125 million fall under the heading of rangeland which includes the uncultivated and uninhabited land—forest, mountain and desert. Iran's rural population in 1974 consisted of 18,800,000 which is equal to 58% of the population. It was distributed among over 65,000 settlements of which more than two-thirds have a population of less than 250, and almost one-third has less than 50. These small scattered populations are a human resource, without which the national resources of Iran's arid lands would produce less. The figures alone are sufficient to show that the degree of interdependence between arid and semi-arid and more fertile areas in Iran makes desertification a national and a human problem. This problem is more critical now than ever before.

IRANIAN CONSCIOUSNESS OF DESERTIFICATION

This brief survey suggests a long period of equilibrium. However, there is evidence to suggest that not only were there great fluctuations in population and investment, but overall deterioration in soil and vegetative cover during this period was considerable. The proportion of Iran affected was sufficient to create the consciousness of a national problem already in the fifties. The disappearance of wildlife and the severity of sand problems and dust storms were among the first factors to attract general attention. The long drought at the end of the fifties and the beginning of the sixties ensured that desertification would receive comprehensive attention in the future. It was at this time that Iran began to embark on a programme of intensive economic development and, a little later, of administrative revolution.

Towards the end of the fifties specialised departments were formed in the Ministry of Agriculture and the University of Tehran, which embarked on long term programmes of sand stabilisation, watershed management, range improvement, wildlife conservation and general programmes of desert research. In 1962 a programme of land reform was begun; in 1963 all forests and rangelands were nationalised, and in 1967 the nationalisation programme was extended to the country's water resources. These administrative and legislative measures—once again exogenous factors—had far-reaching effects on man-land relationships throughout those parts of Iran vulnerable to desertification. In combination with the effects of the drought and increasing availability of motorised equipment, they set the scene for significant changes in settlement and land use systems.

These measures were radical and far-sighted but their effects have not always been restricted to the benefits that were planned. For example certain details of the Land Reform Law combined with the availability of tractors allowed the extension of dry farming onto unsuitable soils (including vertical ploughing of hillsides), which led to increased soil erosion. Nationalisation of rangelands, although it had definite social benefits, has reduced the pastoralists' flexibility, and perhaps also their sense of ecological responsibility—essential features of efficient land use in arid zones--and removed an element of personal investment. It is noteworthy that one result of both of these measures was to reduce the need for investment as a basis for exploitation, and that degradation ensued.

Interest in the deserts generally increased through the sixties among intellectuals and planners, and in the seventies a number of government institutions have established special departments or programmes responsible for the desert areas. The responsibilities of these agencies vary in their emphasis on natural and human factors, and suffer generally from the lack of an overall coordinating and planning authority, specifically and actively concerned with vulnerable areas.

The Department of the Environment, which was established in the Prime Minister's Office in 1974, has shown a special interest in desertification as part of its general programme for the conservation and study of representative ecosystems. This programme includes the establishment of a network of parks and reserves which presently totals 8 million hectares and is divided into four categories of which two are important here: 1) Protected Areas, which are lands of strategic conservation value set aside for management, and 2) Wildlife Refuges, which, in addition, support significant wildlife populations (IUCNNR 1976). Nine of these areas have recently been designated Biosphere Reserves for the purpose of participating in the coordinated worldwide programme of conservation and research organized under the Man and the Biosphere Programme. Concern for the human factor in these areas set aside for conservation in the more arid parts of the country led the Department in 1975 to institute a programme of research aimed at the development of management and monitoring programmes paying special attention to the problem of maintaining a balance between conservation, productivity and socio-cultural viability.

THE TURAN PROGRAMME In order to concentrate this research effort a pilot programme was started in an area chosen for its representativeness. The Turan Protected Area, which includes a Wildlife Refuge, and has now been formally declared a Biosphere Reserve, covers 1.8 million hectares on the northeastern margin of the central deserts. Historically it has formed a no-mans-land between two major provinces (Khorasan and Qumis), and was selected for protection because the potential richness of its vegetation was judged an excellent basis for the development of alternative methods of conservation. In May 1971, it was assessed as severely degraded, partly as the result of an excessive population of domestic animals which were in relatively poor condition. Shrubs were heavily browsed and there was an almost total absence of ephemeral and perennial forbs and grasses.

In order to deal appropriately with the human factor, the human populations outside the Biosphere Reserve, which have traditionally made use of the area, and the human use systems that overlap its boundaries were included in the study. It is these systems, as much as the range of representative habitats in the Reserve, that make this choice of study area particularly significant, since they demonstrate the close economic interdependence of urban, mountain and desert habitats on the Iranian Plateau.

The Turan Programme sought to bring together representatives of all the academic disciplines that could be brought to bear on the history of the interaction of human activity and the natural resources of the area, and formulate a theoretical framework or set of criteria that would integrate their work and lead them to focus on problems of long term management. Specifically, it was aimed to generate a dialogue between representatives of the natural, human biological, and the social sciences. From the beginning it was decided to seek out scholars both in Iran and abroad whose personal research interests and experience fitted into the developing framework of the Programme and to facilitate their work, rather than hire "experts" for limited periods. In this way it has been possible to build a research team with long term interests in the Programme and long experience in addressing the problems it deals with, without cutting them off from normal communication with their disciplines.

This policy has the disadvantage that it does not produce predictable results at predictable times. Nevertheless, the Programme is gathering momentum, and an outline of the components that are in progress and those that are still sought is given in an appendix. The present study has been produced out of current work, mostly preliminary field reports with little time depth of recording. Despite the obvious drawbacks of this type of data, it has been deemed valuable to produce this study from it at this stage because of the comprehensive ecological character of the Programme and its emphasis on the problems of the human component.

DESCRIPTION OF THE STUDY AREA The Turan Programme for Integrated Ecological Research and Management in the Central Deserts of Iran covers the Turan Biosphere Reserve, neighbouring populations that have traditionally used the area and adjacent land forms that have direct relevance to the Reserve such as the sand sea on its eastern boundary. The Reserve presents a variety of habitats, including three extensive plains at different altitudes, varying from 700 to 1400 metres, a saline river system, three mountain systems rising to a maximum of 2200 metres, large areas of broken country and some 200,000 hectares of sand including moving dunes, and a vast expanse of barren playa. Climatological information is incomplete both in time depth and geographical coverage. Published syntheses of existing data show the 200 mm isohyet passing through the northern part of the area. The southern plain probably receives less than 100 mm. A light snow covering appears on the higher mountains for two to four months of the year and snow lies on the higher northern plains for short periods. Only the central salt river (*Kal-e Shur*) flows at least intermittently throughout the year. Rainfall of several millimetres at a time generates sheet run off and wadi (arroyo) flooding. Springs occur on the southern slopes of the mountain ranges. Soils are generally light and sandy except for solonchak in the playas. Vegetation varies according to land form, and, secondarily, according to human activity patterns. Woody shrubs predominate with ephemerals and annuals growing largely in their protection. Perennial cover over most of the plains varies between 5 and 40%. Flora and mammalian fauna generally show great affinity to the Kara Kum in Soviet Turkmenistan to the north. Vegetation is heavily modified by human use in the vicinity of permanent settlement and winter sheep pens, and has been characterised as anti-pastoral throughout the area.

The dominant form of land use is pastoralism of various types, sedentary and transhumant. At present some 150,000 sheep and goats (1975-6 figures, see Appendix 5 for earlier figures) winter in the area from November to May, of which 25,000 belong to the local settled populations and remain in the area through the summer. Local populations also keep camels, donkeys and cattle. Apart from the 125,000 sheep and goats that spend the winter only in the area, most of the local poplulations move their animals in and out of the area seasonally and according to general conditions. Agriculture is also important around settlements and is conducted by means of irrigation, from qanats, springs, diversion of run off and by direct rainfall. The total human population that has at least a potential interest in some part of the area may be estimated at 20,000. Of these, some 2000 in the two groups of villages known as Khar and Tauran on the eastern margin of the area are intimately involved with it. There is a close relationship of interdependence between the settled and transhumant populations.

DESERTIFICATION PROBLEMS Preliminary surveys suggested that the natural resources of the area are deteriorating and the quality of human life is falling further behind that of neighbouring less arid areas. The vegetative cover has been judged to be degraded and possibly still deteriorating in quality and quantity as the result of excessive exploitation by both settled and transhumant populations, which was causing gradual elimination of the more palatable components, increase in wind erosion, and sand accumulation and movement. The human population itself appeared to be declining, and threatened in the long term to cease to be viable owing to the migration of the youth to the cities. Transhumant pastoralists find it more and more difficult to recruit shepherds. Medical and other social services are almost non-existent.

CRITERIA OF RELEVANCE This study makes use of preliminary results from the investigation of these problems. However, it is recognized that evaluation of conditions and trends in these complex and interlocking ecosystems and human use systems can be made only according to certain criteria, not according to absolute standards. The criteria implicit in this study derive from the view that since Iran can cultivate only 10% of its total 165 million hectares in order to support a population of 35 million presently growing at 2.8 — 3.0% per year, and counts 100 million hectares as arid rangelands, it must plan for maximum sustainable productivity from the natural resources throughout its total territory. The problem is how to achieve this aim while also developing the highest possible standard of living for the total population. An example of alternative methods would be strategies to concentrate the population into settlement centres large enough to support the full range of services and facilities recognised necessary to civilised life, *versus* relatively homogeneous distribution of the rural population in order to facilitate the most efficient use of resources. A second example lies in the alternatives of maximum diversification of land use *versus* zoning of specialised land use patterns.

BIASES Besides the short history of the study and the preliminary and incomplete nature of the results so far, the possibility of certain biases must be recognised. The most significant of these derives from the recent pattern of precipitation. 1970-1 is known to have been an extra dry year, but the actual precipitation is not known from anywhere inside the area. Since 1971 there has been a succession of relatively good years. The one professional ecologist who saw the area in spring 1971 and in the subsequent years states that the vegetation now presents a different impression, but it is not possible to quantify this difference in terms of either biomass or precipitation.

The second bias could be more serious. It derives from the effects of legislation concerning use of natural resources generally, and in the area particularly, and of its implementation. Specifically, although no holdings were large enough to be affected by Land Reform, all rangeland was nationalised as an integral part of the Shah-People Revolution that was begun in 1963. Since then there has been no free market in grazing. Secondly, the fact that Turan was given the status of Protected Area, that part of it was reclassified as a Wildlife Refuge in 1976, and the whole was declared a Biosphere Reserve in 1977, held implications for the local populations of protection from or restriction of grazing, and is known to have affected their pastoral and agricultural strategies. These legislative influences are exogenous factors whose effects are difficult to evaluate or quantify, and to the extent that they do not derive from market forces and are due to factors that do not derive from the relationship between the populations of the deserts and the more fertile margins, they are different from the exogenous factors emphasised in this study.

In what follows, the vegetation structure of Turan is first described. This description serves as a basis for an account of the main productive technologies in the area and their distribution. Then the arguments for desertification are given and these arguments are given historical perspective in a section that assembles the evidence for the ecological history of the area. Finally, the situation is assessed from the point of view of economic efficiency and the quality of life of the existing local populations. Throughout it is to be remembered that the data derive from preliminary reports of studies that are still in progress.

2. VEGETATION

The Vegetation Map shows five basic vegetation types in the Turan Biosphere Reserve:

1) *Salsola-Zygophyllum* communities generally in the plains with 5-40% cover up to about 1300 metres

2) *Artemisia-Ephedra-Amygdalus* communities, usually above 1300 metres

3) *Astragalus-Cousinia* communities on the higher mountains, descending to about 1400 metres on northern slopes

4) *Stipagrostis-Calligonum* communities on fixed or shifting sands in some cases up to 40% cover

5) Halophytic vegetation on playa margins, sometimes with dense annual cover up to 90%

This is a first tentative categorisation formulated before the final tabulation of field inventories and comparison with data from similar areas such as the Kavir National Park (a similar reserve approximately 300 kilometres to the west in which all human activity ceased six years ago, and which in the continuation of the Turan Programme will be used as a control area. It is based on identifications made for *Flora Iranica*, but some names are only provisional and further identification is required.

A list of species so far collected and identified is given in Appendix 1. It is worth mentioning that no new species have been discovered in Turan, and so-called narrow endemics are poorly represented even in the mountainous parts of the area. Species rather largely distributed through the most arid parts of the Iranian highlands prevail and larger genera are usually represented by their hardier representatives.

The categorisation on the map is simplified both because of the demands of presentation at this particular scale and because of the basic theme of this study—vegetation as the most significant interface between human activity and natural processes. Simplified to this degree the Vegetation Map conforms usefully with the variation in human land use. It also fits the variation in the degree of vulnerability to desertification processes. For example, types 1, 2 and 4 are used as rangelands by transhumant flocks, except in the close vicinity of villages where they are used as pasture for village flocks and in some cases historically for dry farming.

In fact the vegetation is considerably more complex, and as work is continued it is expected that finer cartographic differentiation of vegetation types will be desirable. In the present map dominant communities are somewhat over-emphasised. In fact throughout the area the various plant communities are arranged in a mosaic according to a combination of geomorphological features and variations in the history of human use, which in turn is based on the variation of natural features. For instance in areas where rock outcrops predominate, such as the predominantly limestone ranges, only the vegetation of that particular habitat is indicated, and the different communities on the slopes with deeper soil accumulation or in the valleys with better water supply, do not appear. Even the comparatively homogeneous vegetation of the extensive plains is interspersed by specific variant communities in the deeper runnels, along the sides of dry rivers and on the gravels of the larger dry river beds. Similarly, small scale variation due to concentration of human exploitative activities could not be shown, for example, around winter sheep pens, spring and early summer milking stations and the immediate environs of the smaller settlements. Finally, because of the vastness of the area it was necessary in several cases to resort to extrapolation, based mainly on contours, and broken lines were used in some cases to indicate uncertainty of border lines between communities.

POPULATION AND DISPERSION STUDIES OF DOMINANT SPECIES

Some researchers prefer to classify the Turan vegetation as degraded steppic rather than sub-desertic. Some of their reasoning will be given later in the discussion of the effects of human activity on the vegetation (Chapter 4). As part of an investigation of the basis of this classification, a series of studies of the population structure and dispersion of dominant species was planned. *Zygophyllum eurypterum* was chosen for the first study since its dominance over large areas gives the vegetation of Turan one of its most characteristic features. An understanding of the interaction between human activity and the population structure and distribution of this species would be an important breakthrough.

Because of the height of the shrub and the deep green colour of the leaves between March and July it gives an exaggerated impression of dominance. One researcher was struck by the regularity both of the distribution and of the size of the plant. The subjective impression that small plants were scarcer than larger ones was tested by measurements made upon the 532 plants of this species within a one hectare exclosure on the plain 9 kilometres southeast of Delbar. Height, maximum diameter and diameter at right angles to maximum diameter were measured for each plant (see Appendix 2A). Frequency distribution histograms were constructed for height measurements which confirmed the initial impression that large plants are more abundant than small ones. A frequency peak occurs between 70 and 90 cm, and few plants were found below 40 cm in height.

These data imply either a low germination success of the species or a very high seedling mortality which could pose a threat to the continued survival of this important species. Several possible explanations of the observed data present themselves:

1. Succession. The community may be unstable in the long term and in the process of transition to a different vegetation type. If this were so, one might expect some other species to be regenerating beneath the *Zygophyllum* cover which will eventually replace it. No such contender for dominance was found.

2. Changing physical environment. New climatic stresses, such as drought or temperature may have reduced the capacity of the species to reproduce efficiently. If this were so, one might also expect reduced productivity and this could be checked by annual growth ring measurement. Viable seed is formed, but appears to be heavily predated on falling from the bush, probably by rodents and other seed eaters.

3. Intra-specific competition. If the environment is effectively saturated by the current population of *Zygophyllum*, *i.e.* the carrying capacity has been attained, then it is possible that further recruitment is discouraged by intraspecific competition pressures. These could take several forms, such as toxic exudates in the leaves or roots of the adult plants, or depletion of a resource such as water or minerals by the adults, thus excluding seedlings. If such intra-specific competition pressures exist one might expect a tendency to regular spacing in the population.

4. Changing biotic environment. Some new predatory or pathological pressure may be causing seedling failure. This could result from:

a) A 'natural' predator or pathogen increase. About 34% of bushes have their rooting areas burrowed by rodents. Direct physical damage and seedling (and seed) predation could increase mortality. An unidentified organism bores into the wood of *Zygophyllum*, apparently invading the roots and boring its way through aerial stems eventually to emerge via a small hole. Several small fungi are found to infect the woody parts. None of these organisms appears to have reached epidemic proportions.

b) Increased grazing pressures, mainly from sheep and goats, may be causing increased juvenile mortality, thus causing population instability.

The third hypothesis above can be supported or eliminated by a simple test of dispersion in the plants. Two techniques were employed to make this test. Random bushes were selected on the basis of proximity to random points (determined by random coordinates within the hectare exclosure) and the distance to the nearest neighbour was measured. Results (50 measurements) have been subjected to preliminary analyses and the implications are that dispersion is non-random and tends toward regularity. Secondly, density and cover measurements were taken within 128 5m x 5m quadrats, arranged in a linear sequence outside the exclosure. In a Poisson (random) distribution the variance of such data should equal the mean. So far density data only have been analysed, but this shows a strong departure from randomness towards regularity. If further analysis and research upholds this hypothesis the implications for management of the use of the vegetation are interesting. The population and distribution of this species are not significantly modified by human activity. However, it is possible that human activity has allowed it to establish this dominance, possibly at the expense of better forage species. The nature of the competitive factors remains to be demonstrated.

Mean weight was also calculated and came to 4.86 kg with a standard error of 0.14 kg. The total biomass amounted to 2581.9 kg/ha—a figure which, given the validity of the above hypothesis, is probably representative for this shrub throughout those parts of the area where it dominates.

DENDROCHRONOLOGICAL STUDIES Dendrochronological studies have also begun. The first project was done on the trunks of *Zygophyllum* shrubs harvested from an area 25m x 25m adjacent to the exclosure and six samples from elsewhere in the area. Preliminary results give indications of the climatic record back to 1889 (see Appendix 2B), and demonstrate the potential of this type of study on desert shrubs, but the sample must be enlarged to allow reliable reconstruction of the climatic record.

SUPPORT FOR THE HYPOTHESIS OF INTRA-SPECIFIC COMPETITION It was noted that the age of the harvested shrubs showed no relation to any other measured parameter. This is probably due to the degeneration in height and general size and weight of senile shrubs. A small shrub, therefore, may be very young or very old—which reinforces the hypothesis of intra-specific competition, since the small end of the frequency distribution is inflated by senile members, and young plants are even scarcer than appears from the data on size.

STUDIES OF GERMINATION AND ESTABLISHMENT The clearance of a quadrat adjacent to the exclosure will allow a long term study of the germination and establishment of *Zygophyllum* at a site where according to the hypothesis of intra-specific competition an increased rate of recruitment would be expected.

PALYNOLOGICAL STUDIES Further assistance in the reconstruction of the climatic record will come from palynological studies that have been commenced in the playas.

Results so far demonstrate that pollen is recoverable from these sediments, but further work awaits the formation of a reference collection of pollen.

3. TECHNOLOGIES

PASTORALISM The key to an understanding of the interaction between human activity and the vegetation lies in the repertoire of productive technologies. It has been argued already that this repertoire remained unchanged for over 2000 years up to 1960. In Turan there has been little technological change since that date (except that certain subsidiary technologies have disappeared), but there has been considerable socio-economic change as the result of mechanisation of transport and legislative developments in the country as a whole. Throughout, the human populations have depended on a network of different pastoral and agricultural technologies, interrelated through the social structure and linking the area with the larger socio-economic system of Iran in various ways.

TRANSHUMANT PASTORALISM The dominant technology in the area is a transhumant form of pastoralism. A group of pastoralists, based on the small town of Sangsar, just north of Semnan, 400 kilometres west northwest of the area, summer in the high mountain pastures of the Alborz and send some 125,000 of their animals into the area for the winter. The animals enter the area in October-November in flocks of 400 with four to five shepherds for every two flocks, and settle in at sheep pens constructed of dung and brush. The shepherds may also bring along a score or so of their own animals. The pen may belong to the owner of the animals or may be rented from a local resident. A certain amount of repair is required from year to year. Until recently, each pen would be burned and rebuilt regularly to destroy vermin, but since the introduction of insecticides, this is no longer necessary. A large proportion of the shepherds are from the local population for whom shepherding for the transhumants represents a valuable alternative resource. The pens are commonly located about four hours' grazing slow walk from a spring or well (which in some cases is used by two or more pens) so that the animals will water at midday in the cold weather. Pens are commonly built in twos in order to allow the shepherds more flexibility. The minimum distance between pens is 6 kilometres. If the minimum grazing area for two flocks, therefore, is a circle with a radius of 3 kilometres, then the densest stocking ratio in the area would be about 3.5 hectares per animal. Apart from investment in a pen, shepherds, a watering point, and a dog, the expenses of the flock owner (who may own any number from one to more than 10 flocks in the area) may include payment for someone to keep local flocks off his grazing during the summer. During the last 12 years, it has become customary to supplement the grazing with barley from January until the spring makes this superfluous, usually early in March. Lambing takes place in late February. Typical flock structure before lambing is 220 pregnant ewes, 100 female yearlings, 10 rams, 50 pregnant goats, 20 female yearlings, 5 males. A certain admixture of goats in the flock is technologically important because goats fulfill some of the functions of the sheep dog in other parts of the world. (Here dogs only protect the flock from predators.) They also give more milk for a longer period. However, the Sangsari are primarily concerned with meat production and use a breed of sheep that is adapted to the long migration but is a relatively poor producer of wool and milk. This Sangsari form of pastoralism is very closely related to market forces—for meat, barley and labour. The economics of this system are discussed below in Chapter 6.

SEDENTARY PASTORALISM Three other technologically distinct forms of pastoralism are currently practised in the area, all of which are on a smaller scale and less directly related to market changes because they are, to a greater or lesser extent, concerned with producing also for their own consumption. One of these three is practised by 60 families from a tribal group of nomadic pastoralists, called Chubdari, who gave up their black tents, built a village and settled in the area 15 years ago. Previously they had moved seasonally as nomads with all their families and belongings between winter grazing in the vicinity of their present village and summer grazing some 50 miles to the north. Animal losses incurred in the 1958-1963 drought constituted a major factor leading to their decision to settle but since the 1970-71 drought their flocks have grown again steadily and now approximate 10,000. They appear unwilling to limit further growth—which has already led to conflict with neighbouring Sangsari. The Chubdari keep a different breed of sheep, which is an all-round producer of wool, milk and meat, with a small admixture of goats, and practice a rotational system within a maximum of 15 km of the village.

The Chubdari also keep about 200 camels which they sell for meat. Most camels in eastern Iran are no longer herded but are left to find their own forage and come to water when they will. They are usually branded in spring but otherwise left alone except when individual owners decide to take one or more for sale as meat. Camel meat (the cheapest available) sells in the towns for Rls 100= $1.40 per kg and a healthy adult animal fetches Rls 30,000 or $425 in meat value. The Chubdari, however, herd their animals. This practice is to some extent a carryover from the pre-1960 system when camels were important to their mobility. But it is also conditioned by official discouragement of camel herding. There has been pressure on pastoralists to reduce the numbers of browsers--both camels and goats. Free ranging camels have the further disadvantage that they tend to monopolise isolated water sources in the summer and inhibit wildlife.

The other two forms are practised by the villages of Khar and Tauran and emphasize goats. Villagers who have very few animals—less than 20—keep them in the vicinity of the village throughout the year, while those who have more, make special arrangements for spring grazing in more favorable areas away from the villages. A few families in Salehabad in Tauran have as many as 1,000 or more, and need to make special arrangements for the entire year. The size of these flocks appears to be effectively limited by the number of women available to milk and to convert the milk into storable products.

ECOLOGY AND ETHOLOGY OF DOMESTICATED ANIMALS

The technology of traditional forms of pastoralism has been little studied and is inadequately understood. In cases like Turan, where pastoralism has probably been the dominant form of land use for many thousands of years, the mechanisms of co-adaptation between the vegetation and the domesticated animals may repay careful attention. The Turan Programme includes a project for this type of study. It was begun during the summer of 1976 in the summer grazing area of 1,000 animals, mostly goats, belonging to a family from Salehabad in Tauran. A brief account of this project is included here because, even though it has scarcely begun, it is theoretically innovative and promises to answer some of the basic questions about traditional forms of pastoralism in relation to desertification.

The basic premise of the study is that it should be possible to study human ecology in the same manner that the socio-ecology of other primates and other species is studied in ecology and ethology. Thus, hunting and gathering populations might be treated as part of a predator-prey system and a herbivore system, and pastoralists could be seen as the attendant predators on herds of ungulates grazing in arid zones. It is possible that human groups with particular subsistence patterns are arbitrarily located with respect to their environment; that their presence in any particular case can be adequately understood historically, and their cultures purely the results of social forces. The introduction of such concepts as evolution, selection and adaptation may be superfluous. For example, while it is well accepted that hunter-gatherers are ecologically adapted in at least certain ways, it is often maintained that nomads—perhaps pastoralists, in general—merely live in the arid environment and not from it. In fact, it is frequently claimed that traditional pastoralism is extremely destructive to the environment that supports it. However, sheep and goat pastoralism in the Middle East is an ancient subsistence pattern. Its long history and widespread use for converting primary productivity of arid zones into milk, meat and wool suggests that it is significantly adapted—even co-adapted—to its environment. This adaptation in the context of progressive degradation raises questions that require careful ecological investigation. In fact, it is necessary to ask why traditional forms of pastoralism in the Middle East are so widespread and enduring. The following hypotheses should be tested:

(1) Middle eastern pastoralism in its nomadic, transhumant and sedentary permutations is an ecologically co-adapted system in which deterioration of the range has been matched by physiological adaptation in the animals and changes in herding strategy.

(2) Cultural practices—the technology—including control over herd movement and reproduction, maximize production, without regard to the condition of the basic resource—the vegetation.

(3) Steady range deterioration over long periods during which pastoralism has exerted greater pressure on the vegetation than a wild herbivore population with its endogenous regulating mechanisms has led to a situation where exogenous factors, such as climatic change, or national, economic or legislative developments, such as the closing of national borders across traditional migration routes, cause permanent disruptions of the system.

(4) The long term coexistence of plants and domesticated animals has resulted in co-adaptation in which the plants have developed toxins and other defenses, and the animals have developed detoxifying physiologies and specialised foraging strategies which allow them to subsist at the price of continuous reduction in efficiency. Furthermore, the domesticated animals, if of more than one species, may be niche-differentiated as a result of human selection for the broadest environmental exploitation.

If a significant co-adaptation of animals and plants exists in spite of a general downward trend, it follows that an understanding of the ecology of the flocks is essential for an understanding of the ecology of pastoralists, which in turn could be an important component of any programme designed to correct the situation. In hypotheses 1, 2 and 3 it is assumed that natural selection, particularly "K" selection, works on cultural systems and that cultural practices can be regarded as normally adaptive, with or without equilibrium. The 4th hypothesis simply requires that the normal relationship between plants and their herbivores has had sufficient time to develop in the case of domesticated herds.

Only this type of study can answer the essential question: whether traditional forms of pastoralism, which is still the only productive technology that can feasibly be employed over vast areas of the world's arid rangelands, should be facilitated and improved or actively discouraged as part of the struggle against desertification. For example, the methods of quantitative ecology will yield the following types of information: what species and quantities do different types of animal choose to graze or browse in different conditions and at different times of the year? how do these preferences and requirements plus the formation of "goat paths", general trampling, urination, and defaecation interact with other natural and cultural factors to affect the quantity and quality of vegetation? what ethological factors affect the general impact on the vegetation on the one hand, and the technology and life of the pastoralists on the other?

Data are being accumulated on the details of sheep and goat behaviour in relation to choice of grazing, social interaction, expenditure of energy, and productivity. Preliminary results suggest that co-adaptation of flocks and vegetation is at an advanced stage. An average of 50 feeding events per 20 minute observation period was recorded among goats—which would maximize their ability to digest toxic material. Further, the animals were in acceptable condition, but it is expected that comparison of biological productivity data with data from less degraded arid rangelands will show lower rates of conversion efficiency.

AGRICULTURE With the exception of the Chubdari all the settled populations in the area also depend to a greater or lesser extent on agriculture. (The Chubdari attempted agriculture when they settled, but were unsatisfied with the results and have long since reverted to an exclusive interest in pastoralism.)

PRINCIPAL CROPS The most important crops are wheat, barley, cotton, tobacco and grapes. Subsidiary crops include vegetables and fruits. Wheat is grown primarily for domestic requirements but in some years a surplus is produced and sold. Barley and other grains such as millet were also grown for human consumption until the sixties but are now used only as animal feed—presumably an indication of an improved standard of living, as well as the spread of urban values and improved access to markets. Cotton is a cash crop grown for sale in Sabzevar as a result of the motorisation of transport. Tobacco is a government monopoly and grown under license. Grapes cannot be moved to the city markets quickly and carefully enough to be competitive, and the excess is rendered into syrup, which is a staple item of diet through the winter.

IRRIGATION Except for wheat and barley, all these crops are grown by irrigation from qanats or springs on cycles of 12 to 16 days. Ground water is abundant in good years but fluctuates annually with levels of precipitation. The historical importance of qanat technology has already been discussed. The principal advantage is that once the investment has been made, the water continues to flow, requiring only a minimum of maintenance. In comparison with mechanised irrigation technologies, this is now seen to be a disadvantage: much of the water is wasted because it cannot be turned off when not required. In Tauran qanat water runs to waste for much of the winter and is often in short supply in the summer. A further disadvantage consists of the vulnerability of qanats to natural events such as earthquakes and floods. The abandonment of the village of Yakarig in 1973 was probably due to the destruction of its qanat by a flood.

DRY FARMING Wheat and barley are also cultivated by direct rainfall. Most of the surface area of central Tauran shows evidence of having been dry farmed in the past. If rainfall is promising in early spring, large areas are sown with wheat and barley on the chance that further rain will bring it to maturity.

BUND FARMING The most interesting agricultural technology for the reconstruction of the ecological history of central Tauran is a form of irrigation that may have the longest history of any irrigation technology in this part of the world. Run off is diverted into prepared fields, trapped by an earthwork and allowed to infiltrate and deposit its sediment. This method will be discussed further below in the section on the ecological history of the area.

FLEXIBILITY AND INTERDEPENDENCE This ends a brief description of the major productive technologies currently practised in Turan. As might be expected in an arid area, in order to cope in the long term with the irregularity and unpredictability of precipitation, users of the area maximize their options. Individuals either keep different species of animal or types of land and irrigation supply and different employment possibilities available, or maintain a network of relationships with others who have access to different resources. The Chubdari, for instance, whose cultural identity involves them closely with one specific technology, cultivate a network of relationships in the villages of Khar and Tauran and the town of Sabzevar for the trade of animals and pastoral products. Interdependence of local residents and transhumants appears to have been particularly important in recent years, but the transhumants are now finding it difficult to compete as employers with the labour market in the towns.

To conclude this section, it should be noted that there are no essential elements of the primary food production technologies in the history of Turan that lead inevitably to degradation or desertification. The causes of desertification therefore must be sought in the factors that determine how these technologies are applied. But first the evidence for present and past desertification in the area will be examined.

4. EVIDENCE OF DESERTIFICATION

Data collected so far provide no quantitative evidence of continuing deterioration of the vegetative cover in Turan. It is expected that such evidence will appear as the Programme proceeds. In the meantime, however, there are a number of indicators that deterioration has occurred in the past and that primary productivity in the area has suffered as a result of the history of human activity. In this section these factors are discussed and related to the technologies described above.

DISTURBANCE VEGETATION A number of features of the vegetation of Turan can only be explained as the result of disturbance. Perhaps the most interesting of these features is the association of *Goebelia pachycarpa* with the dry farmed areas of central Tauran (for plant list see Appendix 1). *Goebelia pachycarpa* is a perennial herb of 15-35 cms with widely creeping subterraneous stem systems causing the formation of large colonies, which often cover thousands of square metres continuously. It is highly unpalatable when green, but is grazed by village flocks when dry. Apart from being very common and often dominant in the dry farmed or irregularly irrigated areas around Baghestan, it also invades the sand dunes to the north and effectively contributes to the stabilisation process, but it is seldom seen in less disturbed habitats. This plant is now dominant or characteristic over some 1000 hectares in central Tauran, where the original vegetation has been replaced or modified by cultivation, although probably less than 20% of this area is ever farmed now. However, although the drainage appears to be in a down-cutting phase, there is no sign of serious soil erosion, possibly because of the binding qualities of this species' root systems.

Other disturbance vegetation is particularly conspicuous within a varying radius of villages and winter sheep pens. The most conspicuous and characteristic species of this disturbance vegetation are *Peganum harmala*—the wild rue, the seeds of which are burned to ward off the evil eye throughout much of the Mediterranean and the Middle East—and *Alhagi camelorum*, "camel thorn". The distribution of the following species in relation to human activity is also interesting:

Cousinia congesta, a monocarpic perennial of 30-60 cm found on deeper soils up to altitudes of 1300 metres, is very common around permanent settlements and indicates heavily disturbed habitats. It is never seen in more natural vegetation.

C. eryngioides, another monocarpic perennial or biannual of 40-70 cm, replaces the former in medium altitudes from about 1350 metres upwards and often penetrates further into less disturbed rangelands, but is also absent from natural rangelands.

C. piptocephla, differs from the foregoing by much longer involucral bracts and an almost globular shape is scattered throughout the area in lower to medium altitudes from about 1050-1300 metres on sandy or gravelly soil. It has a distinct subruderal tendency and grows preferably around settlements and along roads and ravines, often in degraded *Artemisia-Ephedra* communities.

Hulthemia berberidifolia, a creeping dwarf shrub of 5-15 cm which forms dense communities in high altitudes of 1300 metres upwards, is found especially in *Artemisia-Ephedra* and *Stipa-Cousinia* communities on deeper soil, and becomes a dominant weed under strong human influence around villages.

Ephedra intermedia is especially common in areas with a high degree of human influence. It is a shallow rooting dwarf shrub of 20-40 cm, which often covers several square metres and sometimes forms almost complete cover. It is very common on all non-saline soils and in most plant communities from 1150-1300 metres upwards, except north-exposed slopes of more than 1900 metres. It contains an alkaloid and is poisonous to young goats.

E. strobilacea, which is similar to the foregoing but 30-70 cm tall, is very common in the plains and rocky hills up to 1100-1300 metres. It is a major component of *Salsola-Zygophyllum* communities and also contains an alkaloid poisonous to young animals.

Anabasis setifera, a weak dwarf shrub of 10-35 cm, very common and locally dominant up to 1150 metres on almost any soil except strongly saline ones, is particularly common in disturbed habitats.

Salsola tomentosa, a dwarf shrub of 5-25 cm, common in almost any habitat except sand and saline soils, and particularly on plains around settlements and sheep pens, is a typical component of *Salsola-Zygophyllum* communities and its dominance generally indicates strong degradation.

The distribution of *Zygophyllum* and the two species of *Artemisia*, the most common dominants in the area, may also prove to be anthropogenic (see above, Chapter 2). *Artemisia* and the seeds of *Zygophyllum* are important forage and both are used for fuel and construction. The distribution often following also appears to have been affected significantly, especially by use for fuel and construction:

Pistacia khinjuk, a tall shrub or more rarely a small tree, rising to 3 metres, with the shrub habit caused either by regeneration from stumps following cutting or extremely dry periods, is common in all the mountains in the southern part of the area, and is highly valued as fuel—which has undoubtedly resulted in a strong reduction of the population and probably in its disappearance from many suitable habitats which are more accessible and productive.

P. atlantica is a rarer species reaching 4 to 6 metres. The surviving individuals are isolated and sometimes protected—almost certainly remnants of former, much larger populations in medium altitudes.

Certoides latens, a dwarf shrub of 15-35 cm, sometimes collected for fuel, is found in normal density only at some distance from villages.

Haloxylon aphyllum is one of the most valuable fuel species. It is found as a shrub or small tree of 0.3-3 metres, and is very common throughout the area up to 1200-1300 metres on fine-textured soils of plains and valley bottoms (often with a sand layer) and only there the dominant species, but scattered also on rocky slopes except limestone; it often penetrates salt marsh communities of Seidlitzia and sometimes is found even in open *Tamarix* stands. It is evidently favoured by medium to rather high concentrations of soluble salts and the most important stands are adjacent to Seidlitzia marshes. Though it does not depend upon ground water, the tallest specimens are seen in river beds, along runnels or at playa shores. In other habitats it usually reaches only 1.5-2 metres and is often brownish in appearance. In certain depressions, e.g. in the west of the area near Chahjam, it reaches only 0.2-0.5 metres with a habit resembling *Halocnemum strobilaceum*. It is a typical species of *Salsola-Zygophyllum* communities and on some sites develops a variant of its own or even a distinct association. Its distribution has been heavily reduced because of its desirability for charcoal burning and probably also small scale metallurgy (see below Chapter 5)—despite its ability to sprout from stumps. It is also an important forage species for camels and is browsed by smaller stock when the ground is covered by snow. Undisturbed stands with aged individuals and are extremely rare. Since the recent cessation of charcoal burning *Haloxylon* is rapidly expanding, and judging from its high competitive vigour and high seed production it should soon reoccupy lost areas.

H. persicum is also a favorite fuel, but seems to be regenerating only very slowly, if at all. The potential range and density of this species is intimately related to the problem of sand in Turan.

Halimocnemis pilifera is a late developing annual of 3-15 cm—a typical component of *Salsola-Zygophyllum* communities, especially in the *Haloxylon* variant where it often dominates the herbaceous ground layer. As this species is intimately associated with *Haloxylon*, it may serve to indicate sites of previous *Haloxylon* communities.

Salsola orientalis, a dwarf shrub of 15-45 cm, like the foregoing, little browsed and of minor use as firewood, may similarly indicate sites of former *Haloxylon* populations.

S. arbuscula, a shrub of 0.4-2 metres common in low to medium altitudes thrives best in sand but is never dominant. It is little browsed, but the wood of older individuals is collected for fuel.

Calligonum comosum, a tall shrub, occasionally in the form of a tree, was exploited on a large scale for fuel and has reportedly recovered remarkably since the cessation of charcoal burning.

Amygdalus lycioides, a very common shrub in medium and higher altitudes traditionally in great demand as fodder and fuel.

Tamarix spp. —tall shrubs of 2-4 metres common throughout the area, along all river beds with shallow ground water, has been important for construction.

This listing shows how important the role of woodcutting has been in the formation of the present vegetation. Firewood is needed for a number of different purposes and ideally different species are used for different purposes according to the intensity and duration of heat required. Bread ovens, general cooking and heating are three different domestic functions that require a continual supply of firewood. Paraffin has now replaced wood for the latter two in most cases, but so far bread ovens have not been adapted to paraffin. Traditional village baths also require firewood but are gradually being replaced with oil fueled baths. Outside the village all the fuel requirements of winter sheep pens of transhumants and the spring-summer milking stations of local pastoralists must still be supplied by firewood.

Another important use of the ligneous vegetation and of brush generally outside the villages is for construction. Although the effects of this have been mitigated since the introduction of insecticides, which make it no longer necessary to burn and rebuild pens regularly, nevertheless the use of brush for construction must still be the single most important factor controlling the vegetation around pens. Brush is also cut or uprooted to form temporary milking pens on migration. A final relatively minor human impact on the vegetation comes from the gathering of certain other species for use as medicines, tanning agents and foods.

ARGUMENTS FROM THE DISTRIBUTION OF FAUNAL SPECIES

Other arguments concerning the history of the vegetation and present trends have been offered on the basis of the distribution of fauna (see Appendix 2). For example, elsewhere on the Plateau *Gerbillus cheesmani* is typical of sandy areas and tends to predominate in areas of shifting sand. It was therefore expected to occur in the Khar sand dunes in high numbers, if not to the exclusion of other species. However, it proved to be absent. Instead, very high numbers of *Meriones meridianus*, relatively high numbers of *Rhombomys opimus*, and numerous *Dipsus sagitta* were found. These three species predominate in sands of the Kara Kum and until recently *Meriones meridianus*, the most abundant species, was only known from extreme northeast Iran. While *M. meridianus* and *D. sagitta* occur occasionally on shifting sand, *R. opimus* is not a species one would immediately associate with such sites. Its occurrence in the Khar sand dunes suggests that it is filling a niche recently vacated by another species, or a niche which only recently emerged. One possible explanation is that the sands of Khar were relatively stable until recent times, and *G. cheesmani* has not yet pioneered them, but given sufficient time, could do so. A study of interface populations of *G. cheesmani* and *M. meridianus* may shed further light on this question.

A second significant feature is the existence of *Ellobius fuscocapillus* in high numbers. This species requires a soft, moist sub-strate in which to burrow. It typifies the steppic portions of Northern Iran and is absent from the more arid parts of the central Plateau. This suggests two important conclusions: 1) that precipitation is more reliable in Turan than elsewhere in the Plateau, and 2) that much of Turan represents degraded steppe, rather than climax sub-desert flora.

Supporting these conclusions are data on the distribution of other species. *Vulpes vulpes*, a fox unknown in the sub-desert parts of the central Plateau, occurs throughout Turan. *Vulpes ruppelli*, which typifies the sub-desert, is known from only one observation in Turan. Similarly, where one would expect to find only the coronated sandgrouse for similar reasons, only the black bellied sandgrouse is abundant.

Finally, preliminary data from a study of gazelle populations in Turan (reproduced as Appendix 9) suggest that densities are only one-ninth to one-quarter those of comparable habitats in the Kavir National Park, which has been protected from grazing for over ten years.

Each of these factors suggests on the basis of comparison with other parts of the Plateau that Turan has undergone relatively recent degradation but can be substantiated only through further investigations of the climate and the vegetation. Nothing can yet be said of the complementary effects of wild herbivores—rodents, ungulates, birds—and insects on the vegetation.

GRAZING PRESSURE That overgrazing has been an important factor in the history of the vegetation of Turan has been demonstrated by comparison with experience from ecologically similar Protected Areas immediately to the north (Miandasht and the central and eastern parts of Khosh Yeilaq). Shepherds and flock owners alike in Turan today deny that over-grazing can occur in the long term because it would automatically reduce their profits. However, there is evidence that overgrazing is occurring in the Chubdari area, west of Rezabad, as a conscious strategy. After the Chubdari settled at Rezabad with much reduced flocks in the early sixties, the Sangsari took advantage of the situation and used the new nationalisation law and their close contacts with the central administration of the province to obtain permits to graze the areas left vacant by the Chubdari and other nomads. Because of the commercial nature of their pastoralism the Sangsari were able to adapt more efficiently to the drought conditions and build up their flocks more quickly afterwards. During the recent succession of good years, the Chubdari flocks have finally grown again to the point where they are forced to challenge the Sangsari for rights to their old grazing areas. In order to make their challenge effective, they are forced to over-graze as a calculated risk.

The degree of overgrazing appears therefore to have varied historically in response to particular sets of circumstances but derived from exogenous factors. An underlying constant has been the orientation of the pastoralist towards his basic resource—the vegetation. The primary concern of the traditional pastoralist appears always to be in the condition of his animals, which he considers to be his basic capital, not the vegetation which he believes will always recover.

An extremely important but secondary danger to the vegetation comes from wood collection—which could be obviated by management programmes that would include provision for alternative fuels and construction materials, possibly by plantation in the area—that is, by investment.

5. HISTORICAL RECONSTRUCTION

Information on the history of Turan is scanty since no settlement in the area was ever large enough to develop a literary tradition. Historical reconstruction depends on the following types of information:

1. archaeology
2. circumstancial information in historical writings from neighbouring regions
3. occasional traveller's accounts
4. oral history

Because of the nature of these sources, it is not possible to interpret them without relying on a high degree of speculation. Nevertheless, at least two significant themes show through unmistakably: Turan has been subject to continual population movements and (probably closely related) fluctuations in the level of investment.

ARCHAEOLOGICAL EVIDENCE OF SETTLEMENT

Although no excavation or scientific survey has yet been undertaken, archaeological evidence appears to be confined to the regions of Khar and Tauran and consists of settlement sites, burial sites, industrial sites (slag deposits and kilns) and engineering sites (dikes, dams, qanats). The major problem in the interpretation of the evidence so far available is dating. Only the presence of certain types of pottery so far allows fairly reliable dating and this indicates a climax of settlement and economic prosperity and investment in both Khar and Tauran in the late Sassanian and early Islamic periods which coincides with investment history on the Plateau as a whole as outlined in the introduction.

The following historical outline is suggested by the evidence available so far and fits generally with possible reconstructions of the vegetation history. There is no direct unequivocal evidence for human activity in Turan before the introduction of irrigation engineering, which need not have been earlier than the 5th to 3rd centuries B.C. However, there is evidence that could relate to earlier periods and since there is evidence of human activity from other parts of the central Plateau from periods predating the domestication of plants and animals in the Middle East (at least 10,000 years ago), early human activity may reasonably be posited for Turan also. A hunting and gathering adaptation based on the springs in the mountains and the abundant wildlife in the mountains and intervening plains must have been perfectly viable and may very well have lasted here into later times when it had been replaced elsewhere by food production. This pattern may not have changed before the introduction of qanats into the area which—judging by the pottery sample--could have happened at any time between their introduction on the Plateau in the mid first millennium B.C. and the middle of the Sassanian period (5th century A.D.). It is likely, however, that irrigated cultivation by the diversion of run off—a simpler form of engineering that is known to have been introduced much earlier elsewhere on the Plateau in combination with other strategies, might have supported significant pre-qanat populations. Study of the land forms of central Tauran so far suggests that a large percentage of the arable land is composed of sediments formed by this technology, which has been practised long enough to modify significantly the surface drainage and topography of hundreds of hectares. However, probably only the introduction of qanats could have brought settlement out into the centre of the plains, but at the same time qanats introduced a dependence on a system that was expensive and fragile in that it was vulnerable to earthquakes and floods, and made imperative the maintenance of a certain level of investment. This may explain why no mounds developed in the area and there appears to be very little accumulation of cultural deposits, even under existing settlements. The densest and most extensive sherd scatters are around Baghestan, the ruins of Khar in the sand and Hizomi--which suggests that in early Islamic times up to the 11th century these settlements might have been large and diversified enough to be called cities. At the least they represent a larger and more complex society than the present 2000 people dispersed among 35 settlements.

Did the present situation develop as a result of over exploitation of natural resources by the medieval cities of Khar and Tauran? This explanation at first seems obvious, especially since in the case of Khar the site is now surrounded by sand and was in fact finally abandoned completely in 1940 primarily because of the sand. However, a number of other pieces of evidence suggest that the interaction between human history and natural processes in the area has been more complex and that degradation cannot simply be explained as Nemesis. This evidence includes the fact that prosperity and decline in Turan appear to have coincided with prosperity and decline over the Plateau as a whole.

INDUSTRIAL ACTIVITY Another piece of evidence that is difficult to interpret is the existence of industrial sites, and especially of slag. Slag heaps are the most common type of archaeological site in the southern part of Turan. Nearly 40 were located in three weeks of survey. They occur in foothills, in the mountain passes between plains, in the open expanses of the plains themselves, close to modern villages, sheep pens, natural springs and seeps or isolated from any detectable source of permanent water or settlement. One slag deposit was found very close to the edge of the *kavir*.

These sites are all very similar, generally consisting of low piles of black glassy slag (up to half a metre in height and 1-3 metres in diameter), dumped in rough concentric ridges around a slight central depression. The total scatter of slag generally ranges between 15 and 20 metres in diameter, and the maximum dimension of the pieces of slag varies from a few centimetres and fist-sized, although piles of 'pea-sized' pieces, perhaps the result of trampling by animals, were occasionally observed. Fragments of malachite are evident on most sites. No azurite, chalcopyrite, bornite, or other copper minerals have been found.

Sherds are usually rate to absent, and the few that were found were undiagnostic and may not have been contemporary with the slag. Flakes were found on several of the slag heaps, the majority of which were large, of igneous or volcanic rock, with pronounced bulbs and cones and flat striking platforms. Some of them resemble spalls from stone hammers. One site yielded 20 chalcedony artifacts, which included 1 side-scraper, 1 steep nosed scraper, 8 core fragments and 10 retouched flakes. All had flat platforms and pronounced bulbs and cones.

The combination of malachite and slag indicate copper smelting activities. The type of ore and the absence of any signs of crucibles, furnaces, or tools suggest the simplest form of pit-hearth smelting, but without excavation or laboratory testing of the slag, any reconstruction must be provisional. Malachite is one of the carbonate copper ores, an easily smelted type often available in accessible surface deposits. (Many other kinds of copper ore require much more elaborate methods of mining and smelting). From comparable ethnographic and archaeological sources, the process could be reconstructed as follows: malachite, probably in ground form, mixed with charcoal and flux, was added to a pit-hearth dug in the ground, which might have been lined with clay, gypsum, or stones (one site had burnt rocks). The required temperatures were maintained by some kind of *tuyere*—a fireproof blow pipe inserted directly into or over the fire. As the mixture melted, the copper sank to the bottom, and the slag, made up of the rest of the ore, plus perhaps a flux and any residual fuel, floated on top. The cooled slag had then to be dug out and broken away from the copper ingot. Since any kind of crucible or furnace would probably have been destroyed in the process, one would expect to find fragments nearby if they had been used. The materials of the process itself would include fuel, ore, flux and tools, in addition to food, water and transportation for the workers, the raw materials, and the product. The best fuel source would have been charcoal. Brushwood is an alternate possibility—it was and is used for pottery kilns—but probably would not have held the higher temperatures required for smelting. Shallow surface mines of malachite ore were located on survey, but without slag heaps or other signs of smelting activity nearby. Identifying flux is extremely complicated and must await laboratory analysis, but lime, iron ore, and sand are common fluxes for copper smelting (flux facilitates the separation of the metal from the rest of the ore.) The very glassy state of the slag suggests that the flux may have had a high silicon content (the mineral malachite itself has no silicon), so that sand is a likely candidate. The location of the smelting sites was probably determined primarily by fuel supply (brushwood or charcoal) but their distribution relative to sand cover must also be considered.

If it were possible to date and predict the location of slag sites relative to resources, it might be possible also to reconstruct soil and vegetation patterns in earlier periods. It is important to remember that the primitiveness of the method does not in itself imply antiquity (although it is true that in many areas high grade, easily accessible and reducible ores were probably exhausted long ago, forcing metallurgical techniques of increasing sophistication). Dating on the basis of existing information alone is difficult, though several factors suggest that the workings are comparatively recent. First, the piles of slag have not been severely eroded or scattered by surface run-off; second, piles occurring next to drainages that are beginning to undercut their banks have not been badly damaged, and sites in areas of heavy alluviation do not appear to be deeply buried (although without excavation this is speculative). The sites are old enough, however, to be attributed by local informants to the activities of a mythical ancestor.

Slag sites in the area are numerous, but it is difficult to assess their effect on the landscape without knowing how long such a practice continued, its intensity (how many sites were in use in a unit of time) and what the fuel requirements were. It is sometimes suggested that the metal technology of the Iron Age dealt the final blow to the forests and brush cover in other parts of Iran, and certainly the requirements of the Parthians and Sassanians (as well as more recent periods) for metal were enormous compared to earlier periods. Unfortunately, precise estimates of fuel use in pre-industrial metallurgy are not available, except that according to one source (Caldwell 1967) silver workers at Nakhlak and Muteh (in Kerman) reported that they use 35 kg of charcoal, 30 kg of lead ore, and 30 kg of iron ore (flux) in a single day's smelting charge. Copper smelting does not require as much fuel as iron smelting, but the quantities are still great compared to other pre-industrial activities. Furthermore, the smelting in Turan was wasteful, since the oven was probably opened and the metal removed after a single firing. More elaborate systems permit the tapping of the copper from the bottom of the furnace, and therefore a continuously operating fire—a much more fuel efficient process.

Presumably, then, smelting was carried on relatively near but not at ore sources, and in close proximity to fuel supplies, rather than at the site of the next stage in production (probably casting). It might be possible to speculate on the market for this copper if we knew more about the dates involved. For example, most of the Samanid mints (10th century) were located in Khorasan and nearby provinces; one of these mints was at al-Biyar (presently, Biarjomand, see Miles 1975:374). Perhaps the Turan smelters were providing copper for coinage.

As far as sources of ore are concerned, a number of discontinued surface workings are evident but undatable. The best explanation for these data would seem to be that sometime in the historical period there was a relatively short period of intense small-scale mining and smelting activity in the area, which is likely to have had a crippling effect on the ligneous component of the vegetation.

A similar industry which has only recently stopped and may have been practised continuously since early historical times is the production of charcoal. Once again no precise figures are available but charcoal was the favorite fuel for many purposes, not only here but in the towns, until the relatively recent prohibition and rise of paraffin. Travellers' accounts during the last 150 years suggest that charcoal production was a major occupation of males in Turan until as little as 10 years ago.

Once again it is significant that both these industries presumably rose and fell in response to the needs of an urban population on the edge of the Plateau which avoided investment in the improvement or conservation of the resources they were exploiting. The local populations who did the work were taking advantage of the full range of resources available to them. Charcoal burning has been replaced with migrant labouring.

HISTORICAL EVIDENCE Documentary evidence for the ecological history of Turan is sparse. The place names Biarjomand, Khar and Tauran are attested since the 10th century in a somewhat ambiguous position between the two provinces Khorasan and Qumis, but it is difficult to tease any ecological details out of the incidental mentions that have survived. Khar disappears from the record from the 15th century until the visit of an Austrian traveller in 1933 (Gabriel 1935). According to oral tradition it had been hit by an earthquake around 1860 and was finally abandoned in 1940. Tauran, however, is mentioned by each of the four European travellers who actually went through the area and published accounts of their journeys.

The reasons for inattention to this region could be varied: both European and Persian historians have traditionally found the city and its monuments to be more interesting than rural areas, and Tauran has most probably been a backwater territory since the Mongol invasions; the rise of Isfahan and the Safavid dynasty in the 16th and 17th centuries drew interest and travellers to the south and center of the Plateau; this desert alternative to the more heavily travelled mountain and piedmont routes to the north was not very popular. In the words of General Petroosevitch (in Marvin 1881:434), the route from Astrabad to

Meshed "via Shahrood, Biyar, Tavroon, Toormeez, and Toorbet-i Hyderi" was "said to be fit only for caravans; runs alongside the great salt desert; lacks water, fuel, and forage. Did not traverse it myself, but heard nothing but bad about the route." In spite of these disadvantages (or perhaps because of them), George Forster, a civilian Englishman who worked for the East India Company, on returning home from India in 1783, chose the route through this area. His interests were humanitarian rather than scientific or commercial, and his disguise was to conceal his Christianity rather than to secure secret information or safe passage of valuable goods. As he himself describes his encounter with an Armenian (who remained convinced that he had unmasked a jewel-merchant or a spy),

> I endeavored to explain, that, among the natives of Europe, it was a common usage to visit foreign countries, where an observance of the manners and arts of various people improved the understanding, and produced a more extensive knowledge of mankind; and that a frequent intercourse with nations of different customs and religious opinions, taught them to shake off domestic prejudice, and to behold all men with the eye of common affection (p. 152).

Forster's journal, unfortunately, suffers from this need to conceal his identity (he had to take notes furtively for fear of exposure) and his dependency on commercial travel which often moved by night. Nevertheless his account remains, except for Clerk's even briefer notes, the only eyewitness western account of the Shahrud-Turshiz route (which led on through Torbat-e Heidariyeh to Herat). "Few roads," he says, "are of more dangerous passage than that from Turshiz to the Caspian Sea (p. 185).", a condition that had persisted since the Afghan destruction of Meshed some 50 years earlier. His own trip, however, was uneventful. On December 31 he arrived at Doruna, southeast of Tauran. Between Turshiz and Doruna he comments that "the country is open and well cultivated, but like the eastern division of Khorasan, scantily supplied with wood and running water." The area between Doruna and Tauran is described as "a desert, interspersed with low hills and a thin smattering of wood (p.190)" for which he provisioned himself well ahead of time. Judging by the distances given (probably obtained through informants rather than direct observation), he must have come up to Tauran through what is now Talkhab; but he mentions no settlement between Doruna and Tauran. "Towrone," he says, is a "small fortified village, situate in the districts of Ismael Khan, an independent chief, who also claimed the desert, extending from Derrone to this place; nor is it probable that the property will ever be disputed. Many travellers, it is said, have perished in this track, from the intense heats, and scarcity of water, which, in the course of the first stage, is procured but in one spot, by digging small wells (p. 194)." Unfortunately he describes nothing more until he reaches "Khanakhoody" ("fortified and populous") and the Biarjomand plain, ("a wide extended plain, thickly covered with villages and arable land.")

In summary, the area near the end of the 18th century was, in the stretch between Turshiz and Biar, but sparsely populated, without caravanserais (except at Turshiz) and with scanty provisions for food, water and fuel for travellers. There were only 5 or 6 in Forster's party.

Seventy-five years later Captain Claude Clerk travelled across Persia to Herat, returning, like Forster, by the Turshiz-Shahrud route. His notes are abbreviated but he finds the following features of interest: a group of tents pitched at a pool of rainwater; a few small villages on the way to Tauran, which is itself a small village with a fort, but few provisions. He notices water and ruins at Tauchah, but says nothing of inhabitants. At Hizomi, however, besides water, trees and ruins, were a few inhabited dwellings. When he reached the pass at Zughdi between the present Ahmadabad and the *Kal-e Shur* he comments that firewood was abundant.

Otherwise the situation had changed little since Forster's day; he also talks constantly of terror from the Turkmen, though his own trip across the desert route was undisturbed. The area itself remains unimportant, with small villages scattered in the more hospitable regions. In fact the area was unknown enough that on his earlier trip east across the high road to the north he comments that, "between Abbasabad and Mazinan, the desert stretches away to the south and southwest without a break. A region entirely uninhabited til near Tubbes [Tabas] and Yezd." Neither Clerk nor Forster mention pastoralism, tent settlements, milking stations, or in fact any economic activity except agriculture in the area, though almost certainly such activities were present as is indicated by the reference to a group of tent-dwellers.

The only other 19th century traveller who approached the area and wrote anything was Lt. H.B. Vaughan, an English officer of rather more adventurous nature who struck off from Torud close to the edge of the *kavir* in an easterly direction. Vaughan's closest approach to the Tauran plain was at Nur, on the southern side of the mountains. Nur was then called Sheikh 'Abdu'l Hosein Nuri and was a place of pilgrimage at a height of 1440 metres.

Further on Vaughan met the only other group of travellers he had seen since leaving Semnan—"a caravan of tobacco from Tabbas" headed for Tehran. Unfortunately he did not note the route it would take.

Finally, in 1933 Alphons Gabriel, a physical geographer from the University of Vienna, travelling by camel with local guides and collecting flora and fauna, meteorological and geological information, entered the area, as did Vaughan, from Torud. In June he picked up the Shahrud-Turshiz route followed by Clerk at the Zoghdi pass (where he records the saltiness and temperature of the water). Here his guide returned from a trip for provisions, having been forced to go all the way to Biarjomand since he could buy nothing in either Qal'a Bala or Khanehodi. Between here and Hizomi were many abandoned ruins with their cemeteries nearby. Hizomi was then, as now, a summer milking station.

THE LAST YEARS OF KHAR

At Hizomi the road forked and Gabriel took the north branch, "over drifting sands", to Khar rather than continuing on to Tauran. In order to escape the stares of the villagers, who had never seen a foreigner, he camped in the dry bed of the Kal Tauran cut (which was then also surrounded by dunes). The contemporary settlement at Khar consisted of more than 100 houses, the first of which were built about 20 years earlier (that is in the early 1910's) near the abandoned fort. The 500 inhabitants were primarily farmers, but he adds that some men burned charcoal or herded, and comments on the number of women and children in the village. In the gardens at the north of the village grow grapes (which he says ripen in June there), pomegranate and *Zizyphys vulgaris*. Barley and wheat stretch out to meet the dunes. Malaria was reported to be a serious problem, especially in the Fall, with a high mortality rate. Fresh water came by qanat a distance of 18 kms from "the mountain" to the south, but the supply was dwindling, and there were no resources for restoring the system. The villagers were desperate—the sand was taking their fields, and they knew they must leave (as indeed they did, some eight years later).

THE USE OF OUTLYING SETTLEMENTS

Darbahang is mentioned as a small summer grazing station where people from Khar pasture goats and raise wheat. The area nearby had been "seriously altered by firewood collecting." (Ahmadabad which is not mentioned, would probably have had a similar function.) The wind had exposed the clay floor beneath the sand, furrowing it into terraces on the slopes. However, the area generally was excellent camel-grazing, "among the most richly overgrown in the Persian arid zones" (Gabriel 1935), consisting of tamarisk, saxaul, *Calligonum*, *Salsola* and *Atraphaxis*. Surprisingly then Gabriel states that "Khar has few animals now, and imposes a stiff water tax to keep camel owners out of its district, so that the pasture goes unused for the most part."

PREDATORS

Besides the sand, an additional menace were wolves—hardly a night passed without loss, in spite of the dogs. Hyenas, on the other hand, would avoid humans and dogs, but if a herd scattered or strayed, they would move in and slaughter the whole group or at least all those who did not escape to the rocky heights, where the hyena could not follow. Wolves are still a problem, though less so. Hyenas are no longer reported.

NOMADIC PASTORALISTS

Gabriel moved on north, recording black tents of a tribe from Southwest Iran in the vicinity of the present Rezabad. (They do not, he says, weave much, since the demand for rugs and saddlebags is light and wool has become valuable.) Further on, he runs across two tents of impoverished nomads from Baluchistan. The land around Mazinan is, except for the cultivated portions, barren of the rich vegetation that the dunes support to the south. Returning south, further east the dune plants began again—especially thick bands of grass *(Aristida pennata)*. Here there were scattered tents of Baluch nomads. Just north of Talkhab, the "once often used" caravan route from Sabzevar to Tabas joins his track. At Talkhab (where the Shahrud-Turshiz road leads eastward out of Tauran) he found 18 tents of another Baluch tribe.

FORTIFIED VILLAGES

To our great loss, Gabriel now changed his pace considerably, speeding up in order to move out of the desert as quickly as possible to avoid the summer heat. But before he left the Tauran plain he stayed at the small settlement of Fath Hava, which is now an exclusively pastoralist colony of Salehabad, and records that there were 15 villages in Tauran, and that most of them were behind fortifications. None of them had more than 20 households, with Eshqvan, Barm, Zamanabad, Baghestan, Kariz, and Nahar being the largest. The area was well-watered and the land fertile; the harvested wheat in a good year met the villagers' own needs, while the surplus from animal husbandry and charcoal was exchanged for tea, sugar, and woven goods. The dunes to the north were stable and full of vegetation.

Khar and Tauran appear to have been less hospitable then than now. The mention of problems with fodder and firewood suggest that the vegetation was certainly not better then than now but we know that three settlements have been abandoned because of sand since 1940. This general historical picture can be filled out with the aid of oral history.

THE SAND The most conspicuous feature of the landscape around Khar and Tauran is the sand. Khar was abandoned in 1940 because the labour required to keep the qanat free of sand from year to year was leading more and more people to migrate, until the point was reached where the whole population decided to cut their losses and leave. The cause for the abandonment about 1960 of Baba Kuh, a much smaller settlement on the Hojjaj River, appears to have been similar. Another small settlement, Yaka Rig, also on the Hojjaj River and at the southern edge of the high sand, was abandoned in 1973. However, although the abandonment of Yaka Rig is generally said to have been due to the sand, further investigation suggests that an unusually severe flood in the river damaged the qanat, and the sand was simply a factor making it more than usually difficult to organise the investment needed to repair it.

This interpretation fits well with the statements of other informants about the sand, which suggests that since the prohibition of charcoal production finally became effective in the late sixties, there has been significant increase in vegetation on the margins of the sand and decrease in sand movement.

THE IMPACT OF CAMEL GRAZING In this context the travellers' report that the people of Khar had outlawed camel grazing in their territory is interesting. They were after all continuing to produce charcoal—a practice that may have been more lucrative but was probably a more serious threat to the environment. It is difficult to assess the impact of camel grazing on the vegetation historically since it is impossible to know how many camels might have grazed the area on the average, and whether given a much higher population than at present and possibly therefore a somewhat different vegetation, their forage preferences would have been the same. Since camels formed the basis of the transportation system in the area until twenty years ago or less, it is safe to assume that they must have been present in much larger numbers, that their presence over a long period must have constituted an important factor in the history of the vegetation, and that the recent drastic reduction in their numbers must similarly have had a significant impact. Testable hypotheses for the investigation of these processes are not easy to formulate, but should presumably concern the ratio of browse to grazing—an important consideration in determining the current carrying capacity of the rangelands.

THE EFFECTS OF MOTORISATION The change from camels to motorised transportation has affected Turan in other ways that may have greater ecological impact in the long term. Before motorisation, under the camel based system of communications

Khar and Tauran were at the crossroads of a number of desert routes that linked the cities on the northern rim of the Plateau, and towns to the east and south of the central playas *(kavir)*. Much of this traffic was in fact organised by men from Anarak, a settlement on the southern side of the *kavir*, some 450 km west southwest of Tauran. As the mode of transportation changed, the routes also changed, and Khar and Tauran lost contact with areas to the south and east, ceased to be a crossroads and became a *cul de sac* served only from Shahrud and Sabzevar. The most serious result of this change in relations with the outside world is the reduction in the number of exploitable resources: the loss of the opportunity to provide services to through traffic.

THE ESTABLISHMENT OF SECURITY

As already outlined, this change in the mode of communications coincided with several other changes. Villages used to be fortified, and the area was controlled by leaders who sought to concentrate the ownership of resources in their own hands. At certain periods, especially it seems during the forties and early fifties, security was very poor, which further enabled local leaders to expand their power, usurp official authority and exploit local populations. Turan took on the character of a "refuge area", attracting refugees from the effects of economic decline in more fertile parts of the country. Apart from the Kurdish and Baluch nomads which wintered in the area until the 1960's, the population of Turan became a mosaic of tribal and non-tribal groups from origins as diverse as Tabas, Birjand and the southwest of Iran. The most wealthy and influential members of the population of Tauran in the fifties had been exiled from the southwestern province of Fars in the last century. A rival group were outlaws from the same area.

At that time all the local resources were owned by local residents, including the winter sheep pens, which were rented by transhumant pastoralists. It is somewhat surprising that there is no mention in the historical sources of the Sangsari transhumant pastoralists, although there is circumstancial evidence that the area has been used by transhumants for many centuries at least, and seasonal pastoral movement between the Alborz mountains and the arid rangelands along the edge of the central deserts constitutes a niche that, given the patterns of land use throughout the Middle East, is unlikely to have remained empty for long. The Sangsari appear therefore to have risen in importance in recent decades. They benefitted from a combination of the drought and the administrative revolution, which allowed them to buy or otherwise take over many of the pens they use in Turan, to acquire permits to grazing vacated because of the misfortune of other pastoralists, and adapt to the rising meat market generated by the growth of an urban middle class and the expanding national economy and increased security.

This survey of the evidence so far for the history of Turan supports the hypotheses suggested in the introduction. Industrial technologies, which expanded and contracted according to market conditions outside the area, have probably had serious impacts on the primary productivity of the area at certain periods, and the greatest period of prosperity the area has known depended on a higher level of investment (in irrigation) than has been made in the area at any time since.

6. ECONOMICS

THE NATIONAL CONTEXT If the hypothesis is valid that there is a correlation and even a causal relationship between desertification and levels of investment, then exploitation—without desertification—in areas like Turan requires a firm economic basis. It is necessary therefore to look at Turan in the context of the national economy. Since the various types of pastoralism are economically the most important technology in the area, it is necessary here to review briefly the economics of pastoralism in the country as a whole.

Iran has a total human population of about 34 million and an average per caput GNP (1975) equivalent to U.S. $1650. In terms of volume, domestic product (GDP) in recent years has been growing at between 10% and 15% per annum. When changes in international oil prices are taken into account, national product (GNP) has been growing at a rate in excess of 35%, but there is great variation of growth in successive years. Some 40%—50% of GDP originates in the petroleum sector and only about 10%—15% in agriculture. But 58% of Iran's human population live in rural areas; and their per caput expenditure is only about 25%—50% of that of the average in urban areas. As might be expected the emigration rate from rural areas is high.

In contrast to the economy as a whole, agricultural output has grown at only 3%—4% per annum in recent years, and the output of the livestock sector at only 1%—2%. As a consequence of the slow growth of livestock output in relation to that of national income and consumption expenditure, there has been a very rapid rise in the importation of livestock products. For example, recorded imports of meat and livestock for slaughter increased, in volume terms, by a factor of two between 1970 and 1974, amounting to 65,000 tons (about 12% of total meat consumption) of meat-equivalent in the latter year.

Statistics on the size and composition of the Iranian livestock population, and on its economy and modes of production are incomplete. The best recent estimates (relating to 1974) for the size of the national herd give the following range of estimates:

TYPE	HEAD IN MILLIONS[1]	FEMALE ANIMALS (millions)[2]
Sheep	31.3	19.6
Goats	14.5	9.0
Cattle	6.6	3.1
Camels	0.3	NA

[1] Excluding the year's products

[2] Females of reproductive age

Of this total national ruminant livestock population of 53 million (87% of which are sheep and goats), it is estimated that 50%—60% are involved in major seasonal (nomadic or transhumant) migratory movements between grazing areas. A recent estimate puts the number of tent dwelling nomadic pastoralists in Iran at 700,000. Some 25% of all sheep and goats and 18% of cattle are thought to belong to nomads and 13% of the remainder belong to people without land. Among farmers, small land owners (less than 10 ha) control 42% and 54% respectively of the national total of small ruminants and cattle. This confirms the impression gained when travelling around the country that extensive animal husbandry for meat is in the hands of small landowners, landless and transhumant or nomadic pastoralists. The average holding among settled pastoralists is 24 head (sheep and cattle). Herds of more than 50 head make up only 32% of non-nomadic small ruminants. Among non-nomads, ownership of cattle is fairly evenly distributed (90% of all cattle being owned in holdings of less than 11 in number, and 55% in herds of less than 5). The ownership of sheep and goats by non-nomads is rather more concentrated, 32% being owned in holdings of more than 50 in number. The degree of concentration of ownership of the flocks of nomads is not known but is likely to be more concentrated because nomads are generally more specialised.

Available figures, which may be used as a guide to the main production parameters of the national herd as a whole are:

	SHEEP	GOATS	CATTLE
Calving/lambing rate[1]	80%	92%	65%[2]
Mortality - Lambs	15%		
Up to 1 yr incl. lambs/calves	20-25%		
Adult	5%		
Average incl. lambs/calves[3]	13%	11%	10%[2]
Offtake rate[3]	26%	30%	18%[2]
Meat tonnage produced (carcass) in thousand tonnes	180%	60	80
Average carcass weight in kgs	18%	12.7	87
Milk (1000 tonnes)	500	250	800
Wool (1000 tonnes)	48	—	—

[1]Live young born as % of breeding females

[2]Includes specialised dairy herds

[3]Expressed as % of total population including those born in current year

The value of extensive animal husbandry production is in the order of Rls 80 billion, of which 55.4% is from sheep, 28.8% from cattle and 15.8% from goats. The average gross product per female animal is around:

— Rls 7500 ($106) for local cattle
— Rls 2300 ($32.50) for sheep
— Rls 1400 ($20) for goats

Prices of meat and milk products have risen sharply in recent years, probably doubling in the last four or five years (a period during which retail prices generally rose by 50%). Meat prices—at or near the "farm-gate"—are in the following range:

LIVE SHEEP: US $1.1—1.4 (Rls 80—100) per kg live weight

GHEE (clarified butter): US $7—10 (Rls 500—700) per kg

CHEESE: US $2.4—3.5 (Rls 170—240) per kg

If we assume that it takes 28 litres of milk to make one kilogramme of ghee, and from this quantity an additional 1 kilogramme of cheese-like products are made, this gives a value to raw milk (without labour) of about US $0.34—0.48 (Rls 24—33) per kg.

Seventy-five per cent of the total territory of Iran is classified as rangeland or desert. The proportion of total livestock feed contributed by these areas has recently been estimated at 63.5%, the remainder coming from cereals and fodder crops (11.8%), agricultural by-products (23.3%), and industrial by-products (1.4%).

This situation—the combination of the distribution of animal holdings and the importance of "free" grazing—suggests that unless there is an extraordinary rise in the price of meat, animal husbandry for meat and in particular sheep and goat rearing, is likely to continue to be based on the exploitation of wild rangelands, even if they continue to be of poor quality.

The most feasible way for the income of pastoralists to rise in the coming decades is for pastoral production to become steadily more integrated with agriculture. This would allow the continuation of the use of complementary wildlands by means of transhumant adaptations, as with the Sangsari in Turan, but would introduce another factor in the integration of the use of range and farm land in a single human use system, and so allow a degree of intensification, as well as the continued economic use of the country's arid rangelands. This will have another advantage—the need for which is a subsidiary theme of this study—that it will encourage forms of organisation that will integrate traditional and industrial forms of land use, and rich and poor areas.

It is beyond the scope of this study to go into more detail concerning the overall national value of the resources of marginal land and their populations. In summary, rangeland makes up a large proportion of the value of Iran's marginal lands, but marginal agricultural areas are equally important: they cover approximately 30% of the area under cultivation and contribute more than 10% to the production of cultivated land. These resources thus constitute a large amount of capital, particularly for the production of red meat (rangeland and small isolated irrigated areas associated with grazing areas) and for the production of cereals (dry crops, extensive irrigation). A means of conserving these resources is thus indispensable as a means of reducing the country's food deficit.

PASTORALISM IN TURAN

Turan exports substantial quantities of livestock and livestock products, cotton and tobacco. It imports paraffin, consumer durables, clothes, sugar, tea, small amounts of other foods, fertilisers and feed barley. Although 80% of the animals that use the area belong to non-residents, some 30%-40% of the proceeds of the sales from these animals returns to residents in the form of shepherds' wages; and a further small proportion may return as payment for feed barley grown or bought in the area.

Compared to areas of traditional pastoralism in other parts of the world, Turan appears to have quite a healthy economy. Standards of housing, health and hygiene are relatively high. Wage rates for hired shepherds run at U.S. $1,200—2,400 (80,000—170,000 Rials) per annum, plus food, and most shepherds also make some additional income from the farming activities of their families. However, shepherding as an occupation has a low cultural value because it implies an arduous and uncomfortable life without modern facilities. Very tentative estimates of net income from one village in Turan, on the basis of an average livestock and land holding, suggest a possible family income in that village from livestock and cultivation averaging about US $325 (23,000 Rials) per year. Such farm income could be supplemented by employment or craft earnings (e.g., in carpet weaving).

Although this figure is considerably below the per caput GNP indicated above, it must be remembered that GNP figures include much expenditure on government services, investment, etc. not applicable to family income and expenditure. A more meaningful comparison can be made by looking at figures for annual private expenditure per head. In 1973, this amounted to about US $490 (34,000 Rials) per person for Iran as a whole, the total being an aggregate of US $210 (15,000 Rials) per head in the rural sector. On the basis of these figures, and those given in the previous paragraph, and assuming that family size is about 5 persons in Turan, then it appears that incomes in Turan are at least equal to, and may be considerably in excess of those for rural incomes in Iran as a whole, and may approach the level of the working class in urban areas, whose total consumption is only about 50%-70% of the average figure for all urban classes. It is necessary also to bear in mind that in statistical comparisons of this kind the real value of housing, water supplies and domestic fuel tends to be underestimated in published figures and that such figures, therefore, give an unduly poor impression of rural life.

THE TRANSHUMANT FLOCKS The major economic activity in Turan is the winter grazing of the Sangsari transhumant flocks. Besides many that pass through Turan to areas further to the southeast, between three and four hundred of these flocks enter the area between mid-October and mid-November. The flocks average 400 head, consisting of approximately 90% sheep and 10% goats. They lamb in late February, take full advantage of the spring in Turan till mid-April to mid-May, and then slowly follow the spring back up into the mountains to the west, taking some six weeks to cover 450-600 km. The animals are milked in the summer pastures only. Lambing percentages (live births) average 85% of which in turn 85% probably survive to weaning, and in the case of males to sale. Of the combined sheep and goat pre-lambing flock some 70% are breeding ewes, 3% sires and 27% replacement females. The general opinion is that flock size and animal population throughout the area among the Sangsari is constant from year to year. Variation occurs in the amount of barley consumed. This information suggests the following model of income and expenditure for a transhumant flock:

SALES	US $	RIALS
Sale of male offspring 100 @ US $35 (Rls 2500) each	3,546	250,000
Sale of females 70 @ US $50 (Rls 3500) each	3,475	245,000
Sale of milk products @ US $8.50 (Rls 600) for 220 breeding ewes	1,872	132,000
TOTAL SALES	8,893	627,000
COSTS		
One chief shepherd @ US $220 (Rls 14,000) per month	2,383	168,000
One assistant shepherd @ US $100 (Rls 7000) per month	1,191	84,000
Feed barley at 37.5 kgs/head (300-750 grammes/day/head/ for 75 days @ Rls 10 kg)	2,234	157,500
Miscellaneous expenses - food	681	48,000
TOTAL COSTS	6,489	457,500
PROFIT MARGIN (Total Sales less Total Costs)	2,404	169,500

The rate of profit as a % of capital employed (400 head @ US $50 each) is about 12%—rather a modest return.

SEDENTARY PASTORALISTS While holdings of transhumant pastoralists tend to a normal size of 400, the holding of the area's residents vary widely in size. On average, breeding ewes form a lower proportion, since some holdings are primarily "fattening" rather than breeding operations. Lambing percentages in resident flocks appear to be slightly higher (reflecting genetic as well as managerial differences). Mortality may be lower as may be feed costs because of the availability of crop stores to supplement barley grain. The value of milk production per ewe/doe is higher than in the case of transhumants, in reflection of the fact that the animals are milked for a longer period. The estimated value of milk output per annum per ewe/doe is US $14 (Rls 1000). The proportion of the flock sold is slightly lower (since animals on average are kept longer) but the unit value heightens in reflection of higher weights at sale. A local resident who gives roughly equal emphasis to pastoralism and agriculture in his economic strategies is likely to have a minimum holding of 30 animals, mainly goats. On the basis of a 35 head flock of sheep of which 60% are breeding females, sales and expenses might be:

SALES	US $	RIALS
Sale of milk products - 19 ewes @ 1000 Rials	270	19,000
Sale of 5 male lambs @ US $35 (Rls 2500)	177	12,500
Sale of 4 one-year old males @ US $57 (Rls 4000)	227	16,000
Sale of 7 cull ewes @ US $50 (Rls 3500)	348	24,500
TOTAL SALES	1,021	72,000

Costs per head are lower than in the case of transhumant flocks and possibly 50%-60% of sales will represent profit—say US $600 (Rls 40—45,000) per flock of 35 head.

AGRICULTURE Agricultural crops in general appear to be more important for supplying domestic needs than generating income, with the exception of cotton and tobacco which are cultivated explicitly as cash crops, and surplus grains from dry farming in good years. Current "farm-gate" prices per kg for these crops are:

	US $	RIALS
Cotton	0.70	50
Tobacco	0.60	42
Cereals	0.17	12

The amount sown per year by individual families fluctuates according to several factors. The ability to command labour at the right time is one of the most critical of these, and severely restricts the opportunities of some families. But the possibility of adding several hundred dollars to the annual family income by these means is always there.

OBSTACLES TO THE DEVELOPMENT OF THE ECONOMY OF TURAN

Livestock development can be thought of in terms either of the value and volume of total output or of livestock output per inhabitant. They may, but need not necessarily be the same thing, for a constant livestock output coupled with a declining human population may lead to a rising per caput output. What then are the factors limiting the total value and volume of livestock output from Turan? Prices of livestock and livestock products, relative to the prices of other goods, are not, at present, unfavourable in comparison to relative prices elsewhere in the world. It is unlikely that in the foreseeable future the value of livestock output will be raised by government policies designed, as in Europe, to bolster (pastoral) producers' incomes by raising prices to consumers. There may be some scope for reducing costs and margins in the marketing chain, but high costs or margins are not conspicuous in the present system.

Losses from livestock diseases, while not yet quantified, do not appear to be serious. Fertility, especially of sheep, is somewhat low in comparison to some countries, but this appears to be as much due to the low incidence of twinning as to absolute infertility. More twins may not be desirable with present levels of feeding. In Sangsari flocks wool yields are very low, and milk yields, at an apparent 25-45 kgs per lactation, rather low. Proper data on weight gains do not exist but it would appear that male lambs can be sold off at six months without supplementary feeding at about 25-35 kilogrammes live weight, and that with feeding a live weight of 50 kgs at 11 months old can be achieved.

Livestock specialists tend to stress the importance of performance per animal (e.g. milk yield per lactation per ewe, daily rate of live weight gain per head). Where the most important costs (of labour, mainly, or of medicines, housing, etc.) are proportioned to the number of head kept, this emphasis on productivity per animal is useful. Where the most critical scarce resource is feed, however, it may be more useful to emphasise conversion efficiency (feed into milk or meat or wool) and not on performance per head per day. Conversion efficiency is hard to measure, and livestock specialists argue that performance per head per day is very closely correlated with conversion efficiency; that selecting in terms of productivity per head is tantamount to selecting for conversion efficiency. It is possible to demonstrate this under conditions where ample feed is available in front of the animal's nose, but where feed is scarce and difficult to find (hidden away in crevices and under thorny bushes), it may not be so since 8 legs (2 small animals) may gather more food than 4 legs (one large). The conversion rate applicable is then not "product per feed consumed" but "product per feed available if looked for".

The last two paragraphs argue that, while the present performance of livestock in Turan is not impressive, it may not be very easy to improve it without a radical change in the level of feeding. Whether such improvement in feeding can be obtained by "managing" (protecting, rotating, reseeding, etc.) the range, or whether it will require a complete change from "range resources" to "intensive feedstuffs" (implying an abandonment of the range resources to wildlife) is obviously a matter for discussion. But the focus of such discussion should always be the need to determine the most productive use of the resources of arid lands in the long term. In any case, it is not clear whether "feed" is the critical constraint on livestock production at the moment. The high level of barley fed (an innovation dating from the sixties) suggests that it is. On the other hand the low level of "rents" paid for sheep pens (rent for grazing is illegal since nationalisation in 1963), a mere 3% of the value of output from an area, suggests that it is not. Livestock owners and shepherds, in discussing reasons for limiting holdings, put the emphasis on shortage of labour not of feed. On the other hand the last few years may have been exceptionally favourable climatically.

The main pressure on existing systems of livestock keeping in Turan appears to come from a growing labour scarcity (and consequent high cost of shepherding) arising from strong competition from urban industries. The present profitability of transhumants' livestock operations is low. Costs of production appear to come to 70% of the value of output, and 55% of total cash costs are labour costs. There are other non-cash costs involved in the labour required for milking herds, although abandonment of milking in favour of concentration on meat production might not be very serious for transhumants since there would be some compensatory gains in heavier weights of lambs at sale. There appears to be some scope for increasing labour productivity in shepherding, with the implication that, unless total livestock numbers in Turan can be increased (for example, by "range management"), a lower human population would be supported by livestock activities. There may be valid technical reasons determining 400 as the optimum flock size among the Sangsari, but output per head of sheep could be improved, and even if this meant no greater total output per unit area, it might mean more output per shepherd. Undoubtedly, additional equipment and communication devices, and more frequent watering points, could lead to reduction in the need for "assistant shepherds", and probably a 50% gain in labour productivity could be achieved in this way, although at the expense of some capital investment and higher equipment costs.

This economic review suggests that the outlook for transhumant pastoralism in Turan is uncertain unless productivity can be increased and shepherding be made more attractive. Economically, the self-employed resident mixed farmer does relatively well. However, the viability of this latter adaptation during the coming decades will depend on the interest of the younger generation and the rate of migration to the cities. Apart, therefore, from arguments concerning the ecological efficiency of these two adaptations, there is room for serious doubt about the survival of either unless they are included and encouraged in long term management and development programmes.

7. THE QUALITY OF LIFE

The vital question that has not yet been posed concerns the quality of life in Turan, and in what ways it may have been related historically and potentially to processes of desertification. The only historical information comes from sources such as those that have been quoted above. They are generally unfavourable, but they are written exclusively by outsiders and foreigners. Similar appraisals of the quality of life in Turan today are also invariably unfavourable, but the opinions of local residents tend to vary with their age. Many young people, especially youths who have served their statutory term in the armed forces and therefore travelled extensively outside the area, tend to seek ways of moving to the city permanently. The reasons they give fall under the headings of variety of social life and economic opportunities. Other age groups often argue for the advantages of life in Turan. Many of their reasons are negative, deriving from general conservatism, and fear of failure in a new social and economic niche, but positive reasons are also voiced. Freedom to organise their own work and lives, even though the work may be arduous, obviously carries weight, as well as the knowledge that so long as they have land and water they need never depend on others for a livelihood, but can produce for themselves their basic food supply. They are well aware that the food they produce for themselves is generally superior in quality to what they would have to buy at what seem to them inflated prices in the towns. But however definite an informant might be about advantages of life in Turan, he is likely to complain about the lack of medical facilities, and the disadvantages of the lack of good roads and public transport. Studies of drinking water supplies, nutrition and general public health are in progress. Preliminary results do not indicate any major problems, but relevant comparative data are not yet available.

These views come from people who live in some of the more isolated villages in the country, but are aware that during the last twenty years the conditions of life of their community have changed almost beyond recognition. Oral accounts are unanimous that conditions were particularly difficult during the forties and early fifties, and that symptoms of desertification in the form of poorer vegetation and more sand movement were conspicuous—which demonstrates again that conditions in Turan despite its isolation are intimately connected with conditions in the country as a whole. To recapitulate, the principal changes that have come about in Turan since the early fifties are the establishment of basic security, the cessation of charcoal production, the change from camels to motorised transport and the resulting commercialisation of pastoralism and agriculture. It is noteworthy that these are all exogenous changes.

Another fundamental change that is less often noticed has occurred in the structure of the society. The families that provided the leaders of the society up to the sixties no longer fulfill that function, and have either migrated, become impoverished, or are now scarcely distinguishable from the average family.

All these changes—and the list could be extended—lead to a feeling of uncertainty about the future, which unfortunately has been increased by speculation about the implications of the special interest of a government department such as the Department of the Environment, and uncertainty is bad for investment.

8. CONCLUSION

Desertification is not new. In Turan it has probably been more serious in the recent past than now. But from a national point of view it is more critical now than ever before. Old problems are now exacerbated by the increasing differentiation between rates of socio-economic change in city and desert, which leads to a growth in cultural prejudice, that in turn reinforces both neglect and abuse of the deserts and their margins. In Turan social decline, decrease in investment and desertification have been intimately interrelated.

Government intervention is often characterised by a tendency toward solutions with a patronising or charitable flavour. They are often authoritarian, and always technocratic. This is above all the result of distrust for the traditional, rural world. It is also due to a certain ignorance of this rural world.

Desertification processes in vulnerable arid and semi-arid areas have been inseparable from social and economic processes in neighbouring, more fertile areas. In order to counteract them large scale planning and long range management procedures are required that would include desert and related non-desert areas, and apply the same ecological and economic standards to both.

Lack of interest in marginal areas is dangerous for two essential reasons: it encourages their abandonment, even though they have an important contribution to make to present and future production; and it allows continued deterioration of fragile areas which are also necessary for the reduction of the country's food deficit--deterioration that could be contained or reversed by monitoring, planning, management and investment. An example of the way satellite remote sensing materials can be used to improve the data base and monitor ecological change over vast inaccessible areas is given in Appendix 7. It is hoped to extend this project considerably within the framework of the Transnational Project to Monitor Desertification Processes and Related Natural Resources in Arid and Semi-Arid Areas of Southwest Asia (also prepared for the United Nations Conference on Desertification) for which Turan will serve as a pilot area.

RECOMMENDATIONS In the light of these conclusions, it is recommended that the struggle against desertification should be conducted through management programmes based on the reconstruction and evaluation of the ecological history of vulnerable areas. Such programmes should be fully comprehensive and integrated on three levels. They should integrate:

a) the theoretical and field orientations of the physical, biological and social sciences

b) the functions of research, experimentation and management

c) the participation of the research team, the local population and relevant decision makers

Careful attention should be given to building on existing technologies, supporting innovation within existing traditions, and introducing modern or exotic technologies only where the payoff and the risk are well defined. Emphasis should always be given to increasing the interdependence and range of interlocking systems, and to encourage livelihood diversification and flexibility. In more specific terms, in order to prepare for and plan human exploitation of vulnerable areas in the future, and reduce the risk of desertification to the minimum, it is necessary to monitor natural resources, prepare for the effects of predictable desertification processes, and finally by provision of facilities, including public education, and communications, to seek generally to reduce the basis of cultural discrimination between urban and rural living in arid zones.

The most important theme that issues from this study and from the experience of the Turan Programme so far is the importance of investment. In order to provide an element of personal investment in the human use systems of arid rangelands in Iran, and induce the population generally to recognise the value of these renewable natural resources, it has recently been decided at Government level to embark on a programme of long term leasing of the country's rangelands to individual pastoralists. It is hoped that the introduction of an element of personal investment and responsibility in this way will play an important part in Iran's struggle against desertification.

BIBLIOGRAPHY

Adle, Chahryar

1971 Contribution a la Geographie Historique du Damghan *Le Monde Iranien et L'Islam* I: 69-104.

Aubin, Jean

1971 Reseau Pastoral et Reseau Caravanier Les Grand'routes du Khurassan a l'epoque mongole. *Le Monde Iranien et L'Islam* I: 105-130.

Bobek, H.

1959 *Features and Formation of the great Kawir and Masileh*, Arid Zone Research Centre, University of Tehran, Pub. No. 2.

Caldwell, Joseph R. ed.

1967 *Investigations at Tal-i Iblis*. Illinois State Museum Preliminary Report No. 9.

Clerk, Capt. Claude

1861 Notes on Persia, Khorassan, and Afghanistan. *Journal of the Royal Geographical Society*, 31: 37-65.

Forster, George

1970 (1808) *A Journey from Bengal to England*. Punjab Languages Department Vol. I and II

Gabriel, Alphons

1935 *Durch Persiens Wusten*. Stuttgart: Strecker Schroder.

International Union for Conservation of Nature and Natural Resources

1976 *Ecological Guidelines for the Use of Natural Resources in the Middle East and South West Asia*. Morges, Switzerland.

Krinsley, D.B.

1970 *A Geomorphological and Paleoclimatological Study of the Playas of Iran*. U.S. Geological Survey, Final Scientific Report, Contract No. PROCP70-700.

Markwart, J.
1931 *A Catalogue of the Provincial Capitals of Eran-Shahr.* Rome: *Analecta Orientalia 3.*

Marvin, Charles
1881 *Merv. The Queen of the World.* London: W.H. Allen

Miles, G.C.
1975 Numismatics in the *Cambridge History of Iran,* ed. by R.N. Frye. London: Cambridge University Press. pp. 364-377.

National Statistics Center
1973 *Statistical Handbook,* Tehran.

Pabot, H.
1967 *Report to the Government of Iran on Pasture Development and Range Improvement through Botanical and Ecological Studies.* Rome: FAO No. TA 2311.

Rechinger, K.-H. (ed.)
Flora Iranica. Vienna.

Spooner, Brian
1974 City and River in Iran: Urbanization and Irrigation of the Iranian Plateau. *Iranian Studies* VII: 681-713.

Vaughan, Lt. H.B.
1893 A Journey through Persia. *Royal Geographical Society Supplementary Papers* III: 89-115.

Zohary, M.
1963 On the Geobotanical Structure of Iran. *Bulletin of the Research Council of Israel.* Volume 11D, Supplement.

APPENDIX 1

PLANTS OF THE TURAN BIOSPHERE RESERVE

PTERIDOPHYTA
Cheilanthes persica

GYMNOSPERMAE -
Ephedraceae
Ephedra strobilacea

ANGIOSPERMAE -
Dicotyledones
ANACARDIACEA
Pistacia khinjuk

BORAGINACEAE
Arnebia decumbens
A. linearifolia
A. minima
Asperugo procumbens
Caccinia macranthera
Gastrocotyle hispida
Heliotropium acutiflorum
H. eremobium
H. nodulosum
H. popovii
Heterocaryum irregulare
H. macrocarpum
H. rigidum
Lappula ceratophora
L. sessiliflora
L. sinaica
L. spinocarpas
Myosotis minutiflora
Nonnea caspica
N. caspica subsp.*zygomorpha*
N. turcomanica
Onosma johnstonii
Paracaryum calathicarpum
P. intermedium
P. platycalyx
P. salsum
P. stellatum
Rochelia bungei

CAMPANULACEAE
Campanula khorasanica

CAPPARIDACEAE
Capparis spinosa
Cleome coluteoides

CARYOPHYLLACEAE
Acanthophyllum diezianum
Cerastium
Holosteum glutinosum
Lepyrodiclis holostereoides
Silene affinis
S. bupleuroides
S. chaetodonta
S. coniflora
S. conoidea
S. nana
Stellaria blatteri
St. media

CHENOPODIACEAE
Aellenia auricula
Ae. subaphylla
Ae. glauca
Agriophyllum latifolium
A. minus
Anabasis eriopoda
Atriplex dimorphostegia
A. griffithii
A. leucoclada
Ceratocarpus arenarius
Ceratoides latens
Chenopodium vulvaria
Corispermum lehmannianum
Esfandiaria calcarea
Gamanthus gamocarpus
Girgensohnia oppositiflora
Halimocnemis longifolia
H. pilifera
Halocharis sulphurea

CHENOPODIACEAE (cont'd.)
Halocnemum strobilaceum
Halopeplis pygmaea
Halostachys belangeriana
Haloxylon aphyllum
H. persicum
Horaninowia platyptera
H. ulicina
Hypocylix kerneri
Kochia stellaris
Londesia eriantha
Noea spinosissima
Petrosimonia glauca
Salicornia herbacea
Salsola aucheri
S. dendroides
S. incanescens
S. leptoclada
S. cf. nitraria
S. orientalis
S. praecox
S. richteri
S. sclerantha
S. tomentosa
S. turcomanica
Seidlitzia rosmarinus
Suaeda arcuata

COMPOSITAE
Acantholepis orientalis
Achillea tenuifolia
A. wilhelmsii
Aegopordon berardioides
Amberboa turanica
Anthemis austro-iranica
A. odontostephana
Artemisia herba-alba
Carduus pycnocephalus
Centaurea pulchella
Chardinia orientalis
Chrysanthemum gaubae
Cirsium arvense
Cousinia congesta
C. eryngioides

COMPOSITAE (cont'd.)
C. lachnosphaera
C. lasiandra
C. meshhedensis
C. onopordioides
C. piptocephala
C. prolifera
C. turkmenorum
C. sancta
Echinops robustus
Epilasia hemilasia
Gnaphalium luteo-album
Gymnarrhena micrantha
Heteroderis pusilla var. pusilla
H. pusilla var. leucocephala
Jurinea carduiformis
J. radians
J. ramosissima
Koelpinia linearis
K. tenuissima
Lactuca glauciifolia
L. undulata
Launaea acanthodes
Microcephala lamellata
Oligochaete albispina
O. minima
Phagnalon nitidum
Picnomon acarna
Pulicaria crispa
Scariola orientalis
Scorzonera litwinowii
S. paradoxa
S. pusilla
S. raddeana
Senecio desfontainei
Taraxacum pseudocalocephalum
T. pseudodissimile
Thevenotia persica
Tragopogon jezdianus
T. montanus
Varthemia persica
Zoegea purpurea

CONVOLVULACEAE
Convolvulus eremophilus
C. erinaceus

CRASSULACEAE
Pseudosedum multicaule

CRUCIFERAE
Aethionema carneum
Alyssum dasycarpum
A. lanceolatum
A. linifolium
A. marginatum
Arabidopsis pumila
A. wallichii
Brassica deflexa
Cardaria draba
Chorispora tenella
Cithareloma cf. registanicum
Clypeola aspera
C. dichotoma
Crambe kotschyana
Descourainia sophia
Erysimum crassicaule
Euclidium syriacum
Fortuynia garcinii
Goldbachia laevigata
Isatis buschiana
I. emarginata
I. minima
I. trachycarpa
Lepidium vesicarium
Leptaleum filifolium
Malcolmia africana
M. africana var. *trichocarpa*
M. grandiflora
M. strigosa
Matthiola chenopediifolia
Moriera spinosa
Octoceras lehmannianum
Sameraria armena
S. elegans
Sisymbrium septulatum

CRUCIFERAE (cont'd.)
Spirorrhynchus sabulosus
Sterigmostemon acanthocarpum
Tauscheria lasiocarpa
T. lasiocarpa var. gymnocarpa
Tetracme recurvata
Torularia aculeolata
T. torulosa

CUSCUTACEAE
Cuscuta brevistyla

DIPSACACEAE
Scabiosa olivieri
S. rotata

EUPHORBIACEAE
Chrozophora gracilis
Euphorbia buhsei
E. bungei
E. cheirolepis
E. densa
E. gedrosiaca
E. microsciadia
E. turcomanica
E. Turczaninovii

FUMARIACEAE
Fumaria parviflora
F. vaillantii

GERANIACEAE
Biebersteinia multifida
Erodium glaucophyllum
E. pulverulentum
Geranium rotundifolium

LABIATAE
Chamaesphacos ilicifolius
Hymenocrater elegans
Eremostachys hyoscyamoides
E. molucelloides
Lallemantia royleana

LABIATAE (cont'd.)
Lamium amplexicaule
Marrubium alternidens
Nepeta bracteata
N. ispahanica
N. micrantha
N. persica
N. pungens
N. sewerzovii
Perowskia abrotanoides
Salvia leriifolia
S. macrosiphon
Thuspeinantha brahuica
Th. persica
Ziziphora tenuior

LEGUMINOSAE
Alhagi camelorum
Astragalus (Ammodendron) podolobus
A. (Ammodendron) squarrosus
A. (Chronopus) spinescens
A.(Erioceras) ulothrix
A. (Falcinellus) bakaliensis
A. (Harpilobus) campylorrhynchus
A. (Harpilobus) corrugatus
A. (Harpilobus) hauarensis
A. (Harpilobus) hauarensis var. glaber
A. (Malacothrix) comosus
A. (Mirae) mirus
A. (Myobroma)
A. (Oxyglottis) ammophilus
A. (Oxyglottis) oxyglottis
A. (Oxyglottis) tribuloides
A. (Xiphidium) argyroides
Goebelia pachycarpa
Hedysarum micropterum
Medicago lupulina
Onobrychis tavernierifolia
O. Aucheri subsp. *teheranica*
Smirnovia turkestana
Trigonella noeana

MALVACEAE
Malva neglecta

OROBANCHACEAE
Cistanche fissa
C. laxiflora
O. mutelii

PAPAVERACEAE
Glaucium elegans
Hypecoum pendulum
Papaver decaisnei
P. paveninum
Roemaria dedecandra
R. hybrida

PLANTAGINACEAE
Plantago evacina
P. lanceolata

PLUMBAGINACEAE
Acantholimon acmostegium
Limonium iranicum

PODOPHYLLACEAE
Bongardia chrysogonum

POLYGONACEAE
Atraphaxis spinosa
Calligonum cf. comosum
C. leucocladum
C. cf. turkestanicum
Polygonum afghanicum
P. polycnemoides
Pteropyrum aucheri
Rheum cf. ribes

PRIMULACEAE
Androsace maxima

RANUNCULACEAE
Anemone biflora
Ceratocephalus falcatus
Clematis songarica
Consolida rugulosa
Nigella integrifolia
Thalictrum isopyroides

RHAMNACEAE
Rhamnus pallasii

ROSACEAE
Amygdalus lycioides
Hulthemia berberifolia

RUBIACEAE
Callipeltis cucullaria
Galium ceratopodum
G. setaceum
G. spurium
Leptunis trichodes
Rubia florida

RUTACEAE
Haplophyllum furfuraceum
H. pedicellatum
H. perforatum
H. robustum

SCROPHULARIACEAE
Scrophularia leucoclada
S. striata
Veronica anagallis-aquatica
V. anagalloides
V. arguteserrata
V. campylopoda
V. macropoda

SOLANACEAE
Hyoscyamus leucanthera
H. pusillus
Lycium depressum
L. ruthenicum

TAMARICACEAE
Reaumuria fruticosa
Tamarix brachystachys
T. hispida

THYMOLAEACEAE
Dendrostellera lessertii

VIOLACEAE
Viola occulta

UMBELLIFERAE
Bunium cylindricum
B. persicum
B. rectangulare
Bucrosia anethifolia
Eryngium cf. nigro-montanum
Eryngium cf. bungei
Ferula foetida
Prangos latiloba
P. cf. pebularia
Psammogeton canescens
Ps. brevisetus
Scandix
Schumannia karelinii
Zozimia absinthifolia

VALERIANACEAE
Valeriana ficariifolia
Valerianella dufresnia
V. oxyrrhyncha
V. szovitsiana
V. triplaris

ZYGOPHYLLACEAE
Peganum harmala
Zygophyllum eurypterum

ANGIOSPERMAE -
Monocotyledones

ALLIACEAE
Allium borszczowii
A. caspium
A. scotostemon
A. umbilicatum

AMARYLLIDACEAS
Ixiolirion tataricum

CYPERACEAE

Carex diluta
C. divisa
C. physodes
C. stenophylla

GRAMINEAE

Astenatherum forsskahlii
Boissiera squarrosa
Bromus danthoniae
B. tectorum
Eremopoa persica
Eremopyrum bonaepartis
E. orientale
Henrardia persica
Mordeum glaucum
Nardurus subulatus
Pennisetum orientale
Phalaris minor
Phragmites australis
Piptatherum microcarpum
Poa bulbosa
Stipagrostis pennata
Taeniatherum crinitum

IRIDACEAE

Iris kopetdaghensis
I. songarica

JUNCACEAE

Juncus gerardi

LILIACEAE

Colchicum robustum
Eremurus inderiensis
Fritillaria sp.
F. gibbosa
Gagea gageoides
G. reticulata

APPENDIX 2A

DIMENSION AND AGE DATA FOR

Zygophyllum eurypterum

January 1977

from 1 ha exclosure 9 km ESE of Delbar

BUSH NO.	HEIGHT (cm.)	MAXIMUM DIAMETER	DIAMETER AT RIGHT ANGLES	WEIGHT (kg.)	AGE
1	107	200	199	9.57	43
2	79	177	119	5.15	22
3	57	149	135	2.65	51
4	76	183	151	3.41	51
5	30	68	68	0.72	58
6	107	268	222	11.10	52
7	48	90	73	0.31	48
8	82	160	116	3.98	46
9	35	76	75	0.37	17
10	78	187	163	2.48	38
11	120	205	198	10.08	33
12	94	215	200	7.57	21
13	58	170	167	3.78	17
14	43	141	109	2.21	32
15	48	126	121	1.39	19
16	91	211	206	9.98	76
17	100	232	157	12.44	80
18	115	220	191	5.91	58
19	40	108	59	0.66	26
20	82	139	126	1.05	16
21	104	200	200	7.71	47
22	88	173	144	3.15	54
23	39	49	28	0.08	6
24	31	34	29	0.08	8
25	25	39	36	0.05	9
26	42	50	39	0.12	10
27	47	72	68	0.23	12
28	52	46	39	0.21	8
29	50	75	47	0.35	21
30	27	30	25	0.03	6
31	34	50	46	0.11	8
32	57	107	79	0.46	20
33	67	111	67	0.59	19
34	130	272	260	17.15	55

PLANT NUMBER

YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
2	+	+	+	+	+	+	+	-	+	+	+	+	+	+	-	+	-	+	+	-	+	+	+	-	-
3	+	+	+	+	+	+	+	-	+	+	-	+	+	+	+	-	-	+	+	+	+	+	+	+	+
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-
5	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+
6	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
7	-	+	+	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	+	+	-	-
8	-	±	+	+	+	+	+	+	-	+	-	+	+	+	+	-	+	+	+	+	+	+	+	+	+
9	-	+	-	+	+	-	+	+	-	+	+	+	-	+	+	-	+	+	+	+	+	+	+	+	+
10		-	+	+	-	-	-	+	-	-	-	-	+	+	-	+	-	-	-	-	-	+	+	-	-
11		-	+	-	-	+	-	+	+	+	-	+	-	+	+	+	+	+	+	+	+	+	+	+	+
12		-	-	-	-	-	+	-	-	-	-	-	-	-	-	+	-	+	+	+	+	-	+	-	-
13		-	-	-	-	-	-	-	+	-	+	-	-	-	-	+	-	+	-	-	+	-	-	-	-
14		±	-	-	-	-	-	-	+	-	-	-	-	-	-	+	-	+	-	+	+	-	-	-	-
15		-	+	-	+	-	-	-	+	+	-	+	-	+	-	+	+	+	-	-	+	+	+	+	+
16		-	-	-	-	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	-
17		-	-	-	-	+	+	+	-	-	-	+	-	+	+	-	+	-	-	+	-	+	+	+	+
18		-	-	-	-	+	+	+	-	-	-	+	-	+	+	-	-	+	+	+	+	-	+	+	+
19		-	-	-	-	-	-	-	+	-	+	+	+	-	-	-	+	+	+	-	+	-	-	-	-
20				-	-	+	+	+	-	-	+	-	-	-	-	-	-	-	+	-	-	-	-	-	+
21					-	-	-	-	-	-	+	-	+	-	-	-	-	+	-	+	-	+	-	-	+
22							-	-	-	-	-	+	-	+	-	-	-	+	-	+	-	+	+	+	-
23								-	-	-	+	+	+	+	-	-	-	-	+	-	-	-	+	+	-
24								-	-	-	-	-	-	+	+	+	-	-	+	+	-	-	-	-	+
25										-	+	-	-	-	+	-	-	-	+	+	-	-	-	+	+
26										+	-	+	-	-	-	+	+	-	-	+	-	+	-	+	-
27										-	-	+	+	-	-	-	+	-	-	-	-	-	+	+	+
28										-	+	-	+	-	-	-	-	-	+	+	+	+	-	-	+
29										+	-	+	-	-	-	+	-	-	-	-	+	-	-	+	+
30											+	+	-	-	-	-	+	-	-	+	-	-	-	-	+
31											-	-	+	-	-	-	-	+	-	-	-	-	-	+	-
32											+	+	-	-	-	-	-	-	-	-	+	+	+	-	+
33											-	-	-	-	-	+	-	+	-	-	-	-	+	-	-
34											-	-	+	-	+	-	-	-	-	-	-	-	-	-	-
35											-	-	+	+	-	-	-	+	-	-	-	-	+	-	-
36											-	-	+	-	+	-	-	-	-	-	-	-	+	-	-
37												-	-	+	-	+	-	-	-	+	-	-	-	-	-
38												-	-	-	+	+	-	-	-	-	-	+	-	+	+
39													+	-	-	-	-	-	-	-	-	+	+	-	+
40													+	+	-	+	-	-	-	-	-	-	-	-	-
41													-	+	+	-	-	-	-	+	-	+	-	+	-
42													-	-	-	-	+	-	-	+	-	+	-	-	+
43													+	+	+	+	-	+	-	+	-	+	-	+	+
44													-	-	-	-	+	-	-	-	-	-	+	-	+
45														?	+	-	+	+	-	-	-	+	-	+	+
46														'	-	-	+	-	+	-	-	-	-	+	-
47															-	-	+	-	-	-	-	-	-	+	+
48															+	+	+	-	-	+	-	+	-	+	-
49															+	-	+	-	-	+	-	+	-	-	-
50																+	-	-	-	-	-	+	-	+	+
51																-	+	-	-	+	-	-	-	+	+
52																-	+	-	-	-	-	+	-	+	+
53																-	+	-	-	+	-	+	-	-	+
54																		+	-	-	-	-	-	+	+
55																		+	-	-	-	-	-	+	+
56																		-	-	+	-	-	-	-	-
57																		-	-	-	-	-	-	-	-
58																		-	-	-	-	-	-	-	-
59																		+	-	-	-	-	-	-	-
60																			-	-	-	-	-	+	-
61																			-	-	-	-	-	-	-
62																			-	-	-	-	-	+	-
63																				-	-	-	-	-	-
64																				-	-	-	-	+	+
65																				+	-	-	-	+	-
66																					-	-	-	-	-
67																					-	-	-	+	-
68																					-	-	+	-	-
69																					-	+	-	-	-
70																							-	-	+
71																							-	+	-
72																								-	-
73																									-
74																									-
75																									-
76																									+
77																									-
78																									+
79																									+
80																									+
81																									+
82																									-
83																									-
84																									+
85																									-
86																									+
87																									-
88																									+

APPENDIX 2B

SUMMARY OF RESULTS
OF RING ANALYSIS
OF 25
Zygophyllum eurypterum
BY POSITIVE AND
NEGATIVE YEARS
BASED ON THE MEAN
i) BY INDIVIDUALS
ii) GENERALIZED

APPENDIX 2B

Key: + = good year
- = bad year
m = mediocre year

1976	+	1939	m	1902	+
75	+	38	-	01	+
74	+	37	m	1900	-
73	-	36	m	1899	+
72	+	35	+	98	+
71	-	34	-	97	+
70	-	33	+	96	+
69	+	32	-	95	-
68	+	31	m	94	+
67	-	30	+	93	+
66	+	29	-	92	-
65	-	28	m	91	+
64	-	27	m	90	-
63	-	26	m	89	+
62	+	25	+		
61	m	24	+		
60	m	23	+		
59	-	22	-		
58	-	21	-		
57	-	20	m		
56	m	19	m		
55	m	18	+		
54	-	17	-		
53	+	16	-		
52	+	15	m		
51	+	14	m		
50	-	13	m		
49	-	12			
48	m	11	m		
47	-	10	m		
46	+	09	m		
45	m	08	m		
44	-	07	+		
43	m	06	m		
42	-	05	-		
41	m	04	-		
40	m	03	+		

Six trunks collected from other parts of the area (with one exception collected approximately 20 kms north of Biarjomand) show similar values.

APPENDIX 3

MAMMALS OF THE TURAN BIOSPHERE RESERVE

ORDER *INSECTIVORA*

FAMILY *ERINACEIDAE*
Hemiechinus auritus
Paraechinus hypomelas

FAMILY *SORICIDAE*
Crocidura zarudnyi

ORDER *CHIROPTERA*

FAMILY *RHINOPOMATIDAE*
Rhinopoma muscatellum

FAMILY *RHINOLOPHIDAE*
Rhinolophus ferrumequinum
Rhinolophus bocharicus
Rhinolophus blasii

FAMILY *MOLOSSIDAE*
Tadarida teniotis

FAMILY *VESPERTILIONIDAE*
Myotis blythi
Myotis mystacinus
Myotis emarginatus
Vespertilio murinus
Eptesicus nasutus
Nyctalus leisleri
Pipistrellus savi
Miniopterus schreibersi
Otonycteris hemprichi
Plecotus austriacus

ORDER *CARNIVORA*

FAMILY *CANIDAE*
Canis lupus
Canis aureus
Vulpes vulpes
Vulpes cana
Vulpes ruppelli

ORDER *CARNIVORA* (cont'd.)

FAMILY *MUSTELIDAE*
Martes foina
Vormela perequsna

FAMILY *HYAENIDAE*
Hyaena hyaena

FAMILY *FELIDAE*
Felis catus
Felis margarita
Felis manul
Lynx caracal
Panthera pardus
Acinonyx jubatus

ORDER *PERISSODACTYLA*

FAMILY *EQUIDAE*
Equus hemionus

ORDER *ARTIODACTYLA*

FAMILY *BOVIDAE*
Gazella subgutturosa
Gazella dorcas

ORDER *LAGOMORPHA*

FAMILY *OCHOTONIDAE*
Ochotona rufescens

FAMILY *LEPORIDAE*
Lepus capensis

(continued)

ORDER *RODENTIA*

FAMILY *HYSTRICIDAE*
Hystrix indica

FAMILY *DIPODIDAE*
Allactaga elater
Allactaga hotsoni
Allactaga euphratica
Allactagulus pumilio
Jaculus blanfordi
Dipus sagitta
Paradipus ctenodactylus
Salpingotus, sp.

FAMILY *GLIRIDAE*
Dryomys nitedula

FAMILY *MURIDAE*
Apodemus sylvaticus
Rattus norvegicus
Rattus turkestanicus
Mus musculus
Nesokia indica

FAMILY *CRICETIDAE*
Calomyscus bailwardi
Cricetulus migratorius

FAMILY *GERBILLIDAE*
Gerbillus nanus
Gerbillus cheesmani
Meriones persicus
Meriones zarudnyi
Meriones libycus
Meriones crassus
Meriones meridianus
Rhombomys opimus

FAMILY *MICROTIDAE*
Ellobius fuscocapillus
Microtus (Blanfordimys) afghanus
Microtus socialis

APPENDIX 4

CLIMATOLOGICAL DATA FOR TOWNS OF THE NORTHEAST OF THE IRANIAN PLATEAU
(1961-1973)

STATION[1]	ALTITUDE	MEAN MAXIMUM TEMPER-ATURE (°C)	MEAN MINIMUM TEMPER-ATURE (°C)	ABSOLUTE MAXIMUM TEMPER-ATURE (°C)	ABSOLUTE MINIMUM TEMPER-ATURE (°C)	MEAN ANNUAL TEMPER-ATURE (°C)	PRE-CIPI-TATION (mm)	MEAN RELATIVE HUMIDITY 6:30 a.m.	MEAN RELATIVE HUMIDITY 12:30 p.m.	NO. OF FROST DAYS
Sabzevar	944m	23.9	9.0	44.5	-19.8	16.4	160	54	29	74.0
Semnan	1138m	24.3	11.0	44.5	-12.5	17.7	129	52	32	42.9
Shahrud	1366m	20.9	7.4	40.0	-14.0	14.2	149	64	37	84.7
Tabas	691m	29.1	12.8	48.2	- 9.3	20.9	73	54	25	38.1

[1]See Map 1.

APPENDIX 5

CENTRAL TAURAN: POPULATION, RESOURCES, SERVICES

1966 CENSUS

Village	Families	Sheep and Goats	Cattle	Arable * Land (ha)	School	Public Bath	Mosque	Cooperative	Village Council	Headman
Barm	30	1,500	6	38					1	1
Eshqvan	50	5,300	20	13	1		1		1	1
Faridar	20	1,200	9	2			1			
Baghestan	32	400	8	39	1		1		1	1
Ja'farabad	18	700	4	1			1			
Kariz	25	1,000	6	2	1	1		1	1	1
Nahar	13	40	3	4			1		1	1
Nauva	11	200	5	3						
Ravazang	7	1,500	2	6						
Salehabad	25	7,300	25	19	1		1		1	1
Taghmar	6	200	5	4						
Yakarig	3	300								
Zamanabad	46	1,500	10	8			2	1	1	1
Zivar	12	300		6						
Central Tauran Total	298	21,440	103	145	4	1	8	2	7	7

* The 1966 figures for arable land are incomplete and should be treated as minima only.

OUTLYING TAURAN VILLAGES: POPULATION, RESOURCES, SERVICES
1966 CENSUS

Village	Families	Sheep and Goats	Cattle	Arable * Land (ha)	School	Public Bath	Mosque	Cooperative	Village Council	Headman
Asbkeshan	12	500		2						
Chah-e Mer'i	4	500								
Derazab	17	300		4						
Div	7	600	5							
Farinu	9	200	2							
Garmab-e Bala	5	300	4	6						
Garmab-e Pa'in	9	500	3	2						
Hojjaj	18	500	2	4	1					
Jorjis Peighambar	1									
Kalagh Zili	1	250	2							
Kalata-ye Rei	7	600	8	2						
Kalata-ye Reza Qoli	1	400	2	2						
Mer'i	5	100		5						
Narestana	8	50		6						
Nur	11	20	5	6						
Posht-e Asman	2	50		1						
Salamrud	8	200	3	6						
Tejur	1	40	1							
Talkhab	11	900	7	1		1				
Tauchah	3	450	4							
Outlying Tauran Total	140	6,460	48	47	1	1	0	0	0	0

KHAR: POPULATION, RESOURCES, SERVICES
1966 CENSUS

Village	Families	Sheep and Goats	Cattle	Arable * Land (ha)	School	Public Bath	Mosque	Cooperative	Village Council	Headman
Ahmadabad	95	800	80	9	1	1			1	1
Darbahang	42	1,000	80	5			1			
Rezaabad	44	1,500	4							
Khar Total	181	3,300	164	14	1	1	1	0	1	1
KHAR TAURAN TOTAL	619	31,200	315	206	6	3	9	2	8	8

* The 1966 figures for arable land are incomplete and should be treated as minima only.

APPENDIX 6

COMPONENTS OF THE TURAN PROGRAMME

STUDIES IN PROGRESS

Climatological recording

Geological mapping and geomorphology

Soil mapping and analysis

Sand accumulation and movement

Vegetation mapping and botanical taxonomy

Use of LANDSAT data to improve mapping and monitor ecological change

Vegetation history

Plant physiology

Plant population structure and distribution

Palynology

Dendrochonology

Wildlife ecology

Ethology and ecology of domesticates

Dietary studies of all herbivores by means of faecal analysis

Prehistory and history of human activity by means of the study of land forms, archaeological evidence and historical materials

Pastoral and agricultural technologies

Economics, demography, health, nutrition, social organisation and values of the present populations

Comparative economics and ecology of different pastoral and agricultural technologies

STUDIES PLANNED

Hydrology

Plant productivity and succession

Endoparasitology

Ecology of avifauna

Ecology of reptiles

Ecology of insects

Range ecology

Systems analysis

APPENDIX 7

PRELIMINARY LANDSAT ANALYSIS OF SAND AND SETTLED AREAS TURAN BIOSPHERE RESERVE

This appendix presents an illustration of preliminary satellite data analyses carried out in the Turan Biosphere Reserve. These data are derived from one LANDSAT scene. Detailed application of ground truth has not been made in preparing the thematic map which accompanies this appendix; when this is done (following geometric correction to the LANDSAT scene) further refinements to the classifications will be possible.

The material includes 1) a grey-scale printout of band 5 showing the area in question, and 2) a thematic map illustrating the distribution of the signatures indicated below. The area takes in cultivated land, a portion of a sand sea, mountainous terrain, and settlements. Flocks are grazed on much of it.

These data are being used in the development of a dynamic picture of edaphic and vegetative resources in the Turan Biosphere Reserve. Subsequent work will produce time series showing major short and long term trends in the area.

The map has been created on the basis of multispectral radiometric scanner data from ERTS-1 (LANDSAT 1) scene 81382062035 (quality '8' in all bands).

CHARACTERISTICS:

Date:	9 August 1973
Center point of scene:	N35 59 38, E56 49 31
Altitude:	921.4 km
Area mapped:	512 x 512 pixels
Geometric correction applied:	none
Approximate scale of printout:	22000:1

The image has not been enhanced in any way, nor has it been destripped. Destripping will be applied to future maps.

In cases of parallelopiped overlap, more inclusive signatures were processed before less inclusive signatures (see below).

The themes are represented by eight symbols. These are:

* # @ % $ & ? and < ('less than').

The spectral characteristics and ground truth correspondence are:

1) '*' — B4:47-51; B5:57-61; B6:53-56; B7:22-24
Six-pixel area within sand sea.

2) '#' — B4:46-50; B5:54-61; B6:51-56; B7:21-24
Five-pixel area deeper within sand sea.

3) '@' — B4:47-51; B5:54-58; B6:53-56; B7:22-23
Eight-pixel area of high homogeneity in sand sea.

4) '%' — B4:39-49; B5:39-54; B6:62-71; B7:33-35
Small areas within two villages

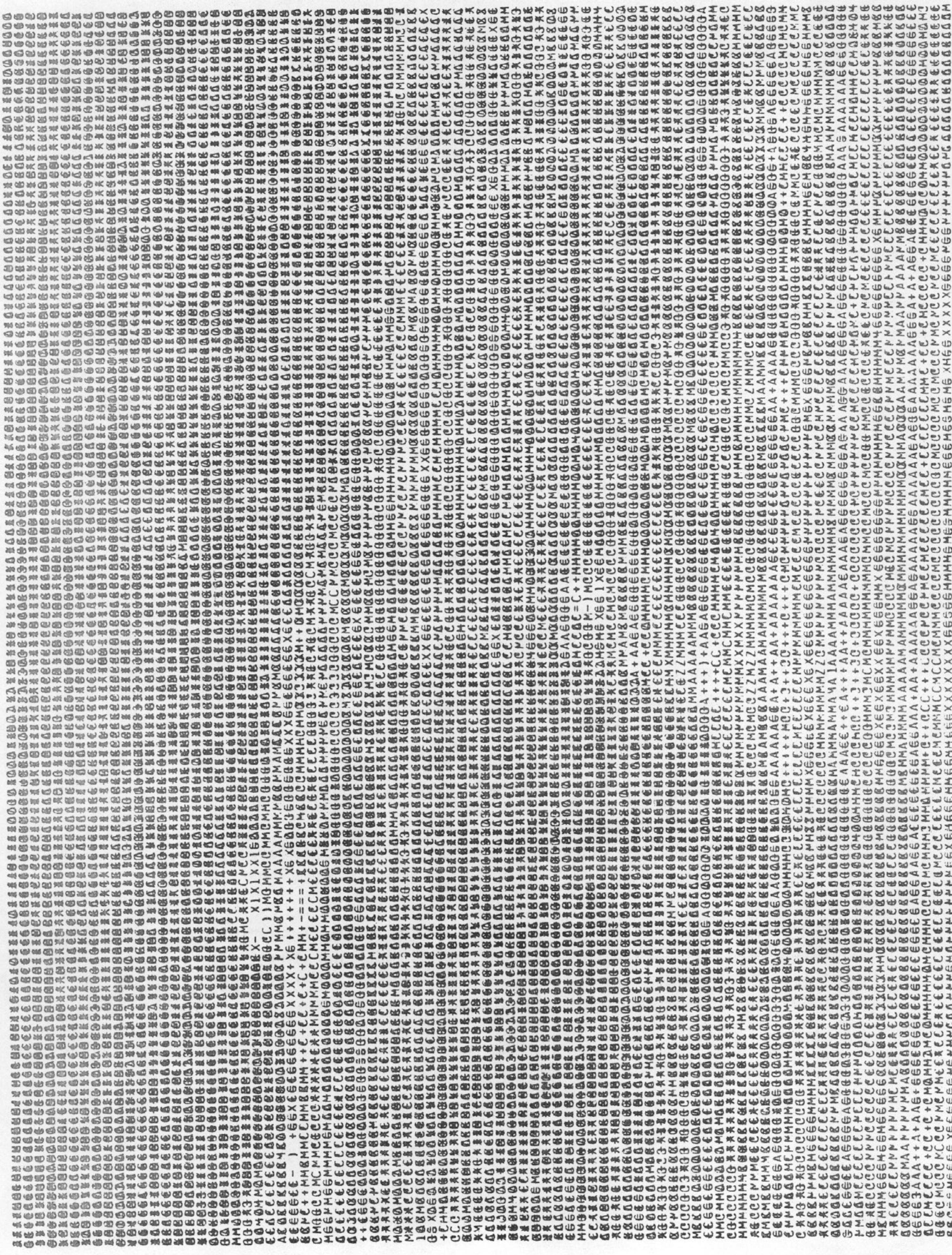
5) '$' — B4:40-56; B5:38-67; B6:63-71; B7:30-35
Village peripheries and outliers

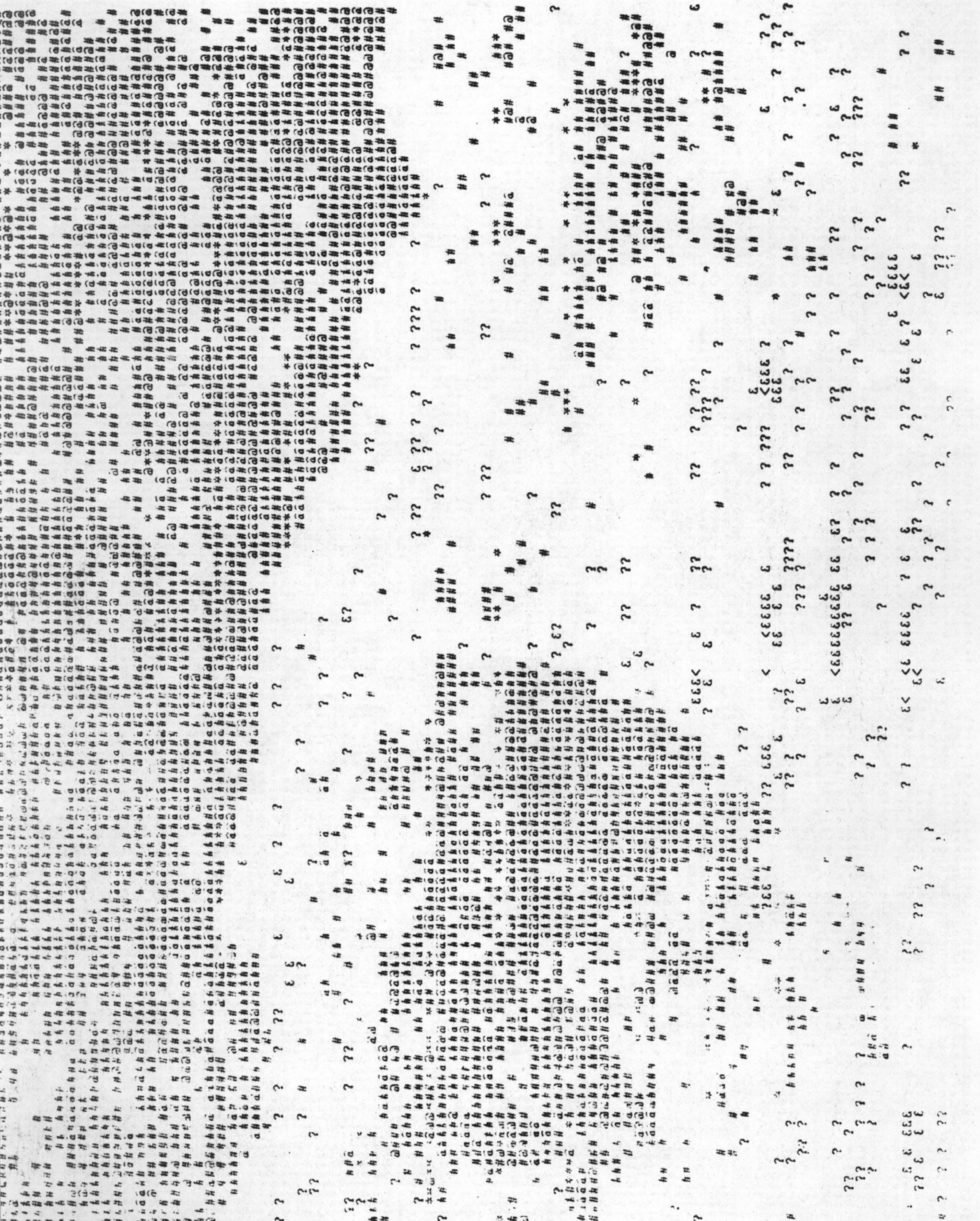
6) '&' — B4:55-57; B5:68-70; B6:62-66; B7:27-30
Eleven pixels to east of village:
peganum (four pixel area)

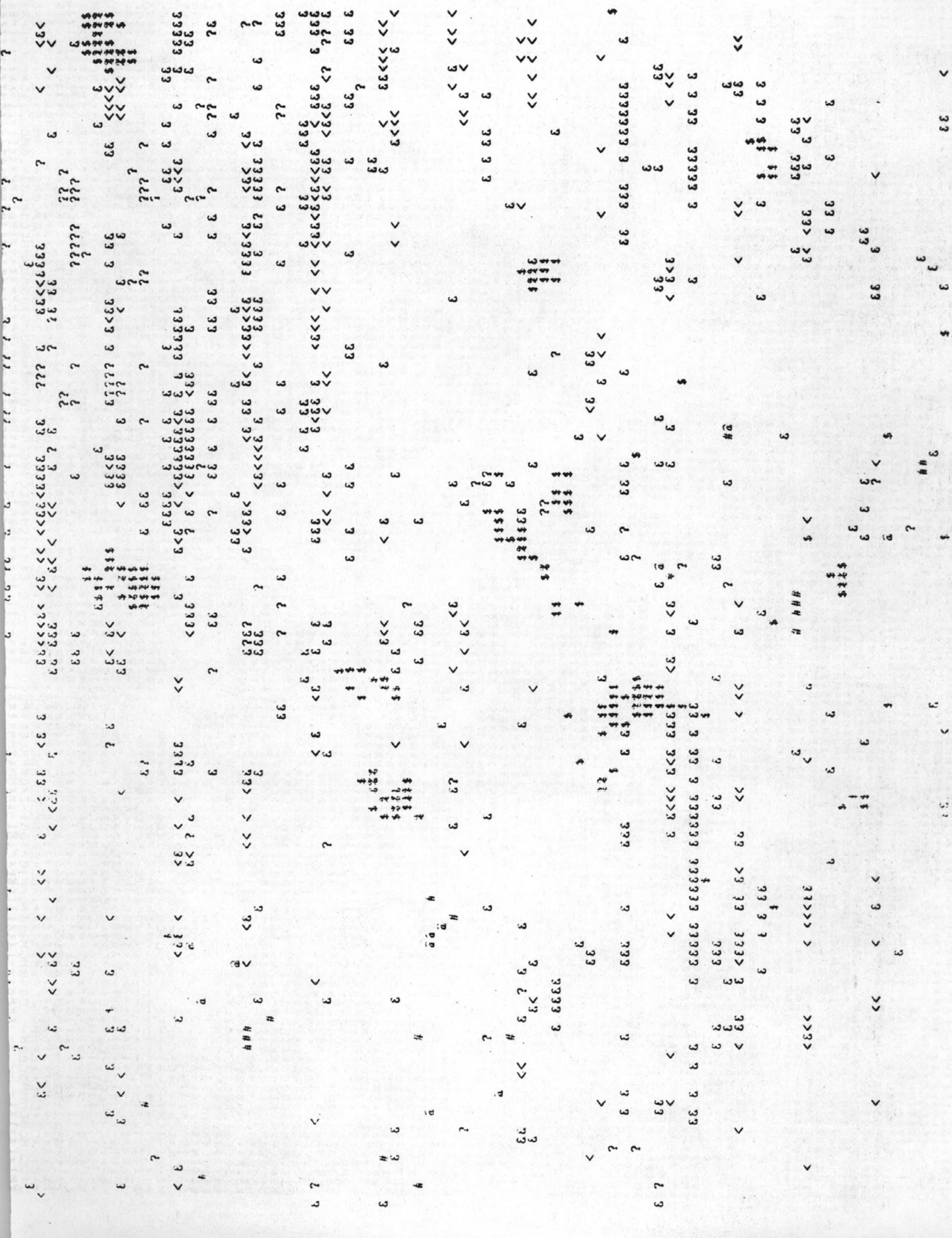
7) '?' — B4:53-55; B5:65-66; B6:58-61; B7:26-27
Abandoned field between Kariz and Zamanabad

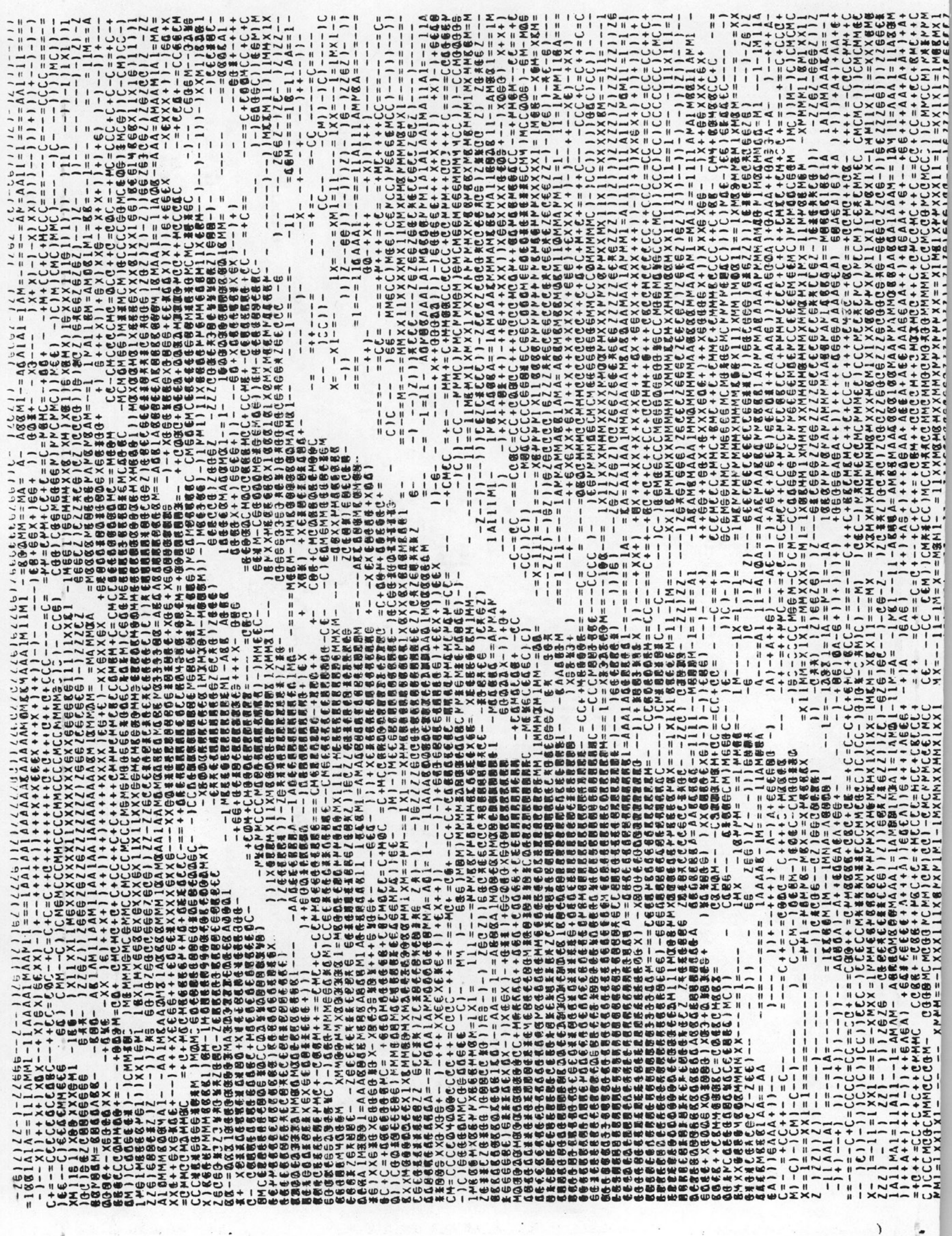
8) '<' — B4:56-59; B5:70-70; B6:66-66; B7:28-29
Trampling and sparse vegetation between Kariz and Zamanabad

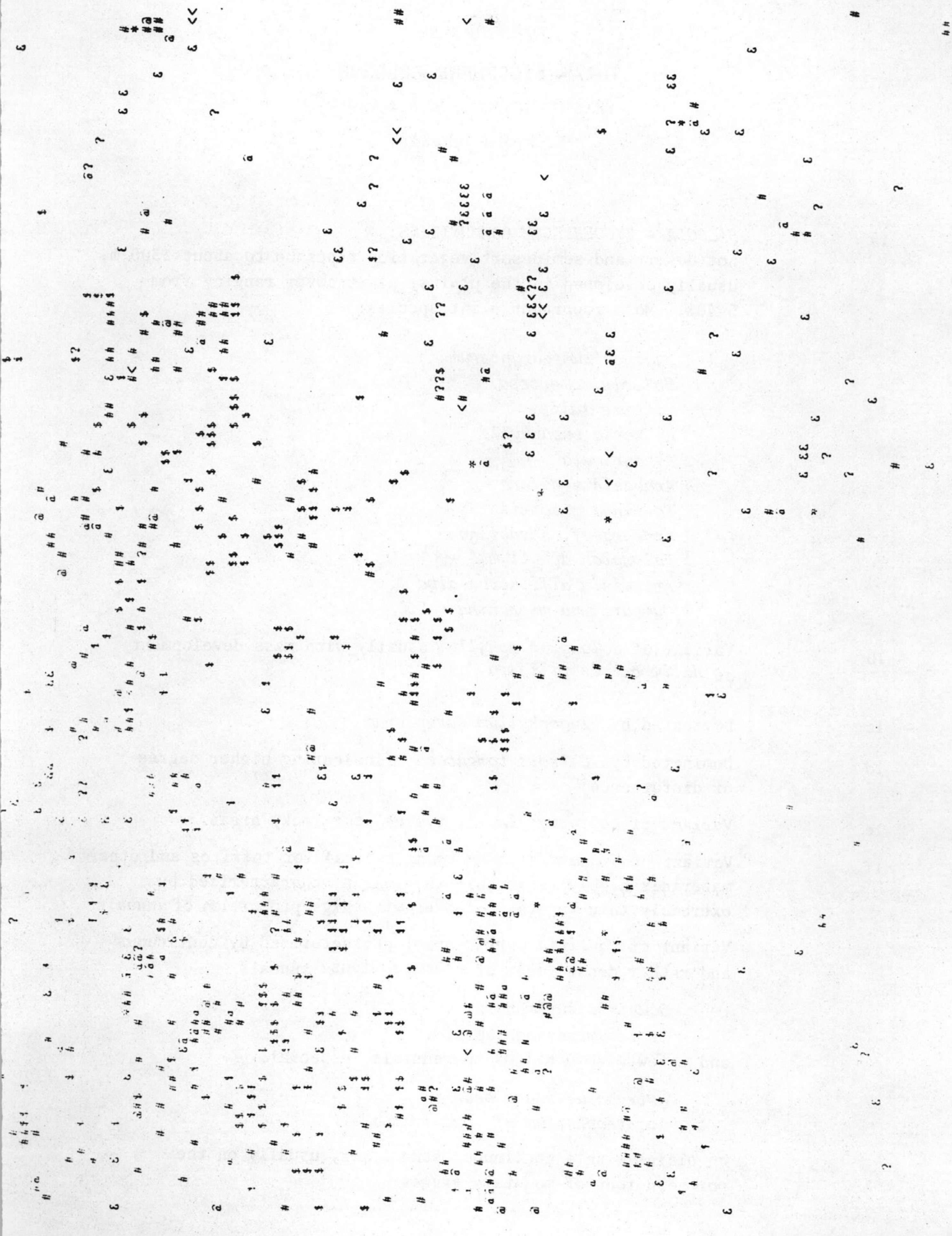
Geometrical distortion: Apart from rubber sheet distortion, which is uncorrected, the printout map format contains a consistent exaggeration of the vertical dimension of 9.812% above the true dimensions of the bulk CCT.











APPENDIX 8

TURAN BIOSPHERE RESERVE

PRELIMINARY VEGETATION MAP

Expanded Legend

1a *SALSOLA - ZYGOPHYLLUM* COMMUNITIES:
hot desert and semidesert vegetation types up to about 1300 m, usually developed in the plains; plant cover ranging from 5-40%. Most important plant species:

Zygophyllum eurypterum
Salsola tomentosa
S. orientalis
Aellenia subaphylla
A. auricula
Anabasis setifera
Fortynia garcinii
Ephedra cf. strobilacea
Haloxylon aphyllum
Artemisia aff. herba-alba
Gymnarrhena micrantha

1b Variant of *Haloxylon aphyllum* usually with mass development of *Halimocnemis pilifera*

1c Dominated by *Zygophyllum eurypterum*

1d Dominated by *Salsola tomentosa* (indicating higher degree of disturbance)

1e Variant of *Aellenia glauca,* typical for rocky areas

1f Variant of *Gamanthus gamocarpus,* typical for tuffites and other materials highly vulnerable to erosion, characterised by extremely thin vegetation cover with high proportion of annuals

1g Variant of *Cousinia turkmenorum,* characterised by continuous and rather dense layer of psammophilous annuals

Cousinia turkmenorum
Lepidium vesicarium etc.

and a few psammophilous perennials, especially

Astragalus squarrosus
Acanthophyllum cf. bracteatum

on plains with a continuous sand layer, usually on the northern foot of mountain ranges

2a *ARTEMISIA AFF. HERBA-ALBA — EPHEDRA INTERMEDIA — AMYGDALUS cf. LYCIOIDES* COMMUNITIES:
more mesic semidesert communities, usually from about 1300 m, mainly on rocky slopes

Most important plant species:

Cleome coluteoides
Ceratoides latens
Amygdalus cf. lycioides
Astragalus glaucacanthos
Cousinia cf. neurocentra
C. piptocephala
Ephedra intermedia
Acanthophyllum div. spec.
Acantholimon div. spec.
Stipa arabica
Artemisia "recta" (Darmaneh-e-K hi)
Noea spinosissima

2b *AMYGDALUS LYCIOIDES — ATRAPHAXIS SPINOSA* COMMUNITIES:
on limestone rocks, in fissures only, vegetation extremely sparse, usually dominated by *Amygdalus*, *Astragalus podolobus* or *Atraphaxis* 3-15%

2c *AMYGDALUS — HYPOCYLIX* COMMUNITIES:
on shales, conglomerates, porphyrs and coarse-textured pediment plain usually dominated by *Amygdalus*, *Hypocylix kerneri*

2d *AMYGDALUS — HYPOCYLIX* COMMUNITIES IN COMPLEX WITH *SALSOLA-ZYGOPHYLLUM* COMMUNITIES:
the former on rocky slopes and outcrops, the latter on deeper soil in the plains, proportion about 50:50

2e Variant of *Cousinia cf. neurocentra*, on marly or other fine-textured soil, often dominated by *Hypocylix*, without *Amygdalus* or *Amygdalus* very sparse

2f Variant of *Gamanthus gamocarpus*
on highly eroded marl hill tops and slopes, in complex with the former

2g Variant of *Ceratoides latens*
on deeper soil, usually dominated by *Artemisia aff. herba-alba*

3a *ASTRAGALUS STROBILIFERUS — COUSINIA MESHHEDENSIS* COMMUNITIES: mostly mesophytic communities in summit regions of the higher mountains, but on North-exposed slopes descending to 1400 m

Most important plant species:

Astragalus strobiliferus
Artemisia "recta" (Darmaneh-e-Kuhi)
Cousinia meshhedensis
Ephedra intermedia
Acantholimon div. spec.
Stipa caucasica
St. turkestanica
Piptatherum molinioides

3b *ASTRAGALUS STROBILIFERUS — AMYGDALUS* COMMUNITIES: usually on rocky slopes, dominated either by *Astragalus* or *Amygdalus*; in the highest North-exposed slopes of the *Kuh-e-Peighambar* by *Onobrychis cornuta* (forming a community of its own); further typical species are *Cotoneaster kotschyi*, *Jurinea stenocalathia*, *Stipa turkestanica*, *Hymenocrater elegans*

The community grows in a mosaic-like complex with *Stipa caucasica-Cousinia meshhedensis* communities on slopes or plateaus with deeper soil, but dominates usually.

4a *STIPAGROSTIS — CALLIGONUM* COMMUNITIES: on fixed or shifting sands

4b *STIPAGROSTIS PENNATA — CALLIGONUM* COMMUNITIES: on fixed sands, with dense shrub and herbaceous vegetation summing up to 40%
dominated by

Stipagrostis pennata
Calligonum leucocladum
C. cf. comosum
Haloxylon persicum
Artemisia eriocarpa

besides a rich annual vegetation, with

Agriophyllum minus
A. latifolium
Euphorbia cheirolepis

4c *STIPAGROSTIS KARELINII* — *SMIRNOVIA* COMMUNITIES:
on shifting sands, cover up to 5% only
dominated by

Stipagrostis karelinii
Smirnovia turkestanica
Heliotropium cf. acutiflorum

5a BARREN KAVIR or clay flats without vegetation or vegetation only in and along runnels

5b Dense annual halophilous vegetation (cover up to 90%) on clay flats, dominated by *Petrosimonia glauca, Cressa cretica, etc.*

5c SHRUBBY SALT MARSH COMMUNITIES:

along Kavir borders, in some depressions and river beds;

differentiated in some communities:

Seidlitzia rosmarinus community, the most common one, usually in contact with *Haloxylon* variant of the *Salsola-Zygophyllum* units.

Halocnemum strobilaceum community, common as the outermost vegetation belt against the barren flats

Halostachys belangeriana communities, more rare than the former and requiring more moisture

Tamarix communities, requiring permanent water supply

APPENDIX 9

ECOLOGY OF *GAZELLA DORCAS* (JEBEER) AND *GAZELLA SUBGUTTUROSA* (GOITERED GAZELLE) IN TURAN BIOSPHERE RESERVE PRELIMINARY REPORT

1. INTRODUCTION

This report combines the results of two field trips in June and July 1976 of ten days and six days respectively. Since these were the first two trips in the area, this must be regarded as a preliminary report. The figures presented—population size, densities, biomass, food intake, etc. —will almost certainly change as work progresses and sample error decreases. Nevertheless, these figures are presented to give an indication of the expected final result.

2. METHODS

Road transects were set up in the area and divided into nine separate strata to simplify sampling and accommodate the varying habitat of the region. The criteria for dividing the strata were somewhat arbitrary, being based on topography, habitat and convenient boundaries such as tracks. Turan is too large to sample extensively, and so only a part of the area was selected in order to allow repeated sampling in the time available.

During repeated driving of the transects, at ten kilometre intervals, topography, soil, and dominant vegetation were recorded in order to provide an indication of the distribution of different habitat types; at the same time the ground was inspected on foot to see what plants were present, and to determine from tracks and chewed shoots which plants were eaten.

Sightings of gazelle were recorded, with the number, sex, age, date, time of day, location and habitat and distance away. Distances up to 400 m. can be estimated accurately, and were periodically checked by pacing, and so the transect width was 800 m. This was multiplied by the distance driven on a transect in order to arrive at the area sampled, and hence densities. For estimating densities, only those gazelles cited within the 800 metre transect width were used.

Two whole days were spent observing gazelle movements from fixed observation points, one at Abul Yahya spring (south-east of Majrad) and one in the open foothills overlooking the spring, both in stratum 6.

Weights of gazelle and domestic sheep and goats have been taken from specimens collected elsewhere. Ecological efficiencies are from studies on the Mountain gazelle in Israel, a species closely related to the Jebeer, and studies on ungulates in East Africa. From these studies, the following values have been used:

TABLE 1

Average weight of Goitered gazelle	-	22 kg.
Average weight of Jebeer gazelle	-	17 kg.
Average weight of domestic sheep	-	30 kg.
Average weight of domestic goat	-	25 kg.
Calorific value of wild ungulates	-	1400 K cals/kg
Food intake by Mountain gazelle	-	100 K cals/kg/day
Assimilation efficiency	-	67% of intake
Production	-	2% of assimilation

3. RESULTS

1. Distribution - The southern limit of the Goitered gazelle range is along the southern edge of the Biarjomand plain where it meets the mountain, the southern edge of the Delbar plain where it meets the Majrad mountain, and from Ahmadabad northwards along the western edge of the sand dunes. The greatest numbers are seen in the plain between Abbasabad and Kuh Do Shakh, and just west of Ahmadabad.

The northern limit of the Jebeer gazelle range is the southern edge of the hills extending from Majrad westwards, the bridge over the Kal-e Shur between Ahmadabad and Delbar, and the southern edge of the Ghariba range of hills.

Individuals are occasionally seen outside this normal range. For instance in December 1973 some Jebeer gazelle were sighted on the Kal-e Shur north of Abbasabad and in June 1976 one Goitered gazelle was seen south of Ghariba spring. No gazelle were seen in the vicinity of the concentrations of villages in the Biarjomand and Tauran plains or the plantless solonchak by the Kal-e Shur.

Jebeer do occur out into the solonchak in the south of the area in dominant *Tamarix* and *Seidlitzia*. Their densities here appear to be very low but this part of the area has been insufficiently surveyed.

2. Habitat characteristics - Habitat categories were defined according to topography, soil and dominant vegetation. The following are the habitat categories and the strata in which they occur:

TABLE 2

Topography	Soil	Dominant Vegetation	Stratum
1. Plain	Sandy/coarse	*Dorema*	1
2. Plain/open foothills	sandy	*Haloxylon*	1,6,7,9
3. Plain	coarse	*Zygophyllum* superdominant	5,9
4. Plain/open foothills	coarse/ stony	*Zygophyllum* dominant	1,3,5,6,7,9
5. Plain/open foothills	coarse/ stony	*Artemisia* dominant	1,2,3,5,6,7
6. Plain	sandy/coarse stony	*Peganum harmala*	2
7. Plain	sandy	*Ephedra*	2
8. River gulleys	sandy/coarse stony	*Pteropyrum*	All
9. Plain/open foothills	coarse	*Zygophyllum*/ *Artemisia* codominant	2,5,6,7

TABLE 2 (continued)

Topography	Soil	Dominant Vegetation	Stratum
10. Plain	halophytic	*Seidlitzia*	4,6,7
11. Plain/gulleys	halophytic	*Tamarix*	4
12. Plain	solonchak	*Tamarix/Halocnemum*	4
13. Plain	sandy	*Stipagrostis*	3
14. Plain	solonchak/ mudflats	*NONE*	1,4

The following table lists the different strata and the gazelle densities for each habitat category within each stratum:

TABLE 3

Stratum	Habitat category	% of area sampled	Density Jebeer	Density Goitered
1.	*1. Dorema*	10%		
	2. Haloxylon	10%		$1.6/10\ km^2$
	4. Zygophyllum	30%		$3.6/10\ km^2$
	14. Solonchak/mudflats	30%		
	5. Artemisia	20%		$1.6/10\ km^2$
2.	*5. Artemisia*	30%		
	6. Peganum harmala	25%		
	7. Ephedra	25%		
	9. Zygophyllum/ Artemisia	20%		
3.	*4. Zygophyllum*	50%		$2.2/10\ km^2$
	13. Stipagrostis	25%		
	5. Artemisia	25%		$1.5/10\ km^2$
4.	*10. Seidlitzia*	20%		
	11. Tamarix	20%		
	14. Solonchak/mudflats	60%		
5.	*5. Artemisia*	20%		
	9. Zygophyllum/ Artemisia	20%		
	4. Zygophyllum	30%		$0.6/km^2$
	3. Zygophyllum superdominant	30%		

TABLE 3 (continued)

Stratum	Habitat category	% of area sampled	Density Jebeer	Density Goitered
6.	4. *Zygophyllum*	50%	2.8/10 km^2	
	5. *Artemisia*	10%		
	2. *Haloxylon*	10%	14/10 km^2	
	10. *Seidlitzia*	10%	1.0/10 km^2	
	9. *Zygophyllum/ Artemisia*	20%	3.0/10 km^2	
7.	4. *Zygophyllum*	25%	2.75/10 km^2	
	9. *Zygophyllum/ Artemisia*	60%	0.7/10 km^2	
	5. *Artemisia*	5%		
	10. *Seidlitzia*	5%	1.5/10 km^2	
	2. *Haloxylon*	5%	1.5/10 km^2	

8. Insufficiently sampled.
9. Insufficiently sampled.

For Goitered gazelle, preferred habitats are dominant *Haloxylon, Zygophyllum,* and *Artemisia,* and for Jebeer *Zygophyllum, Zygophyllum/Artemisia, Haloxylon,* and *Seidlitzia.* The very high density of Jebeer in *Haloxylon* in stratum 6 is due to the fact that this is the habitat of the open foothills, and during the middle of the day the Jebeer move into these foothills. This particular area was always sampled in the late morning. Gazelle do not occur in habitats where one plant superdominates, such as the *Zygophyllum* in strata 5 and 9.

Jebeer will enter foothills where the gulleys are broad and flat, and in effect a continuation of the plain habitat. In rocky hills where they have to step up and down they do not occur unless chased. Jebeer are noticeably absent from dominant *Artemisia.*

3. Biomass and production - By extrapolation from comparable studies (see Table 1), it is possible to give the following figures for the ecology of gazelle in Turan:

TABLE 4

Stratum	Density Biomass kg/10 km^2	Density Energy Content Kcals/ 10 km^2	Food Intake Kcal/ 10 km^2	Assimil- ation Kcals/ day/10 km^2	Production Kcals/day/ 10 km^2
1	28.6	40,040	2,860	2,000	330
2	0				
3	33	45,000	3,300	2,200	450
4	0				
5	4	5,500	400	250	50
6	42.5	60,000	4,250	2,800	570
7	18.7	25,000	1,850	1,250	250
8	0				
9	13.2	18,500	1,300	880	175

In order to give some idea of the extent of competition with domesticates, a survey was made of the sheep and goat population in the strata 2, 5 and 9 (excluding transhumant flocks). The values as described in Section 2 will probably not be the same for domesticates, since their efficiencies generally are less than for wild populations. Therefore, they probably have a greater food intake per kilogramme live weight. The domestic sheep, for instance, contains a lot of fat, deposited in the tail, and the production of this fat requires three times as much energy per unit weight as the production of protein. Nevertheless, the following figures are given for the purpose of preliminary comparison.

TABLE 5

	Density Biomass Kg/10 km^2	Density Energy Content Kcals/ 10 km^2	Food Intake Kcals/ 10 km^2	Assimil- ation Kcals/ day/10 km^2	Production Kcals/day/ 10 km^2
Sheep	7,200				
Goat	5,800				
Combined	13,000	18,000,000	1,300,000	870,000	175,000

4. Behaviour - Breeding on the Jebeer takes place in early November and in the Goitered gazelle at the end of November, beginning of December. Fawns are dropped after a 5-1/2 month gestation at the end of May and in mid-June respectively. Goitered gazelle usually seek out sheltered habitat to drop their fawns, and in Turan appear to move to the western edge of the sand dune area and the low foothills in stratum 3. In the fawning season, the sexes are separate. The males of both species are normally territorial in the breeding season, but this has not yet been established in Turan. Sometimes where densities are low there is not enough interaction to bring about this behaviour.

No seasonal movement has been observed for the Jebeer.

In summer both species have a peak of inactivity in the middle of the day when they either bed down or rest standing and ruminate. The Jebeer commonly move into the springs between 10.00 and 13.00, and remain in the foothills and springs until afternoon when they disperse back onto the plain. Neither species require water in winter and spring, although if it is readily available they will drink.

Jebeer gazelle have been observed to eat heavily the following plants:

Pteropyrum
Artemisia
Seidlitzia
Ephedra
Salsola arbuscula

They are very delicate eaters, taking only the succulent parts of the plant. Other species are undoubtedly also eaten.

5. Population structure - The Jebeer gazelle commonly occur in groups of one to four individuals. The largest group sighted contained eleven. Average group size was two to four. The population comprised 25% male, 46% female and 27% fawns. Female-fawn rates were 1:0.6. The Goitered gazelle occurred in groups of one to seven, the average being 1.8. The population comprised 30% male, 40% female and 30% fawn. The female-fawn ratio was 1:0.73.

4. DISCUSSION

The densities of both species are very low. In the Kavir National Park 300 kilometres to the west the densities are four to nine times greater in equivalent habitats. The Kavir has been protected from grazing for over ten years and the population is expanding. This would suggest that competition from domestics reduces the Jebeer population and therefore there is competition for food and space. The populations of Jebeer and Goitered in Turan are probably stable. The female fawn ratios of 1:06 compare badly with the figure of 1:1 for the Kavir at the same time of year. Similarly with the Goitered gazelle the ratios of 1:0.73 compare unfavorably with the ratio of 1:1.2 in the Shahrud area at the same time of year. It is possible that the populations may even be declining in the long term.

Competition with the Wild ass is probably not as critical, at least for food, since the Wild ass represents the roughage browser/grazer, and can take much woodier parts of the plants which would not be eaten by gazelle.