CONSERVATION SURVEY

of the

SOUTHERN HIGHLANDS

of

JORDAN

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September, 1964

S. G. Willimott
B. P. Birch
R. F. McKee
K. Atkinson
B. S. Nimry

"Few people realise that it is only the thin mantle of the soil covering the earth's crust that allows human life to continue; once this is eroded away human society could not survive."

S.G.W.

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Our thanks are due to Mr. G. McWhirter for the final drafting of the maps.

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FOREWORD

I am very glad that under our technical assistance programme in Jordan the Durham University Survey Team have had the opportunity of studying and reporting on the Southern Highlands.

I am sure that this relatively unpublicised region of great natural beauty and historical interest can become of increasing importance both to agriculture and tourism provided appropriate conservation and development measures are taken. What these measures should be is, of course, a matter for most careful consideration but there can be little doubt that a high priority should be given to the conservation of their natural resources.

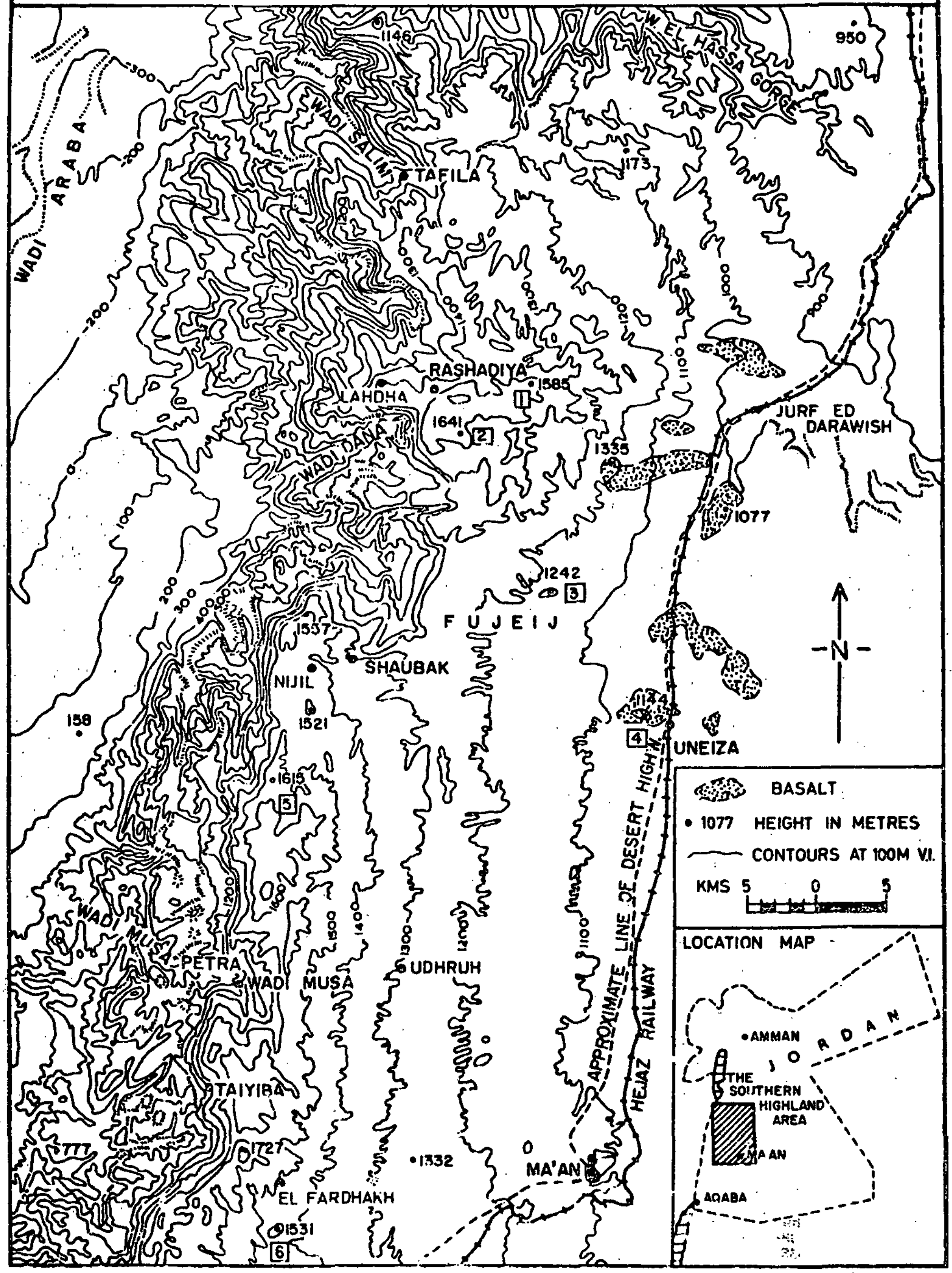
I consider Dr. Willimott and his colleagues are to be congratulated both for their timely presentation of the facts and the scope of their recommendations; and I hope that their report may serve as a basis for drawing up a comprehensive programme for the development and conservation of the Southern Highlands of Jordan.

(Roderick Parkes)

Her Majesty's Ambassador

Amman

FIG. I. TOPOGRAPHY



INTRODUCTION

Following the survey of the Wadi el Hassa carried out in 1962 (1) the Government of Jordan requested the British Middle East Development Division of the then Department of Technical Co-operation, London, that the Durham University Survey Team should carry out an investigation of the present state of land use in the Southern Highlands with recommendations for the better conservation of the natural resources. It will be recalled that, following a short exploratory visit to the area on September 24, 1962, a memorandum (2) was submitted to the Jordan Government on the present hazardous situation. The assignment to survey this highland area was accepted and the cost of the project was again met from technical assistance funds allocated to Jordan by the British Government. Local facilities were again provided by the Jordan authorities and covered such requirements as accommodation at Shaubak, transport facilities, field equipment, and laboratory services. Mr. B.S. Nimry M.Sc., of the Department of Research, Ministry of Agriculture, Amman, was seconded to the team for part of the time by the Jordan Government. The team responsible for the survey was as follows:-

S.G. Willimott (Leader)	University of Durham
B.P. Birch	University of Southampton
R.F. McKee	University of Durham
K. Atkinson	University of Durham
B.S. Nimry	Ministry of Agriculture, Amman

The British members of the team left for Jordan on August 6, 1963, and work continued without interruption up to September 7, 1963.

No hard and fast terms of reference were laid down, the main object of the survey being to locate the important problems of present land use in the area, to devise plans for conservation and to make practical recommendations for better land use, taking into account a long-range view rather than the demands of short-range expediencies. It seemed to us that only by this approach could a worthwhile scheme of permanent value to the community, with some promise of the realisation of better living conditions and prosperity for the majority of the people of Jordan be ensured. (Cf.3) It was further hoped that any improved measures in this limited but extensive area would have their repercussions in the integration of different schemes for the development of the country as a whole. Two important considerations were early realised. First, that in a generalised survey of a considerable area many specialised problems must remain for further study and investigation. Secondly, that immediate results are not to be expected in plans which must necessarily require a decade or more to fructify and that patience and tenacity must be exercised.

The area of survey (Fig.I) extended approximately from the southern scarp of the Wadi el Hassa, lying to the north of Tafila, to Rum Sadaqa, (1531 metres - point 6 on Fig.I), about 16 Km. south of Wadi Musa. The western scarp of the highlands overlooking the Rift Valley, formed a natural boundary of the survey area to the west, and the Desert Highway was taken as the boundary to the east. The line of the eastern boundary was decided somewhat arbitrarily but nevertheless represented roughly the effective eastern limit of the range lands. The survey area was thus of the order of approximately 2,760 square kilometres. Some of it rises over 1,500 metres above sea level with distinctive features of localised climate, natural vegetation, drainage patterns and ancient settlement. Access to the area is readily gained by the new Desert Highway to Ma'an and the metalled road to Wadi Musa; or by the new road following the track of the disused branchline of the Hedjaz Railway to Shaubak, or by the older road from the north via Kerak (Fig.8). During the rains of the 1963-4 winter considerable sections of this road were washed away. Road communication is thus reasonably good in the north-south direction but requires development for east-west access.

Chapters 2 and 6 of this report present a description and analysis of the topography, geology, structure, climate, soils and natural vegetation of the Southern Highlands of Jordan; all these factors must be taken into account in any attempt to evaluate and conserve the existing natural resources. From this point of view the most significant factor is the natural vegetation and on this basis it is logical to divide the area into forest, range and wadi bottom zones. The effects of past and present land use practices in each of these zones is then considered in Chapter 7. In Chapter 8 recommendations are put forward in some detail for the best use and conservation of the resources of these three zones, which should lead to an improvement of the living standards of the people dependent on these lands for their subsistence. To carry this out effectively it appears to us essential to establish an independent Conservation Service working in close conjunction with the various Government Departments concerned. Other important aspects concerning the improvement of roads and the development of tourism, both of which are involved in the problem of the betterment of economic conditions in settlements of the Southern Highlands, are dealt with in the concluding chapter. In Chapter 1 a summary of objectives and recommended methods of conservation is presented.

ACKNOWLEDGEMENTS

We would wish to record our appreciation and thanks for the assistance rendered and facilities provided by the following authorities and organisations:

The Jordan Government

The different administrative officials and specialist officers of the Ministry of Agriculture, the Jordan Development Board, the Central Water Authority, the Department of Lands and Surveys, the Department of Statistics, the Meteorological Office, the Agricultural Research Station, Jubeiha, the Department of Forests, the Jordan Embassy, London, the Jordan Tourism Authority, Amman.

The British Embassy, Amman and the Foreign Office, London

H.B.M. Ambassador and the British Embassy Staff.

Ministry of Overseas Development

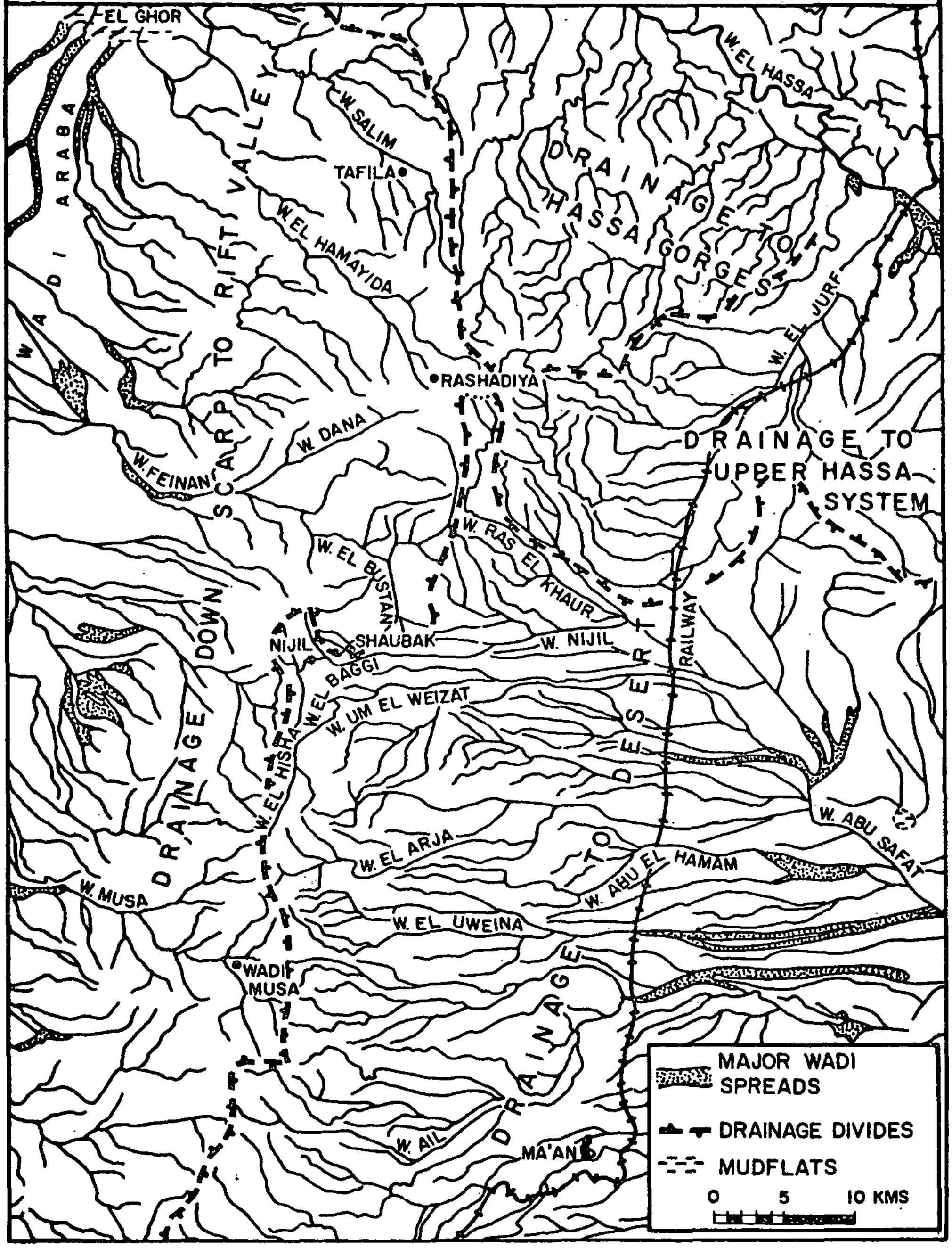
Headquarters at London and the British Middle East Development Division at Beirut.

The German Geological Mission, Amman

The University of Durham

The Professor of Geography and Director of the Middle East Centre, Durham.

FIG. 2 DRAINAGE



Chapter I

SUMMARY OF RECOMMENDATIONS

For the purposes of conservation and development the Southern Highlands of Jordan should initially be divided into three zones: a Forest Zone, a Grazing Zone, the Wadi Bottoms.

A. The Forest Zone

Objectives

1. The establishment of complete watershed management for soil conservation.
2. The local supply of small timber for roofing and fencing.
3. The local supply of adequate fuel resources.
4. The establishment of economic tree crops.
5. The provision of controlled grazing on a long term basis.
6. The creation of modern amenities for a tourist industry and for the local population.

Conservation and Development Measures

1. The enclosure of selected areas to allow natural regeneration of the forest.
2. The systematic collection of forest products.
3. The prevention of all grazing during the initial stages of regeneration.
4. The improvement of communications, especially roads and telephones, and the provision of tourist facilities, e.g. resthouses, petrol stations and information throughout a remote area of unique historic and scenic interest.
5. The expansion of the staff of trained foresters.

B. The Grazing Zone

Objectives

1. Higher productivity and improved stock-carrying capacity.
2. The partial stabilization of migratory grazing.

Conservation and Development Measures

1. The prevention of both ploughing and the clearing of brush for fuel.
2. The fencing of selected areas for rotational grazing in the Fujeij.

3. The introduction of improved fodder crop species of grasses and legumes and better breeds of grazing animals.

4. The provision of more watering points particularly in the east of the Zone.

5. Experimental research on local grazing problems based on the Range Station of the Fujeij.

C. The Wadi Bottoms

Objectives

1. Soil stabilization.

2. Greater use of the existing rainfall.

3. Increased food production.

4. The marketing of horticultural produce on a standardized and integrated basis.

Conservation and Development Measures

1. Contour ploughing, stone wall ridging, bank ridging and stone wall terracing.

2. The restriction of ploughing to land with a reasonable expectation of crop production.

3. The abandonment of deep disc-ploughing by tractor and the use of mechanized implements adapted to the special conditions of dry farming.

4. The dissemination of ideas and techniques of modern irrigated fruit production in villages supplied with sufficient spring water.

5. Education, demonstration, supervision and extension by District Agronomists, based on Shaubak Agricultural School, to integrate the above measures.

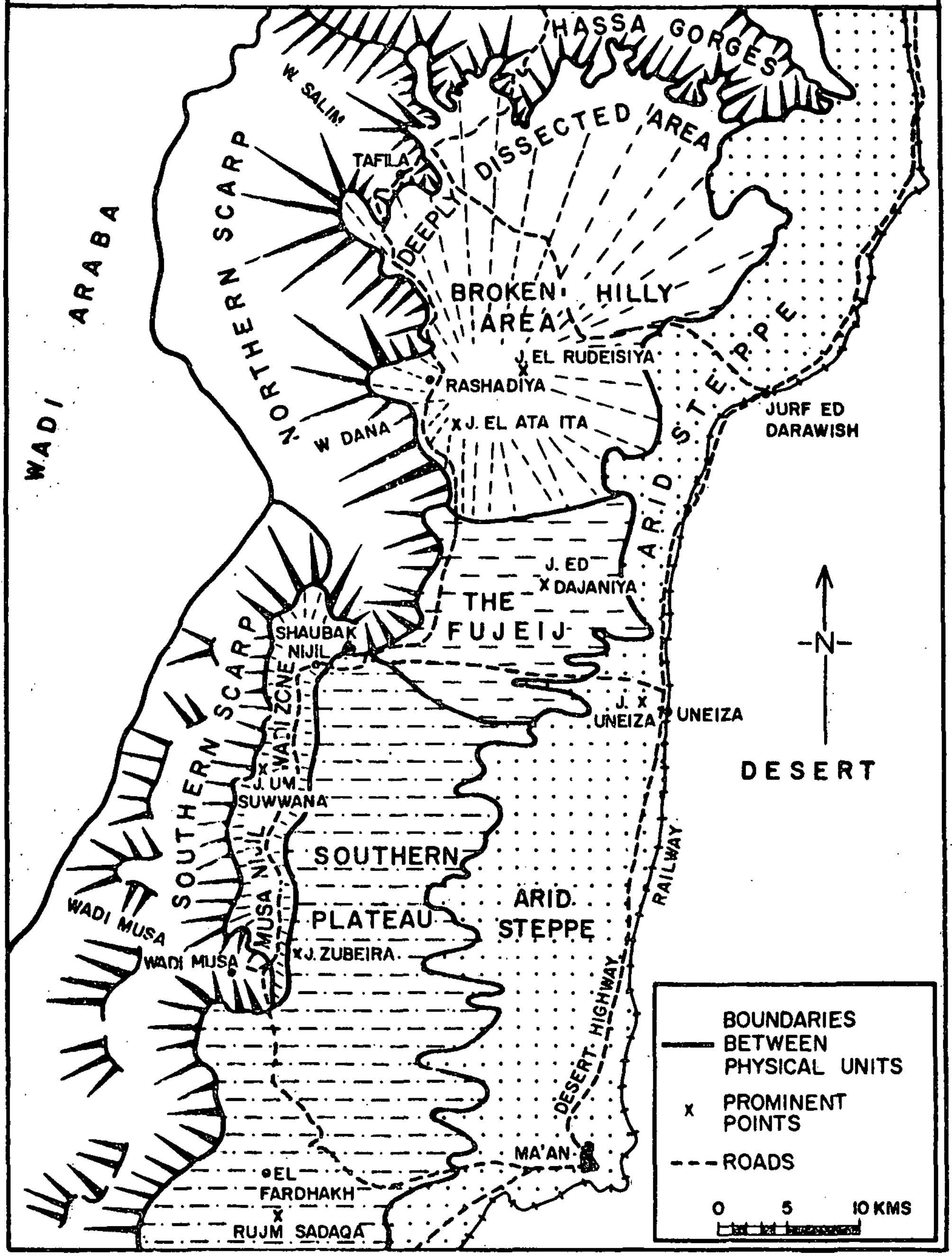
6. The establishment of regional Government Farms with the objectives of commercial viability, market research and the dissemination of efficient management techniques.

7. Government sponsored private farms.

8. Improved communications to promote the marketing of regional produce.

9. The establishment of an independent Department of Conservation for Jordan with a separate division for the Southern Highlands.

FIG 3 LAND FORMS AND PHYSICAL DIVISIONS



Chapter 2

TOPOGRAPHY

The area surveyed extends from the southern slopes of Wadi el Hassa gorge in the north to El Fardhakh, south of Wadi Musa, forming a rectangle about 92 Km. long and approximately 30 Km. wide (Fig. 3) giving an overall area of roughly 2,760 square kilometres. It is a plateau bounded on the west by the deeply dissected scarplands, overlooking the Wadi Araba section of the Rift Valley, whilst to the east the boundary roughly follows the line of the arid steppe lands parallel to the Desert Highway.

The whole area forms part of the greater East Jordan Plateau which is generally gently tilted eastwards. There is no perennial surface drainage but most of the wadi systems open out to the eastern desert, especially into the Al Jafr depression. These follow the dip of the limestones, cherts and marls of the Balqa Series, underlying much of the area.

The general eastward trend of this drainage is, however, interrupted by the major westward drainage system of the Wadi el Hassa in the north and other wadi systems draining the scarp further south, notably Wadi Salim, Wadi Dana and Wadi Musa. In the case of Wadi el Hassa this rejuvenated drainage has cut back eastwards since the Miocene, as the Rift Valley has been lowered by downward movements. In the case of the wadis draining the scarp, this headward erosion has been far less effective, with the result that the watershed between drainage to the Wadi Araba and towards the eastern interior follows closely the line of the scarp. Thus for the most part the drainage of the plateau proper is eastwards except in the northern area. (Fig.2)

The base levels which these wadis have attained, and the nature of the underlying geology, largely account for the degree of dissection in the various sections of the region. As the major part of the area drains eastwards to the desert depressions, wadi dissection over this area has been comparatively slight and the landscape is thus undulating to rolling, but more dissected in the north. The hills are composed of limestone, cherts and chalk-with-flints whilst some of the major wadis have a stony, gravel or sandy cover. Aeolian materials also accumulate in some wadi bottoms and many of the hill slopes have a flint and boulder cover resulting from aeolian erosion and sheet wash.

Eastwards towards the desert the undulations of the landscape die out and the country becomes a plain with gravel and sand strewn depressions, with occasional basalt boulder fields, and widely scattered inselbergs of more resistant volcanic necks standing up as striking remnants of an earlier peneplain.

On the other hand, to the west where the scarp edge of the plateau and parts of the plateau itself drain directly to the lower base level of the Wadi Araba, much deeper erosion has occurred. Here lightly dissected rolling country gives way to deep precipitous wadis and steeply rocky slopes of limestone and sandstone.

Topographic Regions

On the basis of structure and the pattern of dissection it is possible to recognise three main sections which can be subdivided as follows:-

1. Scarp

   (a) South of Shaubak.

   (b) North of Shaubak.

2. The main Plateau Block

   (a) Deeply dissected El Hassa area.

   (b) Hilly area east of Rashadiya.

   (c) The Fujeij.

   (d) Rolling area of the southern plateau.

   (e) Wadi section between Wadi Nijil and Wadi Musa.

3. The Arid Steppe Region

1. The Scarp

Within the survey area the scarp can be divided into two parts. From south of Wadi Musa as far north as Shaubak Castle the scarp area is formed of a series of parallel ridges cut by precipitous wadis and covered with scrub forest.

North of Shaubak, the crest of the scarp turns north-eastwards to cut an extensive embayment into the edge of the Fujeij section of the plateau. From the Fujeij northwards the line of the scarp edge is less regular being broken by the deep wadis of Dana, Bustani and others. This irregularity in the line of the scarp edge is also continued north of Wadi Dana where parts of the plateau area have been cut into by wadis draining to Wadi Araba or Wadi el Hassa, leaving considerable areas of ridge and plateau land standing high above the deep gorges. In this region the division between the scarp zone and the plateau is not well defined.

2. The main Plateau Block

(a) The El Hassa Section

North of the Jebel el Rudeisiya drainage from the plateau block is mainly north to the el Hassa gorges and west to the Wadi Araba. Little of the land rises above 1200m., unlike the hilly region to the south (see (b)) but dissection is considerable in the north since the Hassa gorge has cut down 1,000 metres below the general plateau level. Similar dissection is found round Tafila where the wadis Salim and Hamayida drain to the Ghor at the southern end of the Dead Sea. With steep gradients these wadis provide no flat land or gentle slopes thus restricting useful level land to the ridge tops over 1,100-1,200 m.

(b) Hilly area east of Rashadiya

This area is the highest part of the region being uplifted higher than areas to the south; since much of it is drained by wadi systems flowing to the east and to the upper parts of the El Hassa basin it is not as extensively dissected as the land (see (a)) draining to the scarp and to the lower parts of the Wadi el Hassa system.

In the area east of Rashadiya, the highland region slopes down from the scarp edge at Wadi Dana towards the more undulating land in the region of the Desert Highway. The highest peaks occur on the western edge (Jebel el Rudeisiya 1585m., Jebel el Ata Ita 1641m.), where steeper slopes and more broken land are to be found than is the case further east. Spread of basaltic boulders cover considerable areas towards the Desert Highway.

(c) <u>The Fujeij</u>

This section of the plateau extends about 12 Km. from east to west and about 10 km. north-south. It is characterised by a more gently undulating surface and lower elevation than the hilly zone of the north around Rashadiya, (partly no doubt as a result of the Lisan Marls which underlie much of the area).

The Fujeij is delimited clearly on the west by the scarp edge, roughly followed by the Nijil-Tafila road. Here the land drops down dramatically from nearly 1300 m. on the western edge of the Fujeij to 200m. only 16 km. to the west in the Feinan area.

To the south of the Shaubak-Uneiza road, following the line of the abandoned railway track which serves as an approximate southern boundary of Fujeij, the land becomes more rolling. This area represents a transition zone between the Fujeij and the southern plateau area.

The northern limit of the Fujeij is marked by a rise in elevation of over 100 m. into the hilly country east of Rashadiya; on the east more arid conditions appear as the Desert Highway and the Hedjaz Railway are approached. This area of land falls into the region of the Steppe land. Here again, the undulating character of the Fujeij is replaced by flatter areas strewn with gravel, sand and boulders. The undulating tableland of the Fujeij is also characterised by the following features:-

<u>i</u> A gentle slope from west to east, from a general elevation of about 1250 metres at the scarp edge to about 1100 metres as it merges into the desert.

<u>ii</u> Wadi systems, which drain to the east across the whole of the Fujeij, apart from a narrow strip west of the Nijil-Tafila road, where drainage down the scarp is found. Wadi Nijil is the major wadi draining eastwards into the internally drained desert depressions. The northern half of the Fujeij is also cut by wadis (e.g. Wadi Ras el Khaur), draining southeast off parts of the hilly region to the north and producing some sloping land in the northern Fujeij not characteristic of the whole area.

<u>iii</u> The gently undulating surface is divided into a series of east-west ridges and shallow wadis. Bare rock outcrops are

rare except along some parts of the Wadi Nijil and Ras el Khaur. All these slopes and surfaces are still able to carry a fair cover of Artemisia brush, but indiscriminate patch-ploughing has induced local gully erosion on many slopes.

iv A few small conical hills rising up to 100 m. above the general surface are present in the central part of the Fujeij. The largest of these, Jebel el Dajaniya (1242 m.) is a volcanic vent (point 3 on Fig. 1).

(d) The Southern Plateau

This plateau represents a southern continuation of the Fujeij region, being made up largely of limestones and cherts (Balqa Series). It differs from the Fujeij, however, in being rather more dissected and rolling and in reaching rather higher elevations (1600 m.) in its western section (350 m. higher than the western edge of the Fujeij). Furthermore, it is separated from the scarp zone by a series of north-south wadis (see section (e)). Nearly the whole of the region drains to the east by way of several major wadi systems e.g. Wadis Arja, Uweina, and Ail, which link up eastwards into several wadi depressions, These depressions can be traced beyond the Desert Highway coalescing towards the Al Jafr depression.

The rolling character of this area flattens out eastwards as the land gradually slopes down to the arid zone at 1200 m. bordering the Desert Highway. The basalt steppe zone intrudes further westwards than in comparable areas further north. The greater aridity in the south also results in some of the more hilly lands taking on the appearance of arid steppe with gravel spreads and meagre vegetation cover.

(e) The Wadi Zone between Nijil and Wadi Musa

Between the southern section of the scarp and the southern rolling plateau area there is a well-defined zone made up of a series of minor tributary wadis aligned north-south unlike most wadis in the region. This north-south wadi zone is formed by the Wadi el Baggi in the north, draining through the village of Nijil to join the upper part of Wadi Nijil on the Fujeij; the Wadi el Hisha, which drains northwards for 6 km. before turning east to drain through the southern rolling area by way of the Wadi Um el Weizat; the head valleys of the Wadi Arja. At 20 km. south of Nijil village the north-south valley is continued by a branch of the Wadi Musa system flowing to the south. This wadi runs south for 6 km. before reaching the main Wadi Musa, where it turns to drain westwards through the scarp. The same north-south zone dies out south of Wadi Musa.

The presence of this north-south zone of gentle and moderate slopes and flatter plateau tops creates a type of landscape not present in other parts of the region. This is rolling to hilly country yet free from rocky outcrops and suitable for afforestation like much of the scarp zone, but with the advantage of greater accessibility.

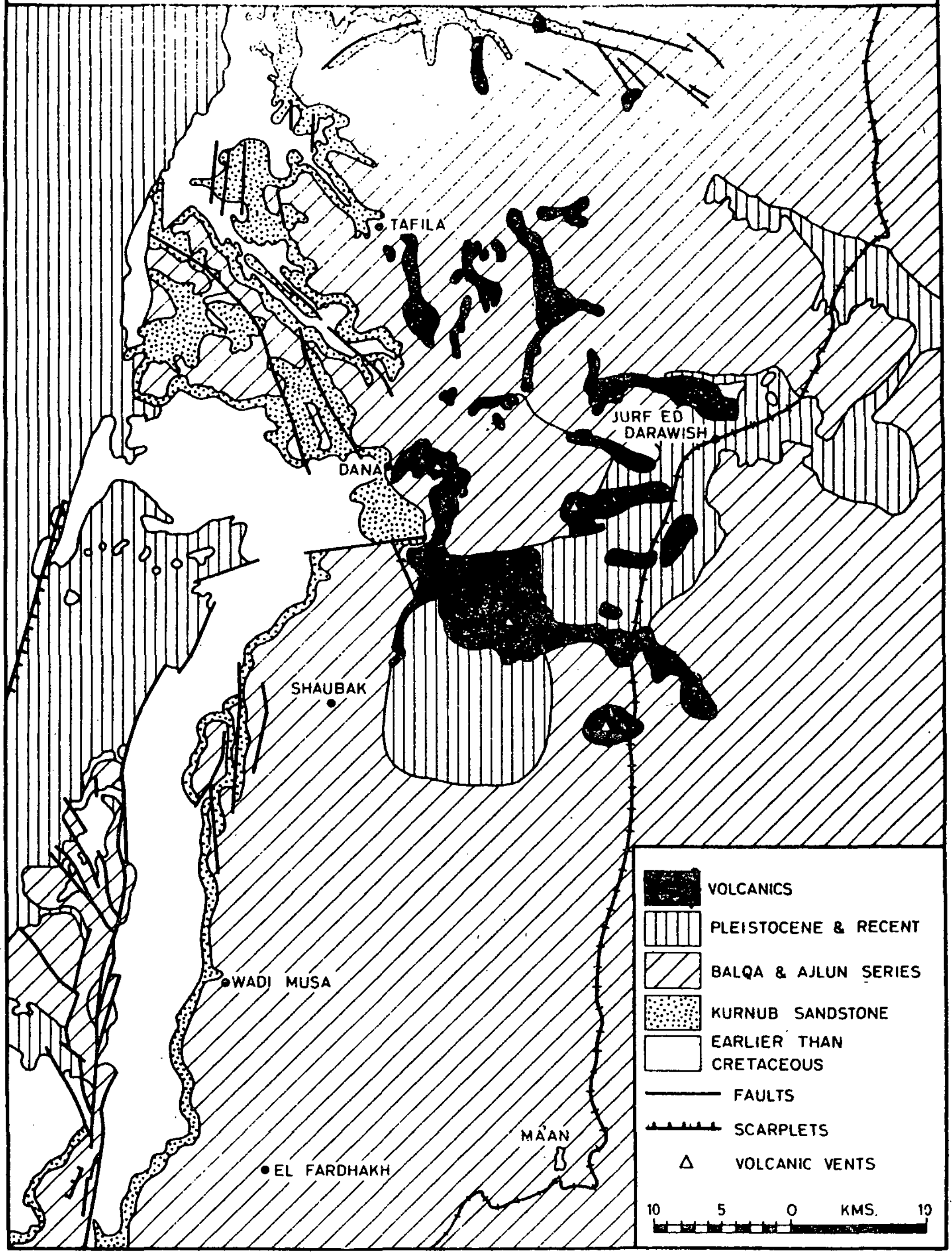
The Wadi el Baggi is broader and more open than the wadis to the south and its slopes on the east and west only rise about 50 m. above the wadi floor. As there are no major tributary wadis, these wadi slopes are extensive and free from steep sections. The head of the wadi is low and the road south to Wadi Musa drops about 25 m. only to enter Wadi el Hisha. But this wadi is narrower and its slopes rise far higher and more steeply so that flatter land is of more limited extent and is generally found only on the ridges, (Jebel Um Sawwana at 1600 m. and above,(marked as point 5 on Fig. 1).

13 km. south of Nijil the road to Wadi Musa passes across more hilly country at the head of Wadi Arja before entering the northern branch of Wadi Musa. Here the Wadi drops from 1625 m. to 1300 m. within a distance of 6 km. producing a landscape of narrow wadi floors and moderately steep slopes, often terraced, and typical of the whole Wadi Musa area. The eastern boundary of this wadi is especially well marked by the scarp of Jebel Zubeira.

3. The Arid Steppe Region

East of the rolling plateau country and towards the Desert Highway the landscape loses much of its hilly and rolling character and becomes flatter and more sand and gravel-strewn; it is characterised also by a poorer cover of brush vegetation (Artemisia) and by the intrusion of halophytic plants. The western boundary of this region lies roughly on the 1100 m. contour in the northern and Fujeij areas, but with increasing aridity southwards similar conditions of vegetation are found at 1200 m. in the southern area. Thus, as the Desert Highway describes a route roughly SSW to Ma'an so the steppe country makes a band about 10 km. wide parallel to the Highway along its western margin. Irregularly strewn basalt boulder fields characterise parts of this strip and would reduce the usefulness of considerable areas. A few scattered volcanic vents (Jebel Uneiza 1144 m.) and other inselbergs are also found in this section.

FIG. 4 GEOLOGY AND STRUCTURE



Chapter 3

GEOLOGY AND STRUCTURE

The geological evolution of the Southern Highlands region illustrates extremely clearly the effects of crustal instability on structure and relief. Structural movements are so recent in geological age and have been so large in scale that their influence on landforms and relief still retains a youthful dramatic appearance in the field.

The two main structural zones which can be distinguished are:

(i) The Main Scarp Fault zone, overlooking the Wadi Araba.

(ii) The Eastern Plateau. (See Fig. 4)

Both are distinctive units from the point of view of tectonics and geological succession, yet the relationships of one to the other must not be disregarded since both display an evolutionary unity when the structural development of the whole region is considered. East Jordan generally lies across the northern rim of the African-Arabian shield, which since pre-Palaezoic times has remained essentially a land surface, surrounded by seas receiving sedimentary erosion products. In East Jordan epeirogenic movements of the shield have periodically resulted in marine transgressions leading to the deposition of marine sedimentary strata. In the Southern Highlands calcareous, deep water sedimentaries of Secondary Age predominate, although varied terrestrial deposits can also be traced, being derived from Cambrian and Triassic land surfaces.

1. The Scarp Zone

The formation of the Jordan Rift Valley during Tertiary and Quaternary times has proved to be the most important event in the geological evolution of the region. Several theories have been advanced to account for the development of this rift valley, the most recent being the "Wrench Fault Hypothesis" of Quennell (4, Cf. 48). Although the detailed tectonics of the formation of the Jordan Rift Valley have not been verified, each successive opening and downward movement of the Rift has lowered the general base-level and has rejuvenated streams flowing into the tectonic depression, thus allowing them to cut farther and farther eastwards into the plateau and to capture additional areas for the drainage basin of the Rift.

Intense rejuvenation by erosive processes has resulted in the exposure of the complete geological succession in many areas of the Scarp Zone. This is particularly the case opposite the Dead Sea depression where the greater relative lowering of the base level has revealed 1750 m. of strata in the Wadi el Hassa Gorges, ranging from the Pre-Cambrian basement through Palaeozoic to Upper Cretaceous.

2. The Eastern Plateau

Contemporaneous with the wrench faulting of the Rift Valley is a series of East-West faults which extend eastwards for 30-60 km. from the Rift, showing maximum displacement near the Rift and dying away gradually to the east. These dislocations are generally thrust faults with some slight dexteral displacement (see Burdon, 5). The Wadi el Hassa fault turns slightly to south of east and this slight movement in a dexteral direction is reflected in a certain amount of drag folding which accompanied the thrust. To the east the thrust dies away in a series of minor faults. The Wadi Dana Fault is similar, except that horizontal movement is slightly north of east, whilst the Shaubak Fault is essentially a thrust, developed by a downward throw of some 800 m. on the southern side, accompanied by slight drag folding caused by dexteral horizontal displacement.

The western boundary of the plateau proper occurs along the watershed dividing the inland drainage basin of Eastern Jordan from the drainage systems of the Jordan Rift Valley. The plateau, for the most part, displays a flat, open relief with slightly incised wadis draining inland. The plateau is composed largely of marine chalks, chalk-with-flints, and marls, with subsidiary limestones, all part of the Ajlun and Balqa Series, and the age of sedimentation ranges from Senonian to Eocene. The strata are not folded and tend to lie horizontally, or with a slight dip to the east as a result of the differential uplift of the block. Towards the western edge of the area the influence of scarp rifting becomes more pronounced and the sedimentary strata show signs of flexuring and occasional monoclinal arching.

Gravels, sands, silts and muds of terrestrial and lacustrine origin infill some of the depressions, the age of these sediments ranging from Miocene through Pliocene to late Quaternary. The gravels and silts covering the wide floors of the wadi depressions are generally assigned to a late Quaternary cycle.

A further element of diversity is given towards the higher ground to the west by the presence of surface flint tracts resulting from the erosion of chalk, which once enclosed the flints, and by the occurrence of a loessic deposit on some of the broader interfluvial flats. Volcanic activity associated with the Tertiary-Quaternary crustal instability has resulted in cone formation and volcanic outpourings in the north, east and south-east of the region.

The Eastern Plateau as a whole is probably the oldest topographical unit in the Southern Highland Region and is generally looked upon as a relic peneplain developed during the Oligocene, i.e. part of the so-called "Arabia Surface" (900 m) of Quennell (4). Rejuvenated drainage into the rift was initiated in the Miocene and has extended farther and farther eastwards by headward erosion into the old peneplain.

Succession

Using the geological maps prepared by A. M. Quennell, 1954, (6) and the handbook of the Geology of Jordan, 1959, (4), the succession is as follows:-

A. Scarp Area

1. Aqaba granite complex (Pre-Cambrian). These granites with basic and acid intrusives outcrop as steep to sheer-sided hills in the Rift complex west and south of Shaubak.

2. Quweira Series (Cambrian). Composed of sandstones, quartzites,

shales, grits and conglomerates; this series outcrops in the Wadi El Hassa, Wadi Dana, Petra and throughout the scarplands.

3. Ram and Um Sahm Sandstones (Ordovician to Triassic). These coarse-grained, loosely cemented sandstones occur widely along the scarp.

4. Kurnub Sandstone (Upper Jurassic to Lower Cretaceous). This sandstone is seen mainly along wadi sides and throughout the whole scarp area. These almost vertical cliffs support an inaccessible tree cover dominated by juniper (*Juniperus phoenicia*), on the sandstone, and oaks (*Quercus coccifera spp.*) on the adjacent Cretaceous limestones of the scarp edge.

B. Highlands and Arid Steppe

1. Ajlun and Balqa Series (Turonian and Senonian). The Ajlun Series of marine sediments consists mainly of limestones, sometimes dolomitic, with some interbedded marls. Shales, sandstones and chalk are more uncommon. The Balqa Series is composed of cherts, chalks, limestones and chalky flints.

   (a) Limestones are the most important representatives of both the Ajlun and Balqa series. On weathering the limestone dissolves to give a strongly calcareous or silty clay. In the west this clay has a typically red-brown colour, depending partly on the moisture regime. It is heavy and contains little debris from the original limestone. Free lime may be as high as 20-25 per cent. In the drier eastern areas dissolution is not as complete and debris is considerable; the lime status is often over 50 per cent. Here the clay is yellow-brown and has a coarser nature.

   (b) Chalks do not occur in large areas; only where rainfall is comparatively high in the north-west do dissolution clays occur.

   (c) Marls and clays occur in both series but again do not occupy large areas. Unweathered marl has a white to yellow colour, weathering to red-brown or dark grey-brown.

   (d) Flint layers are frequently present in the Balqa Series. They do not contribute to the finer soil-forming material but are of great importance as a stony residue in most soils.

2. Lisan Marls are shown on the map over a large area to the east of the plain of the Fujeij. They consist of thick gravels overlying the southern extension of the plateau basalts; they are possibly of Pleistocene age and do not include any true marls.

3. Volcanics, originating from vents before the present erosion pattern was so clearly established, are extensive south of Tafila and east of Shaubak. The flow extended to Jebel Uneiza but in most of its southern extent it is concealed. In parts of the more arid areas there is little soil

development and the surface is covered with basalt boulders. Where weathering does occur a yellow-brown, extremely silty clay results or a red-brown calcareous clay with similar characteristics to limestone dissolution clays.

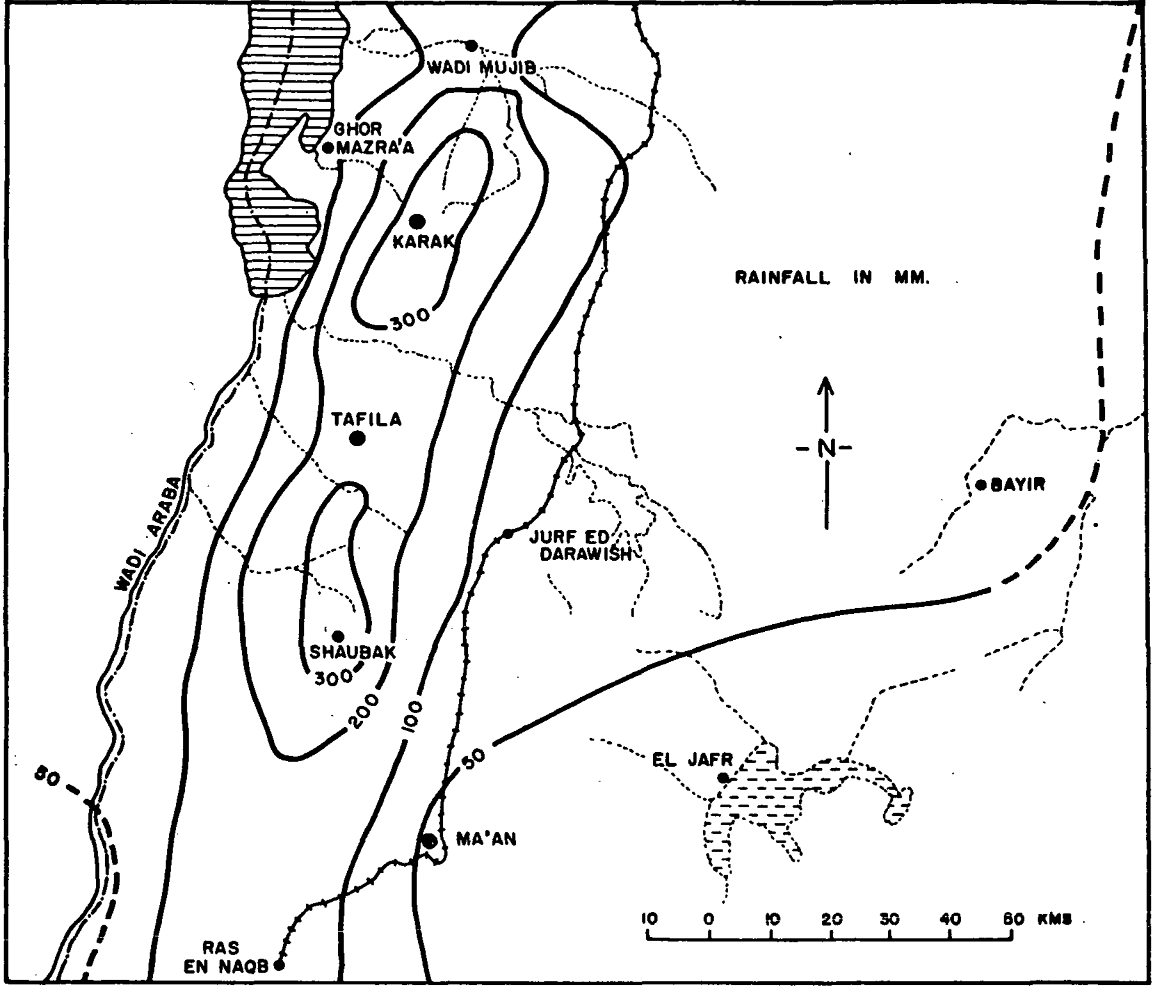
4. Recent Deposits:-

(a) Semi-Lacustrine and fluviatile sediments are extensive on the eastern boundary of the region. Heavy silt-clays, loams and gravel are found mixed in wadi and wash areas. The colour is yellow and towards the east increasing salinity of the soils is encountered.

(b) Colluvial sediments are seen in most wadis and valleys throughout the region. They usually consist of dissolution clay from the limestone, or basalt clays, with many flinty fragments. The picture is complicated as colluvial material is very extensive and few soils are derived from the solid geology directly beneath them.

(c) Aeolian deposits are very difficult to separate from colluvium as admixture is so great. Some deposits are pre-historic, as seen by flint artifacts on the present surface; some are historic, as evidenced by the remains of Roman constructions; others are contemporary in the form of miniature mounds accumulating behind plants in the eastern Fujeij. These tend to lift the vegetation slightly above the surrounding surface and may be adding considerably to the complex of materials of colluvial, lacustrine and fluviatile origin.

FIG. 5 RAINFALL



Chapter 4

CLIMATE

The existing meteorological data for the Southern Highland region are variable in detail and sparse in content and they thus tend to give a relatively incomplete picture of the climatic conditions obtaining in different parts of the area. Rainfall figures since 1937 are available for a wide range of stations but other meteorological information, for example, snowfall, temperature, humidity, evaporation and wind data, is virtually absent. Since September, 1960 more detailed readings have been taken at Shaubak Agricultural Station but the records available are, of course, of too short a range to permit accurate analysis of the regional climate.

In the region under study it is impossible to give a single climatic designation to summarise all observable features. The picture which emerges is one of gradations and transitions: gradations from north to south, from east to west, and across topographic features. According to the climate types of LONG (7), much of the area would be defined as "the Mediterranean Arid Bioclimatic Type", with a transition from the cool variety on the higher ground to the warm variety in the eastern scrub area. A more accurate designation, however, would give much more importance to micro-climatic effects but as already indicated this is precluded by a lack of adequate meteorological data of local variations.

The dominating characteristic of the climate is of course aridity. The mean rainfall figures show that only the immediate environs of Shaubak receive over 300 mm. per annum. A belt of higher ground, stretching from a point approximately 20 km. south of Shaubak to some 20 km. north of Tafila, and almost 30 km. in width receives over 200 mm. per annum; the remainder of the area falls between the 200 mm. and the 100 mm. isohyets (see Fig.5). The highland ridge from Shaubak to Tafila thus forms an area of relatively higher precipitation with steep gradients tending towards aridity west to the Wadi Araba, east to the eastern Deserts, and south to Wadi Musa. On average, the annual precipitation at Shaubak is 340 mm. at Tafila 270 mm. and at Lahdha just west of Rashadiya, 298 mm.; these figures fall off sharply to 180 mm. at Wadi Musa, 140 mm. at Udhruh, and 68 mm. at Jurf ed Darawish. (Table II).

The outstanding characteristic of the precipitation regime is its marked restriction to the months from November to April, with only an occasional light fall in May.

Tables I and II summarise the salient details:-

TABLE I

Features of Annual Precipitation

STATION	Wettest month	Percent of annual Precip.	2nd Wettest month	Percent of annual Precip.
Shaubak	February	40	January	30
Tafila	February	35	January	30
Lahdha	February	45	January	35
Wadi Musa	February	40	January	25
Jurf ed Darawish	February	40	November	40
Ma'an	November	33	January	20

Thus on the highland ridge February is invariably the wettest month, accounting for some 35-45 per cent of the annual total. The second wettest month is usually January, and the two wettest months together receive 65-80 per cent of the annual precipitation.

On approaching the eastern desertic areas, the precipitation becomes concentrated less and less into a single winter maximum. Instead, two separate maxima begin to emerge, one in November and the other in the January/February period. The smaller the annual precipitation the greater the tendency towards two maxima, until at Ma'an November becomes the wettest month. Over the entire area the summer drought exists for at least six months in the year, from June to October inclusive.

A second important feature of the precipitation is its unpredictability and wide variation from year to year (Table III). This feature is so marked that mean totals become almost meaningless when used to predict moisture available for plant growth; it should be noted, however, that even in arid years the isohyet map still emphasises the relative wetness of the highland ridge. The regional distribution of precipitation is perhaps its most constant and striking characteristic. The unpredictability of the precipitation is a feature characteristic of the whole region and it appears to be governed by general rather than local circulatory conditions. The following table summarises the regional rainfall conditions:-

TABLE II:

Average Annual Precipitation 1937-61.

STATION	Minimum mm.	Maximum mm.	Mean mm.
Shaubak	128	702	343
Tafila	87	464	268
Lahdha	126	429	298
Wadi Musa	88	310	181
Jurf ed Darawish	26	142	68
Ma'an	0	103	41

The intensity of the precipitation is another important feature of climate. Although no accurate records exist per se, the concentration of the annual rainfall into relatively few rain days points to a marked intensity of rainfall. On average the February precipitation at Shaubak (105 mm.) falls on eleven days while the February precipitation of Lahdha (124 mm.) falls on fifteen days. The greatest intensities recorded in Table III, however, are much more striking:

TABLE III:

Maximum Rainfall recorded in a single day 1937-61

STATION	mm.	Per cent average annual rainfall.
Shaubak	98	27
Tafila	83	35
Lahdha	89	30
Wadi Musa	58	33
Jurf ed Darawish	38	55
Ma'an	30	75

Whilst the relative intensity shows a tendency to increase towards the eastern desertic areas the intensity of precipitation is a critical feature of the whole of the region. When one considers the regional characteristics of soil slope, and surface run-off, soil-conservation methods assume an added importance. It is unfortunate that the only criterion of rainfall intensity available is the greatest rainfall per day.

Perhaps even more unfortunate is the lack of data pertaining to snowfall during the winter months. A significant proportion of the January precipitation falls as snow along the highland ridge but no accurate records of the amount, depth, cover and longevity are available. In any study of moisture available to plant growth, this represents an important omission. Precipitation in the form of snow is less liable to evaporation loss, it forms a protective soil cover and has a higher comparative soil penetration percentage than an intense downpour of rain.

The relative humidity figures for Shaubak (1960 - September 1962) emphasise the comparatively simple pattern of high relative humidities in January and February (the coldest and wettest months) and the low humidities in July and August (the hottest months). The seasonal average varies from 75 per cent in January to 30 per cent in August with marked fluctuations in winter again being evident. The prevailing low humidities suggest that dewfall is insignificant, and only two slight falls were observed by the team during late August, 1963. The annual temperature range is equally great. Long term figures are not available and so averages, which would be meaningless, cannot be given. At Shaubak, however, January has an estimated mean minimum of 1-2°C with an absolute minimum of -7°C. During the summer months the mean temperature exceeds 17°C and the maximum temperatures in August lie between 31°C and 33°C. The maximum diurnal range recorded in summer is 21°C and in winter 14°C. Towards the eastern desertic areas mean summer temperatures rise to 20-21°C, and the maximum temperatures in August rise to 35-36°C. January also becomes warmer, with the mean minimum rising to 4°C. This corresponds to the transition eastwards to the "warm" from the "cool" variety of the Mediterranean Arid Bioclimate.

An important aspect of temperature data is the length of the frost-free periods. This varies from year to year and from locality to locality, depending upon topographic conditions; it is significant that this period is rather shorter than elsewhere in Jordan, height and exposure probably being the two main factors involved. The first frosts of the winter season generally occur at the beginning of November and even in mid-October in an extreme season. The last frosts of spring usually occur during late April to early May. Consequently, a reliable and effective frost-free period for plant growth can be taken as only 150 days.

Wind is also an important element in the climatic environment of the region. A westerly to south westerly wind predominates throughout much of the year and accounts for the chief winter precipitation. The situation is complicated by occasional easterly winds, which assume the thermal characteristics of the desert; they are cold and dry in winter, and hot and dusty in spring and summer. The mean force varies from 2-5 knots (Beaufort 1-2) in summer to 5-7 knots (Beaufort 2-3) in winter, with a recorded maximum of 21 knots (Beaufort 5) at Shaubak in December 1960. Much stronger gusts can be expected in winter on aspects exposed to the west and south-west winds. Records again are scanty and discontinuous.

The most significant fact which emerges from a study of the available climatic data of this region is that for much of the year potential evaporation is greatly in excess of natural precipitation. Although no scientific information is available, it is probable that only in January and February does the precipitation-evaporation ratio approach unity. For the remainder of the year the high temperatures, the intense insolation, the low relative humidity and the prevailing winds all contribute towards a high evaporation rate with its limiting effects on plant growth and hence on crop production.

As already indicated the weather conditions prevailing in an abnormal year can be of more local importance than the hypothetical weather suggested by statistical averages. A striking demonstration of this was apparent in the winter of 1963-64. The unusually high precipitation resulted in the washing out of considerable stretches of roads with the destruction of bridges and culverts, and serious localised gully erosion. The prolonged low temperatures, accompanied by frequent and extensive snowfalls and the refreezing of snow-melt, also had a disastrous effect on tree seedlings, whether under nursery conditions as at Shaubak, or when planted out in the Fujeij. (See Appendix II).

On the human side, T.E. Lawrence (8) records some pertinent observations on the climate of this region in the course of his desert campaigns of the First World War. In "The Seven Pillars of Wisdom" frequent reference is made to the severity of the winter in the Southern Highlands; he describes his campaign as "Fighting in a little Alp". His journey in mid-February by camel from Shaubak to Tafila reveals a vivid picture of yard-deep snowdrifts, frozen mudbanks, rain and floods, and icy winds.

Chapter 5

SOILS

General

Geological formations are important since on weathering they give rise to parent materials which, to a large extent, determine the soil character in this arid environment. The parent materials responsible for the existing soil pattern in the survey area have been considered in the section dealing with the geological succession; little therefore need be said here. The heterogeneous nature of some of the soils and the colluvial zoning frequently found within the profile render horizon connotation difficult and in some cases impossible. Nevertheless, a generalised differentiation of the soils is feasible. Perhaps the most striking physical feature in the field is the difference in soil colour while contrasts in topography and related soil phase are also significant.

From Moorman's soil survey (9) three main groups can be established. He distinguishes certain differences from the Great Soil Groups as found elsewhere, but at this stage there is no reason for differing radically with this useful overall classification:

1. Red Mediterranean Soils

   (a) Red Mediterranean Soils and Lithosols (Basalt areas).

   (b) Red Mediterranean Soils and Lithosols (Chalk and limestone areas).

2. Yellow Mediterranean Soils

   (a) Yellow Mediterranean Soils and Regosols.

   (b) Yellow Mediterranean Soils and Basalt.

3. Yellow Soils

   Yellow Soils and Regosols.

1. Red Mediterranean Soils

These soils are formed on limestone, chalk, basalt and to some extent on sandstones. High base saturation distinguishes these soils from the Great Soil Group, Red and Yellow Mediterranean Soils. They might therefore be classified as the East Mediterranean or Dry variety of Red and Yellow Mediterranean Soils. Free calcium carbonate is present throughout the profile.

(a) The Red Mediterranean Soils and Lithosols on Basalt are similar to the red soils over chalk and limestone in most respects. The original A horizon is at least partly eroded away and is always low in organic matter. Colour may be very slightly darker than in lower horizons; structure is variable, but mainly crumb and granular, and the surface horizon is always calcareous. Below this a second horizon is distinguished texturally and by clay coatings on single peds. There is always a distinct to strong prismatic tendency with angular to sub-angular peds. A C_{Ca} horizon may be present with the deeper phase. Here lime nodules occur frequently and may represent up to 40 per cent of the lower material. A lime pan is rare but this may occur over basalt. Transition to the C_{Ca} or D horizon is abrupt.

(b) Red Mediterranean Soils and Lithosols on limestone and chalk occur in the so-called "barrocal areas" on slopes of over 6-8°, and in pockets on even steeper slopes. In deep pockets dissolution clay soils similar to 1 (a) occur. Regosols are frequent within these areas and shallow stony soils are extensive. Natural terracing following the geological outcropping, sometimes assisted by the construction of stone walls, is a notable feature of this colluvial area.

2. Yellow Mediterranean Soils

Where present in this area, these soils are transitional from Red Mediterranean Soils to Yellow Soils. They reveal some characteristics of both groups but are more closely related to the Yellow Soils.

There is always a clear but weak A horizon with low humus content and the difference in colour from lower horizons is only slight. In natural conditions surface structure is crumb to granular but with over-grazing it becames weakly platy. The hard consistence of all horizons distinguishes this sub-group from Yellow Soils. The second horizon has a finer texture. Structure is angular to sub-angular blocky and is often arranged in prismatic units. Single peds may have weak clay coatings in areas transitional to Red Mediterranean Soils. In very arid areas no clay skins on peds are seen. Except in a very shallow-phase profile there is a transition to a C_{Ca} horizon.

(a) Yellow Mediterranean Soils and Regosols are found in two areas:-

(i) Hilly or mountainous relief in the scarp and rift area.

(ii) Transitional to the eastern desert with rolling to hilly relief and some steep slopes.

(i) Here regosols predominate with Yellow Mediterranean Soils found only on small, less sloping areas. Regosols are formed from slope colluvium of varying composition and may be clayey (over limestone) or sandy. They are very stony and highly calcareous. Lithosols are common on steeper slopes.

(ii) These comprise more extensive areas. Phase is deepest in valleys and on plateaux but on slopes depth of soil can be very shallow. Lithosols are present but erosion is less than in the areas of Red Mediterranean Soils; even under heavier rain they resist erosion better than red soils.

(b) Yellow Mediterranean Soils on Basalt occur only in a very small area, where they are partly on basalt and partly on a loess-like material. On flatter relief a medium to deep phase develops but on slopes the soils are very shallow with many basalt boulders. Relief is mainly undulating interspersed with occasional level areas.

3. Yellow Soils

These are distinguished from the true Grey Desert Soils (Sierozem) because there is no desert pavement, or only an incipient one. The colour is yellow-brown throughout. There are many roots in the surface horizon arising from steppe vegetation. Structure in the surface and second horizons is crumb to granular and there is a compact C_{Ca} with weak blocky to prismatic structure. Consistence is always friable except at depth, where secondary concretions of lime make the soil much firmer.

Where there is over-grazing the surface layer is compacted to a weak platy structure and a surface skin forms. This skin is absent south-east of Tafila where grazing is not so intense.

Yellow soils and Regosols are found in two types of area:-

(i) Hilly to mountainous scarp and wadi areas.

(ii) Eastern area transitional to desert.

(i) Regosols on slope colluvium predominate in this group with Yellow Soils on flatter parts and more stabilised slopes. Lithosols occur over limestones on steep-slopes and detailed survey is difficult.

(ii) The eastern area is important for grazing. A deep phase is characteristic especially over loess-like material. On slopes the soil tends to be shallower and Regosols are infrequent.

In the course of this survey 13 profile pits were carefully sited and recorded so as to be as representative of the region as possible. The intention was that they should be of assistance in the interpretation of existing land use. For more detailed soil mapping, which was not the present objective, a much greater density of soil profiles would obviously be required.

Using the above classification the soils encountered in the profile pits here recorded may be classified as follows:

Pits 1, 2, 3, 4, 5 and 10, 11, 12

Red Mediterranean Soils.

Pits 6, 7, 8 and 13

Yellow Mediterranean Soils.

Pit 9

Yellow Soils.

SOIL PROFILES

Pits 1-5 inclusive represent the soil conditions found along a transect of the Wadi Hisha, running approximately east-west at a point 15 km South of Shaubak Agricultural Station. It is situated in the heart of the open scrub oak forest in very stony ground. Ground vegetation consisted mainly of Artemisia brush.

PIT 1.

Situated on a small flat ridge on the west of the transect line. Much of the surface soil was covered with small and large stones.

Profile

0-5cm.

Brown loam (10 YR 5/3) with a small to medium nutty structure. Very friable and free-draining. Mat of fine grass roots throughout the horizon. Stones of all sizes present measuring up to 8 cm. in the longer axis.

5-20 cm.

Brown loam (7.5 YR 5/4). Blocky structure; constitution friable. Fewer large stones, mostly averaging about 2 cm. diameter consisting of limestone fragments, chert and sandstone. Single soil beetle observed. Horizon boundary sharp and fairly uniform.

20-32 cm. +

Parent rock, limestone, with larger roots penetrating to about 12 cm.

PIT 2.

Sited on the west slope in an old terrace in open evergreen oak scrub forest (Quercus coccifera sp. calliprinos) with a scattered ground cover of Artemisia brush. The land sloped to the road at the bottom of the wadi and showed evidence of earlier terracing, now derelict. The soil surface was almost covered with stones, which consisted of flints, sandstone, limestone and chert of varying size. There were small patches of ploughed land in the vicinity.

Profile

0-86 cm.

Brown silty loam (7.5 YR 5/4) with little horizon differentiation. Stones throughout with a tendency towards a greater concentration towards the base. Firm blocky structure; friable with the surface layer pulverising readily. A few short vertical cracks; no burrows or soil animals seen. Slightly compacted with depth. Numerous medium and fine roots throughout this horizon; also $CaCO_3$.

86-98 cm. +

Pale brown (10 YR 8/3). Solid rock consisting of fine grained sandstone, siliceous and calcareous. Little weathering evident on the rock surface.

PIT 3.

Shallow roadside cutting. Soil surface littered with small and large stones; gentle aspect to the south in the scrub oak forest.

Profile

0-99 cm.

Colour reddish yellow loam (7.5 YR 6/6) showing mainly blocky structure with some cracking. Some of these structural units measured 19 am. x 14 cm. Lower third of the horizon showed increasing stoniness, consisting mainly of limestones and weathered flints. Fine, medium and large roots found throughout the horizon. An animal burrow observed.

99-135 cm. +

Colour reddish yellow marl (7.5 YR 8/6); massive and compacted with no roots.

PIT 4.

On the east side of the wadi; slope approx. 15°. Horizontally bedded outcrops of calcareous rocks occur up the slope. Soil surface almost covered with stones of all sizes with evidence of erosion. Natural vegetation of oak and wild hawthorn less dense than on the west side; most of the trees are stunted and mutilated by random cutting for firewood and by grazing. A few large pistacia trees are a dominant feature of the landscape with some underbrush.

Profile

0-14 cm.

Shallow horizon, pinkish colour (7.5 YR 7/4) overlying limestone rock. Very gravelly and stony. Greyish-yellow sandy loam. Friable throughout. Structure granular to nutty. Calcium carbonate abundant.

14 cm.-depth

Some root penetration of the limestone rock.

PIT 5.

On flatter land on the crest of the jebel, east of the road. Soil profile similar to Pit 4. Much green Artemisia brush together with other small plants, one resinous, and Zignan (Daphne linearifolia). Fine grasses present. Soil surface almost covered with small stones and a few larger ones, consisting mainly of limestones and flints. The east ridge of the wadi, especially the higher ground, was almost denuded of tree vegetation.

Profile

0-15 cm.

Grey soil (7.5 YR 5/5). Good loam with nutty structure breaking down to powder, and very friable. A mat of fine grass roots is a characteristic feature of the horizon. Some small stones and gravel present.

15 cm.-depth

White surface (10 YR 8/2) reveals an uneven horizon, a few roots penetrate the joints and cracks.

PIT 6.

Almost flat area near the Fujeij Station. Stone-free surface with a 15 per cent cover of dried Artemisia scrub. Some plants elevated on individual mounds of aeolian material. No signs of serious water erosion. Gopher mounds frequent and snail shells numerous. Thin surface skin formed.

Profile

0-12/18 cm.

Light yellowish brown (10 YR 6/4) sandy clay loam with massive and granular structure tending to blocky. Occasional fine to medium gravel up to 3 cm. on long axis; mainly limestone fragments. Frequent fine to medium roots and occasional large roots; free-growing. Boundary with limestone sharp but geological surface uneven. $CaCO_3$ present throughout.

18-60 cm.+

Very pale brown (10 YR 8/4) soft limestone with upper part weathering to material similar to above horizon. Occasional fragmentation in upper zone. Occasional fine to medium roots penetrating to 30 cm.

PIT 7.

Terrain similar to Pit 6 and 3 Km north-east of the Fujeij Station. Cultivated with stubble remaining from previous crop. Gopher mounds frequent. Thin surface crust observed.

Profile

0-16 cm.

Light yellowish brown, sandy clay loam (10 YR 6/4). Structure mixed, with some large granular, but mainly angular blocky. Few stones of gravel size. Frequent fine, free-growing roots and occasionally large well defined ones. Horizon boundary clear. Highly calcareous reaction throughout.

16-68 cm.

Light yellowish brown (10 YR 6/4) sandy clay loam. Highly indurated with massive structure. Occasional small stones of small gravel size giving calcareous reaction. Penetrated by fine roots throughout. Animal holes present. Lime concretions of various dimensions increasing in frequency with depth. Boundary clear.

68-90 cm.+

Very pale brown (10 YR 7/4). Similar to above but slightly moist and less indurated. Rare fibrous roots. Increase in calcareous fragments both in size and frequency. Calcareous concretions more frequent and calcareous lining of cracks common. Occasional animal holes. High content of $CaCO_3$ throughout.

PIT 8.

Very gentle slope above Wadi Nijil on the Fujeij. Deeply ploughed. Large stones of varied origins on the surface. Surface skin formed.

Profile

0-17 cm.

Very pale brown, sandy clay loam (10 YR 7/4). Structure small blocky in a powdered single grained matrix. Friable. Stones common; angular flints and large rounded boulders. Medium to fine roots frequent. Boundary clear but wavy. Calcareous reaction throughout.

17-40 cm.+

Very pale brown marl with occasional flints (10 YR 8/4). Buff colour on weathering. Roots infrequent. Root holes and channels throughout. Permeable.

PIT 9.

Flat area of out-washed gravels on the outer Fujeij about 6 Km. from the Desert Highway. Vegetation, Artemisia scrub and some halophytes. A surface skin 2 mm. thick.

Profile

0-6 cm.

Yellow silty loam (10 YR 7/6). Weakly developed platy structure. Frequent small flints. Few medium to fine roots. Boundary variable. $CaCO_3$ present.

6-16 cm.

Very pale brown silty loam. (10 YR 7/4). Similar to above but structure angular blocky with prismatic tendency. Boundary well defined. $CaCO_3$ present.

16-96 cm.+

Brownish yellow (10 YR 6/6); mottled with calcareous nodules. Silt clay loam; very indurated. No well-marked structure but blocky trends in upper part. Soil riddled with fine holes and pipes. Occasional medium gravel flints. Calcareous nodules increasing with depth to dominate the horizon soil material. Roots penetrate to 58 cm. but infrequent. Animals' nest found at 24 cm. Lower base compact and indurated. Highly calcareous throughout.

PIT 10.

Taken in a section on the site of the proposed Shaubak Agricultural School. North-south section 35 m. long; east-west section 20 m. long.

General Observations

The expected deepening of the soil towards the valley bottom and down the wadi did not occur because of the extremely contorted surface of the underlying lime-capped conglomerate. From the soil sections certain general pedological observations were made. The history of the site would seem to be as follows. A conglomerate of flints and limestone was deposited and exposed to weathering. A hard limestone cap developed over a contorted and pitted surface. At a later stage a chocolate coloured hill-wash sludge covered the surface, filling hollows and holes. Later colluvial material, including a clear stone horizon, was deposited in places directly on the limestones, elsewhere above the protected pockets of hill-wash. The present soil is therefore of varied phase and profile, in parts progressing from fine colluvium through stones and wash to the basal conglomerate, consisting of a shallow, fine colluvium lying directly over the capped conglomerate.

Site. Gentle 2° slope near the wadi bottom. No vegetation. Puddled surface.

Profile

0-10 cm.

Reddish yellow colour (7.5 YR 6/6) clay loam. Granular structure. Fibrous roots frequent. Occasional large gravels. Gradually transitional to lower horizon.

10-95 cm.

Reddish yellow colour (7.5 YR 6/6) clay loam. Angular blocky structure tending to prismatic. Face speckled with small lime nodules and concretions. Large gravel and stones of all shapes. Large gopher hole noted. Roots frequent, large and fibrous throughout. Boundary clear. Reaction calcareous.

95-109 cm.

Stone layer. Large stones in clay matrix darker than above. Small blocky structure. Roots still penetrating but less frequent than above. Boundary well-defined but contorted. Calcareous reaction.

109-160 cm.+

Variable colour with whites and browns dominating. Conglomerate with flints and occasional limestone fragments. Capped by 5 mm. lime crust. Roots penetrating to 150 cm. Much calcium carbonate present.

PIT 11.

Situated in the centre of a plot of Egyptian clover (berseem), planted in June, on the Shaubak Agricultural Station. Gentle slope above 2° from the south-west towards the wadi floor. Irrigated agriculture. Colluvial material; surface cleared of large stones but still very stony, the stones consisting mainly of flint.

Profile

0-14 cm.

Yellowish red colour (5 YR 5/6). Friable although slightly damp. Granular to nutty structure. Brown silty loam. Fine rootlets throughout. Small stones increase towards the stone horizon.

14-22 cm.

Yellowish red colour (5 YR 5/6). Stone horizon of angular flints. Same colour and texture as above; nutty structure; fine rootlets throughout. Flecks of $CaCO_3$.

22-105 cm.+

Yellowish red colour (5 YR 5/6). Massive structure with polygonal cracking, more compacted and heavier texture of silty clay. Considerable number of white patches of $CaCO_3$ and small flints frequent. Larger stones at the base of the horizon. Live roots found at depth of 89 cm.

PIT 12.

In the orchard of the Station, ½ km. from Pit 11. Slope of 1-2° to the east. Grove of olives, apples, and cherries without irrigation. Small and large stones scattered on the soil surface.

Profile

0-16 cm.

Reddish yellow colour (7.5 YR 6/6) silt loam, very friable. Variable structure from single grain to medium angular blocky. Some gravel present. Live roots throughout the horizon; boundary sharp but wavy.

16-43 cm.

Yellowish red colour (7.5 YR 5/6) silt clay loam; blocky structure with some vertical cracking and white flecks of $CaCO_3$. Some stone and gravel present; occasional pockets of dark red soil of nutty structure. Live roots prominent.

43-114 cm. +

Parent material of weathered limestone with flints, giving a marly appearance. Roots observed to a depth of 105 cm. Whole profile is highly calcareous.

PIT 13.

1½ km. south of Uneiza road and 6 km. south-east of Shaubak. Rolling expanse of open ploughed land to distant jebels 8 km. to the south. Soil pit sited on a flat shallow area, ploughed to a depth of 4 inches.

Profile

0-21 cm.

Reddish yellow colour (7.5 YR 7/6) thin friable surface skin up to 0.5 cm. thick. Brownish yellow colour (10 YR 6/6) silt loam; friable with a nutty to blocky structure. Wavy horizon varying in depth from 16-31 cm. No vertical cracking observed. Fine and medium grass roots. Some small stones and flints.

21-64 cm.

Very pale brown (10 YR 7/4) clay loam. Massive structure breaking down to nutty and blocky, with no vertical cracking. Still penetrated by fine roots and occasional round holes of animals. Becomes more compacted with depth.

64 cm. +

Limestone with larger flints at depth. Fine roots found at 66 cm. Profile calcareous throughout.

Interpretation.

The soil samples taken in this survey were analysed in the Department of Agricultural Scientific Research, Ministry of Agriculture Jubeiha, Jordan. The routine analytical methods employed were based on those given in "Diagnosis and Improvement of Saline and Alkaline Soils" (10). The data for "available P" and "available K" are given in terms of Kg/donum, the working equivalent being 1 ppm = to 4 Kg/donum.

Soil depth was found to be very variable. It ranged from bare rock outcrop to a soil depth exceeding 135 cms. and thus cannot be correlated with the general system of classification adopted in this section. Wherever erosion had not been a serious degrading factor the deepest soils which also exhibited good structure fell into the group of "Red Mediterranean Soils". "Yellow Mediterranean Soils" were found to be more stable than the "Yellow Soils", but the climatic disadvantages of the "Yellow Soils" environment are probably more significant from the agricultural point of view. As regards texture this varied from sandy loam to silt and silty clay in the different horizons of the soil profiles. The texture of the topsoil varied less widely and in general approached that of loam.

The soil reaction in most horizons was greater than pH 7.5. Only in the forest transect at Shaubak were figures found to be lower than 7.5 but never below neutrality. The presence of calcium carbonate dominated all the soil profiles examined. Here acid fertilizers such as ammonium sulphate could be used effectively since the pH is generally in excess of the optimal for normal agriculture. It is noteworthy that, in general, there was no problem of salinity until the area of the eastern Fujeij and the Desert Highway was approached.

In general, cationic data (Appendix I, Table 4) showed a low exchange capacity. The ratio of Ca:Mg usually lies near the optimal of 1:1, 2:1 and 3:1. (11); only in five profiles was the magnesium status higher than that of calcium, but the imbalance was not serious.

The Na cation was not generally present in high proportion except, rather surprisingly, in Profiles 1 and 2 of the forest transect, where ratios up to 6:1 = Na:Ca were found; also in Profile 7, horizon 2 an abnormal ratio of 7:1 = Na:Ca was present. Because it does not fit into any pattern with other profiles of its group this latter finding is of doubtful significance.

The K ion status was in most cases surprisingly high. In Profile I it approached 1:1 = K:Ca, a fortunate circumstance since here the Mg ion, which in excess is known to cause potassium deficiency, is in fact in excess of calcium. Nowhere was the K ion seen to be proportionally too low, although it must be remembered that under present conditions there is little actual return of potassium to the soil, as compared with the concentration of calcium released from the abundant weathering limestone.

In conclusion, it can be seen that all reserve nutrients are obviously low since the organic matter status of the soil is also generally low (See Chapter 7). The present balance of nutrients is not unsatisfactory but, should it be decided in the future to introduce fertilizer practice, the programme would need to be carefully controlled. With such a low cationic exchange capacity imprudent application of fertilizers might soon induce nutrient imbalance with consequent deficiency. The situation is aggravated by the fact that, as a result of the arid conditions, these soils are inherently deficient in nitrogen. (12).

The above is a review of the general development of soils within the region but many minor variations exist throughout. Pockets of red soil occur at various elevations within areas dominated by soils of yellow colour. The yellow coloured soils themselves vary throughout the region; some are yellowish white, some olive-yellow and some yellow-brown. Most of the variations are of little importance in an area of primitive agricultural techniques and development. Available water, infiltration rate and methods of conserving soil and moisture are of more immediate concern, but soil phase and stoniness merit consideration and perhaps more detailed mapping.

FIG. 6 CULTIVATED AND WOODLAND AREAS

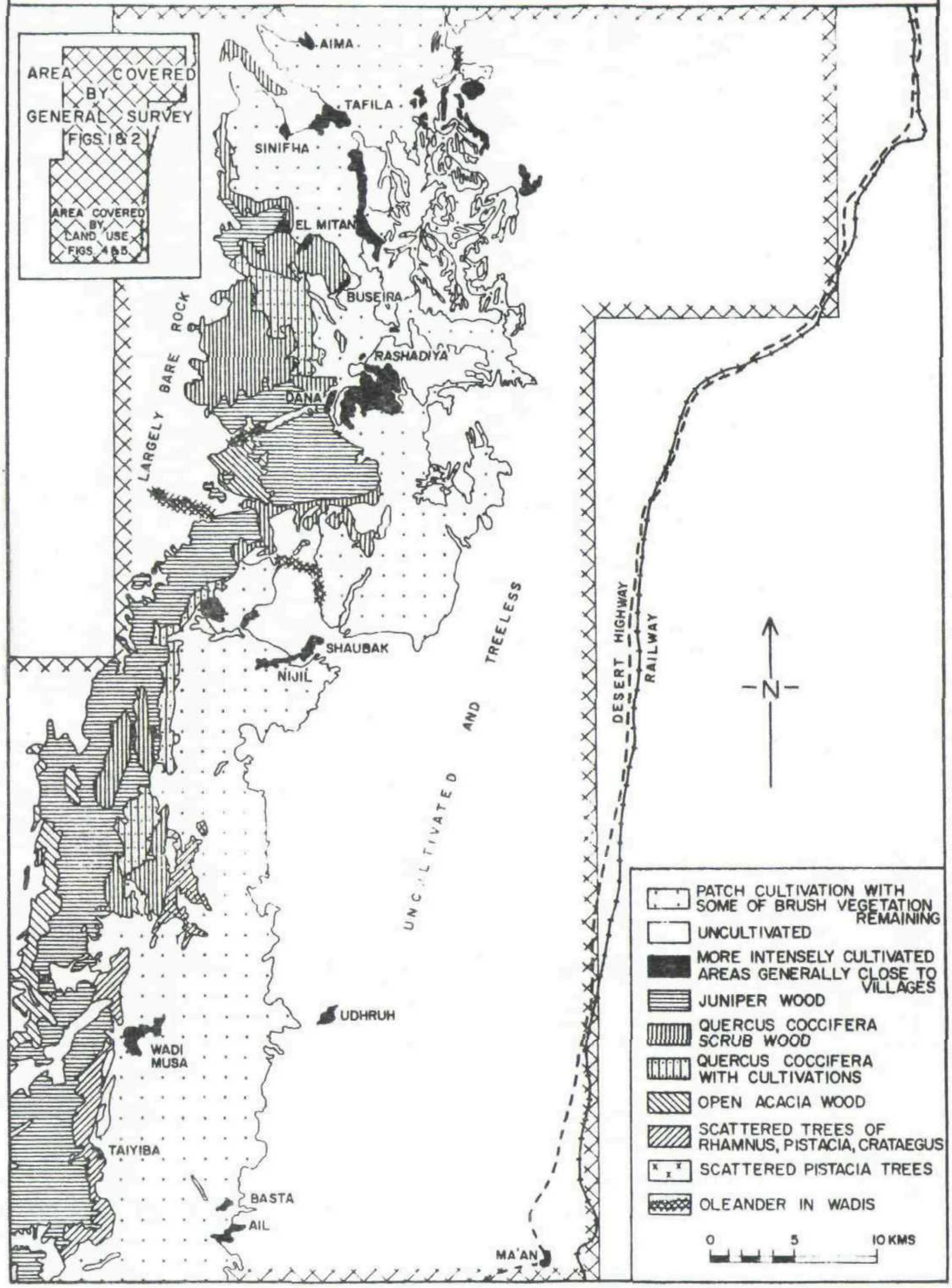
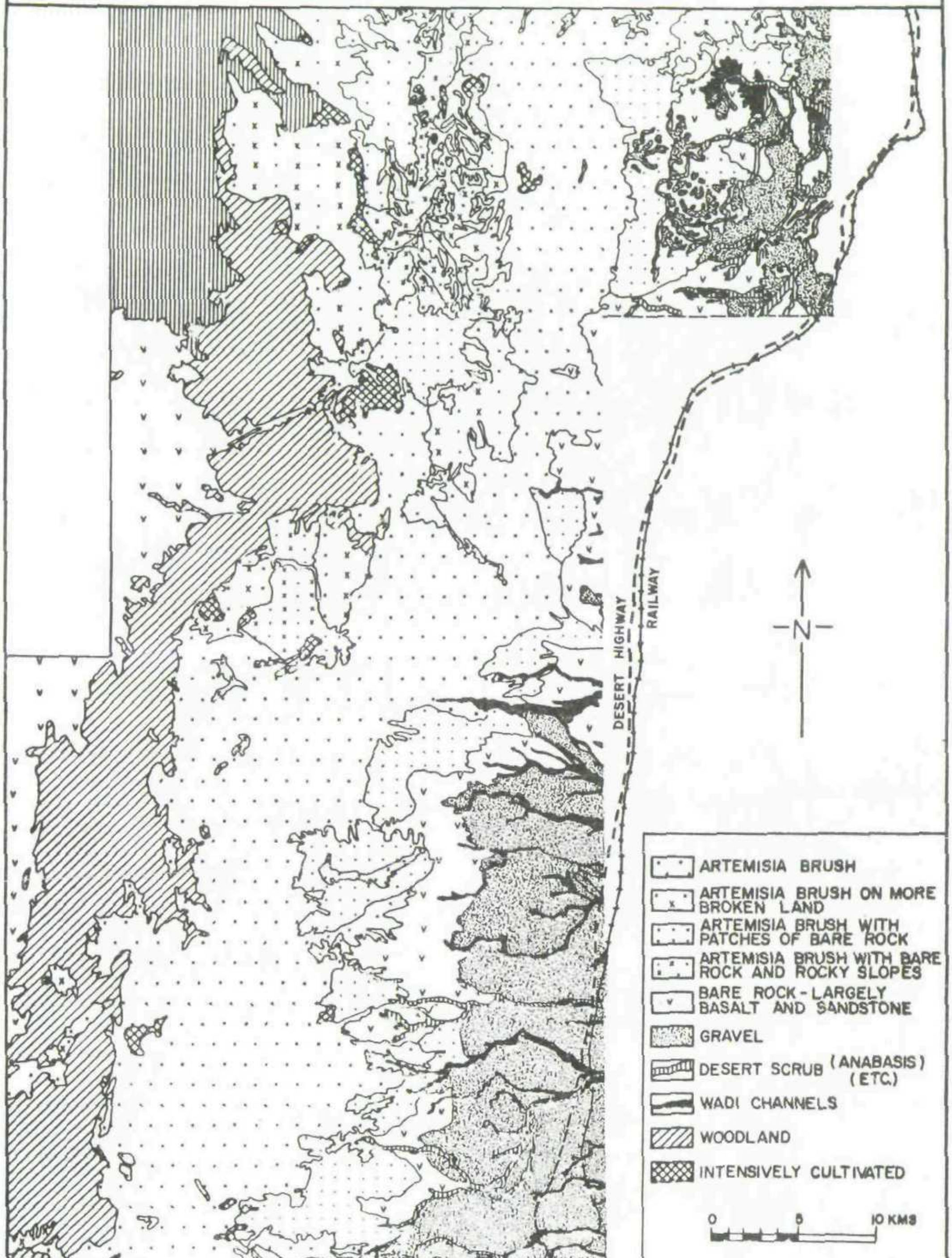


FIG. 7 RANGE CLASSIFICATION



Chapter 6

NATURAL VEGETATION

The natural vegetation of the region may be divided into three categories: the natural forests and open woodlands, the grazing ranges, and the wadi bottoms. These will be considered in turn. Fig. 6 (Cultivated and Woodland Areas) and Fig. 7 (Range Classification) are based mainly on the Range Classification Survey of Jordan, completed in 1956 for the Jordan Government by Hunting Technical Services Limited. (13, 14) The main purpose of this survey was the provision of basic information required for the planning of a national range management policy. This valuable survey inter alia can provide a basis for more accurate mapping of plant associations and soils in selected sample areas and for help in the choice of sites suitable for Range Management projects; the photographic mosaics can also serve as dependable field maps. The country is divided up into "Range Types" based on overlays to the mosaics and maps on a scale of 1/25,000. These Range Types are sufficiently uniform in terms of climate, soil and vegetation to be regarded as units in future land-use development.

In survey work it is well recognised that vegetation is one of the most significant criteria of local conditions. The Hunting report rightly claims that "the distribution of natural vegetation reflects precisely changes in rainfall, temperature, soil, presence or absence of ground-water, and other factors. Moreover, because of the length of life span of many species, it gives an average value for these measurements over a long period of time, and, in a country where variation from year to year is as great as in Jordan, can give more valuable data than any but very long term meteorological measurements. When the vegetation has been submitted to millenia of human use it has usually been deeply modified and reflects present conditions, but relict species or relict soils may give evidence of its potential capacity. Human interference almost invariably changes the vegetation of a Mediterranean or arid region in the direction of greater aridity; and a satisfactory system of Range Types should always consider the country not only in terms of present state but also of capacity for improvement." (13).

The flora of the Southern Highlands and its distribution fall into three phytogeographical territories: the Mediterranean, the Irano-Turanian, and the Saharo-Sindian (15). Each of these phytogeographical territories is distinguished not only by its flora and vegetation but also by its climate and soils (16).

The Mediterranean Territory

In the Southern Highlands this territory embraces a narrow discontinuous strip near the scarp top extending from Tafila to about El Fardhakh, north of Naqb Ishtar. Its boundaries cannot be sharply distinguished from the adjoining Irano-Turanian territory. Although its vegetation is distinctive, the Mediterranean vegetation of the eastern and southern margins, bordering on steppe and desert, has been exposed to drastic devastation by man. As a result, plants from adjacent territories have been able to invade this border area to such an extent as to form a broad but variable transition belt of a mixed flora and vegetation. As we have seen in Chapter 4 the territory as a whole is characterized by a subhumid Mediterranean climate with minor variants which result from differences in topography, distance from the sea, and local variations in annual rainfall. The common soil type is terra rossa but rendzina, basalt and sandy soils also occur. With the exception of areas unsuited edaphically for tree growth, such as the transition belt, the territory in general is distinguished by forest and maquis climax communities.

The Irano-Turanian Territory

This virtually encircles the Mediterranean territory of the Southern Highlands. It forms a broader band in the east than in the west where the zone is much narrower, since the transition to desert conditions is rapid. The climate is of a more continental character and the precipitation is between 150 mm. and 300 mm. The rainy season is somewhat shorter and the monthly rainfall less evenly distributed than in the Mediterranean territory. The chief variations in vegetation are correlated with soil differences. The grassland is mainly confined to the more stable soils and the widespread Artemisetum is found throughout on the Yellow Soils. The climax vegetation was probably a "Tall Grass" steppe. As in the previous territory agriculture is almost entirely confined to the wadi bottoms and plains. Some Irano-Turanian trees and shrubs, such as Pistacia atlantica and Zizyphus lotus, penetrate into the Mediterranean territory in areas where the primary forests in the west have been degraded. In the same way Artemisetum invades the Saharo-Sindian as pockets of intrusions along the wadis and depressions.

The Saharo-Sindian Territory

Only the eastern margin of the Southern Highlands falls within this territory which lies mostly beyond our region and extends east and south into the deserts of Saudi Arabia. Here again the boundaries between the Irano-Turanian and the Saharo-Sindian cannot be determined with precision. Between the steppe and the desert regions thus represented there is a broad zone of natural vegetation which again forms a gradual transition from one to the other in response to a steadily decreasing rainfall, generally below 100 mm. In general, most of the limestone desert is of low relief. The common features of the soils are hammadas of basalt or flint, loams, loessal deposits and salinity. The brushland of the steppe with its sporadic cultivation gives way eastwards to rough grazing. Finally before the Desert Highway is reached the Artemisetum is largely replaced by poor halophytic vegetation, scanty except in the wadis and runnels in which Anabasis articulata is dominant. Probably the climax vegetation was little different from what is here today.

Natural Forests and Open Woodlands

There can be little doubt that most of the highlands of Jordan were formerly well covered with forests of oak, pine cypress, juniper and pistacia, and other associated vegetation. The natural forest stretched from Ajlun in the north to the head of the Gulf of Aqaba in the south. It was aligned generally north and south along the uptilted edge of the plateau forming the eastern escarpment of the Jordan Valley and the Wadi Araba wherever there was sufficient rainfall. The natural forests that still survive are found in two main regions: the Northern Highlands and the Southern Highlands.

The former, to the north of Wadi Zerka, includes the forests of Salt, Jerash and Ajlun; the latter the forest areas of Tafila, Shaubak and Petra. The forest areas of the north enjoy better natural conditions and are consequently more developed and protected than those of the south.

The forests of Jordan are mainly open and in the north comprise coniferous and broadleaved elements such as Aleppo pine (Pinus halepensis), native to Jordan and sometimes dominant, but associated with evergreen oaks such as: Quercus coccifera spp. calliprinos, Q. infectoria, Q. aegilops and Arbutus andrachne. By contrast, in the Southern Highlands are found the oak, (Q. coccifera spp. calliprinos) (Plate 7), cypress (Cupressus sempervirens ssp. horizontalis) (Plate 10), juniper (Juniperus phoenicia) (Plate 9), and pistacia (Pistacia atlantica) (Plate 8,). It is significant that here Aleppo pine does not appear to be present in the natural state. The climax vegetation was probably P. halepensis or Q. aegilops in the north-west and Q. coccifera ssp. calliprinos, further south on the limestone, with Juniperus phoenicia on the sandstone and C. sempervirens as a possible important element.

It is estimated that the remnants of the forests in the Southern Highlands have now shrunk to an area roughly 55 kilometres by 10 kilometres, thus giving a forested area of about 550 square kilometres situated at an altitude between 900 to 1700 metres above sea level. Rainfall is the dominant factor and the average precipitation is between 300 to 400 mm. although part of it is in the 400 to 500 mm. zone; towards the south the rainfall falls off to a level between the 200 and 300 mm. isohyets. As already indicated the concentric pattern of the rainfall of the region is its most striking feature (see Fig. 5). The forests and open woodlands are found mostly on the upper parts of the steep, westward-facing scarp, which drops precipitously into the Wadi Araba. When observed from a helicopter the falling density of the forest vividly reflects the effect of the decrease in rainfall as one descends westward from the scarp ridge. At certain points on the scarp formation, as in the juniper forests around Petra, there is a definite rain shadow when compared with the higher elevations towards the ridge top.

Several observers have recorded the fact that the geology of the region is of special significance in its relationships to soil, vegetation and drainage (17,18). The upper section of the scarp and ridge is a limestone formation with good water-holding capacity and capable of weathering down to a fertile soil of good structure. Considering the present adverse conditions soil erosion is less than might have been expected and often the soil depth is good and the area suitable for reafforestation. The limestone cap overlies thick beds of red and purple Kurnub sandstone and the contact of the two formations can be found some little distance down the scarp slope. The sandstone formations weather down to a friable, sandy soil of poor nutrient status, and in their exposed position are open to the full force of soil erosion both by wind and water. As a result practically no soil remains on the scarp precipices, and observation from the air confirms the fact of juniper growing out of crevasses in the solid rock. These areas of lighter rainfall carry only juniper forest, sometimes in pure stand or in association with P. atlantica near Buseira, or with C. sempervirens in the Lahdha area. Forests of Q. coccifera ssp. calliprinos occur side by side with J. phoenicia in this area, the former being restricted generally to the calcareous soils, and the latter to sandy soils.

The almost constant correlation between oak on the limestone and juniper on the sandstone is striking but is, contrary to what is sometimes thought, a feature by no means peculiar to Jordan. It is perhaps relevant to note that the cork oak (Q. suber) does best on leached, acid siliceous soils of the western Mediterranean and is conspicuously a calcium-sensitive species and intolerant to salinity (19). This pronounced difference in natural vegetation sometimes observed at the contact of two dissimilar geological formations, is well demonstrated, for example, in a mountain area of south Nevada, where piñon pine (P. cembroides edulis) and juniper (J. scopulorum) flourish together on the dolomites while the siliceous sandstones on the opposite side of the valley are almost devoid of vegetation (20). In these two examples the soil preference of the species is again distinctive although the preference is not the same as in the Southern Highlands. The golden oak of Cyprus (Q. alnifolia) is another classical example of a forest tree with definite soil preference. It flourishes on the Troodos massif of Cyprus and its distribution corresponds closely with the igneous formation and does not transgress these limits to invade the surrounding sedimentary rocks (21); the line of the demarcation is very sharp.

Kasapligil (22) estimated the area of the juniper forests to be 50 square kilometres; the rest of the Tafila mountain range as far as Wadi Musa is occupied by forests of C. coccifera ssp. calliprinos. Juniperus phoenicia is dominant in the following areas:

Table IV: Juniper Forests of the Southern Highlands (22)

Forest	Composition		Density
	Per Cent	Per Cent	
Dachil	70 Juniper	10 Pistacia atlantica	-
Gair	75 do.	25 do.	440
Gileil	70 do.	30 Pistacia and Rhamnus	-
Magda	70 do.	30 do.	-
Seyyarin	70 do.	30 Quercus coccifera	-
Elbid	Pure stand	-	670
El Musekni	do.	-	790

The lower limit of juniper forest is given at 850 metres above sea level but scattered trees can be found in protected valleys at 600 metres elevation; the upper limit is 1500 metres or more in the Tafila mountains. Soils under juniper forest are erodible; they consist of brown loamy sands to sandy loams overlying sandstones and with very little humus. In our experience regeneration was not impressive and seedlings and saplings were rarely seen; goats were the most serious hazard. When vegetation is at its maximum during early spring, foliage density of the ground vegetation is of the order of 40 to 60 per cent (22). Herbs such as Artemisia herba-alba and Poa sinaica are associated with the Juniperus forests, good forage plants being rare and unpalatable plants common.

The Cypress Grove near Rashadiya

Ever since Chapman (23) established the fact that this celebrated grove near Rashadiya consisted of Cupressus sempervirens ssp. horizontalis and not cedar, it has been the subject of much speculation and interest by foresters and botanists. The grove is found in a small wadi little more than one kilometre to the north-west of Ain Lahdha in broken and dissected country at an altitude of about 1500 metres. Kasapligil (22) records that the grove now consists of 54 trees occupying 1.5 hectares and, although roughly fenced in at the time of our visit, showed all the evidence of past injury and misuse. A number of fine specimens had been felled as indicated by several remaining stumps. The stand is unique in that it contains the finest specimens of cypress in Jordan and probably in the Middle East. The circumference of the largest tree is 3.6 metres and its height 10 metres. Most of the trees are very old and their age ranges from 250 to 400 years. As a permanent record of the age and rate of growth of this grove a section of a mature specimen is still preserved in the Department of Forests, Amman. There was no indication of a spring near the grove or of underground water; also no evidence of regeneration was seen but the stand was still producing an abundance of ripe seed. Because of its limited size and effects of centuries of mistreatment, this grove is not so impressive a sight as the stand of cedars remaining in Lebanon or the State Forest cedars of Cyprus. Nevertheless, it is well worth preserving for posterity and could well be the subject of detailed research for permanent record.

In the surrounding scrub woodland there were many fine specimens of cypress, singly or in scattered groups, which suggested that the cypress forest was formerly far more extensive and important. In this context it is interesting to note that some scholars consider the 'gopher-wood' of the Bible to be a resinous conifer identifiable with C. sempervirens, of which wood Noah's ark was believed to have been made (24). Cypress like the pistacia is found spread over a wide area of the Southern Highlands, normally high up with the evergreen oak and wild hawthorn (Crataegus azarolus) on the limestone, or at lower levels with juniper and 'zignan' (Daphne linearifolia) on the sandstone. Although obviously more prolific in the Dana-Tafila area of the north the suggestion that the Rashadiya grove represents its southernmost extension in Jordan cannot be accepted (22). One would certainly agree, however, with Kasapligil's conclusion that C. sempervirens is the ecotype most suitable for propagation in this area. Specimens of cypress, associated with evergreen oak and juniper, often much mutilated by cutting and by grazing, were noted as far south as the Wadis Nijil, Hisha and Musa. Given any reasonable protection the cypress woodlands would soon recover as it regenerates better and grows more quickly in this environment than juniper. Waterer has recorded that from the forester's point of view it is the most valuable of the four main species (18). It is drought-resistant and produces excellent roof poles so much in demand by village communities. It gives good fuel, wood and indeed much of the demand for coniferous timber could be met from C. sempervirens in the south just as P. halepensis could supply the needs of the north. It was observed (April 1964) that the cypress seedlings in the Shaubak Nursery, as well as those planted out in the district, had survived almost entirely the rigours of the frost and snow of the winter of 1963-64. By contrast, the pine seedlings were found to have suffered a very high mortality. This result is not surprising since P. halepensis is outside its normal habitat in the south.

The dominant species of the scrub woodland of the south is the evergreen oak, Q. coccifera ssp. calliprinos. It may occur in pure stand (95 per cent Q. coccifera and 5 per cent D. linearifolia) or associated with C. sempervirens, J. phoenicia, P. atlantica and C. azarolus. Q. coccifera occupies the western zone of the Tafila-Musa range keeping mainly to the higher elevations; Kasapligil (22) estimates the total area of Kermes oak forest to be 100 square kilometres. The soil type is calcareous loam, stony and carrying a thin layer of humic material, highly eroded and associated with outcrops of limestone. The soil may be classed as a degraded terra rossa. A pedological study was made of a transect across the Wadi Hisha (Soil Profiles 1 to 5, Chapter 5) in the heart of the open scrub forest. The open stand at Dabbagat south of Shaubak carries 610 trees per hectare and has as its main associate Colutea istria.

The whole region has suffered drastically from continuous felling, over-grazing and shifting cultivation. Because of the succulent fodder provided by its shoots, leaves and bark, Q. coccifera has had to withstand the brunt of the ravages of uncontrolled grazing. Because of this relentless onslaught the trees rarely present any natural structure but have cushioned and misshapen forms unrecognizable as normal evergreen oaks (Plate 16). Occasionally a standard tree may be encountered rising from the centre of the closely coppiced cushion at the base of the trunk. The open oak woodland has also been very much thinned by scattered patch cultivation as in the valleys between Wadi Nijil and Wadi Musa, and further north around Rashadiya. Because of overgrazing the ground vegetation is meagre and densities taken in the spring ranged from zero to a maximum of about 25 per cent. Palatable forage plants, such as Medicago agrestis, Hordeum bulbosum and Poa sinaica, are depleted while unacceptable ones are prolific. In the more accessible areas the oak woodland has been much thinned by cultivations so that brush species occur within the wooded zone. Areas with Rhamnus palestinus, Crataegus azarolus and Pistacia atlantica also occur east of the oak woodland and probably represent a degradation complex where a few scattered trees have survived. Xeric species, such as Poa sinaica, Artemisia herba-alba and Noea mucronata form a ground vegetation with these trees. Many acorns and cupules were found in the scrub oak areas but regeneration had little chance against such intensive grazing pressure. As a rough average the height of the stunted oaks is about two metres and perhaps five metres exceptionally; their irregular trunks are unsuited for timber and at present incapable of economic exploitation.

Pistacia atlantica is thinly but widely distributed in the Southern Highlands. No stands exist today but isolated specimens are to be found scattered along wadi bottoms, on the slopes of jebels and on the ridge tops. Sometimes the trees roughly follow the horizontal bedding of the country rocks. Fine specimens of this handsome tree are to be seen in the Wadi Hisha and its minor tributaries; they are of great age and size and contribute a characteristic feature to the landscape. The circumference of a number of pistacia trees measured at breast height ranged from 4 to 6 metres, and from 2.5 to 3.5 metres in height with a canopy of up to 3 metres radius. In the tributary Wadi Arja altogether 42 specimens were counted from the road within a distance of 2 Km. of Arja village. Scattered specimens also occur in limited areas north of the Fujeij between Dana and Gharandal; these pistacia trees usually do not attain the same proportions as those found further south. This remarkable tree, which is deserving of much more study in Jordan, is extremely hardy and drought-resistant. This is also demonstrated by the survival of the unique pistacia grove at Wadi Butum, situated well into the pre-desert area of Azrak. Here the rainfall is too scanty to support pistacia and it is believed that their deep root system is able to draw upon underground moisture collected in the wadi bed from periodic spates.

Wild Species of Fruit Trees

Wild fruit trees of the region include the olive, almond, pear, hawthorn and others. The wild olive (Olea europaea) occurs thinly scattered over extensive areas of hillsides from Tafila to Wadi Musa. At present these two localities are the only important economic centres of olive cultivation by irrigation. The wild olive tree has usually been shaped by grazing and are often choked with parasitic mistletoe. Since the last war much has been done in the grafting of wild olives with cultivated varieties but, wherever the rainfall reaches 300 mms., there is scope for much more extension. The wild carob (Ceratonia siliqua) like the olive is a tree native to Jordan especially in the north western areas; in the Southern Highlands, however, it is not of importance. The wild pear (Pyrus syriaca) occurs in the forests but again is not grafted with cultivated varieties.

The wild hawthorn (Crataegus azarolus) is found widely scattered over an extensive area in a kind of 'steppe-maquis', in which the almond (Amygdalus communis) and pistacia (Pistacia atlantica) are also present. This 'steppe-maquis' forms a borderland fringing the Mediterranean woodland on its eastern steppe and desert boundary, which Zohary (16) regards as an impoverished variant of maquis which has lost its characteristic Mediterranean element in its approach toward the steppe. The largest specimen of C. azarolus (in bloom) was observed 12 kilometres south of Shaubak in the Wadi Nijil on the fringe of the oak forest. Four erect stems growing closely together rose from a surrounding cushion of heavily grazed evergreen oak; this white hawthorn had a total girth at breast level of 1.4 metres and a height of 1.7 metres. In some places young hawthorn trees with straight stems afforded some protection from grazing to pistacia growing in assocation with them. A neighbouring speciment of hawthorn revealed mistletoe (Viscum cruciatum), established in the crown of the tree. It is noteworthy that wild hawthorn is a suitable stock for pear grafting. Amongst the local villagers there still appeared to be ignorance and apathy in regard to the possibilities of grafting of wild varieties of fruit trees.

Individual trees have often been left standing in field and pastures as a protection against the summer sun and to provide shade, or because of the edible fruit they produce. In the Southern Highlands this would apply particularly to the hawthorn tree but it is also true of the other wild varieties noted here. Probably for similar reasons single specimens of old trees have been allowed to survive in the larger cities such as Jerusalem and Amman.

Acacia is limited to the lower parts of the scarp and to the wadi bottoms, and is found on sandstone and granite formations. Two main species occur, Acacia spirocarpia and A. raddiana, associated with short grasses. The trees are short, ranging from 1 to 6 metres high, and have flat table-like crowns; the trees are found scattered in the area at more or less regular intervals. Kasapligil (22) found the upper limit of vertical distribution to be 600 metres above sea level on the eastern flanks of the upper Wadi Araba. At this level they meet the zone of Artemisetum and Juniperus spp. by penetration through side valleys. On the eastern slopes of the middle Wadi Araba, where precipitation is 100 mm., acacias go as high as 750 metres. The area of the Acacia grasslands is extremely arid and the average annual rainfall is 50 mm. and in some areas less than 25 mm. Acacias are accompanied by small shrubs in Wadi Araba, such as Balanites aegyptica and Haloxylon persicum, both of which are edible to stock. The ground flora consist mainly of short grasses and certain ephemeral plants which appear after the winter rains; tall grasses are rare and may have been eliminated by the combined factors of overgrazing and intense aridity.

The Grazing Ranges

This area falls into the Irano-Turanian territory and its transition zone with the Saharo-Sindian. It extends eastward from the Highlands plateau almost to the line of the Desert Highway and its southern limit is found around Naqb Ishtar, the present terminus of the Hedjaz Railway. The Grazing Ranges thus comprise the most extensive of all three zones of the survey area included in the Southern Highlands. The more broken terrain with rocky outcrops of basalt and sandstone occur in the north-east especially, and gravel and flints towards the south-east. As seen from the air the basaltic deposits are clearly defined by their black colour and even on a cloudless day give the impression of dark cloud shadows on the ground (Plate 3). The dominant species on the steppe is Artemisia herba-alba var. laxiflora in association with a variety of grasses with intrusions into the eastern desert by way of the wadis and gullies. Figure 5 shows the extent and nature of this brush as well as the location of the few intensively cultivated patches and the colonisation by desert species of some of the wadi channels to the south-east.

Artemisia herba-alba is seen to cover by far the greatest area of any species as a broad belt running from the edge of the wooded highlands towards the more desertic terrain bordering the Desert Highway. The climax area of Artemisia is found as a belt running north and south between Tafila and Naqb Ishtar where the herb exhibits vigorous growth and forms a dense cover (Plate 11). This area lies within the elevations of 1,200 and 1,700 metres with an annual rainfall varying between 100 and 300 mm. On the western slopes of the Tafila mountains the lower limit of the vertical distribution reaches sea level. Artemisia has been found associated with Poterium spinosum in the Tafila-Rashadiya district at an elevation of 1,500 metres. This area represents the upper limit of the Mediterranean territory and both species are found growing together in the transition zone from Mediterranean to Irano-Turanian. Villagers in this district collect Artemisia for fuel (Plate 18) and leave Poterium; Poterium therefore increases while Artemisia tends to disappear in these grazing areas. As a result of overgrazing several species of thistle, such as Carlina corymbosa, Cousinia moabitica and others, are abundant in the mountain steppe between Tafila and Rashadiya (22).

On the western part of the broad belt of Artemisia the brush has been affected by patch cultivations which are at present tending to spread into the areas of thinner brush cover towards the east where the annual rainfall is less. Where Artemisia is dominant other plants such as Poa sinaica and Carex spp. form a natural ground vegetation. Ononis natrix and Centaurea calcitrapella appear where the brush vegetation is recovering from past overgrazing. It has been observed that where the surface is covered with grass or Carex turf it is relatively protected, but where this is absent marked sheet erosion can occur even within the life of one generation of Artemisia (13). Considerable sheet erosion must have taken place since the Roman road crossing the Fujeij was built, judging from present-day levels. The brush cover is discontinuous because of the occurrence of rocky outcrops and wherever the ground is more broken as in the northern hill area, the eastern desert zone, and in the vicinity of the scarp in the north. Here Ononis natrix, Noea macronata, Ephedra alata and Daphne linearifolia are found in association with Artemisia on skeletal soils. In the southern area, however, where the terrain is more gently undulating the natural vegetation is more uniform.

Varying between 5 and 10 kilometres from the Desert Highway, in the transition zone to the Saharo-Sindian territory, the Artemisia thins out to a cover of less than 10 per cent. Bare rock, gravel and hammadas become more frequent with basaltic areas dominant. Only a very sparse vegetation covers the ground. Along some of the wadi channels and sand formations, where the wadis are poorly defined, desert species in which typical halophytes such as Anabasis articulata, Zygophyllum dumosum and Suaeda vermiculata are represented, afford a 10 per cent cover of vegetation.

The Wadi Bottoms

These consist of the broad beds of major wadis such as Wadi Musa, Wadi Hisha and Wadi Nijil with a number of minor tributary wadis leading into them. Because of their usually deeper and more fertile soils and the presence of surface or subsurface water, they are edaphologically suited to carry a diversity of natural and cultivated vegetation. It must also be realised that wadis and depressions collect water draining off from the surrounding terrain and are thus able to support an improved diversity of tree and field crops. This is probably the reason why deserts with rough topography are less devoid of vegetation than those dominated by unbroken plains and mudflats. Oleander (Nerium oleander) is a typical hydrophytic plant which flourishes along the beds of wadis or on terraces just above them. The wadi may be flowing throughout the year but more usually the water appears on the surface only seasonally. In suitable habitats oleander has been encountered from Wadi el Hassa in the north to Wadi Musa in the south. With its red or white inflorescence it is a striking feature in the vegetation of the Sik of Petra and is often associated with Tamarix in the complex of wadis characteristic of that district. It is toxic to animals and is usually not cut for firewood.

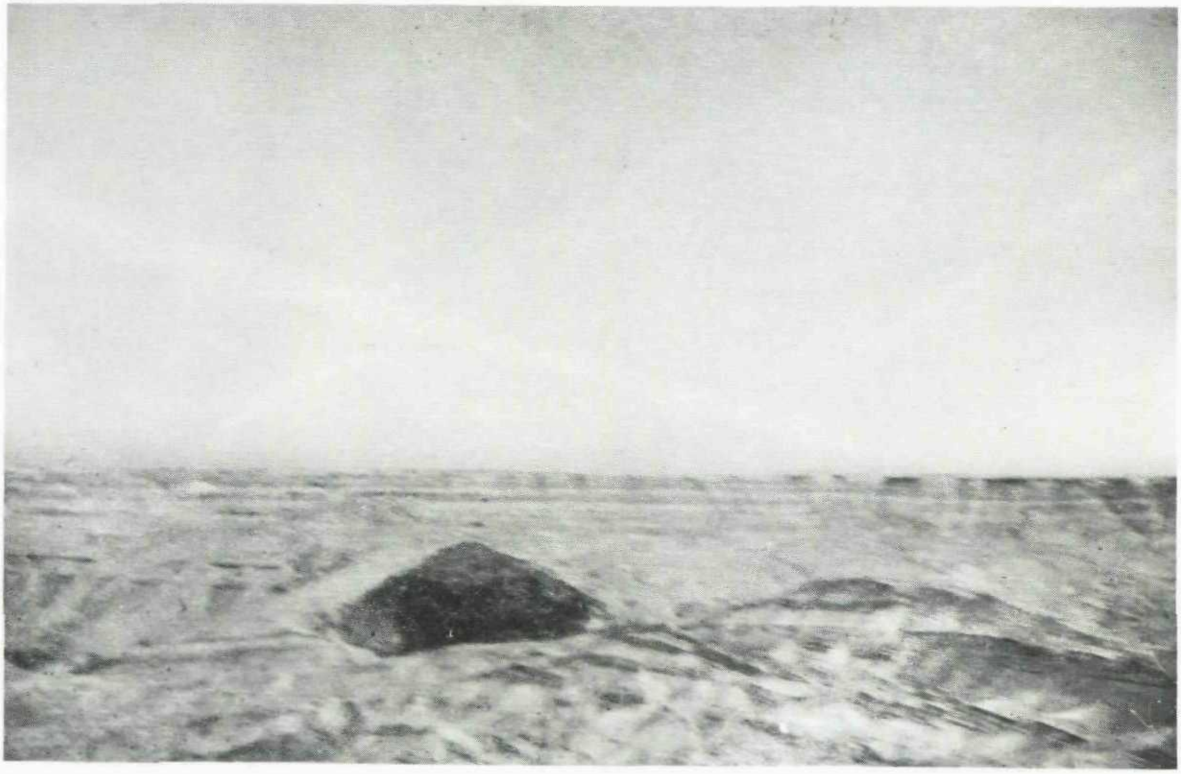
Pistacia. As already indicated Pistacia atlantica is in its natural habitat in Jordan when growing along wadi bottoms and wadi sides. Its many uses in a semi-arid environment have already been considered and, apart from its profitability in such environments nothing further need be said here. At the Shaubak Agricultural Station 1000 seedlings were being raised for extension purposes.

Poplar (*Populus nigra*) Since the time of Waterer's survey (1949), when he recorded the fact of the scarcity of poplar and eucalyptus, a notable change has taken place. In a number of wadis today the poplar forms a dominant feature of the vegetation of the wadi bottoms and is sometimes accompanied by eucalyptus. It is a quick-growing tree which yields good roofing poles and fuel wood. Moreover, its propagation by cuttings is extremely simple although restricted in its habitat to the vicinity of water. The fig is native to Jordan and does well in the moist bottom lands; its cultivation could be greatly extended in suitable localities.

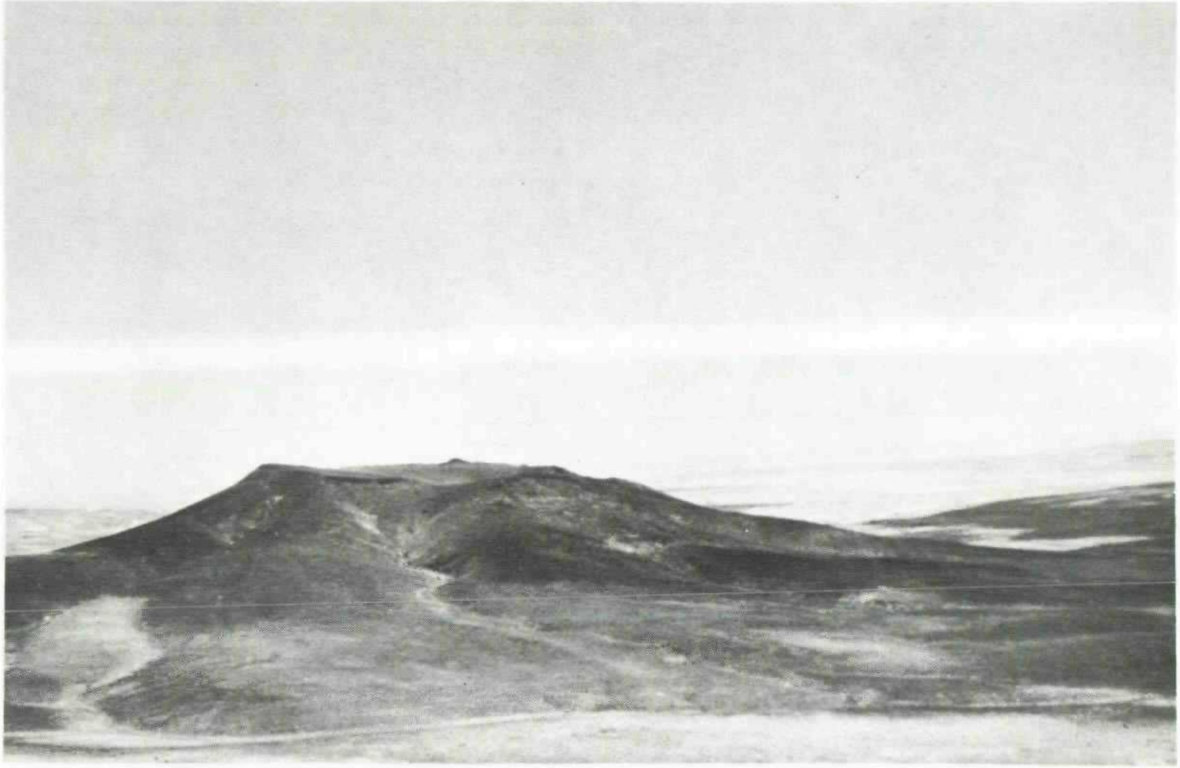
Eucalyptus Small plantations of eucalyptus are scattered widely throughout the country and, although an introduced species, it may be considered as an element of the natural vegetation in this context. Species of this valuable tree, which has much wider uses than poplar, are well suited for development in the wadi bottoms and village lands of the Southern Highlands, and good specimens were seen in the Wadi Musa. Isolated trees can also be found in most of the gardens of railway stations from Amman to Ma'an. Eucalyptus is specially useful for the provision of hardwood timber, fuel and shade; the paucity of hardwoods is a serious gap in the timber needs of the country. The tree prefers deep soils and can tap successfully subterranean water well outside the range of most crops and shrubs; it therefore stands up to drought very well.

Nevertheless, there are problems involved in Eucalyptus afforestation. The early attempts in the country with *Eucalyptus camaldulensis* (synonym - *rostrata*) proved that it was not thrifty on calcareous formations which go to make up so much of the soil pattern of the country. But in a survey of *Eucalyptus* afforestation in Jordan, Pryor (25) concluded that species taken from areas of comparable climate (rainfall and temperature) in southern Australia are potentially suitable in Jordan and that the *Eucalyptus* family has definite soil preferences and different species frequently occupy these different soil types. For instance, those species found to thrive on non-calcareous soils will not succeed on calcareous soils, and vice versa. Provided these conditions are observed the *Eucalyptus* can make a significant contribution to the tree products of the country.

Topography typical of the Southern Highlands.



Volcanic plug in Wadi el Hassa, seen from the air.



Basalt spread seen from the air.

Sandstone formations. The Sik, Petra.

Dissected limestone area north of Nijil.
Erosion resulting from the heavy rainfall 1963-64.

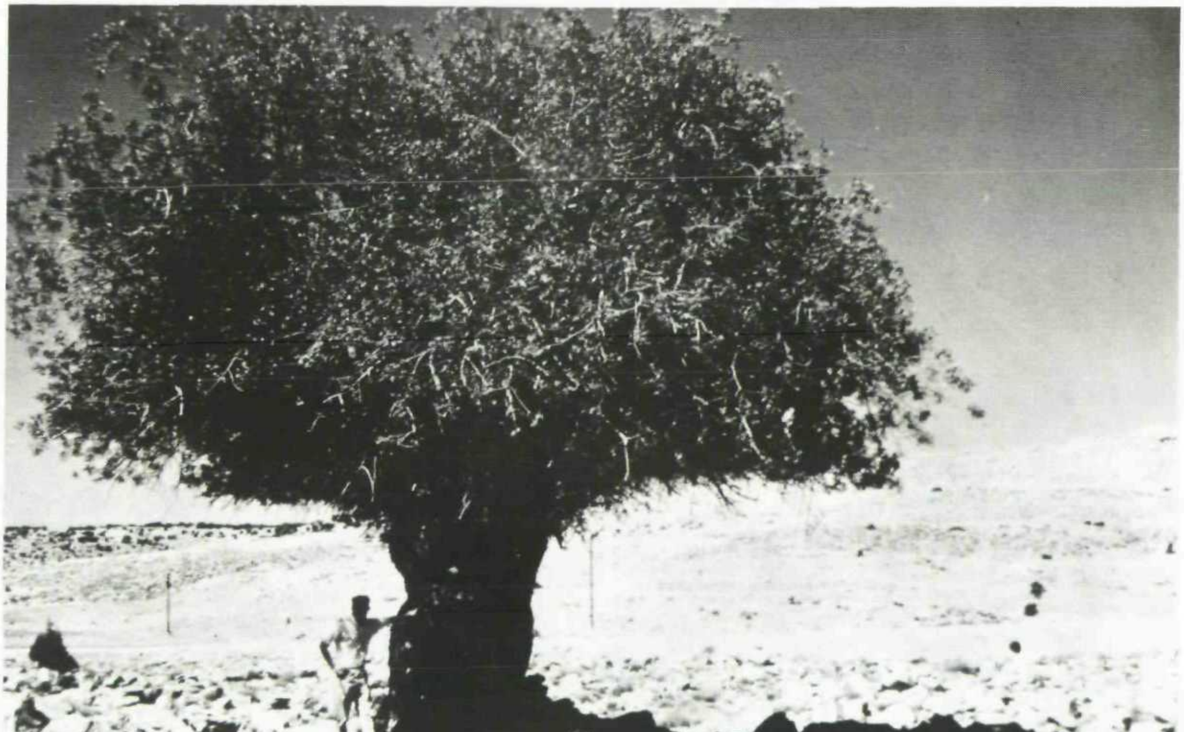
Part of the road from Shaubak to Tafila.

Erosion resulting from the heavy rainfall 1963-64.

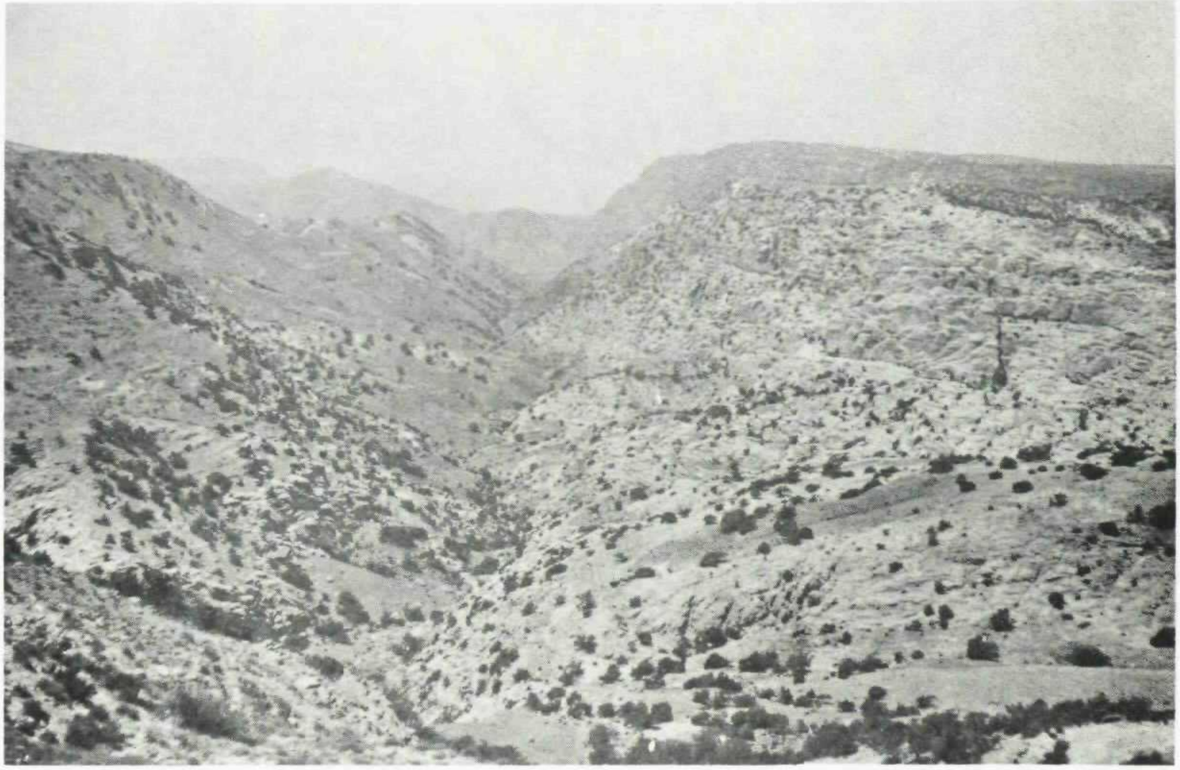
Remains of a bridge on the Shaubak to Tafila road.

The start of gulleying on the Fujeij.

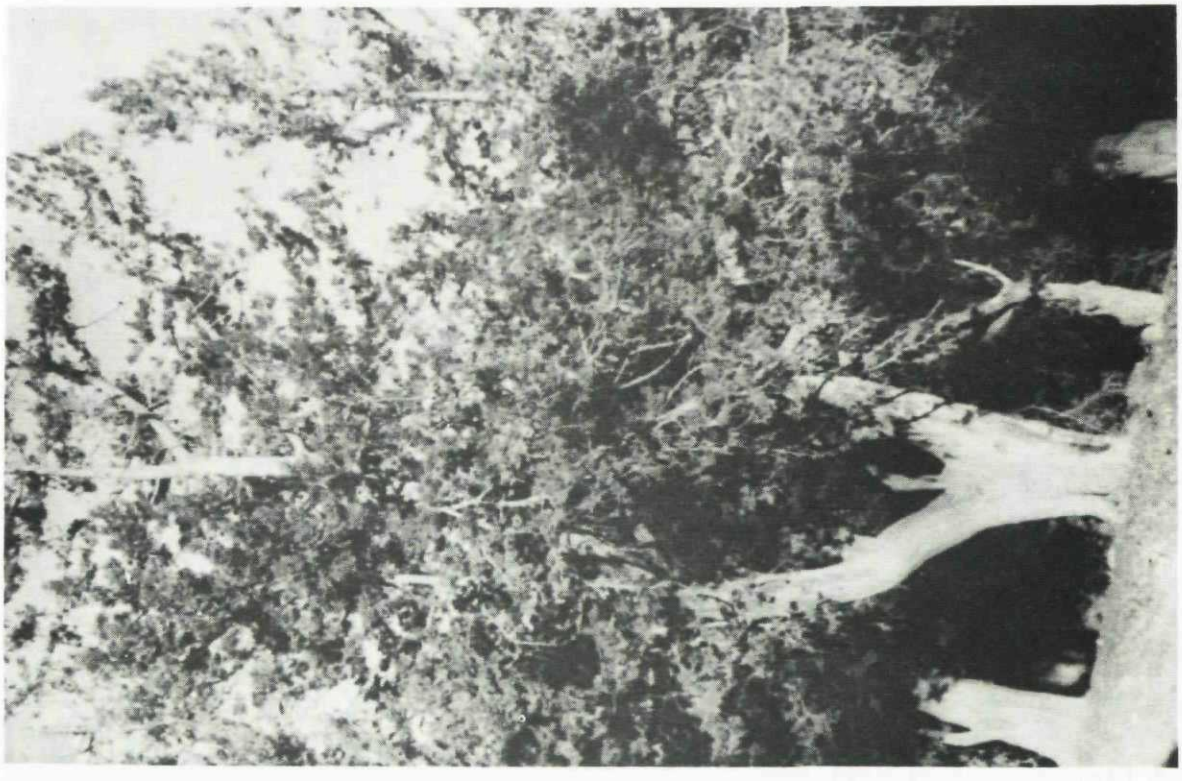
Open Oak Woodland of Wadi Hisha.



Old Pistacia tree, Wadi Hisha.

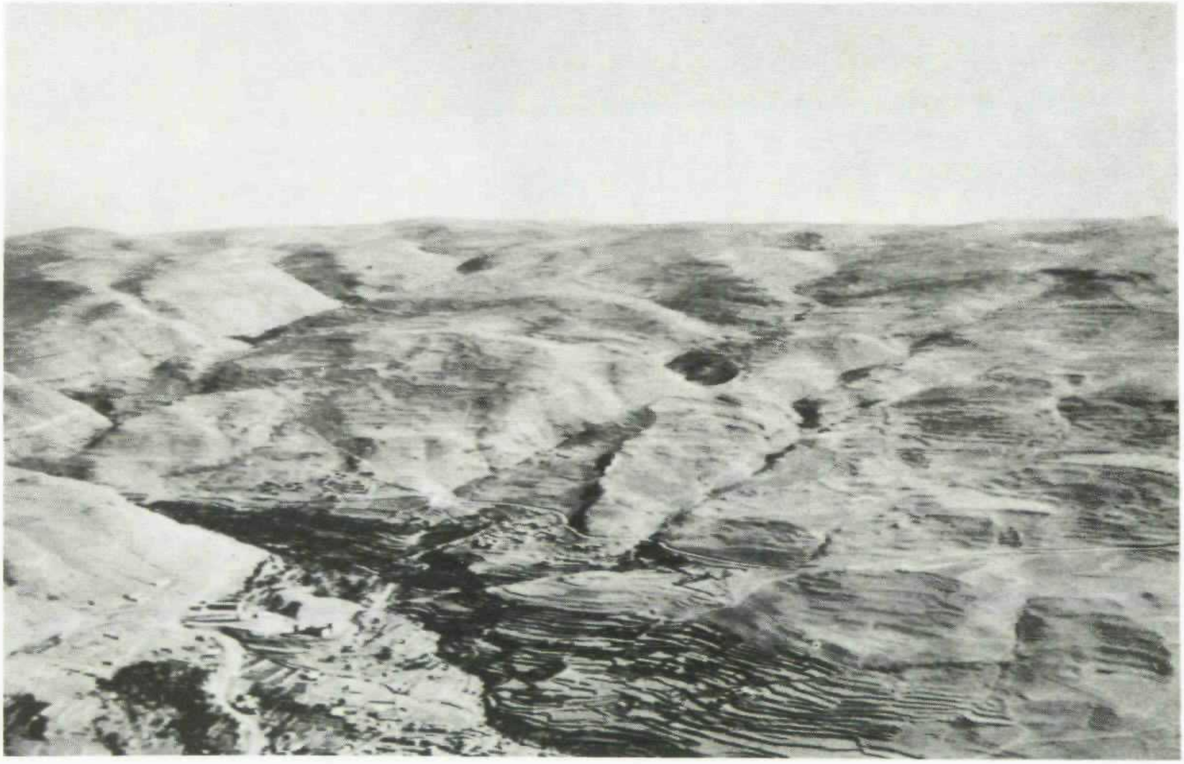


Juniper on the steep slopes of Wadi Dana.

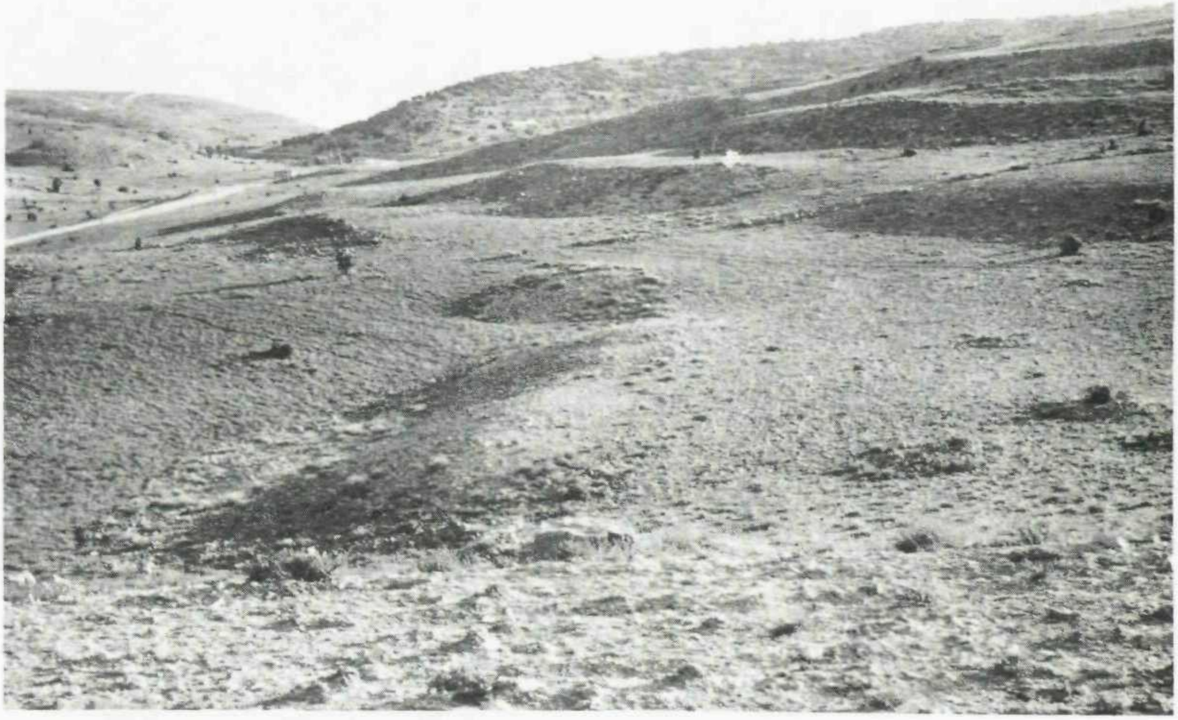


The Cypress grove a Lahdha.

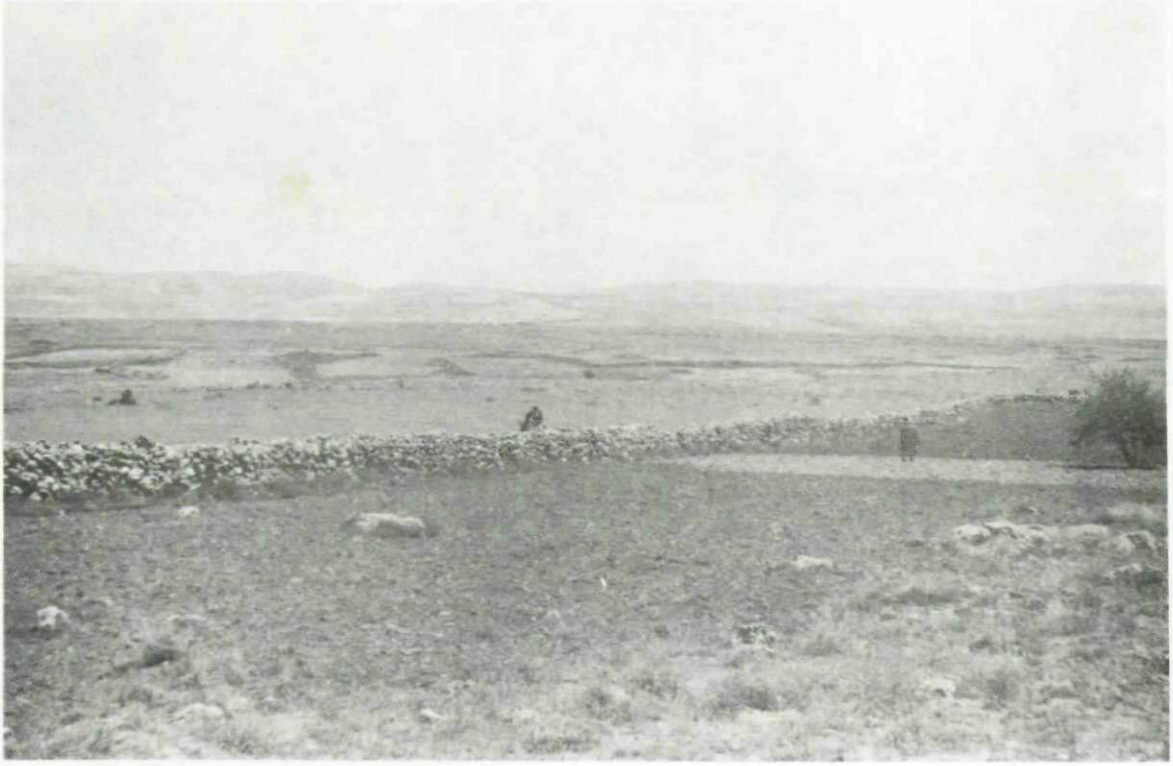
Artemisia brush alongside the Roman road, Fujeij.



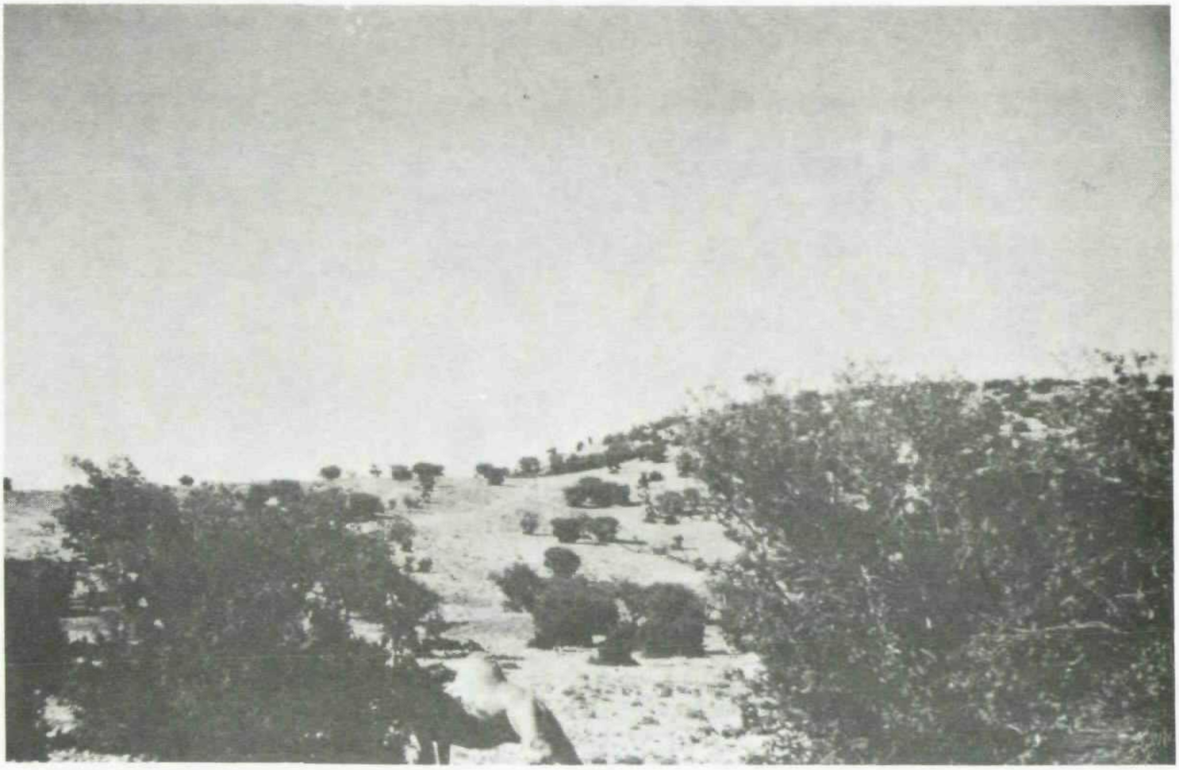
Ancient terraces seen from the air.


Ancient earth banks, Wadi Hisha.


Ancient stone and earth terraces, Wadi Hisha.



Boundary walls near Rashadiya.

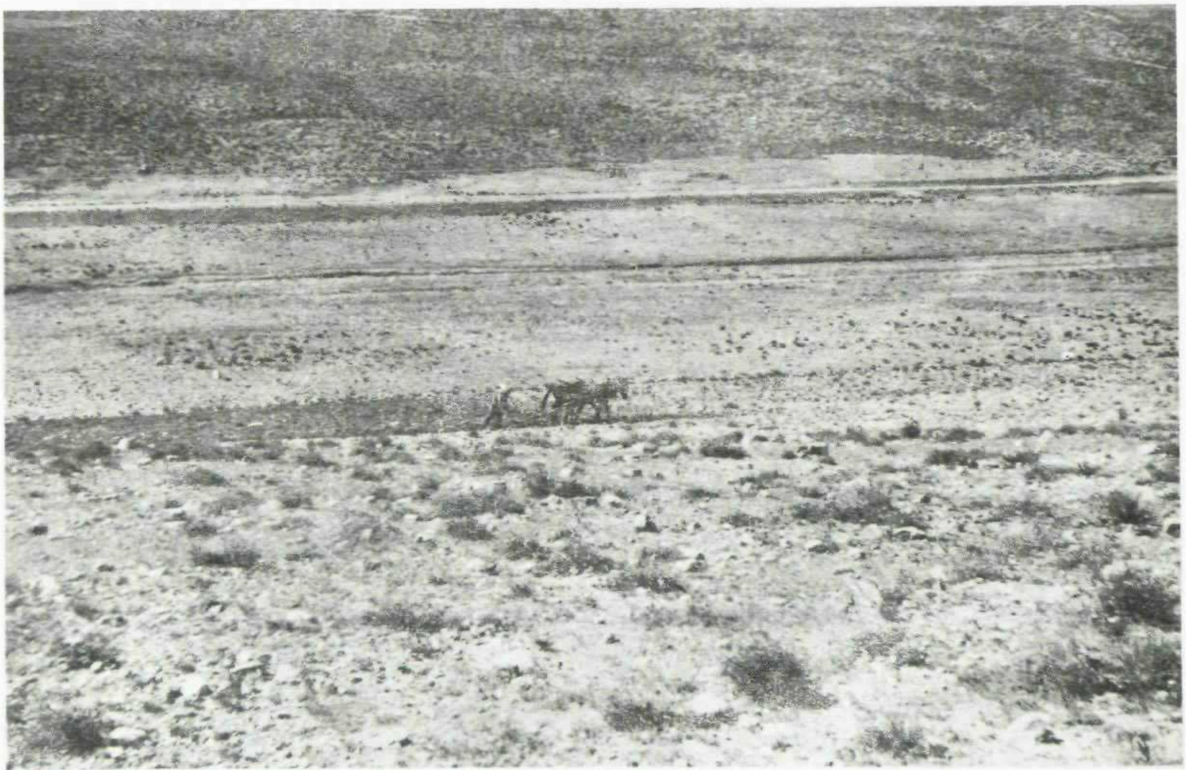


Results of grazing in the Oak forest.

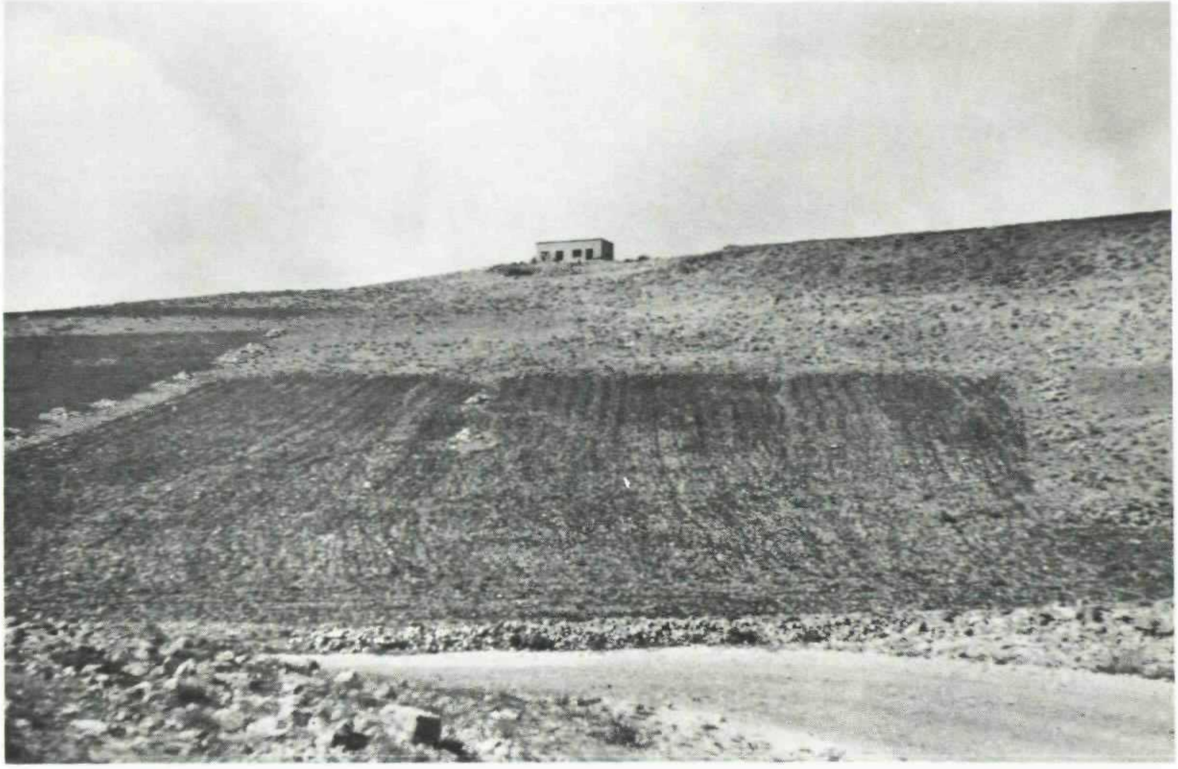
Cultivation on the Fujeij, seen from the air.

Artemisia collected for domestic fuel.

The native plough, Nijil.



Ploughing at Al Muqariya.



Ploughing downslope leads to erosion.

Woodland at Wadi Hisha selcted for protection.

Chapter 7

LAND USE

1. Past History

The history of land-use in this part of Jordan appears to have been the object of little integrated study. Only a broad picture based on records of land-use in the eastern Mediterranean area over the past centuries is therefore possible (Whyte, 26); such knowledge can be reinforced by the relevant observations of Glueck (27), Huntington (28), Reifenberg (29), and Lowdermilk (30, 31, 32) concerning the Southern Highlands of Jordan.

There is little doubt that the Jordan Valley and the highland areas to the east and west can claim, according to some estimates, a long history of agricultural settlement stretching back as far as ten thousand years. As early as the 24th century B.C. the Southern Highlands had a fairly densely settled farming society with the population living in communities fortified against intruders. After some centuries this society went into decline, but by the 13th century B.C. another had arisen in the region of Edom, a development which followed a long period of warfare and strife that saw the decay of the earlier agricultural systems. This civilization, which persisted up to the 6th century B.C., in turn declined and was replaced after a period of desolation by the Nabatean culture centred on Petra about the second century B.C. This continued until about 100 A.D. during which time an agricultural and trading society, stronger than any previous group, was created; the zenith of its prosperity came after its absorption into the Roman Empire and was not subsequently surpassed.

This alternation of periods of prosperous, sedentary agriculture with centuries of neglect was the result of the intermittent influx of Bedouin nomadic tribes, who destroyed much of the foundations on which agricultural societies were based in arid environments. Eventually each of these successive nomadic groups became sedentarized to varying degrees and thus created new agricultural societies on the ruins of the old, only to be attacked in turn on the arrival of new invaders. There is no evidence whatever that the fall of these agricultural societies was the result of an adverse climatic change, as Ellsworth Huntington (28) has suggested. Each of these societies depended largely on underground water resources and the rational utilization of the sparse precipitation. Furthermore, the vine, fig, olive and pomegranate are frequently mentioned in the Qoran el Kareem as well as in the Bible, which suggests that these were common crops in the Eastern Mediterranean region then as now. Any increase in the aridity which developed, as each agricultural society declined, was probably the result of overgrazing, the control of which is still the key to any improvement in the land use problem of Jordan. Other factors of misuse, such as random felling of forests on the watersheds and the consequent loss of fertile soil by erosion, all contributed to the advance of aridity and the decline of soil fertility. The decay of the land into near desert is partly the story of wars but largely the result of the nomad and his goat (33) (30) and cannot be associated directly with hypothetical changes in the climate. This deterioration is by no means confined to Jordan and there is an historic parallel in the Roman dominions in North Africa; Libyan agriculture fell into serious decline with the fall of Rome and the increasing encroachments of nomads, a decline which has persisted until modern times (46, 47).

Very little is known of the agricultural systems of the pre-Nabatean societies; more investigation has been carried out on the Nabatean society proper. For example, Glueck (27) from an examination of pottery finds, has estimated that there were approximately 500 Nabatean villages located in the area to the east of the Jordan River. Many of these were located in the Southern Highlands and around Petra, although it seems evident that the Nabateans spread into the equally arid regions of the Negev Desert, since the wetter areas further north were already densely settled. To support a population of this size under conditions of low rainfall meant that the Nabateans had developed advanced methods of water control and soil conservation in order to initiate and maintain cultivation in marginal areas. A well, for example, had been dug at the site of Monreale's Crusader Castle at Shaubak some time in the Iron Age, certainly before the 6th century B.C., and terraces had been constructed near Petra. Elsewhere the Nabatean cultivators dug more wells and constructed extensive terraces on hillsides in order to control run-off water and hold the soil in place. Many of these terraces are still to be seen around the villages of Wadi Musa. This early conservation work was no doubt assisted by the nature of the rock outcrops in the region of the scarp. Also they appear to have been the first to construct cisterns to collect and store water underground, where losses by evaporation could be reduced. A comparable situation is to be found in Libya where there is abundant evidence of the skill of the Romans as dry farmers and the soundness of their land use system (34).

Similarly many wadis, even in their upper tributary parts, were dammed at intervals to hold the soil and slow down run-off after rains, and so allow some of the water to seep into the soil. Again on many slopes not useful agriculturally, water-collecting devices of different kinds were constructed to ensure that as much rainfall as possible was directed from such slopes to areas of more productive land. Many of these constructions find a modern counterpart in agricultural projects for the development of arid land. Hill slopes were also cleared of stones as they are today and it is believed that the object of this was to speed the run-off of the water so that the minimum was lost by seepage into useless soil and the maximum was allowed to reach the lower fertile land of the wadis where it would be most useful. The stones collected were piled into mounds or built into walls: this, it is believed, helped to guide the waters of the flash floods to the desired areas of the bottom lands. Lastly, as an example of the ingenuity of the Nabatean civilization the remains of the water supply channel, which led water from the head of Wadi Musa, can still be seen on both sides of the Sik at Petra standing at a height varying from about one to three metres above the present ground level.

Once the elaborate systems of irrigation and conservation were allowed to break down their remnants contributed to the speeding up of erosive processes by directing, but no longer controlling surface run-off water. Flash floods which once brought enrichment to cultivated areas can now bring disaster. In 1963 a sudden flood, with no conservation measures in being to control or check it, brought a deep and rapid wall of water and debris rushing down the Petra Sik and unhappily drowned many French tourists.

The absorption of the Nabatean civilization into the Roman did not result in decline. The population continued to increase and further developments in agriculture took place and communications were improved by the building of the Egypt-Damascus road through the region. It is possible that settlement spread further to the east with the construction of scores of reservoirs on the desert edge (35), such as that at Dajaniya on the eastern side of the Fujeij. These were able to collect some of the run-off water after rainfall and were usually sited near wadis and provided with silting tanks to prevent the filling in of the cisterns. It is not known how large a population they would support, but the scale of the fort near the cistern examined at Dajaniya suggests that settlement might have been considerable. Whilst cisterns of this type represented an eastward limit of permanent settlement, the main zone of settlement was still confined to the upper scarp edge along the line of Tafila to Wadi Musa as it is today (cf. Fig. 8). It probably stretched further to the south, and north to the El Hassa gorges, where areas of terracing can still be traced. A second smaller zone of settlement sprang up between Udhruh and Basta, where a monoclinal flexure in the Senonian chalk brings east-flowing water to the surface.

Since the Roman period there is evidence of continuous deterioration of the natural resources of vegetation, soil and water. Fresh incursions of Bedouin nomads with their flocks of goats and sheep reduced the natural cover of pasture in the uncultivated lands whilst the cultivated areas suffered neglect and many of them declined into common pasturage. Forests were depleted by widespread grazing and random tree-felling. The sum total of this misuse of the natural resources has resulted in soil erosion and a general lowering of the water table so that many springs have dried up, for example, at Muqariya, Shaubak and Nijil. The effects of the loss of topsoil are clearly demonstrated along the Roman road in the Fujeij where the foundation stones now stand well above the level of the surrounding ground. Finlay (36) cites a 10th century Arab geographer, who describes the district around Udhruh as a rich fertile land but passing into decline through the neglect and indifference of the Bedouin who were in control.

There can be little doubt that the slopes of the Southern Highlands over-looking the Wadi Araba were well wooded during the time of the Nabateans and the Romans and it seems likely that much of the woodland survived until the beginning of the present century. In particular, the limestone areas would have supported a better tree cover than would the sandstone formations, where the cover of the juniper could be expected to be thinner. Waterer (18) quotes the example of Qasr Bint Faroum at Petra, a massive ruined shell of a three storey palace dating from about 312 B.C., in which the timber lintels supporting the upper floor joists are still to be found embedded in the ruined masonry. These timbers of juniper are still in reasonably sound condition after being exposed to the elements for more than 2,000 years; it is therefore small wonder that this species is so sought after today for virtually indestructable roofing poles.

Although exploitation of these woodland areas began in such ancient times the period of drastic depredations did not take place until about a century ago; this reached its culmination during the First World War when the Ottoman Government built a branch line from the Hedjaz Railway into the forest area of Nijil to extract timber for the locomotives working the railway. In this way evergreen oak, cypress, juniper and pistachio were utilized. One good stand of Cupressus sempervirens still survives near Rashadiya and has been considered already, but it may here be added that such a fine stand shows clearly what the condition of the country might have been were it not for the folly of man's lack of foresight. Together with wood sought for charcoal burning, lime burning and for building purposes the large-scale extraction of fuel for the railway has reduced the natural woodland coverage to a state of degradation.

Such evidence as there is enables this brief history of land use to be constructed. There is no doubt that the fertility of the region has drastically declined and that this can be attributed to the imprudent use of the area by man. More specifically, the degradation has been caused by the adoption of land use practices unsuited to the arid environment which have brought about the decline of soil fertility and the incidence of soil erosion.

2. Present Misuse

Jordan has only three resources, soil, water and vegetation. It boasts no economic deposits of oil or coal and very little else except rock phosphate as exploitable minerals. Thus over the centuries agriculture has dominated the economy of Jordan and it is upon the products of agriculture, in the widest sense, that the majority of its two million people must continue to depend for their livelihood and prosperity. Jordan, with a cultivated area of not more than five per cent of the total land acreage, at present lacks the resources to support its population. Hence the study of the optimal use of land, a complex subject, is fundamental to an understanding of the problem. The problems of land use and conservation in Jordan only reflect the global problem of steadily expanding populations and the contraction of natural resources. Self-sufficiency and prosperity will depend upon production from the land. If, therefore, production is low so will the standard of living be low. It follows that the good work already initiated by the Government, for the correction of the traditional misuses of the land by the adoption of a rational system of conservation, must be intensified if the land is to be restored to a state of full production. To do this a comprehensive, long-term land use policy for the Southern Highlands must be drawn up and applied as a "blue print" for the guidance of future administrations irrespective of the changes and chances of the economic scene.

All the historic abuses of the land already considered are present in Jordan today with the addition of some others. The effects of this in the forests, grazing ranges and wadi bottoms have been to degrade the natural resources of soil and vegetation to the condition so often seen today. The basic problem of land use is that the country is still drastically overgrazed as it has been for centuries. Waterer (18) sums up the present situation in his conclusion that "the control of grazing is the key to any improvement of the whole land use problem in Jordan". The balance between pastoral usage and other forms of land use has been seriously disturbed, leaving a situation where uncontrolled grazing is imposed supremely over the whole country. Once again it is the age-long conflict between the pastoralist and the cultivator, between the desert and the sown. Many previous observers have arrived at the same conclusion in particular Mooney (35), Long (7) and Kasapligil (22).

It may be difficult for the people living in Jordan to appreciate the intensity of land use in their country. The reason for this appears to be that they are so accustomed to regard the present state of affairs as normal that they resign themselves to it. But to the outside observer it must be apparent at once that overgrazing lies at the root of the problem of land misuse in Jordan. Indeed, to experienced observers it is difficult to think of a country which has had to endure a greater pressure from the onslaught of grazing animals.

The Forest Zone

The chief misuses that have resulted in the present degraded state of the natural forests of the Southern Highlands can be summarised as follows:

1. The unrestricted browsing of goats, sheep and camels, in this order of destructiveness, on the arboreal and ground vegetation of the forest areas.
2. The indiscriminate felling of oak, cypress, pistacia, and juniper, and in some cases the total deforestation of watersheds.
3. The uncontrolled lopping and pollarding of larger trees such as the pistacia.
4. The destruction of the root systems of oak trees for the collection of the root bark for tanning.
5. Shifting cultivation of grain crops by Bedouins and villagers in woodland areas.
6. The drastic clearance of brush cover, in particular *Artemisia* and *Poterium*, for fuel, charcoal and lime burning.
7. The use of fire either as a means of felling large trees, or in camp sites.

The effects of these malpractices will be considered briefly in turn.

Of the remaining forests and woodlands of the south the ever-green oak (*Quercus coccifera* ssp. *calliprinos*) and cypress (*Cupressus sempervirens*) have had to bear the brunt of this merciless grazing. In the Wadi Hisha forest area individual specimens are now so mutilated and deformed as to defy recognition of the species by the shape of the trunk and canopy. They take on the appearance of a strange and cushioned form at the base of the tree, as if by pruning, while the trunks are misshapen and the branches are usually torn and mutilated (Plate 16).

While no adequate Forest Service is in operation on the site all manner of abuses can be expected even in areas declared to be protected by law. For example, a Bedouin encampment with families and flocks was established within the protected forest area at Shaubak. At one point goats were found grazing the lower 'pincushion' vegetation of the oaks; others by their agility in climbing succeeded in browsing the foliage a metre or more from the ground. As can be seen in Plate (16), the foliage remaining out of reach of the goat was devoured by the camels. In many cases all that remained was this 'pincushion' of small, green oak leaves, or a cone of leaves enclosing the trunk with fantastic distortion of the canopy. Some evidence of regeneration existed but it stood little chance against the ruthless attack of grazing animals. Under such harsh conditions the wonder is, not that regeneration is rendered virtually impossible, but that any forest remains at all. Other species of forest and wild fruit trees are by no means immune and the case of the pistacia will be considered later. All these misuses of the forest only serve to emphasise the extent of human encroachment, which has been greatly under-estimated, upon the natural vegetation.

The illegal and random cutting of trees has contributed to the thinning of the stands which remain; in consequence the woodlands are of a very open character. Nonetheless, few stumps are to be seen as the root stocks have been grubbed up for fuel or tannin bark. The shortage of fuel in the Southern Highlands has led to a massive destruction of the forests for centuries and perhaps reached its peak during the First World War. It was then that the Ottoman Government built the "Forest Railway", a branch line from Uneiza on the Hedjaz Railway to Wadi Hisha, to exploit the oak and pistacia forests for fuel to fire the locomotives. No doubt that period of reckless felling, in addition to the ever-present local demands, was largely responsible for the present dereliction of the Wadi Hisha forests. This type of misuse was not confined only to this region. It is noteworthy that the exigencies of war have also been responsible for serious damage to the deciduous oak and carob forests of the Yarmuk valley and to the Ishkara forest near Ajlun. All this exploitation was provoked by the ceaseless needs of the State Railways for wood fuel.

The accounts of eyewitnesses are difficult to come by but, when they are supported by independent evidence, they can sometimes throw a revealing light on present-day problems. In regard to the pistacia tree two such accounts are available. An old tribesman of the Wadi Nijil recountered to us his first-hand impressions of the manner and extent of these operations by the Engineer Corps of the Turkish Army in 1917. Saws rather than axes were used for felling but in the case of the large timber, in particular the pistacia, explosives were commonly employed to fell the tree. The second instance, recorded by Oedekoven (37), refers to the district north of Jarash, which although outside our region, is informative and again relates to the long-suffering pistacia. He quotes the eyewitness report of an old man "who, as a young boy, watched a fight between rival tribes, which had each gathered their warriors with tents and horses and had them hidden in thick Pistacia forests. Today, there is not a tree left".

Apart from browsing, the uncontrolled lopping, hacking and pollarding of trees is another serious misuse which can explain much of the mutilation seen in these forests. But in these cases the root stocks are sound and if managed wisely can survive for a long time. Such trees should never be cut down to ground level or within the reach of browsing animals. In the case of the oak it is known that trees would die off for the most part because they do not possess the same capacity to coppice from ground level as they do to produce shoots from pollarding. Waterer (18) states that "the browsing animals would effectively prevent either oak or carob shoots from getting up once the trees were cut down to within their reach". In many cases where pollarding has been practised, the trees have been cut too low thus enabling browsing animals to reach the regrowth. This constitutes another factor of misuse provoked no doubt by the urge to obtain the maximum quantity of fuel. But it is an error nonetheless to be avoided because regrowth cannot then occur for many years. In effect, the practical recommendation has been wisely made that where pollarding is feasible no tree should be cut back to less than 2.5 metres from ground level. This precaution would have the effect of keeping the regrowth above the range of grazing animals.

Still another harmful practice was the habit of barking the roots of oak trees (Q. calliprinos) for the tanning matter they contain. Apparently the root bark carries a higher percentage of tannin than does other parts of the tree. But the practice is fatal to the tree. In the past a centre of this activity was in the Bir Ediddabbaqhat forest, 10 kilometres south of Shaubak, where almost pure stands of this oak occur. This local industry, which was in the hands of the Arab womenfolk, has fortunately now ceased.

As we have already seen one of the factors in past history most destructive of forests and woodlands has been their conversion into arable land. This devastation still continues in the form of shifting cultivation on a much reduced scale in the forests and woodlands of the Southern Highlands. Indeed, in considering the poor returns against the great damage involved the system has little merit and in face of the rising rate of increase of the population it is remarkable that it still continues. Low yields, crop failures and extension of erosion are results all too familiar in this type of primitive agriculture. Needless to say this practice must be abandoned in all forest reserves.

The usual method of clearance has been to fell the trees and burn the undergrowth before the root stocks are removed. Such clearing of the forests demands a vast expenditure of time and labour, especially in hilly terrain or on broken ground. It has been observed in general that this is particularly the case in the regions of terra rossa soils, where root systems penetrate crevices and fissures of the rock (16). It also explains the fact of the terra rossa regions of Jordan never having been converted to arable to the same extent as other soil types. Hence, it is the terra rossa soils that carry much of the remaining forest and maquis-type of vegetation. On the other hand, in the mountain region the conversion of rendzina soils to arable has proved both more successful and more extensive. On these soil types the eradication of the oak and pine forests has been a simpler task. On the alluvial soils of the wadi bottoms the forest was readily wiped out and the land made suitable for agriculture.

In a region where vegetation enjoys so little respect it is not surprising to find even the brush cover of the forest and hills grubbed out to meet the persistent shortage of firewood and formerly of charcoal. Artemisia has to bear the burden of this fuel collection but sometimes its associate, Poterium spinosum, is also taken. The eradication of this valuable soil-stabilising plant continues on a much greater scale in the steppe zone where it reaches its climax. It is a familiar sight in the morning to encounter a team of donkeys, led by women, carrying an astonishing amount of this herb back to the villages. The collection of scrub plants for fuel is of course common in the Near East, as in Tripolitania, Libya, where it is a potent cause of soil erosion as it is in Jordan. The needs of local village industries, for charcoal production and lime kilns, have led to raids on the forest lands for timber and kindling, causing heavy damage to the vegetation. Until little more than a decade ago charcoal was the common fuel in towns and villages alike in spite of the availability of petroleum products. Zohary (16) mentions the fact of a village in the hills of Samaria, whose name Umm el Fahm means "Mother of the Coal". Fortunately, with the increasing use of oil fuels the production of charcoal has fallen off and it was not encountered in our survey. But a lime kiln was found to be in active operation in the Wadi Nijil and using as fuel the outer covers of motor tyres and vast quantities of Artemisia.

We have already seen that the felling of large trees such as the pistacia presented a difficult problem and drastic measures were sometimes used. Fire, in particular, is believed to have been one of these from the evidence of the partly burnt boles of large specimens of P. atlantica occurring to the East of Wadi Waran. If this were the case it was evidently a singularly unsuccessful method of felling the tree and, in view of the finding of occasional large pistacia trees in the Wadi Hisha similarly treated, it is believed that the tree provided a convenient camping site for nomadic herdsmen. One fine specimen found about 10 kilometres south of the Shaubak Agricultural Station revealed the following evidence of man's maltreatment of the tree. The main branches, of which there were 14, had all been sawn off giving a hemispherical but unnatural shape to the canopy above the thick cylinder of the trunk. The upper foliage had suffered severely from the browsing of camels while the surrounding ground vegetation of Artemisia and Cistus had been well browsed by goats. The girth of the trunk measured 5.5 metres. On the side of the trunk remote from the road, a cavity 132 cms. in height from ground level and 144 cms. wide, had been hacked out of the hard red wood and used as a convenient fireplace. To survive such treatment over the years is a testimony of the remarkable stamina of this species. This old pistacia had yielded its branches for fuel, the cavity provided a fireplace while accessible branches had been browsed by the ubiquitous camel. The pistacia tree must be well adapted to the environment to be still vigorous enough to produce the abundant seeds that were observed at the time of our survey (August, 1963). No regeneration was evident and the tree appeared to be free from disease. Other examples of similar damage inflicted on the pistacia were noted in the area between Rashadiya and Tafila.

The darkening of the soil in the vicinity of this tree was very striking and indicated the status in organic matter. In view of the significance of humus in the soils of semi-arid environments it was considered worth while to make a more detailed study of this question. Accordingly, samples were taken in the Wadi Hisha at three points covering approximately the area of soil covered by the canopy of the two trees indicated in Table V, where the complete analytical data are summarised. We are indebted to Dr. F.H. Grüneberg, of the German Geological Mission, Jordan, for kindly completing this analysis in Amman. In each case these data show a clear gradation of increasing content of organic matter from the outer zone to that contiguous to the trunk of the tree. This gradation is reflected in the values for colour, reaction, per cent calcium carbonate, and especially in the per cent humus and the cationic exchange capacity. Although the presence of some animal dung must have been a contributory factor to some extent there is little doubt that the major contribution to the organic matter of the soil was made by the leaf-fall and seeds of the trees themselves.

TABLE V

Soil zones under pistacia trees in Wadi Hisha

		Outer	Middle	Inner
Tree 1	Distance from trunk	8 m.	4 m.	1 m.
	Colour (Munsell)	5 YR 4/4	5 YR 4/2	5 YR 3/3
	Soil Colour	Reddish brown	Dark reddish grey	Dark reddish brown
	pH	8.6	8.0	8.0
	$CaCO_3$ (per cent)	16.75	18.1	15.3
	Humus (per cent)	2.66	3.04	10.08
	C.E.C. (me/100 g.)	22.2	23.7	42.2
	Texture	Loam	Loam	Loam
	Structure	Crumb	Crumb	Crumb
Tree 2	Distance from trunk	6 m.	3 m.	1 m.
	Colour (Munsell)	5 YR 4/4	5 YR 4/3	5 YR 3/2
	Soil colour	Reddish brown	Reddish brown	Dark reddish brown
	pH	8.6	8.3	7.9
	$CaCO_3$ (per cent)	19.25	19.3	18.4
	Humus (per cent)	2.80	4.21	12.15
	C.E.C. (me/100 g.)	22.2	24.2	46.0
	Texture	Loam	Loam	Loam
	Structure	Crumb	Crumb	Crumb

The effect of shade afforded by the canopy of trees of the size of the pistacia upon the soil conditions is also important; especially in the case of the soil moisture and soil temperature as well as of the organic matter. Measurements of the shade cast by mature specimens of pistacia and oak were therefore made in order to gain some idea of the area of soil affected. These observations were carried out in the Wadi el Hisha again in the forest area south of the Shaubak Station. Measurements were taken at 1400 hours on September 2nd, 1963. In general, at 1200 hours the shade cast by the pistacia tree was of the order of 3-4 metres radius while that of the oak was about 2-3 metres radius from the base of the trunk. The results are shown in Table VI, in which the longer axis of the shaded area is represented by the letter A, and the shorter axis by letter B, the units being in metres and square metres.

TABLE VI:

Measurements of Shade Cast by Mature Pistacia and Oak

Specimen	Tree	A	B	Area Shaded
		metres		square metres
1	P. atlantica	9	7	38
2	do.	10	6	39
3	do.	7	5	22
4	Q. coccifera	9	5	28.5
5	do.	8	6	32
6	do.	9	6	35

From the data on shading effect and nutrient status provided by these samples it is easy to understand the general decline in the fertility of the remaining soil as a result of the deforestation of large areas.

Pistacia atlantica has also considerable economic possibilities. The rational pollarding of branches above the reach of grazing animals can provide an excellent fuel of high calorific value whether in the form of wood or charcoal. The drought-resisting properties of the pistacia enables it to flourish and produce a valuable edible oil in areas of sparse rainfall where the olive could not thrive without irrigation. The preservation of Pistacia atlantica is therefore of peculiar significance to the Southern Highlands.

The Grazing Zone.

Misuse of land in the Grazing Zone is perhaps less obvious than in the Forest Zone but its results are no less serious. The natural vegetation of Artemisia herba-alba with Poa sinaica and Carex pachystylis is a degraded climax but even this cover cannot persist and regenerate in the face of the damage by marauding animals. Local village herds might possibly find sufficient pasturage under present conditions in the Grazing Zone, especially if the goat was to be replaced by sheep. The seasonal incursion of migratory herds of goats results in impossible demands on the available vegetation, however, and natural returns to the soil to enhance fertility are infinitesimal when compared with the losses. It is well known that the goat will consume almost anything it can discover and, in wandering freely over bare ploughed land, it finds apparent satisfaction in dead roots and even the refuse of other animals. In these semi-arid environments the hunger of all domestic animals and their poor condition are striking. On one occasion mules and donkeys were observed making a meal out of cardboard cartons.

The area of land suitable for grazing is itself being drastically reduced by large-scale mechanised ploughing. The reasons for such ploughing are varied. In some cases it is done undoubtedly with the intention of gaining a crop should the rainfall prove sufficient. In others, the land is left in a fallow state with the intention of accumulating enough moisture for sowing in the following year. Large areas are also ploughed as a means of establishing ownership of the land but with little regard to cropping or fallowing. The effects of this widespread ploughing up of grazing land are clear enough from the ground but when observed from the air they are seen to be of alarming dimensions (Plate 17). Large areas are rendered redundant by the current year's ploughing because rainfall is frequently too low to produce a grain crop. Still larger areas of earlier ploughing lie unproductive for a considerable time because several years are required before completely bared land can be recolonised to any appreciable density of vegetation.

The cumulative result of this ploughing up of vast areas of land is to encourage soil erosion both by rainfall, when it occurs, and continually by wind. Furthermore, the type of plough in use has serious disadvantages inherent in its design and mode of operation. The mould-board plough is totally out of place in this environment and the deep, rough ploughing associated with it allows far too much evaporation of valuable moisture; disc ploughing has similar effects but to a smaller degree. In a dry area such as this, shallow ploughing just sufficient to scrape the surface, break the weeds and allow the covering of seed is all that is required. The native plough (Plate 19) is still a highly appropriate implement for this region, as Eyre points out (38), and its replacement by tractor-drawn mould-board or disc ploughs is to be regretted. The native 'nail' plough, drawn by donkey or camel, does not produce soil hard-pans so readily; nor does shallow cultivation allow such intensive evaporation of soil moisture from the profile. It is noteworthy that the native plough can also be misused, and some plots were observed in the Fujeij where several cultivations with this implement had reduced about 35 cm. of top-soil to a dried out dust or hard baked clods. Mechanised ploughing has its own virtues, the chief being that less time and physical effort are required to cultivate a given area (Plate 20). The implement drawn by the tractor is of great importance, however, and the European and American ploughs have left behind costly demonstrations of their unsuitability almost everywhere they have been used outside their place of origin. Tractor-drawn implements better adapted to the drier regions, include the rotary cultivator and the simple scuffle. They have the advantage that they can easily be set to plough a very shallow furrow or if the weeds are not too thickly established, to provide in a single cultivation a level seed bed. Used with caution and with as few cultivations as possible the rotary cultivator can be a satisfactory replacement for other forms of mechanised ploughing in this region. It is recommended in Chapter 8 that ploughing in the Grazing Zone is best abandoned altogether. If this cannot be achieved immediately it must always be borne in mind that, as long as limited ploughing persists in grazing areas near villages, the most important factor to be considered is the conservation of soil moisture.

Another serious misuse of the land is the age-old system of ploughing up and down sloping ground. The causes of this illogical practice are buried in the traditional systems of land tenure and fragmentation by inheritance. This has led to the division of land into blocks and long strips of varying width, often running up and down slope. It is a notorious cause of gullying and allows the soil to be washed out along the plough furrows. In this way much fertile land had gone out of cultivation at the time of Waterer's survey, but this bad practice still persists. Even if circumstances rendered it impracticable to reshape the plots to allow cultivation on the contour, other conservation devices are available in the form of stone terraces, earth banks and ridges.

A further cause of land misuse in this region is the persistent practice of grubbing out the Artemisia for domestic fuel and for limestone burning (Plate 18). The shrub is collected in vast quantities either in its living or its dormant state, which causes the further depletion of the soil-stabilising vegetation cover, as well as the removal of a useful source of animal fodder. Although its nutritive value is admittedly low Artemisia herba-alba constitutes the main source of fodder for grazing animals in this Zone. Its rooting system is normally deep and it associates well with the different species of shallow-rooted grasses. Under present conditions Artemisetum represents poor grazing land, but this situation could be improved by the introduction of better forage grasses. On the wadi slopes and the flatter parts of the Fujeij the Artemisetum climax itself has deteriorated so that any measure which can afford it protection should be welcomed and applied immediately.

Lastly, there is the form of land misuse associated with the earth roads of the region. As the use of motorised transport increases there is a constant encroachment of widening tracks on grazing land, which has now reached serious proportions. A broad belt on each side of the road from Uneiza to Nijil is typical of a considerable acreage that has today been reduced to a compacted and rutted state with a thin cover of blown sand, useless for any agricultural purpose. This increasing wastage of land adds further to the arguments advanced in Chapter 9 for the general improvement of road surfaces throughout the region. A potential cause of gully erosion by defectively constructed road drainage was also noted by Waterer (18) some 15 years ago. In certain cases it still applies today. The side drains to roads, if not terraced and kept grassed down so as to fix the soil, inevitably develop into gaping gullies wherever the soil is deep and soft enough to allow it. Such gullies may not only endanger the road itself but provide the foci for rapid extension of gulley erosion.

The Wadi Bottoms.

Too often in the wadi bottoms land use is characterised by an atmosphere of neglect. Lack of care and maintenance appears to dominate most undertakings and enterprises. For instance, gardens and groves are freely open to children and animals alike, and fruit trees are subjected to repeated damage by crude methods of harvesting. Retaining walls and terraces are frequently found to be in a state of disrepair and weeds are prolific. Present tree and vine stocks are often in poor condition while some are seriously diseased. Little evidence is to be found of the planting of new stock or replacement trees.

Outside the irrigated areas of the Wadi Bottoms similar examples of misuse occur as in the case of the Forest and Grazing Zones.

The method of dry farming by deep ploughing, involving the damage of large areas of good land, and the scrubbing out of vegetation by overgrazing and fuel collection, result in a summer landscape dominated by bared and baked soil. With the arrival of the rains in winter erosion inevitably follows, with wastage of soil and precious water in run-off. It is no exaggeration to state that lack of order, organisation and purpose are all typical of land-use in the greater part of the Wadi Bottoms. The Southern Highlands suffer from the disadvantage of climatic conditions unfavourable to high-yielding intensive agriculture. This natural limitation is magnified by the traditional misuse of the land by its present occupants. It must be remembered that the land will not continue indefinitely to tolerate such imprudent exploitation..

Chapter 8

CONSERVATION MEASURES

Forest Zone

From the discussion in Chapter 6 it is clear that the natural botanical climax was formerly a forest cover occupying those western parts of Jordan where rainfall was sufficient to support it. It is also clear that if the natural forests of the Southern Highlands are to avoid final extinction it is essential to protect them as much as possible from the worst effects of grazing. To make these forests again productive, selected areas must be completely protected by fencing and careful management. There are sufficient reasons for regarding conservation of forest areas in the Southern Highlands as a matter of major importance.

The first consideration of importance is the value of a forest located on the watershed of a region such as this. An adequate tree cover serves to mitigate the harmful effects of heavy rainfall which encourage soil erosion. In coniferous forests in Britain the tree cover can hold up as much as 19 per cent of the rainfall from immediately reaching the ground. The coverage in the Southern Highlands is not sufficiently dense to have this effect but nevertheless there can be little doubt that the existing tree cover will hold up a significant quantity of water before it reaches the ground. The effect of this is to increase infiltration. The presence of the forest also prevents much of the water from running off the surface and causing erosion and wastage. A forest-covered soil will also absorb moisture more readily. The springs in the wadi bottoms will enjoy a more dependable water supply once the watershed is covered with forest. It must be remembered that in the initial stages tree regeneration and planting may have the reverse effect on the constancy of water supplies from springs. The young trees will find and use water which has previously percolated down to the springs. (17). But as far as regional hydrology is concerned once the rejuvenated forest is established its effects are entirely beneficial.

The second reason for preserving the forest is economic. Jordan is without timber supplies of its own in the form of sawn timber for construction; there is also an increasing shortage of wood fuel, roof poles and timber suitable for agricultural implements. All these products of the forest are in great demand in this region and the only means of satisfying this at present is either to pay the high market prices ruling, or to steal timber from a neighbouring forest. With an enlightened policy and scientific management the forests of the Southern Highlands could be made to supply all local needs for small timber; on a long term basis it is not impossible that they could also develop the potential to supply some larger timber for constructional purposes. In this way the region could help relieve Jordan of one important item of imports. Priority objectives of forest development concern the supply of roof poles and fuel. The fuel shortage is a national problem and the forests are being depleted at a rate which threatens their ultimate destruction. With a prudent policy of forest conservation all the villages of the region could be made self-sufficient in fuel supplies. Because the winter season is severe and comparatively long the local demand for wood fuel is naturally high although the increasing use of Kerosene stoves has helped to relax the pressure on the forests. But in the present situation many villagers find themselves without adequate supplies and so have recourse to pilfering from the forest, or are forced to scrubbing up valuable vegetation from the grazing lands and even to burning dung. When this stage has been reached, with almost all natural regeneration suppressed in forest and range alike, drastic measures are indicated.

Apart from the demands for construction and fuel forests can also be a source of valuable tree crops. Protection is essential for this form of 'farm forestry'. It should not be difficult to convince local villagers of the value of planting fruit and nut trees in their fields in the Forest Zone as an insurance against crop failure; and suitable trees for the supply of firewood only may be confined to the uncultivable areas. Any such enterprise will be greatly discouraged if villagers have to combat the hazards of herds of wandering sheep and goats, even if they succeed in keeping their own animals under control. But the advantages are many, including the protection afforded from wind and exposure to the sun, and the control of soil erosion. The overall objective is a more balanced village economy closer to the ideal of self-sufficiency. However, the responsibility for planning and control must be a duty falling on the government in the establishment of an adequate independent Conservation Service to work in close co-operation with existing Forestry, Agricultural and Water Services, and the Development Board.

Tree crops suitable for development by villagers in this area are the olive (with irrigation), fig, almond, apricot, pear and other stone fruits, pomegranate and the carob. In the case of the pear, grafting of cultivated varieties onto wild stock, in particular wild hawthorn, is feasible. The pistacia is another useful tree with considerable possibilities and well adapted to the exacting environment of the region. The tree is dioecious (i.e. unisexual) and the female tree bears numerous seeds (drupes) from which an edible oil can be expressed and an acceptable confection prepared by roasting. Little is known of this in Jordan and at present no economic use whatever is made of the oil. In a region where the sparse rainfall limits the production of olive oil the neglect of the valuable edible oil of the pistacia is remarkable. A minor product of the pistacia tree is the natural gum which exudes as tears from the trunk and branches in the hot season and also from wounds. This is a translucent and teneacious gum possessing insecticidal properties similar to the gum of the cashew nut tree of the tropics, to which it is botanically related. Such gums have uses in book-binding especially in tropical climates.

The dominant species of this region is Pistacia atlantica. In eastern Syria and North Africa it has been widely employed as a stock on which P. vera can be successfully grafted (16). The Department of Forests has already carried out trials for grafting P. vera on to P. terebinthus stocks; these trials might well be extended to include the dominant species of P. atlantica. Pistacia vera is the source of the green edible pistacia nut of commerce, a favourite delicacy in Arab communities as well as a valuable product for export. In view of the success in comparable environments there seems no reason why such trials should not prove equally successful in Jordan, in which case the country could produce its own requirements of pistacia nuts as a village crop. Any production in excess of domestic needs might provide a useful export for overseas markets.

The evergreen oak forest provides some useful products other than timber. A considerable supply of acorns is available each season for consumption both by man and animals. Acorn flour is at present prepared for human consumption while stock are allowed free range to grub their own acorns in the forest; this latter practice again has all the disadvantages of suppressing regeneration and leaving the existing trees open to mutilation and damage. The system of grazing stock, especially swine, as in the oak forests of western Europe, cannot be applied to Jordan in the absence of strict control (Willimott, 19). The cupules are an excellent source of tannin but are not employed in local tanning industries; only the bark of roots and stems are used for this purpose. It is clear that this practice is as unnecessary as it is harmful. The solution is to collect both acorns and cupules for their respective uses and to exclude animals from grazing in the forest. In the event of the implementation of this latter recommendation fencing posts in large numbers would be required for the protection of forest reserves from the depredations of nomadic herdsmen and their grazing animals. The juniper forests if well managed could easily supply sufficient posts for this purpose.

A further consideration which lends force to the need for conservation of the forests of the Southern Highlands is the opportunity for developing the tourist industry. It is possible that the scenic attraction of this part of Jordan is without equal. This aspect will be discussed in Chapter 9 and here it only requires to be stated that in the matter of climate, scenery and historic interest the Forest Zone, especially in the area of Wadi Hisha, is unsurpassed in southern Jordan.

For several reasons the implementation of conservation measures would be on a limited scale. As already indicated the northern forests of Jordan offer more immediate and spectacular rewards while the forests of the south present difficulties in the form of traditional grazing rights and necessary protection measures. It is obvious that, although desirable, it is not practicable to fence off the whole of the remaining forest zone to allow natural regeneration to do its work. It is therefore suggested that a start be made in the nucleus of the existing forest. Two ridges to the west of Wadi Hisha, (35° 30'E, 30° 25'N, 198981 Palestine Grid), where almost pure stands of oak persist, could be completely fenced and protected. A policy of selected felling and replanting could supplement the results of natural regeneration. A central pilot scheme such as this would before long show good results and lead to expansion. The wisdom of concentrating on one centre rather than diffusing the limited resources of the Forestry Service over a large area has been emphasised by foresters and conservationists who have studied this problem in Jordan (18). The value of such a pilot scheme would create renewed interest in the tree and all it represents in the life of the local population; on the other hand, small isolated schemes are open to failure and likely to convince the cultivator that the planting of trees and conservation of forests does not pay in this part of the country. With a prudent policy of conservation the tree can be made to serve a vital function in the economy and well-being of the Southern Highlands.

The Grazing Zone

Conservation of the Grazing Zone represents a complex problem. This stretch of land, which extends the full breadth of the region between the forest zone and the desert fringe, is today suffering from the effects of two main degrading influences. First, overgrazing and misuse of the natural vegetation by the random collection of brush for fuel has reduced much of the soil cover to a very unstable condition. Erosion by wind and water is in constant evidence. Secondly, extensive areas are ploughed up and exposed to the elements, thus increasing the conditions conducive to soil erosion. The present vegetation cover is sparse and mainly of low grazing quality. In spite of these difficulties the solution of the problem of the Southern Highlands, and to some extent for greater areas of Jordan, lies in the successful conservation of this important zone.

Grazing occurs in two forms. The local villagers use nearby land to graze their flocks while migratory flocks would seem to enjoy similar rights of access. In order to preserve the forests and the cultivated areas both local and migratory grazing must be prohibited in those areas. The only grazing land available is therefore in the zone under consideration. Furthermore, in order to protect the better agricultural land of Northern Jordan from the dangers of overgrazing, this southern grazing zone must be improved so as to carry a greater density of stock. The problem is to discover ways and means of carrying this greater density on land that is at present overgrazed and degraded.

With sparse rainfall and impoverished soils the Southern Highlands cannot sustain on the same land a mixed agricultural system throughout the year. In a more temperate climate mixed farming can be successful on the basis of the integration of different divisions of husbandry which can yield variable returns to the soil to maintain its fertility. In this area of Jordan, however, mixed husbandry involves at least three elements which are all exhaustive to the soil; the pressures of grazing, cropping, and fuel gathering throughout the year. Grazing cannot be separated from village life. Improved techniques and increased production can be an important means of encouraging settlement. The problem of land conservation in the grazing zone is therefore best tackled by an approach to the village grazier. With patience and tact he must be shown that the deep ploughing of limited grazing land in the hope of taking a chance crop and the scrubbing up of brush for fuel are harmful practices. In recent years the system of grazing sheep in place of goats has made some progress but the advantage of this change-over justifies stronger emphasis. Ranges impoverished through centuries of overgrazing can be improved by methods such as the use of local species of grasses and legumes for reseeding and by breeding of the palatable species found in steppe and desert regions. During the rainy season most of the grazing is provided by annual grasses while leguminous plants, which grow mainly in winter, are important components of natural pastures in the spring. Species of these valuable pasture plants, together with the perennial grasses, are well represented in the local flora (39). It therefore requires no emphasis that the villager should be instructed in the rudiments of grazing management and control with emphasis on rotational grazing and the dissemination of better grazing plants.

Here the example and supervision of the Fujeij Range Station will be of signal importance. It is for this reason that field experiments in conservation practice on a pilot scale are suggested for the Fujeij area where there are better soils than over much of the grazing area. For example, blocks of land ordinarily grazed by local villagers should be divided and fenced; part allowed to regenerate and part used for current grazing. Depending on the extent of previous misuse the time required for effective regeneration will vary considerably but, in the case of fenced forestry plantations, remarkable regeneration of the ground vegetation has already been observed. The fenced forest reserve of Rumman in the Northern Highlands, for example, with steep slopes and contoured gradoni has shown excellent regeneration of the ground vegetation after nine years; also the El Majdal forest enclosure has provided spectacular regeneration of the natural vegetation within about 10 years (18). The oak forests of Wadi Sham and the pine forests of Dibbin have shown remarkable regeneration within seven years (35). The problem is great in scope and the human implications are difficult to assess. It is well known that traditional practices die hard and large communities of people cannot be forced to transform their customary way of life, especially when beneficial results are inevitably slow to materialise. It is therefore very desirable that the pilot schemes should be carried out within the sphere of influence of the new government Range Station. In the same way, reseeding of the ranges and the introduction of better breeds of animals can be achieved more readily under the guidance of the research station. As in the case of the Forest Zone success can be followed up by a systematic expansion of the development project.

The problem of migratory grazing is more difficult and large-scale alternate grazing is obviously not immediately feasible. The most practical measure would seem to be to increase the number of selected watering points particularly in the eastern part of the Zone. To some extent this would have the effect of discouraging the present trend to move westward into the more productive areas and would result in the partial stabilization of migratory herds in known centres. Pilot experiments in pasture recovery by enclosure might well demonstrate the value of rotational grazing even in the eastern section. This could alleviate the grazing problems of the south by increasing the potential stock-carrying capacity.

A further source of controlled grazing will eventually become available when the Forest Zone has had sufficient time to recover and so justify the limited use of the ground vegetation for sheep grazing. This is a long term prospect but when it is accomplished additional benefits will accrue by relieving pressure on the Grazing Zone and allowing nomadic graziers to use the land by this time improved by rotation. At present the whole range is grazed to the limit of capacity so that the pastures stand little chance of recovery. Under these circumstances the pasture must continue to deteriorate because only the less palatable species can survive and the invasion of weeds is greatly encouraged. Conservation measures on the lines suggested in this discussion must be initiated at the earliest possible time; otherwise the improvement of the whole of the Southern Highlands will be impeded. Development must occur concurrently in all three Zones in order that each may make its distinctive contribution to the success of a comprehensive well-integrated scheme.

The Wadi Bottoms

Conservation practice in the Forest Zone has great possibilities for this part of Jordan but, as we have seen, the objectives are necessarily long term. In the Grazing Zone, however, conservation can produce more immediate benefits on a small scale but its larger potential must again be long term in effect. But the needs of the local population are pressing and immediate and the speediest results from conservation, in terms of food production, are to be expected from arable husbandry in the wadi bottoms and the associated tributary valleys and slopes.

There are two main sources of production in these comparatively small pockets of fertility, irrigation and dry farming. Where water is available at the surface, as at Nijil, Shaubak, Buseira and Musa, irrigation is possible and horticulture can flourish. The grape, fig, olive, and almond figure largely in the gainful occupation of the villagers. Other types of tree crops can also be supported; for example, at Nijil walnut, peach, pomegranate, mulberry, plum, apple, pear, quince, cherry and vine, were all thriving and bearing fruit using irrigation water available in the wadi. Numerous Lombardy poplars and some Eucalyptus were also thriving and provided highly desirable shelter and shade. The present difficulty in such favoured localities is that the water supply is now considerably less than it was in the recent past. Within the last 20 years the effective irrigation area of Wadi Nijil has contracted considerably and retreated towards the head of the valley by some two kilometres. Stark, leafless trees, ruined terraces and boundary walls and abandoned plots provide visible evidence of this decline. A very similar picture can be seen in the neighbouring villages of Shaubak.

Recommendations for conservation in such locations are obviously limited in scope but it is imperative that what remains of value should be preserved. A recent and valuable development has been to cement the area of the springheads and water channels. But the gardens and cultivated plots showed signs of neglect in many cases. Thistles and other weeds were prolific; terrace walls in a state of disrepair; trees damaged by knocking down the fruit with sticks; animals not properly excluded from the orchards and gardens while children were allowed free access with resulting damage to what represents some of the best soil in the Southern Highlands. Moreover, many of the fruit trees were observed to be suffering from the attack of parasitic boring insects. It is pointless to recommend planting replacements until all diseases and pests are controlled and the damaged trees removed. In any case there seemed to be little indication of any consistent attempts to plant new trees, and the present occupants are enjoying the legacy of the prudence of their forefathers. In the case of grape culture this also could be improved by the introduction of a system of elementary education in improved techniques. Excellent table grapes can be produced in this area and on a much increased scale but the chief problems lie in management, ready markets and transport.

Practical solutions of the problems of the irrigated valleys are therefore comparatively few and simple. They rest mainly on the dissemination of the knowledge of modern techniques throughout the zone. A mobile horticulturist, based preferably on the Shaubak Agricultural Station and thereby gaining local cultural experience, could ultimately revolutionize fruit and nut production in this area expecially if the incentive of dependable markets could be added. Integration of village farm units, signifying more co-operation in the growing, grading and packing of produce, is one important aspect of development that should emerge. Detailed planning would of course be the responsibility of the local adviser, who could assess specific needs and would be in a position to modify projects and schemes to meet new contingencies. Education and planning can therefore be regarded as the basic elements required in plans for the conservation and development of horticulture in this zone and, with the establishment of the new Agricultural School at Shaubak, neither should be difficult.

Dry farming, the other system of crop production, is more extensive but more precarious since it must rely on the available natural precipitation. It is employed where no continuous supply of water is available at the surface, but where the soil is sufficiently deep and stable to support crops. Although in this case satisfactory solutions are more indefinite some practical suggestions can be offered. First, the common practice of ploughing up large areas of land, as in the case in the Grazing Zone, on the off-chance of having sufficient rainfall to grow a cereal crop needs considerable modification. It has already been indicated that the lessons of the past can supply answers to present-day problems (see Chapter 7). On the basis of sound conservation practice, which allowed a large production of grain, the land was once able to support a population considerably greater than at present. Today conservation is still in its infancy and even the uncertain practice of dry farming is misused. As in the case of the Grazing Zone and for the same reasons, land is often ploughed without the intention of sowing or conserving moisture for a crop in the following season. The energy of the local population would be better applied in directing as much as possible of the run-off water of the rainy season onto land they really intend to cultivate for cereal crops. Although small and often scattered, many areas could be profitably utilised in this way. It is noteworthy that the historic sites of cultivation comprised pockets of deep fertile soil of the wadi bottoms, gentle valley slopes, and numerous small tributary valleys.

Jordan is a stony land and the removal of these stones from the surface in cultivable areas is essential before an economic use can be made of the soil, or for a plough to be used and an even growth of the crop assured. The present practice is to gather the unwanted stones into heaps. This system has obvious disadvantages apart from that of putting out of cultivation considerable areas of otherwise productive soil. Past land use practice again provides the answer. Stones were gathered and built into terraces and walls at points which served to check water run-off and soil erosion. Today few walls are to be seen throughout the region, although some still remain in the area between the Fujeij and Tafila (Plate 15). In the case of maintained terraces these are almost non-existent but their remains are ubiquitous (Plates 12 & 14).

Conservation measures are directly linked with productivity and involve channelling all available water onto land to be cultivated and the control of run-off water and soil erosion. To do this the simplest measure is to adopt the system of contour ploughing. This may require more time and rather more skill than ploughing up and down the slope but its merits are obvious. In such environments there is probably nothing more conducive to soil erosion that the practice of ploughing down-slope; examples of this are all too frequent in the Zone (Plate 21). Ploughing along the contour checks surface run-off, allows more of the limited rain-water to be absorbed into the soil where it is most needed, and holds the soil in place. Stone wall ridging serves a similar purpose and comprises a rational use of the stones in preference to the system of collecting them in heaps. On the steeper slopes, where contour ploughing may not be adequate to hold all the water in place, stone wall ridging should certainly be applied. The ridges can be set at intervals depending on the steepness of slope and the width of land most convenient for cultivation. In the case where stones are insufficient or where the slope is not too steep to justify continuous stone ridges, a system of bank ridging may be employed. This results in the transformation of a sloping field into graded steps or sloping terraces by forming banks of earth. The purpose of all these devices is simply to ensure that the soil will lodge rather than wash away imperceptibly and that water will infiltrate.

A more ambitious and also more costly method, which could bring into production the steeper valley slopes and upper parts of the tributary valleys, is the construction of permanent stone-walled terraces. In this case, and in some degree in the systems already considered, some provision for excess water must be made. Because of the permanence and cost of the terraces themselves their construction will be warranted only by the value of the crop produced. Vines, fruit trees, and early vegetables are usually the only crops of sufficient value to justify the building of such terraces. Such works must be well constructed since badly built structures are a waste of time and money. Badly constructed terraces may survive for a number of years and allow the establishment of an orchard only to be washed away by the pressure of water absorbed after a season of unusually heavy rainfall such as that of 1963-64. The walls must thus be of sufficient strength to withstand the heaviest rainfall that the area can expect to experience (40). The foundations must be made of heavy stones buried and bonded. When using stones of irregular shape and without cement, the face of the terrace must be built so as to slope backwards. Strengthened sections must be provided to allow overflow of water to the terrace below. Apart from preventing soil erosion the object of such terracing is again to lead the water onto cultivable soil. For this reason, the terrace system must run across the natural lines of drainage. Perhaps the best plan is to start terracing at the head of a tributary valley and to extend operations onto the upper slopes of the main wadi side, allowing for a gentle fall across the contour to carry the water to its maximum limit of usefulness. A series of successive walls down the tributary will have its counterpart in terraces along the valley sides. Where terracing is used in the main wadi bottoms it must be sited with discretion. At the head of the wadi small terraces built across the line of natural drainage may be safe enough but lower down adequate provision must be made for the escape of surplus water. In this case subsidiary check dams along the main wadi course are a useful precaution against gully erosion. It should be stated, however, that once a system of terracing is established the amount of water reaching the wadi bottom and thus allowed to run to waste will be much less than in the past.

The above measures are usually simple in application and within the capability of the local population given some measure of supervision and instruction for the integration of schemes. Equally important is the need to secure adequate co-operation of the labour involved in such enterprises. Systems for installing simple field works such as these have been initiated, for example, in parts of India on the basis of the village unit. The village pays for its conservation system either in terms of labour or in cash, the government supplying the technical 'know-how' and overall supervision.

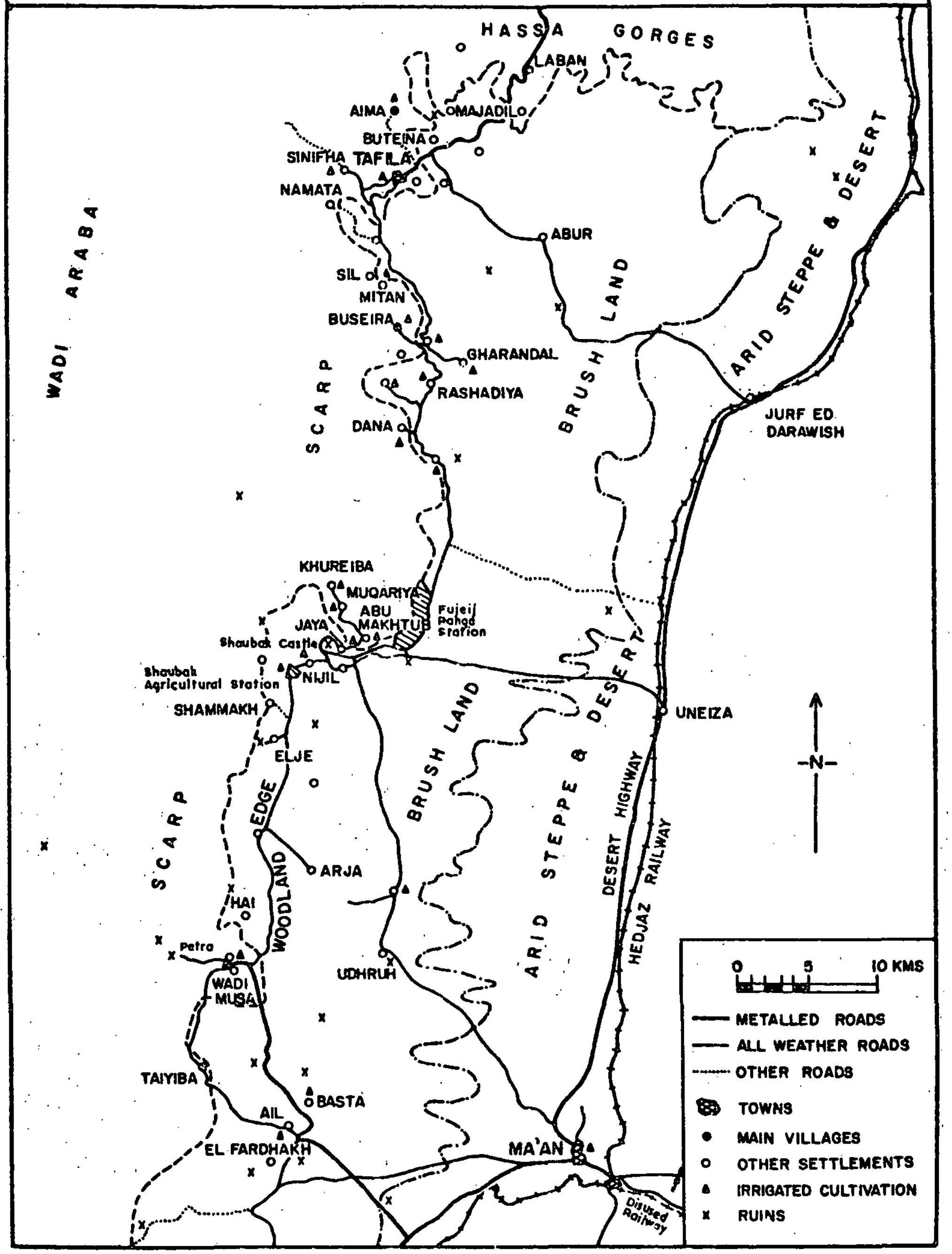
After the building-up of these systems co-operation can be profitably extended into the sphere of standardization of produce and distinctive packing with the object of establishing prestige markets. Although more active co-operation at the local level is essential there can be little doubt that the administration will have to accept responsibility for many of the measures necessary for the improvement of arable agriculture to meet the present and future needs of the people of the Southern Highlands. Keen (41) has suggested that the sons of sheiks or selected villagers could be grouped into working units in the dry farming areas of this region. This would involve the surrender of certain rights of ownership in selected places. The idea could be further developed in the following way. Selected personnel would be financed by the government in the initial stages of development of economic agricultural units, the condition being that the land is worked in accordance with a strict programme laid down by government during the subsidized period. Normal repayment of interest on the capital should not be difficult to arrange. Once the farm unit is established government control would be diminished and repayment of capital gradually introduced. There should be no shortage of people wanting to farm in this manner although the number possessing the required skills would be more limited. A necessary requirement would be the setting up of a compulsory course reaching an agreed standard and based on the Agricultural School at Shaubak. It is believed that the supply of suitable candidates would be satisfactory but the capital involved would obviously be high.

A further means of government assistance could take the form of Government Farms scattered throughout the region and working on a partly experimental and partly economic basis. Such farms, using the best methods available and selected seed, would serve as a practical example to local communities. They would also have the merit of employing and training some of the present excess labour force. To be economic these enterprises would need to study and develop adequate marketing facilities, a further factor of local benefit. Once the roots of a cash economy have been established these marketing facilities could grow rapidly and absorb the produce of villagers who could not otherwise establish such a system by their own initiative and resources.

Finally, and of great importance, the region requires well trained Jordanian agronomists to form an Extension Service to advise and guide at all stages of development. To be effective the village conservation system needs expert supervision. The private subsidized farms also need continuous guidance in their initial stages, and the whole region demands knowledgeable representatives to meet regularly to integrate the development. Perhaps this last requirement is the most difficult to fulfil. It is general experience in many parts of the world that isolated and exacting regions remain unattractive to the highly trained specialist on a permanent basis.

By abandoning imprudent practices such as indiscriminate deep ploughing, overgrazing, clearing of the ground flora and general neglect, and by the introduction of positive measures, for example, implementing conservation methods, teaching improved techniques, integrating production and marketing, and bettering communications, the urgent needs of the Southern Highlands can be met.

FIG. 8 SETTLEMENT AND COMMUNICATIONS



Chapter 9

SETTLEMENT, COMMUNICATION, AND TOURISM

"The early Arab conquests and the initial spread of Islam were carried out by bedouin armies.....Meanwhile, the basic economic production which made...developments possible and the dominant way of life of the mass of the people, continued as it does today, to be centred in the villages. That observers in both the Middle East and the West have tended to give more attention to the nomads than to the villagers and townsmen reflects an historic interest rather than an actual assessment of the relative importance of the three types". (42).

In common with the rest of the Middle East, a logical division separates the population of Jordan into three occupational classes; pastoral nomads, village agriculturists, and townsmen. From Chapter 8 it is patent that the village agriculturist will be mainly responsible for implementing the different improvements suggested and stands to benefit most by their achievement. As sedentary conditions improve and the standard of living rises the village dweller will gain in respect, by virtue of his increasing efficiency and prosperity. Then the traditional social superiority of the nomad and his distaste for sedentary life may be modified; and by the example of the success of the villager he may be encouraged to accept more willingly some settled way of life.

Many social questions in Jordan are coloured by the problem of what can best be done for the nomads. The Jordan of 1964 is witnessing the social phenomenon of the slow transformation of the nomadic peoples into settled agriculturists. Modern developments all tend to hasten the process although nomads still form a major part of the population of the Southern Highlands. Thus motor transport is replacing the camel and the government fiat now rules in desert communities where formerly only tribal law was known. Younger nomads after the advantages of military service are disenchanted on their return to life in the black tents, and the general discontent of nomadic peoples is apparent in face of the relative affluence of the sedentary communities. "Bedouin ways were hard", says Lawrence (8) "even for those brought up in them and for strangers terrible; a death in life". Small wonder if the younger generation of nomads is taking a fresh look at their predicament and turning slowly, if reluctantly, to the more rewarding ways of the settled agriculturist. As we have already seen, the region in the past was able to support a much more dense and settled population than is the case today. With an expanding economy the nomad should find a place in the labour forces essential for the restoration of the Southern Highlands to its former capacity and prosperity.

The total population enumerated in the towns and villages in the region at the time of the 1961 Census was nearly 21,000. Over half of this number (11,149) lived in two towns of Ma'an and Tafila, and the rest of this total (9,614) inhabited 17 villages with populations ranging between 100 and 1,300 (Table VII). Twenty other settlements have populations under 100 each, for which detailed figures are not available. There are, of course, seasonal unenumerated additions to this total population caused by the arrival of semi- and fully nomadic peoples in the district. Neither are other inhabitants living outside the towns and villages fully accounted for. The total estimated population of

Tafila Sub-District, covering the northern half of the Southern Highlands, was over 21,000 in 1957 (43): rather fewer are found in the south which forms part of the Ma'an Sub-District. Ma'an is easily the largest settlement (6,643). Lying in the south eastern corner of the region (See Fig. 8) it is essentially a centre for the whole of the arid south of Jordan. It is the only settlement of any size on the whole length of the Desert Highway between Amman and the port of Aqaba; consequently it derives much of its trade from the movement of traffic on this important line of communication. It also enjoys the advantages of the Hedjaz Railway, which passes a little to the east, and will benefit still further from the increase in passenger traffic when the 'pilgrim line' to Medina in Saudi Arabia is reopened after the present reconstruction is completed. Ma'an is linked with Wadi Musa by a metalled road which continues northwards as an improved all-weather route; a second all-weather road also connects Ma'an with the Shaubak area. Branch roads and tracks lead into the Highlands from the Desert Highway.

Tafila (4,506) provides far fewer services than is the case with Ma'an but it lies in the middle of a number of smaller settlements in the north of the region. It marks the southern end of the metalled road from Kerak and has an all-weather road connecting it to the Desert Highway at Jurf ed Darawish. It is largely an irrigated agricultural settlement, as are the surrounding villages, but possesses a market, some shops, a secondary school and other central services. Unlike Ma'an there is no petrol station. As a marketing centre for the collection of agricultural produce for Amman and other northern towns Tafila would benefit from the further improvement of the connecting road to the Desert Highway.

Most of the villages in the Highlands district are found spread out along the westward-facing scarp south of the Hassa gorges. Their distribution is shown in Fig. 8. The largest of these villages include Aima (1,147) and Buseira (1,219) in the north. Shaubak including Jaya and Abu Matktub (1,099), Wadi Musa (654) and Taiyiba (1,007) all lie in the south. They occupy flattish land near the top of the scarp or, in the case of Shaubak and Wadi Musa, they lie in valleys cut into the scarp face where spring water makes irrigation patches possible. All lie a short distance off the connecting road from Tafila to Ma'an; the further improvement of this north-south route would therefore make all these villages more accessible for the marketing of produce, developing services, and attracting tourists.

Several smaller villages, with populations not exceeding 500 inhabitants, lie in close proximity to these larger settlements. These are often overflow settlements arising from the population of the main community expanding beyond the limits of irrigated, cultivated and grazing land. The settlements around Shaubak grew up when the village, within and without the Castle, could no longer contain its inhabitants. New valley and spring sites had therefore to be found. Gharandal was settled recently as the population of Buseira expanded. Wadi Musa has a collection of smaller adjoining settlements. Other small villages stand alone. These include some located on the scarp such as Elje, and also Dana perched picturesquely on a ledge above Wadi Dana. Others lie on the main north-south link and include Rashadiya and Nijil. There is also a scatter of settlements in the southern area of brushland, for example, Basta and Udhruh where water taken from wells allows a limited area of subsistence cultivation. Further small communities are to be found at Uneiza and Jurf ed Darawish on the Hedjaz

Railway north of Ma'an.

The overall distribution of village settlement in the region emphasises the fact that water supply is the major factor impelling settlement to concentrate largely along a narrow strip on the western edge where springs occur and wells offer reasonable supplies. With the exception of Ma'an itself the size of settlement decreases eastwards at the same time as their density declines. It also means that woodland, brushland and pockets of fertile soil along the scarp, where much of the land is steeply sloping, have been exposed to excessive exploitation when, in fact, they required more prudent management and persistent conservation.

From the viewpoint of developing the accessibility of these settlements with the object of encouraging agricultural marketing and the tourist industry the first requirement is the improvement of the north-south road between Wadi Musa and Tafila, especially the section from Nijil to Tafila. This will render both Tafila and Ma'an more accessible to the smaller settlements as well as encouraging the use of the old road south via Kerak and Tafila by the many tourists visiting Petra. Historic, archaeological and scenic attractions too numerous to mention lie along this road; unfortunately they are not sufficiently publicized. More adequate signposting of sites of historic and scenic interest could well supplement the existing conventional road signs. Facilities such as well-sited resthouses, roadside cafes, petrol stations and shops are all necessary if a thriving tourist industry is to be built up. A reliable telephone service and hospital facilities are other essential requirements. The publication of a comprehensive official guide for intending visitors to the south would also prove a considerable advantage. Facilities at present are few and inadequate and there is ample scope for development in order to encourage what could be a very lucrative local industry. In these days of extensive travel, increasing leisure and available means Jordan possesses in its Southern Highlands an enticing opportunity to attract tourists from Europe and America and beyond; in this way it can share in the tourist traffic of the world. Already a good start has been made and over the last few years there has been an encouraging increase in the tourist traffic in Jordan. From the data given in Table VIII it can be seen that since 1959 the total number of tourists has more than trebled. These statistics, prepared by the Jordan Tourism Authority, suggest that with the provision of the modern facilities here recommended the tourist industry of Jordan has prospects of considerable expansion. It is interesting to recall that in recent correspondence in the London press tourism was rightly designated as "Jordan's only major industry". (44). To anyone familiar with this part of the country it is nostalgic to recall the dramatic natural beauty of the forests and landscape of the Southern Highlands, allied to its genial summer climate and set in a pattern of ancient cities and crusading castles, enough to claim for this region the status of a National Park.

A good road from Wadi Musa and Petra to Ma'an and the Desert Highway already exists. The road connecting Uneiza on the Desert Highway with the Shaubak villages should also be metalled at least as far as Nijil. This would facilitate the important role that the Nijil and Fujeij Stations will have to play in the agricultural development of this region as well as making the new Agricultural School near Nijil accessible at all times of the year. This route would also encourage the development of the marketing of agricultural produce in the various villages around Shaubak and also provide an alternative fast road to Petra. The road south from Nijil is reasonably good though unmetalled. Lastly, the road from Tafila to the Desert Highway, recently improved, might later be metalled in order to provide the district with an adequate network of acceptable roads.

In conclusion, it must be restated that satisfactory access by means of good roads is essential in the Southern Highlands if they are to achieve a measure of real prosperity. The speedy conveyance of local perishable produce to market and the safe and comfortable transport of tourists to the places of interest they wish to visit are requirements which when satisfied will surely hasten the realization of the objectives indicated in this study.

TABLE VII

Population, 1961

Town or Village	Census 1961
Aima	1147
Tafila	4506
Sil	271
Mitan	244
Buseira	1219
Gharandal	460
Rashadiya	109
Dana	385
Muqariya	618
Shaubak	1099
Nijil	462
Shammakh	257
Bir Khidad	195
Hai	610
Wadi Musa	654
Taiyiba	1007
Basta	461
Ail	416
Ma'an	6643
	Total 20763
Butaina Laban El Fardhakh Udhruh	Each listed as less than 100

Note: No data are available for other places shown in Fig. 8. From observation they would appear to be very small and to include less than 100 persons each. Nor are data available for the population living outside towns and villages.

TABLE VIII

Tourist Arrivals 1959-1963

Nationality	Year				
	1959	1960	1961	1962	1963
Arab Countries	58.740	64,988	78,873	106,396	138,899
Middle East	2.882	3.636	7.616	18.843	63.557
Britain	5.290	6.979	9.342	10.667	15.144
France	2.361	3.259	4.858	5.644	10.381
Germany	3.640	4.741	6.301	6.999	9.981
Italy	2.131	2.621	3.056	4.124	6.774
Other European Countries	7.929	12.222	13.888	16.633	24.962
U.S.A.	16.517	23.378	26.392	28.698	37.247
Canada	1.000	1.650	2.128	2.282	2.943
Other American Countries	1.659	3.177	3.550	4.430	6.462
Other National-ities	1.945	5.047	6.054	4.285	7.320
General Total	104.094	131.699	162.058	209.001	323.470

Source: Department of Statistics (45).
Amman, Jordan.

APPENDIX I

ANALYTICAL DATA

TABLE I

SAMPLE No.	PIT No.	HORIZON	DEPTH (cm.)	pH		MUNSELL (COLOUR)		COLOUR NAME DRY
				SOIL PASTE	SAT. EXT.	DRY	MOIST	
1	1	1	0- 5	7.2	7.4	10 YR 5/3	10 YR 3/4	Brown
2		2	5-20	7.6	7.8	7.5YR 5/4	7.5YR 4/4	Brown
3	2	1	0-86	7.6	7.8	7.5YR 5/4	7.5YR 4/4	Brown
4		2	86-98	7.3	7.8	10 YR 8/3	10 YR 7/6	Pale Brown
5	3	1	0-99	7.6	7.9	7.5YR 6/6	7.5YR 5/6	Reddish Yellow
6		2	99-135	7.7	7.9	7.5YR 8/6	7.5YR 6/6	Reddish Yellow
7	4	1	0-14	7.6	7.9	7.5YR 7/4	7.5YR 5/4	Pink
8	5	1	0-15	7.5	7.8	7.5YR 5/5	7.5YR 4/4	Grey
9		2	15+	8.0	8.0	10 YR 8/2	10 YR 7/3	White
10	6	1	0-18	7.7.	7.9	10 YR 6/4	7.5YR 5/6	Light Yellowish Brown
11		2	18+	7.6	7.8	10 YR 8/4	10 YR 7/4	Very Pale Brown
12	7	1	0-16	7.8	7.8	10 YR 6/4	7.5YR 4/4	Light Yellowish Brown
13		2	16-68	7.9	8.0	10 YR 6/4	7.5YR 5/4	Light Yellowish Brown
14		3	68+	8.0	7.9	10 YR 7/4	10 YR 6/4	Very Pale Brown
15	8	1	0-17	7.6	7.7	10 YR 7/4	10 YR 5/4	Very Pale Brown
16		2	17+	8.0	7.9	10 YR 8/4	10 YR 7/3	Very Pale Brown
17	9	1	0- 6	8.0	7.9	10 YR 7/6	7.5YR 5/6	Yellow
18		2	6-96	7.8	7.5	10 YR 7/4	7.5YR 5/4	Very Pale Brown
19	10	1	0-95	7.6	7.8	7.5YR 6/6	5 YR 4/6	Reddish Yellow
20		2	95-109	7.8	8.0	7.5YR 6/6	5 YR 4/6	Reddish Yellow
21	11	1	0-14	7.8	7.9	5 YR 5/6	5 YR 4/4	Yellowish Red
22		2	14-22	7.8	8.0	5 YR 5/6	5 YR 4/4	Yellowish Red
23		3	22-105	7.7	8.0	5 YR 5/6	5 YR 4/4	Yellowish Red
24	12	1	0-16	7.8	7.9	7.5YR 6/6	5 YR 4/4	Reddish Yellow
25		2	16-43	7.7	8.0	7.5YR 5/6	5 YR 4/6	Yellowish Red
26	13	1	0-21	7.7	8.1	7.5YR 7/6	7.5YR 5/6	Reddish Yellow
27		2	21-64	7.8	7.9	10 YR 7/4	10 YR 6/4	Very Pale Brown

TABLE 2

SAMPLE No.	PIT No.	HORIZON	SAND %	SILT %	CLAY %	$CaCO_3$ %	TEXTURE	I.R. cm/hr.
1	1	1	53	36	11	20.26	Loam	
2		2	43	42	15	25.95	Loam	
3	2	1	27	39	34	6.37	Clay Loam	
4		2	43	43	14	20.05	Loam	
5	3	1	21	40	39	6.64	Clay Loam	
6		2	37	38	25	46.91	Loam	
7	4	1	51	39	10	55.59	Loam	
8	5	1	38	52	10	26.58	Silt	
9		2	64	26	10	82.59	Sandy Loam	
10	6	1	53	39	8	58.72	Sandy Loam	2.86
11		2	27	54	19	33.31	Silt	
12	7	1	40	50	10	18.92	Silt	3.13
13		2	21	61	18	25.33	Silt	
14		3	17	56	27	29.74	Loam	
15	8	1	48	41	11	28.61	Loam	2.25
16		2	-	-	-	61.92	-	
17	9	1	48	44	8	51.85	Loam	0.74
18		2	27	52	21	25.92	Silt	
19	10	1	27	45	28	11.83	Clay Loam	3.00
20		2	19	44	37	15.78	Silty Clay	
21	11	1	25	49	26	44.57	Loam	1.46
22		2	22	46	32	41.84	Clay Loam	
23		3	18	45	37	45.03	Silty Clay	
24	12	1	33	53	14	22.72	Silt	2.50
25		2	29	47	24	24.47	Loam	
26	13	1	27	45	8	23.74	Loam	3.57
27		2	28	47	25	33.86	Loam	

TABLE 3

SAMPLE No.	PIT No.	HORIZON	Conductivity Saturation Extract	Total Soluble Salts %	Saturation %	Kg./Donum	
						P_2O_5	K_2O
1	1	1	3.57	0.32	31.29	20.40	164
2		2	3.61	0.60	54.55		
3	2	1	2.77	0.18	26.18	12.50	136
4		2	14.70	1.80	51.97	4.80	150
5	3	1	1.27	0.86	48.93	9.99	143
6		2	0.51	0.06	58.59	2.61	139
7	4	1	1.11	0.10	53.85	2.95	128
8	5	1	0.76	0.09	56.09	13.20	132
9		2	0.40	0.06	62.05	14.10	164
10	6	1	0.88	0.07	44.70	6.35	125
11		2	0.68	0.07	43.28	11.11	178
12	7	1	0.77	0.04	30.27	3.86	118
13		2	5.16	0.42	49.36	5.44	178
14		3	1.28	0.07	63.02	2.95	136
15	8	1	0.74	0.05	59.42	2.61	136
16		2	0.56	0.09	62.14	7.71	171
17	9	1	1.47	0.11	72.17	4.99	107
18		2	0.50	0.08	60.20	8.39	164
19	10	1	0.50	0.05	53.40	4.54	132
20		2	0.66	0.04	33.40	2.95	143
21	11	1	1.22	0.08	45.64	2.95	143
22		2	0.66	0.03	30.31	7.71	178
23		3	0.59	0.03	30.64	3.86	143
24	12	1	2.41	0.13	49.11	2.95	139
25		2	0.63	0.05	34.61	6.80	150
26	13	1	0.74	0.06	47.61	4.08	132
27		2	1.15	0.09	57.15	8.39	164
						4.54	139

TABLE 4

SAMPLE No.	PIT No.	HORIZON	SATURATION EXTRACT (me./100 grms.)									
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	SO_4^{--}	HCO_3^{-}	Tot. Cations	ESP	SAR
1	1	1	0.56	1.08	1.75	0.42	0.31	2.88	0.20	3.81	13.8	11.8
2		2	0.98	1.20	6.27	-	0.67	7.59	0.19	8.45	25.8	24.0
3	2	1	0.50	0.13	1.18	0.34	1.44	0.24	0.13	2.15	14.2	12.0
4		2	4.37	3.83	15.59	0.60	20.80	2.73	0.26	24.39	46.0	60.0
5	5	1	0.49	0.49	0.12	0.39	0.49	0.12	0.49	1.49	2.1	2.4
6		2	0.29	0.24	0.08	-	0.23	0.15	0.23	0.61	1.4	1.7
7	4	1	0.38	0.27	0.08	0.40	0.38	0.11	0.23	1.13	1.4	1.8
8	5	1	0.28	0.34	0.04	0.34	0.34	0.04	0.28	1.00	0.4	1.0
9		21	0.25	0.12	0.05	0.37	0.19	0.04	0.19	0.79	-	0.5
10	6	1	0.31	0.45	0.04	-	0.18	0.37	0.25	0.80	-	0.25
11		2	0.35	0.21	0.04	0.35	0.13	0.28	0.19	0.95	-	0.3
12	7	1	0.15	0.15	0.09	0.24	0.18	0.03	0.18	0.63	0.6	1.3
13		2	0.59	0.69	3.50	0.57	0.43	4.10	0.25	5.35	22.0	20.0
14		3	0.79	0.47	0.49	0.13	0.63	0.09	0.63	1.48	0.6	1.20
15	8	1	0.59	0.30	0.10	0.59	0.44	0.25	0.30	1.58	0.8	1.50
16		2	0.93	0.31	0.06	0.13	0.93	0.06	0.31	1.43	0.3	0.80
17	9	1	0.72	0.72	0.09	-	0.92	0.16	0.45	1.53	0.6	1.20
18		2	0.45	0.15	0.04	0.18	0.30	0.04	0.30	0.82	2.8	2.80
19	10	1	0.40	0.27	0.05	0.16	0.27	0.11	0.34	0.88	0.9	1.40
20		2	0.33	0.26	0.05	0.10	0.33	0.06	0.25	0.74	1.4	1.80
21	11	1	0.46	0.57	0.11	0.14	0.57	0.17	0.40	1.28	1.6	2.10
22		2	0.45	0.31	0.08	0.15	0.15	0.54	0.15	0.99	1.6	2.00
23		3	0.31	0.23	0.06	0.12	0.23	0.14	0.23	0.72	0.6	1.30
24	12	1	0.98	0.49	0.83	-	1.96	0.09	0.25	2.30	4.7	4.30
25		2	0.26	0.26	0.06	0.17	0.26	0.06	0.26	0.75	0.6	1.40
26	13	1	0.48	0.12	0.12	0.19	0.36	0.12	0.24	0.91	0.4	1.00
27		2	0.57	0.14	0.42	0.28	0.57	0.14	0.42	1.41	3.1	2.90

APPENDIX II

THE SHAUBAK AND FUJEIJ AGRICULTURAL STATIONS

Seed Propagation Station

The Ministry of Agriculture controls two field stations in the Shaubak area, the Seed Propagation Station (Shaubak) at Nijil and the Sheep Range Station on the Fujeij. (Fig. 6).

The Seed Propagation Station was established in November 1958, on 1200 donums* of gently sloping land in the Wadi el Baggi. The station lies at 1400 metres above sea level so that the duration of the growing season is only 5½ months, i.e., late April to mid-October. Winters are very cold and summer temperatures comparatively moderate. Evaporation rates are high under cloudless skies with south-west prevailing winds, especially in winter. Average rainfall is of the order of 340 mm. Relative humidity is low in summer and dewfall is insignificant.

An appropriation of $50,000 of American funds was made available for the establishment of this station under the Point Four programme. This allowed for the purchase of land, the provision of buildings and fencing, the water supply, roads and farm machinery.

In October 1959, the Station was taken over by the Ministry of Agriculture and came under the direct control of the Ministry's Research Department in October 1962. The Superintendent, Mr. Mohammed Taha, B.Sc., has a staff of three field assistants, five technical labourers and a seasonal labour force of up to thirty men.

The station is organised in five main sections:

(a) Orchards

(b) Cereal seed propagation

(c) Vegetable trials

(d) Forest belts

(e) Forest nursery

The orchards cover 120 donums and include apple, pear, almond, cherry, plum, peach, apricot and grapes, all under dry-farming conditions. Plans are being considered to irrigate half of the orchard area when the total irrigation capacity of the Station is increased from the present 150 to 450 donums. The main problem at present in the orchard section is root damage to the trees by gophers as well as frost damage to some of the vines.

In the cereal section, 400 donums are given over to the propagation of certified seeds, wheat and barley. In the vegetable section, 100 donums are reserved for crop and varietal trials, including experiments on optimal time of planting and management. A variety of

*1 Donum = approximately 0.25 acre

vegetables including tomatoes, beans, squash, cucumbers, melons, sweet corn, carrots, cabbages, cauliflower and potatoes are under cultivation. Channel irrigation and a three year rotation of cereals, vegetables and legumes, especially clover (berseem), are practised. It is hoped that in future this station can provide potato tubers for the Jordan Valley to reduce importations from Europe, as well as for propagating a variety of vegetable seeds for cultivation in other districts.

At present terraces are being built for forest belts which will eventually surround the station. In 1963 150 donums of land were prepared for this purpose and it is hoped to extend the forest belt by 50 donums each year. The forest nursery of 20 donums is a separate section of the station under the control of the Department of Forests. Seedlings of *Pinus halipensis*, *Cupressus sempervirens*, and *Pistacia atlantica* are being propagated under irrigation for planting up forestry projects throughout the Ma'an Forestry District.

Range Sheep Station

The Range Sheep Station on the Fujeij lies north-east of Nijil on the western scarp of the Fujeij Plateau; it is also controlled by the Research Department of the Ministry of Agriculture. An area of 5,200 donums of Government land, much of it consisting of very steep slopes, was fenced in 1961. Buildings for the reception of sheep from the Shomari Station, Azrak are now nearing completion; this is made possible by a grant from American funds. The Station will concentrate on improvement of the breed of Jordan sheep, on better range management, and conservation measures generally. Water is available from a spring-fed reservoir and from rainfall collection. Some of the steeper slopes have been terraced and planted successfully with pine seedlings although growth has been slow. (September, 1963).

It should be stated that as a result of the severe weather conditions of the 1963-64 winter, the majority of the pine seedlings in the nursery at Shaubak as well as those planted on the boundary of the Range Station at Fujeij had succumbed. By contrast, the cypress and pistacia seedlings and the mature fruit trees survived the wintry conditions. (April, 1964).

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