THE SOILS OF THE SYRIAN MID-EUPHRATES REGION

WITH PARTICULAR REFERENCE TO

GYPSIFEROUS SOILS

AND

THEIR INFLUENCE UPON AGRICULTURAL DEVELOPMENT

V O L U M E T W O

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Doctor of Philosophy

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1976

EX BIBL. UNIV. EDINBURGEN

C O N T E N T S

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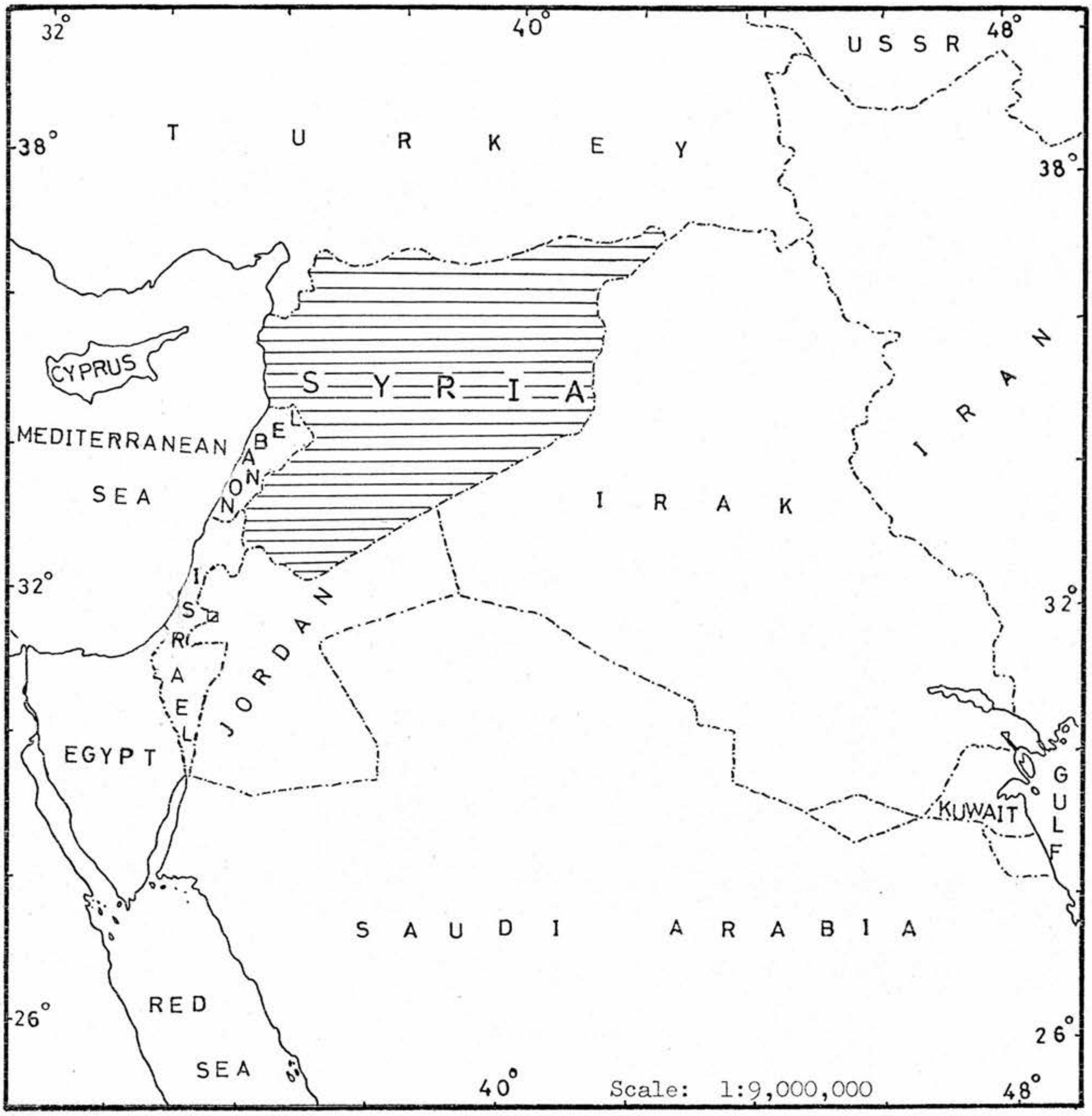


Figure 1.1
THE SITUATION OF THE COUNTRY

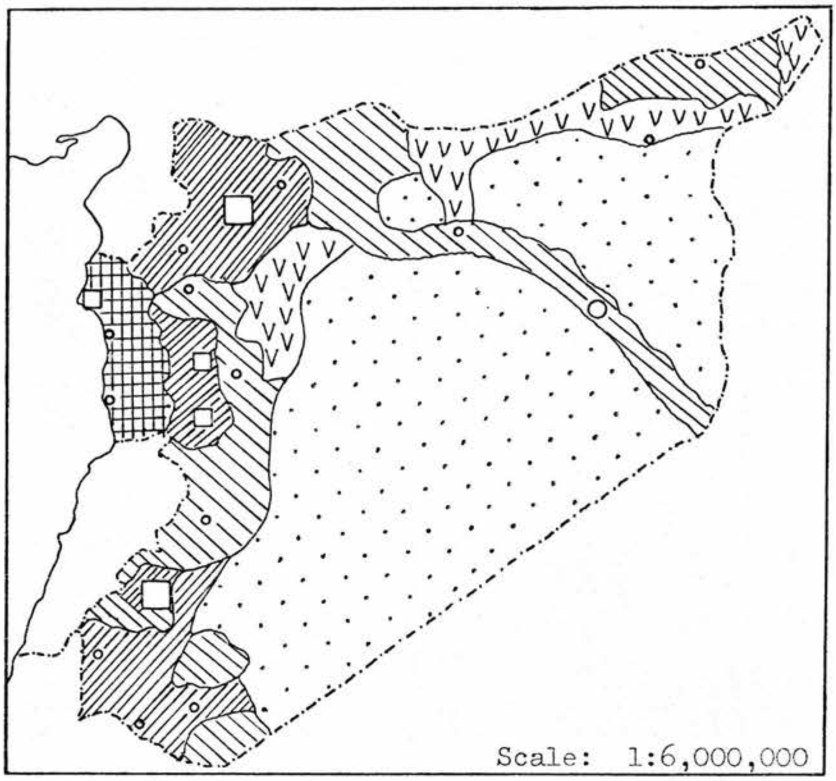


Figure 1.2
THE POPULATION DENSITY

Over 100 persons per km^2

40 - 80 persons per km^2

15 - 40 persons per km^2

5 - 15 persons per km^2

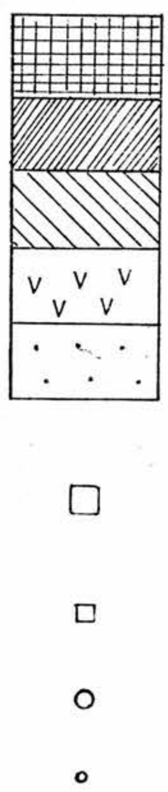
Under 3 persons per km^2

over 500,000 persons

100,000 - 200,000 persons

60,000 - 100,000 persons

17,000 - 45,000 persons



Source: Ministry of Planning, Damascus, 1971.

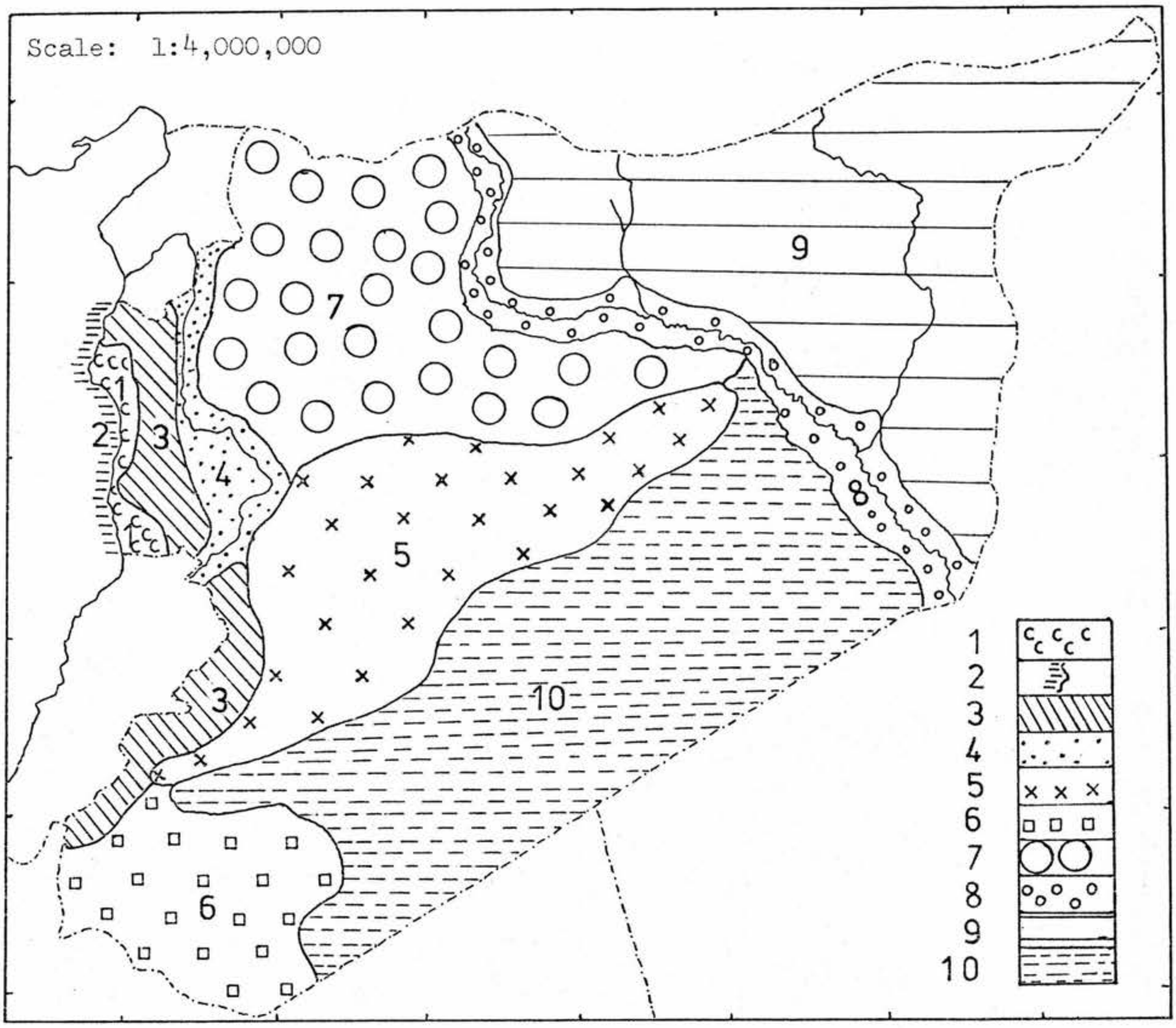


Figure 1.3a
PHYSIOGRAPHICAL UNITS

1. The coastal plains
2. The shelf line
3. The western mountains
4. The rift valley
5. The central mountains
6. The south west
7. The north west
8. The Euphrates valley
9. The Jezirah
10. The Syrian desert

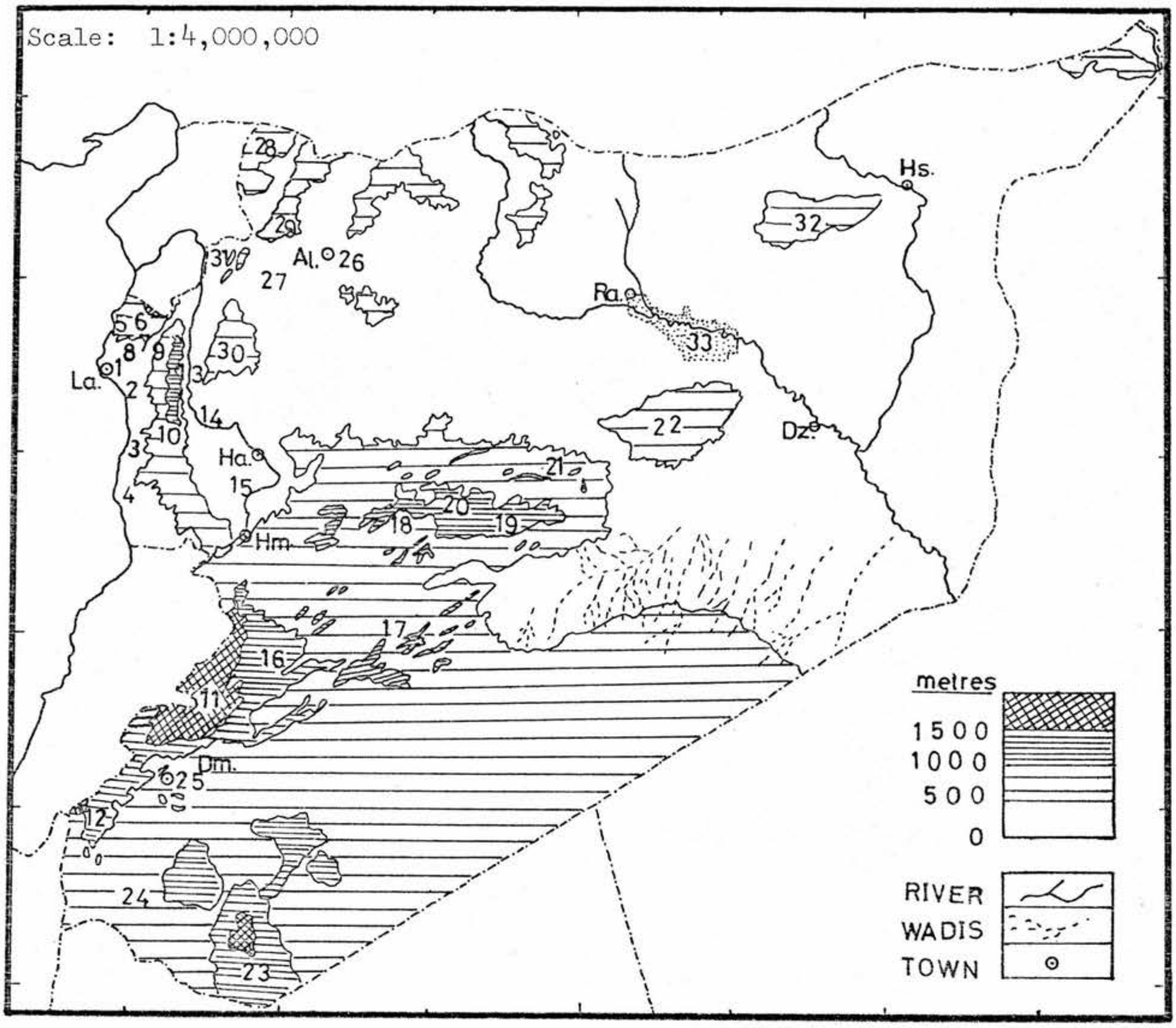


Figure 1.3b
PHYSIOGRAPHICAL FEATURES

1.	Latakia pl.	12.	Haramon Mt.	23.	Druz Mt.		
2.	Jablah pl.	13.	Gab pl.	24.	Horan pl.		
3.	Banias pl.	14.	Asharna pl.	25.	Ghota pl.		
4.	Tartus pl.	15.	Homs-Hama pl.	26.	Aleppo pl.		
5.	Bassit Mt.	16.	Kalamun Mt.	27.	Edleb pl.		
6.	Akra Mt.	17.	Palmyrean Mt.	28.	Kurd-Dag Mt.		
7.	Baer Mt.	18.	Balas Mt.	29.	Simon Mt.		
8.	Akrad Mt.	19.	Abiad Mt.	30.	Zawiya Mt.		
9.	Sahyoun Mt.	20.	Eshaara Mt.	31.	El-Ala Mt.		
10.	Ansariya Mt.	21.	Boueida Mt.	32.	Abdul-Aziz Mt.		
11.	Anti-Leban Mt.	22.	Bichri Mt.	33.	The Study Area Loc.		

La. Latakia	Hs. Hassakah
Al. Aleppo	Ha. Hama
Ra. Raqqa	Hm. Homs
Dz. Dier-ez-Zor	Dm. Damascus

Source: Ministry of Agriculture, Damascus.

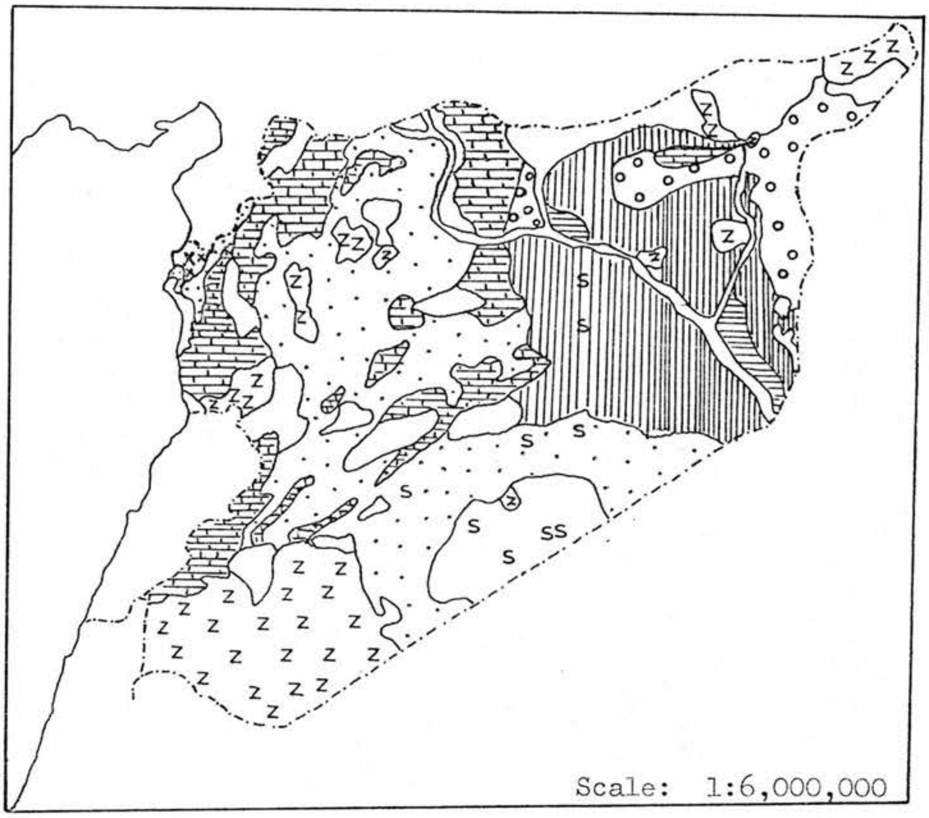
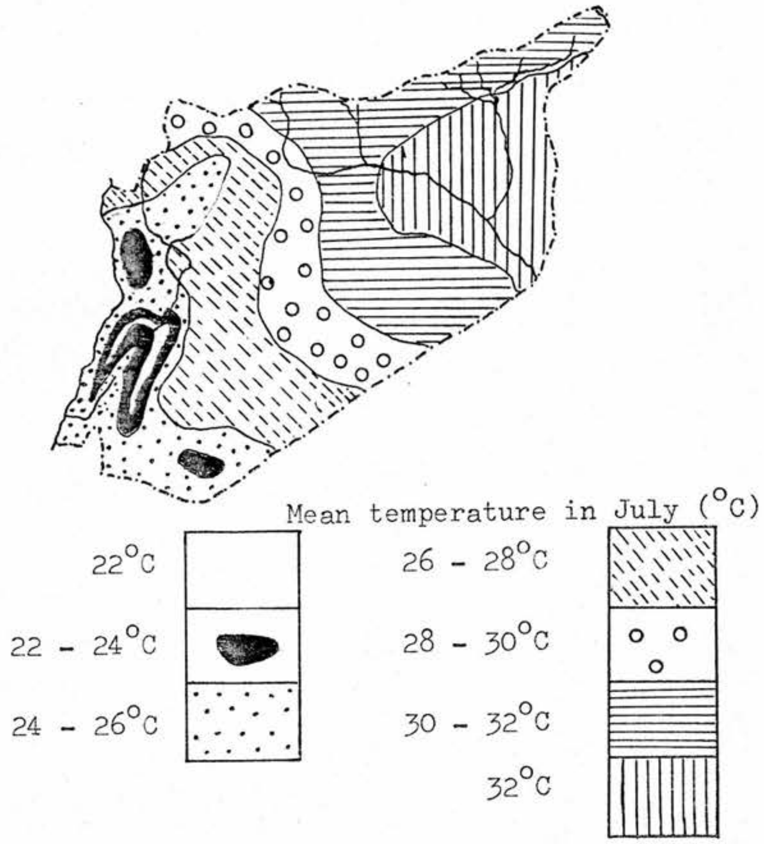


Figure 1.4
GEOLOGY OF SYRIA

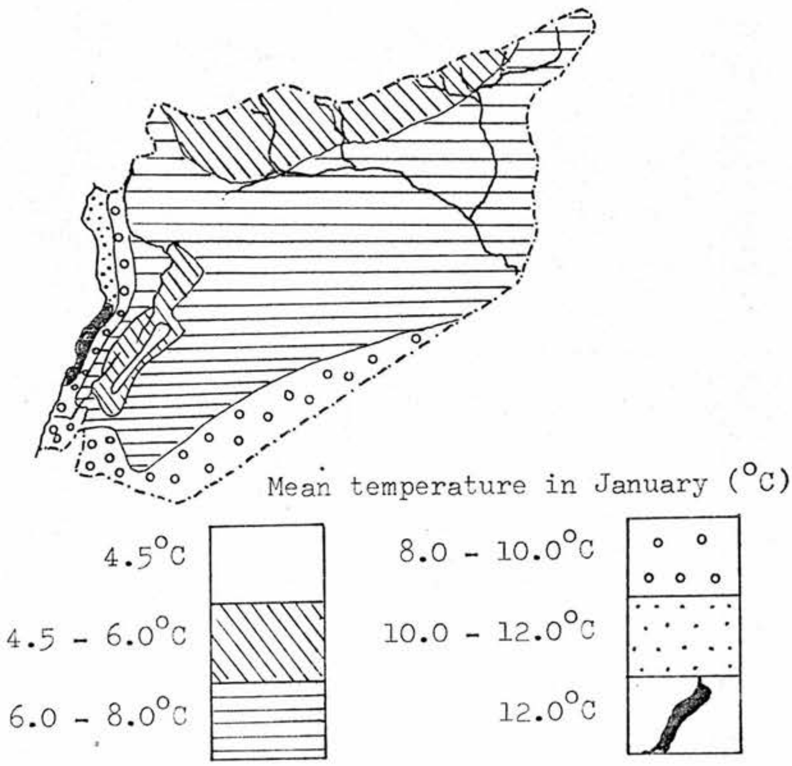
- fluvial, colluvial, and unconsolidated littoral sediments (marl, clay, sand, gravel)
- terrace sediments of the Euphrates and Khabour (sand, gravel, marl, partly with gypsum)
- limestone and dolomite limestone
- sandstone, partly with marl and limestone
- marl, in southeast possibly limestone (and dolomitie limestone)
- mainly lagoon sediments (gravel, marl, gypsum, anhydrite)
- gypsum and anhydrite (in spots limestone)
- basaltic soil mass
- volcanic green rocks (pyroxenolites, periodotites, serpentines) - gabbro and diorite - tuff

Source: Adapted from Department of Geology and Mineral Research, Damascus.

Figure 1.5
THE MEAN TEMPERATURE



Scale of the maps: 1:9,000,000



Source: Adapted from Ministry of Agriculture, Damascus.

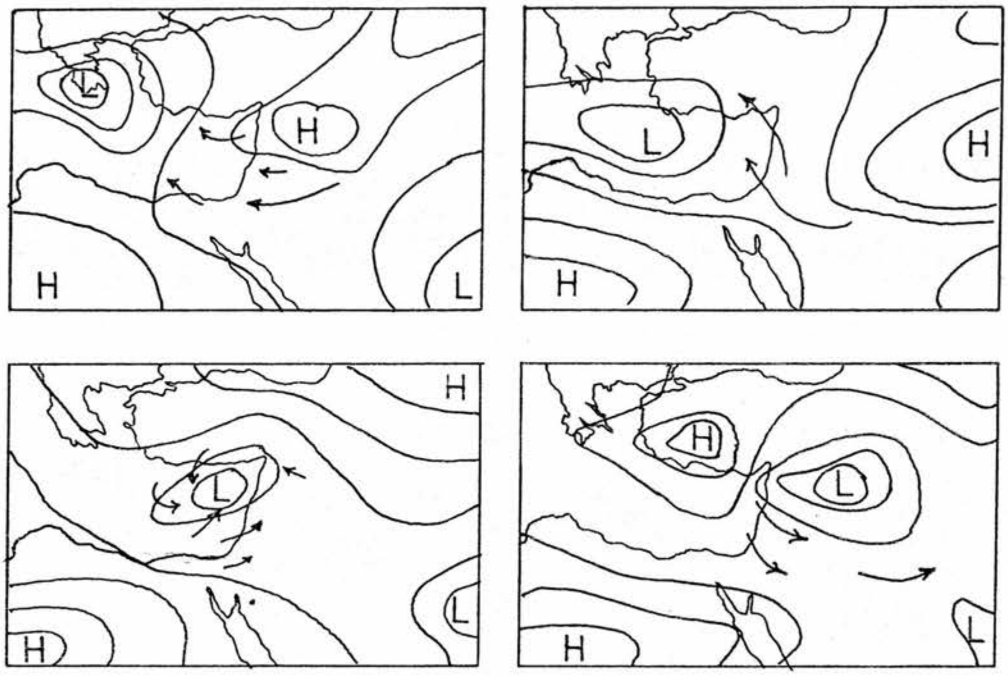


Figure 1.6
MOVEMENT OF CYCLONES AND ANTICYCLONES
OVER EAST MEDITERRANEAN COUNTRIES

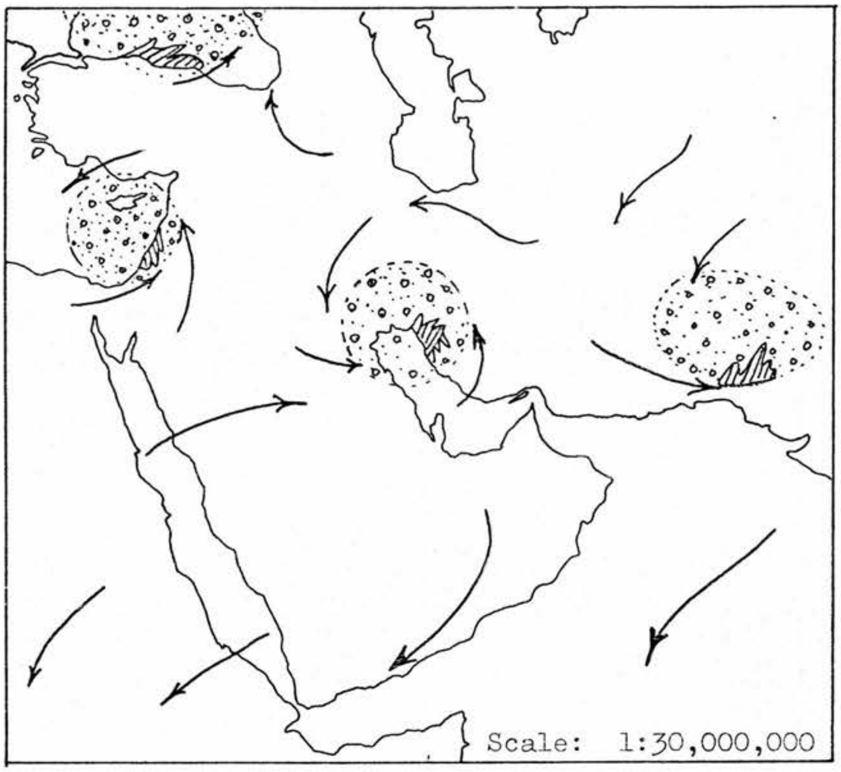
(L) Cyclones

(H) Anticyclones

(⟶) Wind directions

Source: Adapted from Fisher, 1971.

Figure 1.7
WIND SYSTEMS IN WINTER



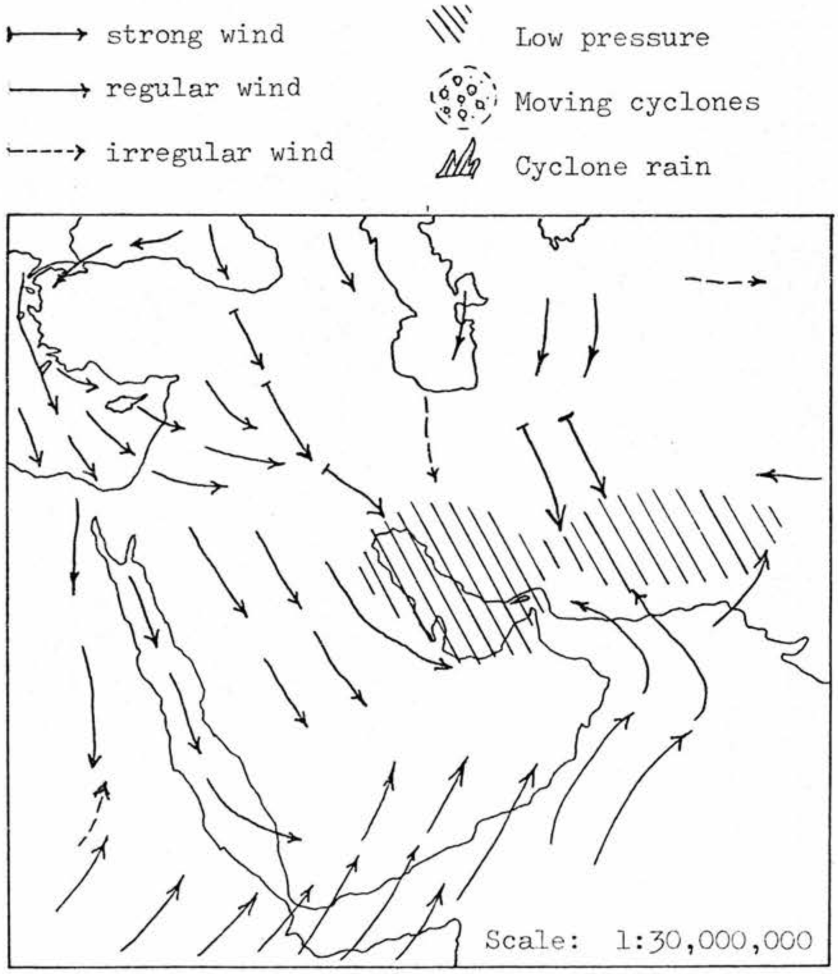


Figure 1.8
WIND SYSTEMS IN SUMMER

Source: Based on Fisher, 1971.

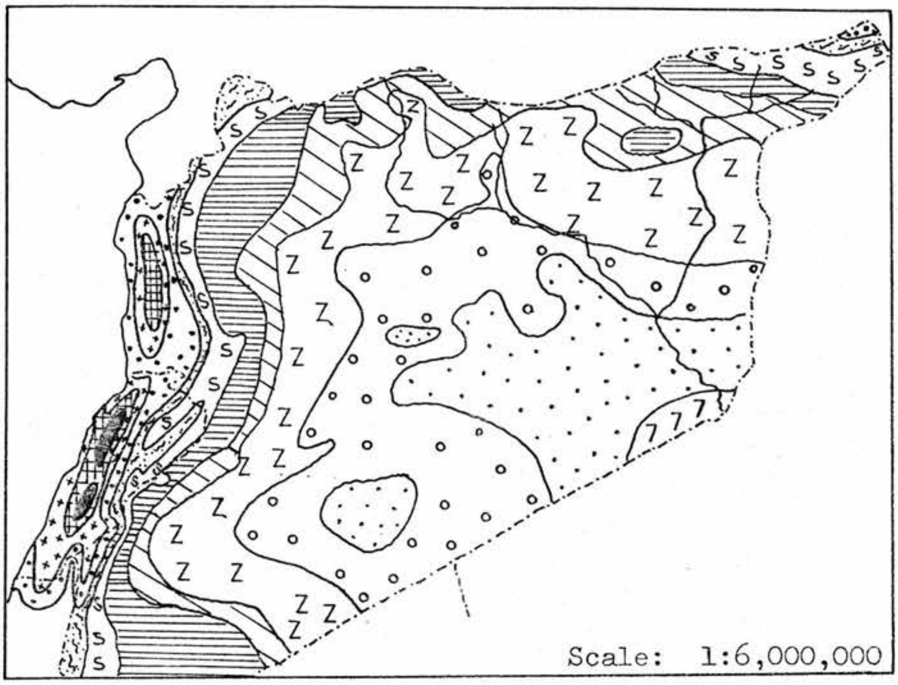
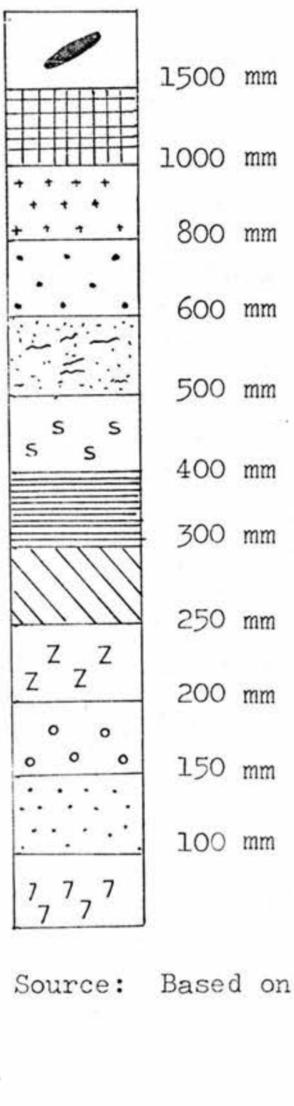


Figure 1.9
MEAN ANNUAL RAINFALL



This figure shows that the rainfall is increasing from the arid zone (100 mm) towards the Mediterranean coast (1000mm).

Source: Based on: Ministry of Agriculture, Damascus; Strebel, 1967.

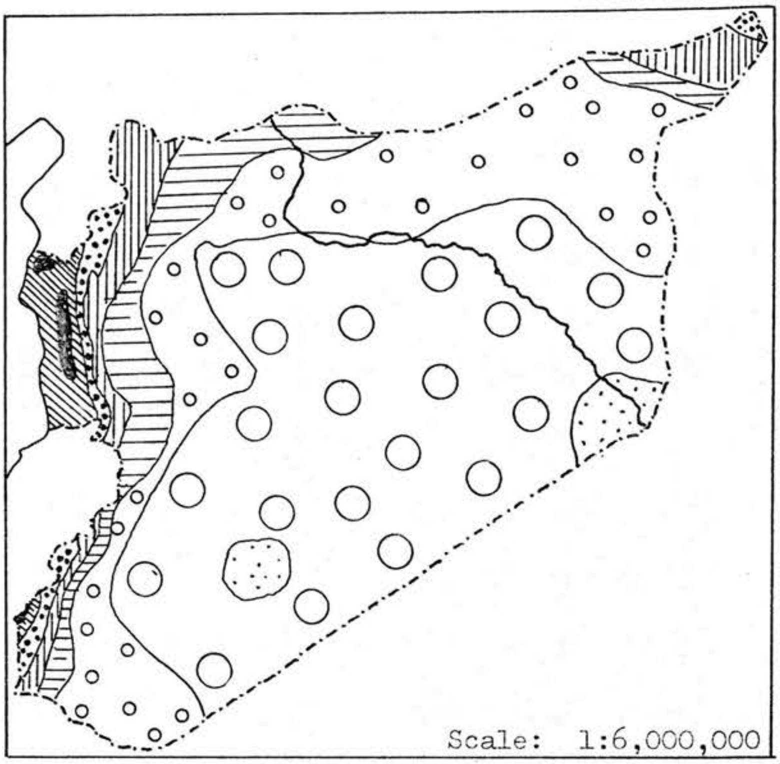
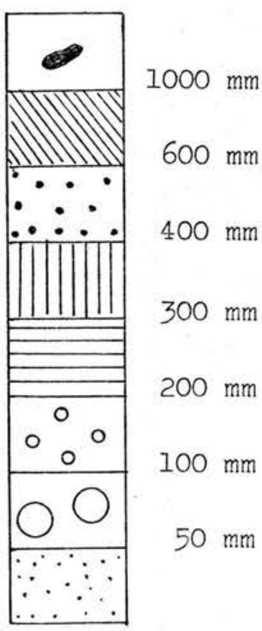


Figure 1.10
MEAN ANNUAL RAINFALL OF THE DROUGHT
PERIOD 1957-1961



Source: Based on Ministry of Agriculture, Damascus.

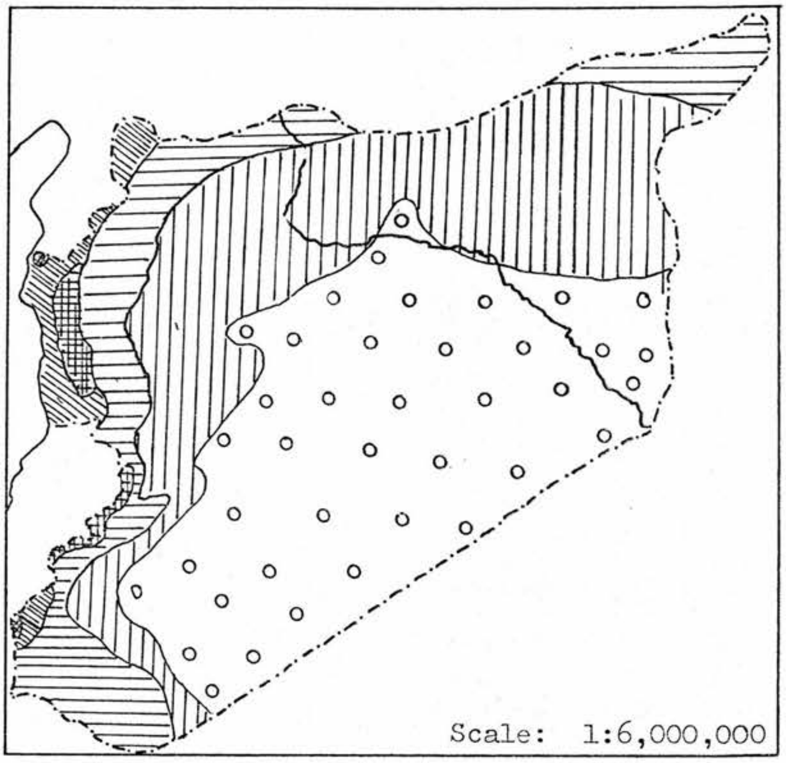
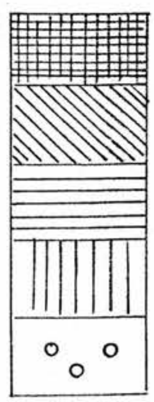


Figure 1.11
CLIMATOLOGICAL ZONES OF SYRIA



Mediterranean coastal zone

Semi-humid zone

Mediterranean mountain zone

Semi-arid zone

Arid zone

Source: Based on Ministry of Agriculture, Damascus.

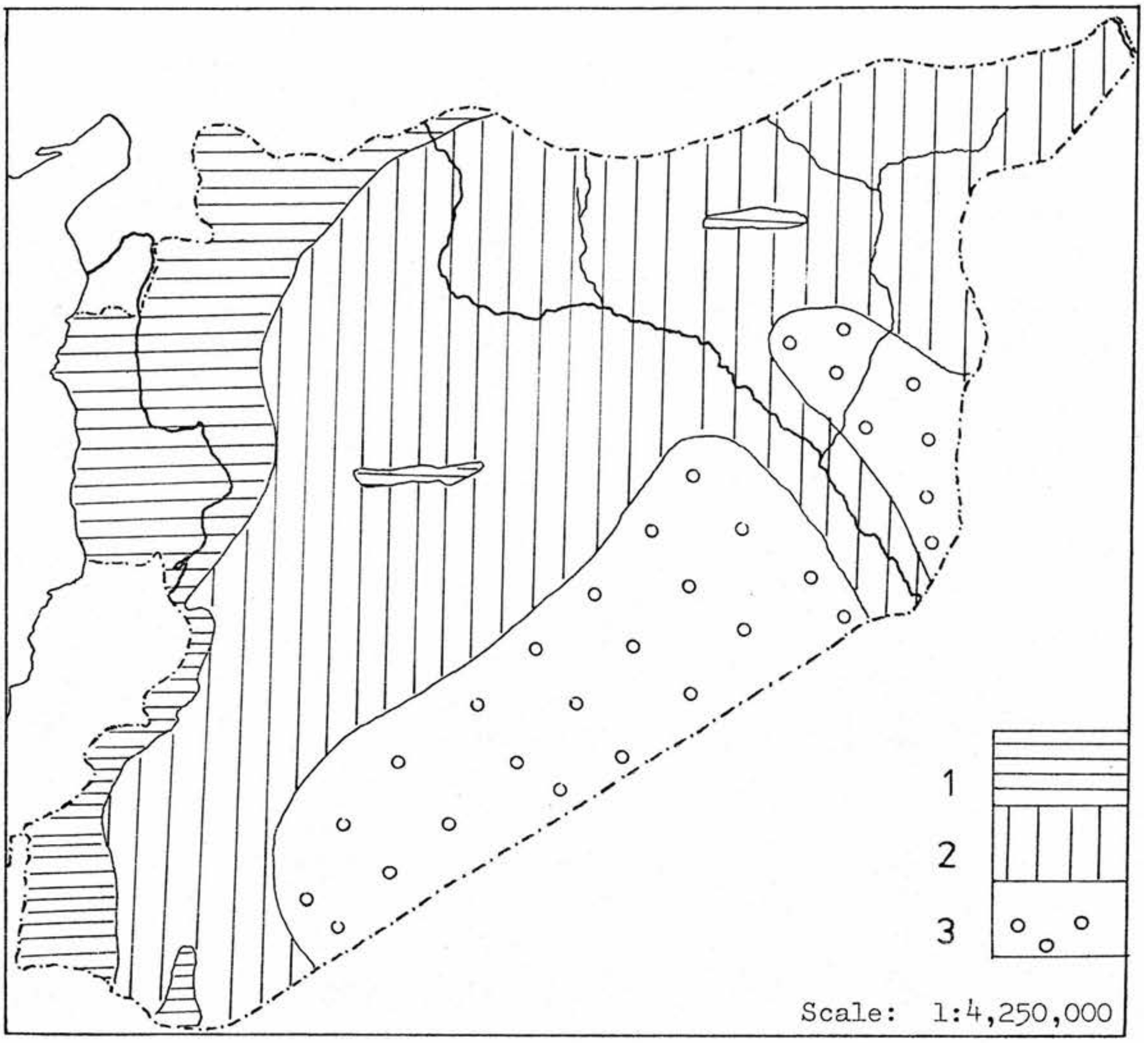


Figure 1.12
PHYTOGEOGRAPHIC REGIONS

1. The Mediterranean region

2. The steppe region

3. The desert region

Source: Based on Zohary, 1973.

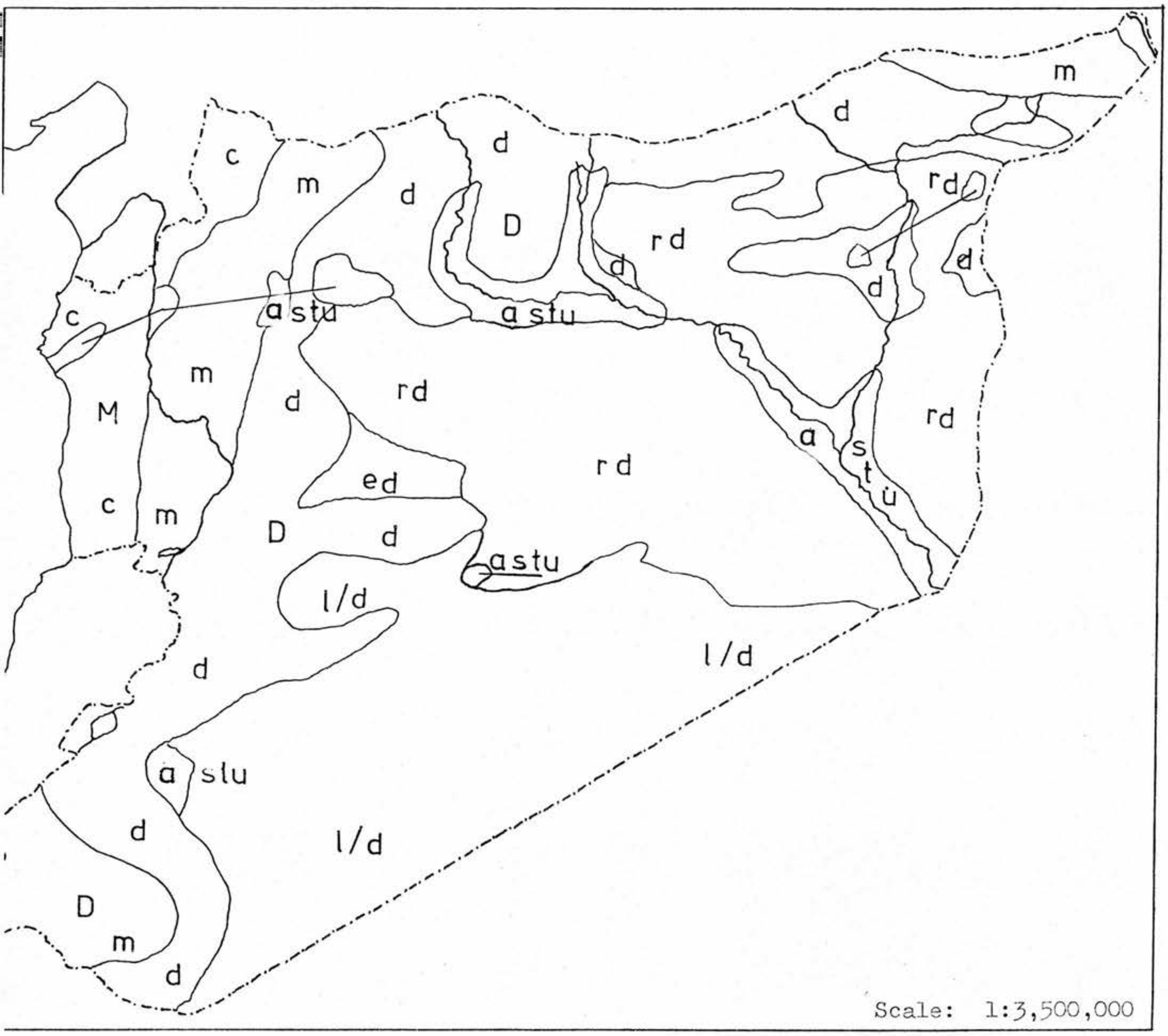


Figure 1.13
SOIL OF SYRIA

) desert

I Mediterranean mountain

Ic Mediterranean cinnamonic (the non-desert plains)

) <u>desert</u>

- alluvial
- . arid brown
- d desert sands
- . lithosols
- ; saline
- solonetz
- planosols
- 1 dark clay
- ·d serozems

M <u>Mediterranean mountain</u>

- c cinnamonic soils

here also the following:
terra rossa
recent brown
rendzinas
cinnamonic brown

Mc <u>non-desert plains</u>

- u planosols

here also the following:
rendzinas
terra rossa
recent brown

Source: After Papadakis, 1969.

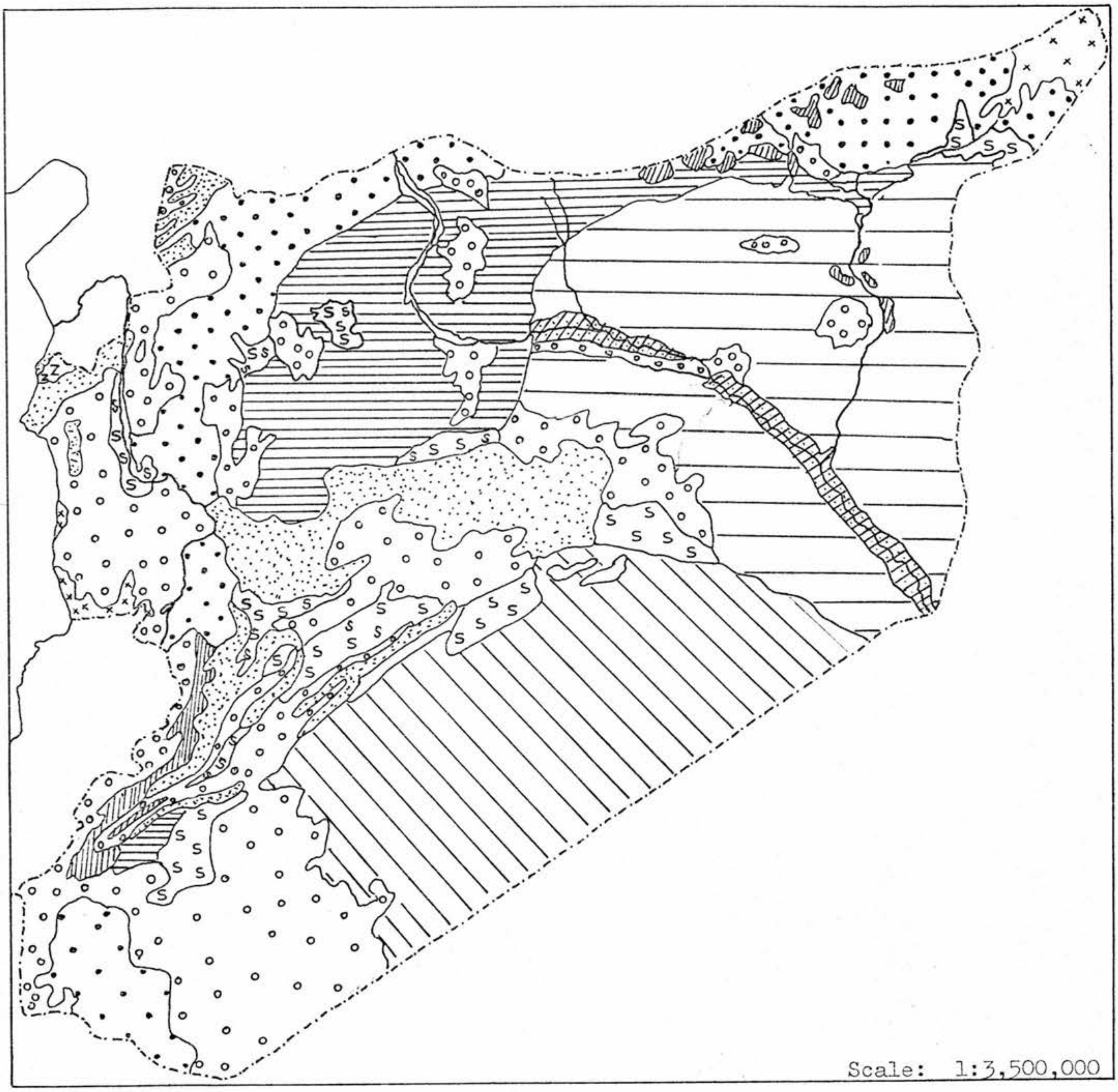
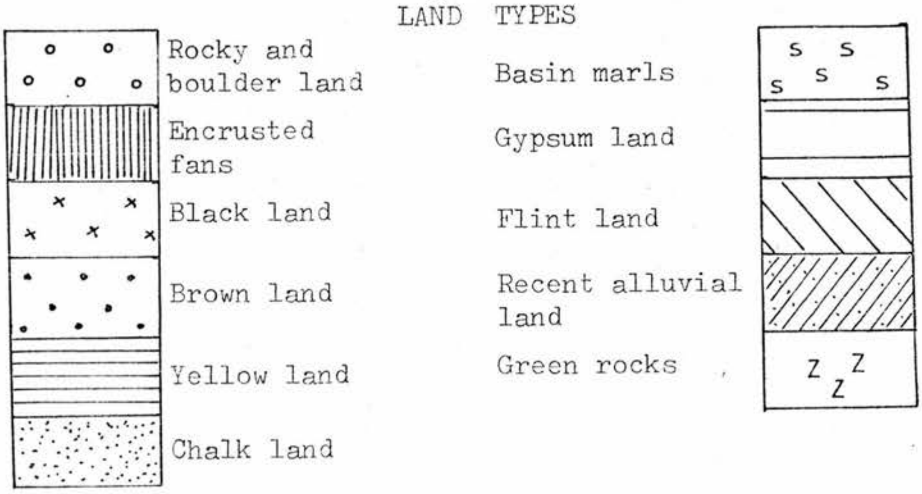


Figure 1.14
LAND TYPES



Source: Based on Ministry of Agriculture, Damascus;
Forestry Department, Latakia.

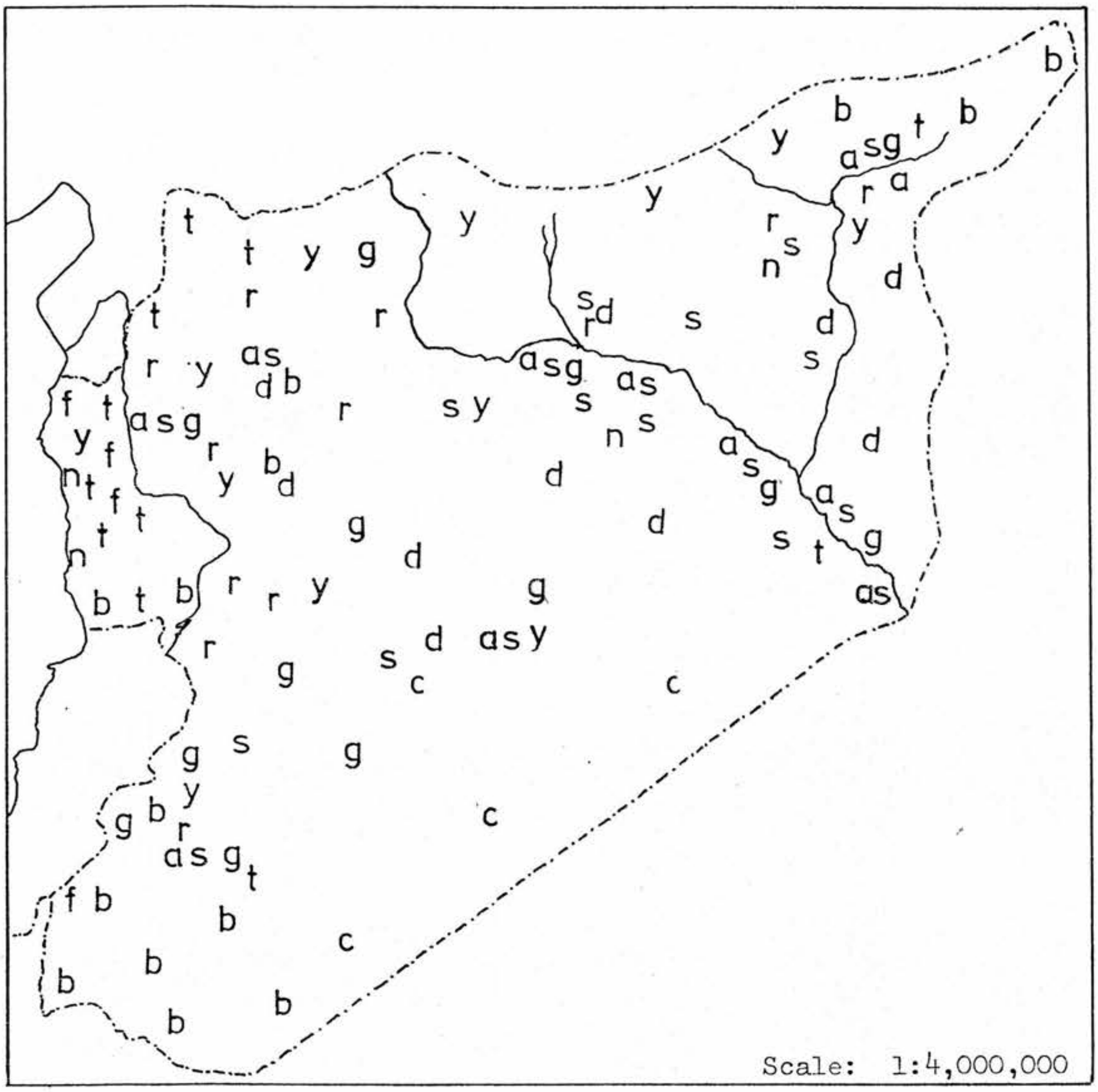


Figure 1.15
SOIL GROUPS OF SYRIA

R <u>The Syrian Arid Zone</u>

d	Brown desert soil	(1)
s	Solonchakous brown desert soil	(2)
a	Undeveloped alluvial soil	(3)
c	colluvial soil	
h	Hammada soil	

S <u>The Syrian Steppe Zone</u>

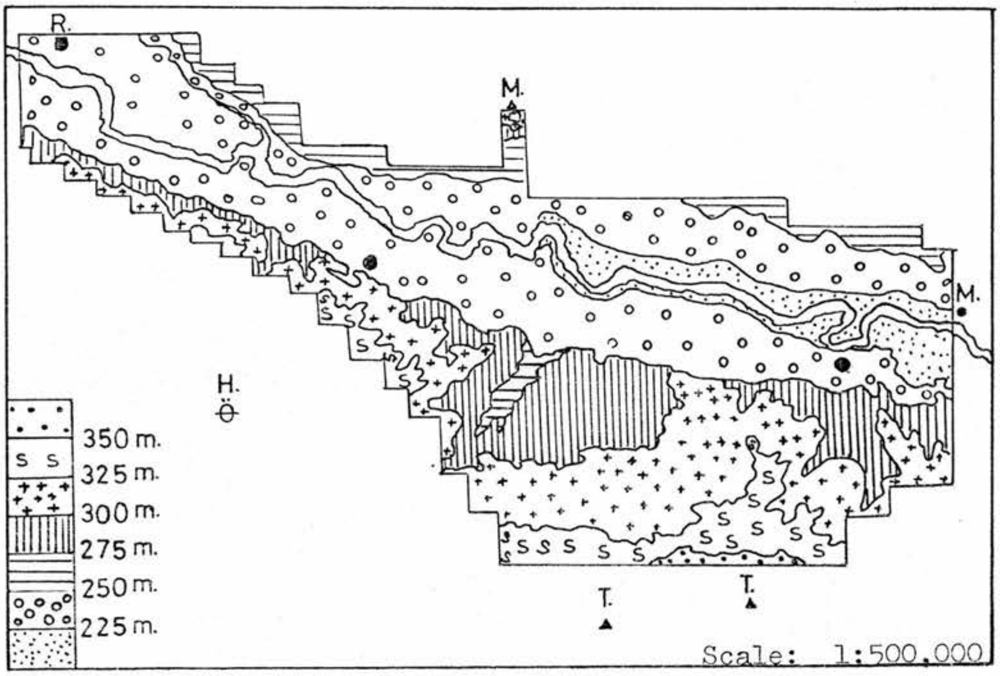
g	Grey-yellowish soil	(4)
r	Red-brown soil	(5)

M <u>The Syrian Mediterranean Zone</u>

t	Terra rossa soil	(6)
b	Brown soil on basalt	(7)
y	Greyey-yellow soil	(8)
n	Reddish sandy soil	(9)
f	Brown forest soil	(10)

Source: Based on: Ministry of Agriculture, Damascus; Muir, 1951; Strebel, 1964; Wolfart, 1967.

Figure 2.2
PHYSICAL FEATURES OF THE STUDY AREA



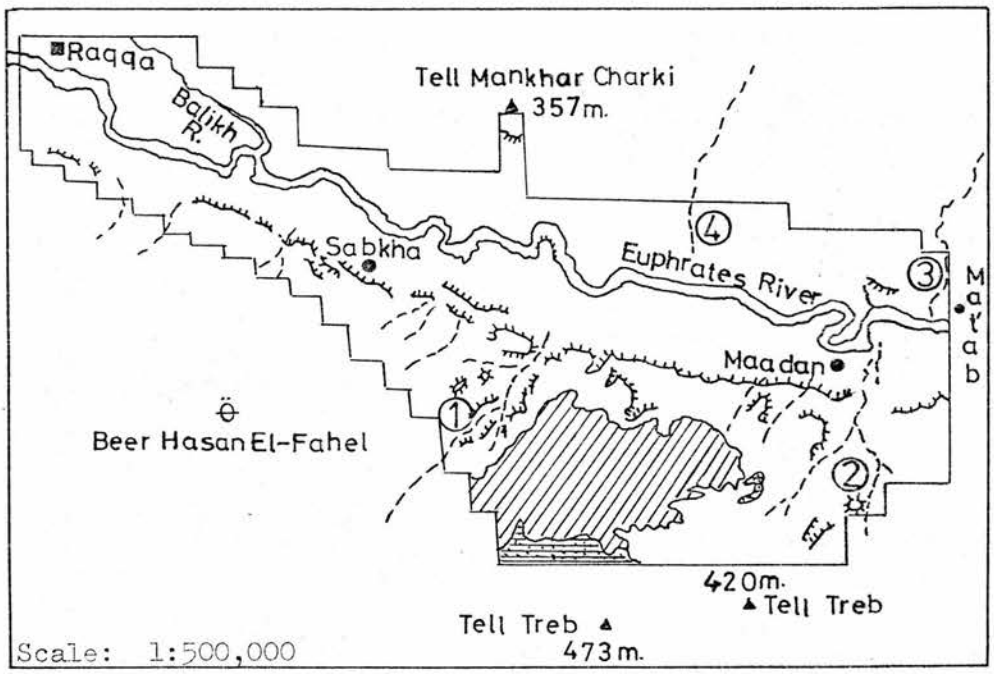
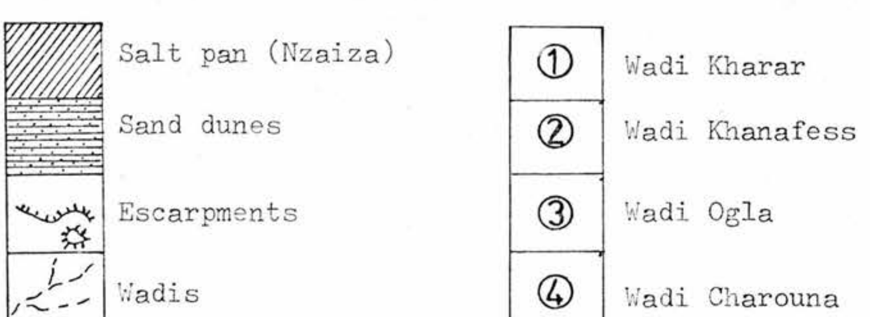


Figure 2.1
THE SITUATION OF THE STUDY AREA



Source: Topographical Syrian map 1:200,000.

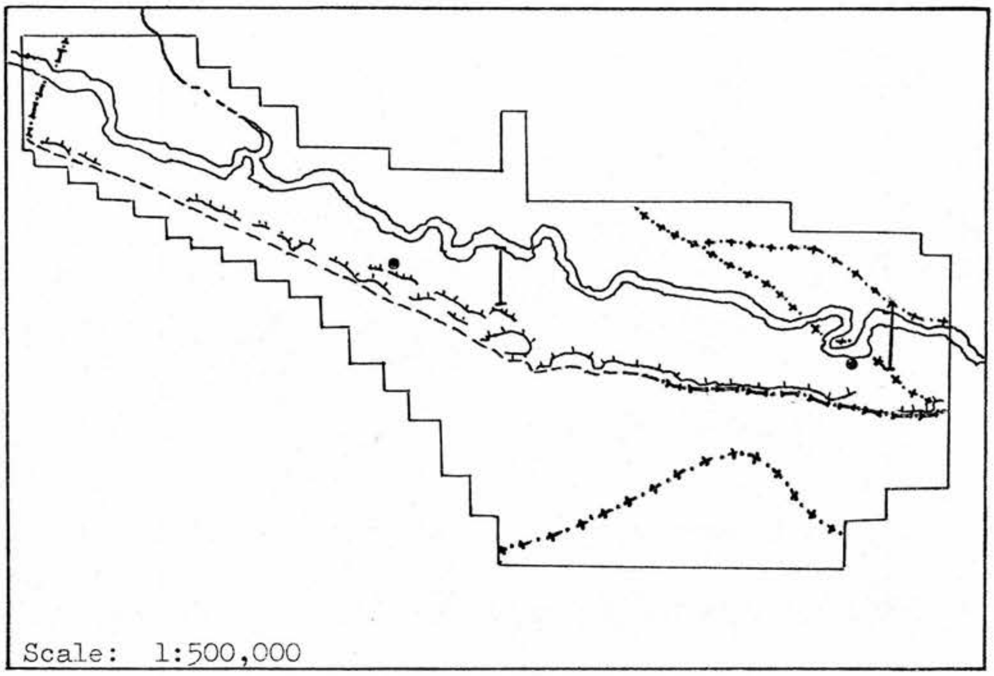
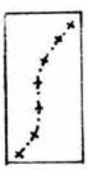


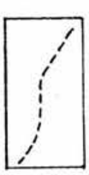
Figure 2.3
TECTONIC SCHEME

Source: Department of Geology and Mineral Research, Damascus, 1967.

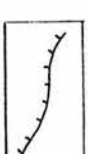


Anticlines (according to gravimetric data

Faults (according to geophysical data)



Faults expressed in landscape

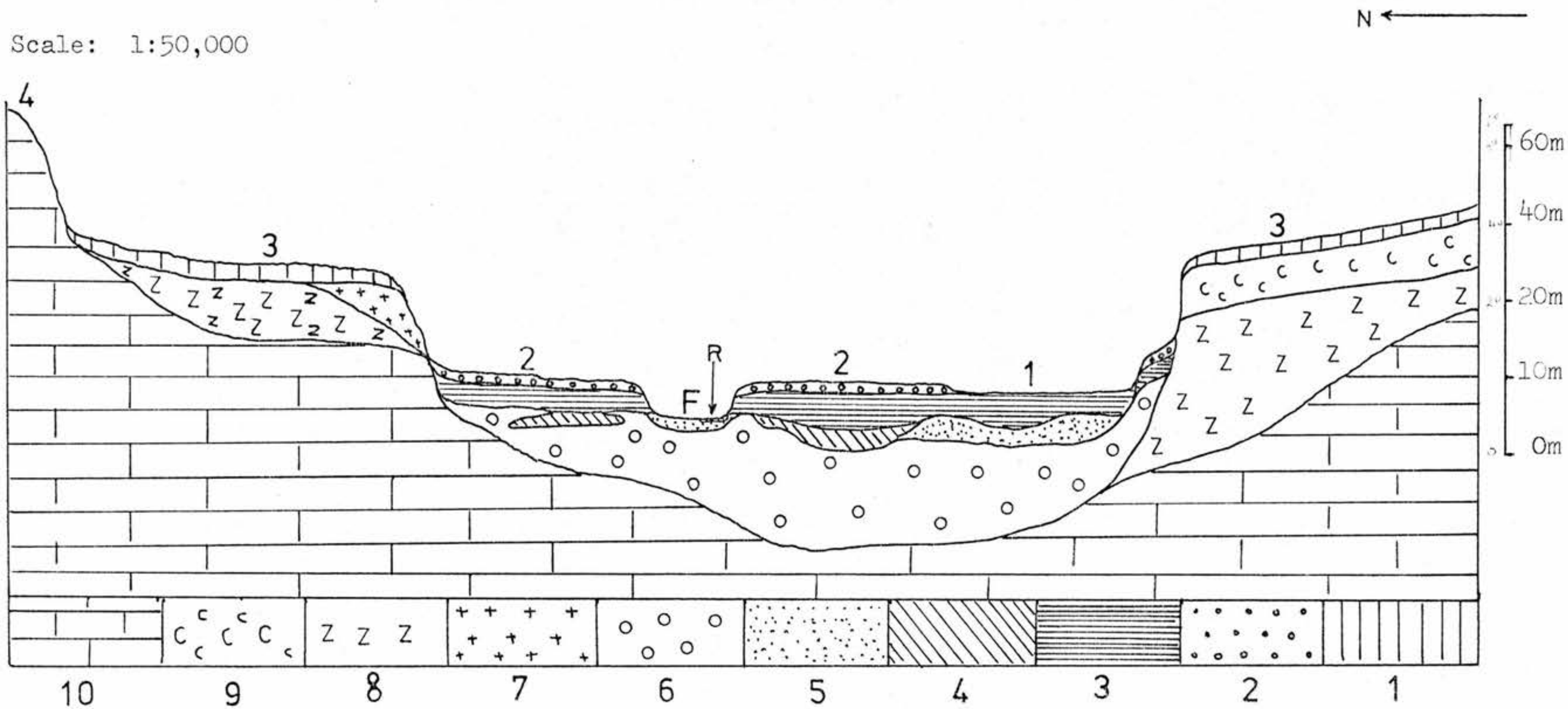


Escarpment

Location of the cross sections

Figure 2.4
CROSS SECTION OF THE EUPHRATES VALLEY 4 km EAST OF MAADAN VILLAGE
(Location of this cross section is given in Fig. 2.3)

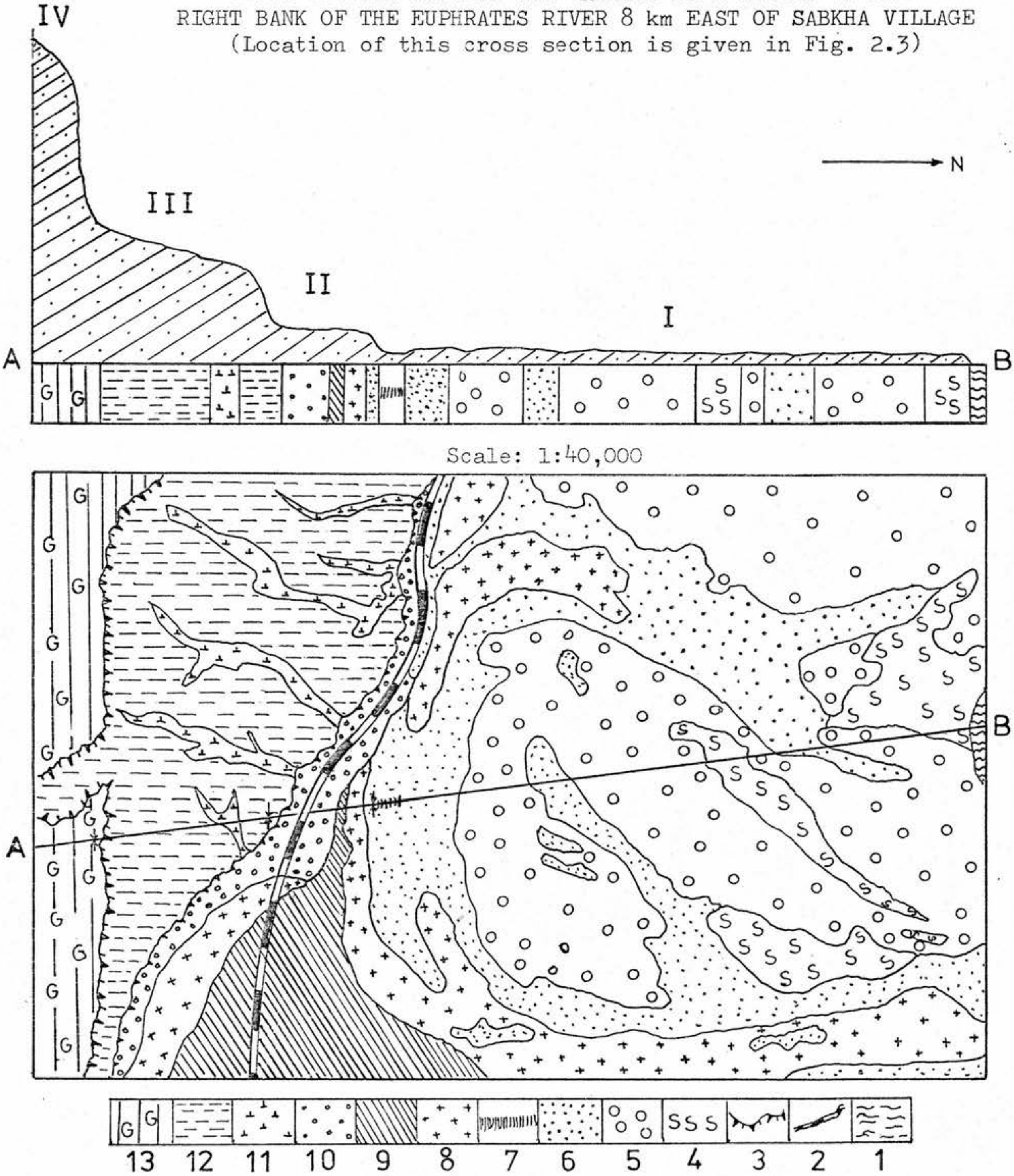
Scale: 1:50,000



1. Modern soils
2. Alluvial silty loams
3. Alluvial sandy loams
4. Alluvial sands
5. Alluvial gravelly sands
6. Alluvial shingle
7. Alluvial mixed with small pebbles and conglomerates
8. Alluvial mixed with fine pebbles and motteed conglomerates
9. Loams derived from aeolian
10. Bed rocks

Source: Based on: Department of Geology and Mineral Research, Damascus;
Fieldwork, Zouzou, R., 1961-74.

Figure 2.5
CROSS SECTION SHOWING THE VARIOUS SOIL GROUPS ON THE RIGHT BANK OF THE EUPHRATES RIVER 8 km EAST OF SABKHA VILLAGE
(Location of this cross section is given in Fig. 2.3)



The Euphrates river 1

Motorway Aleppo - Deir-ez-Zor 2

Escarpment 3

Terrace I
- Sandy soil deposits 4
- Sandy loam soil deposits 5
- Loamy soil deposits 6
- Alluvial loam and alluvial sand deposits with isolated saltwater ponds 7

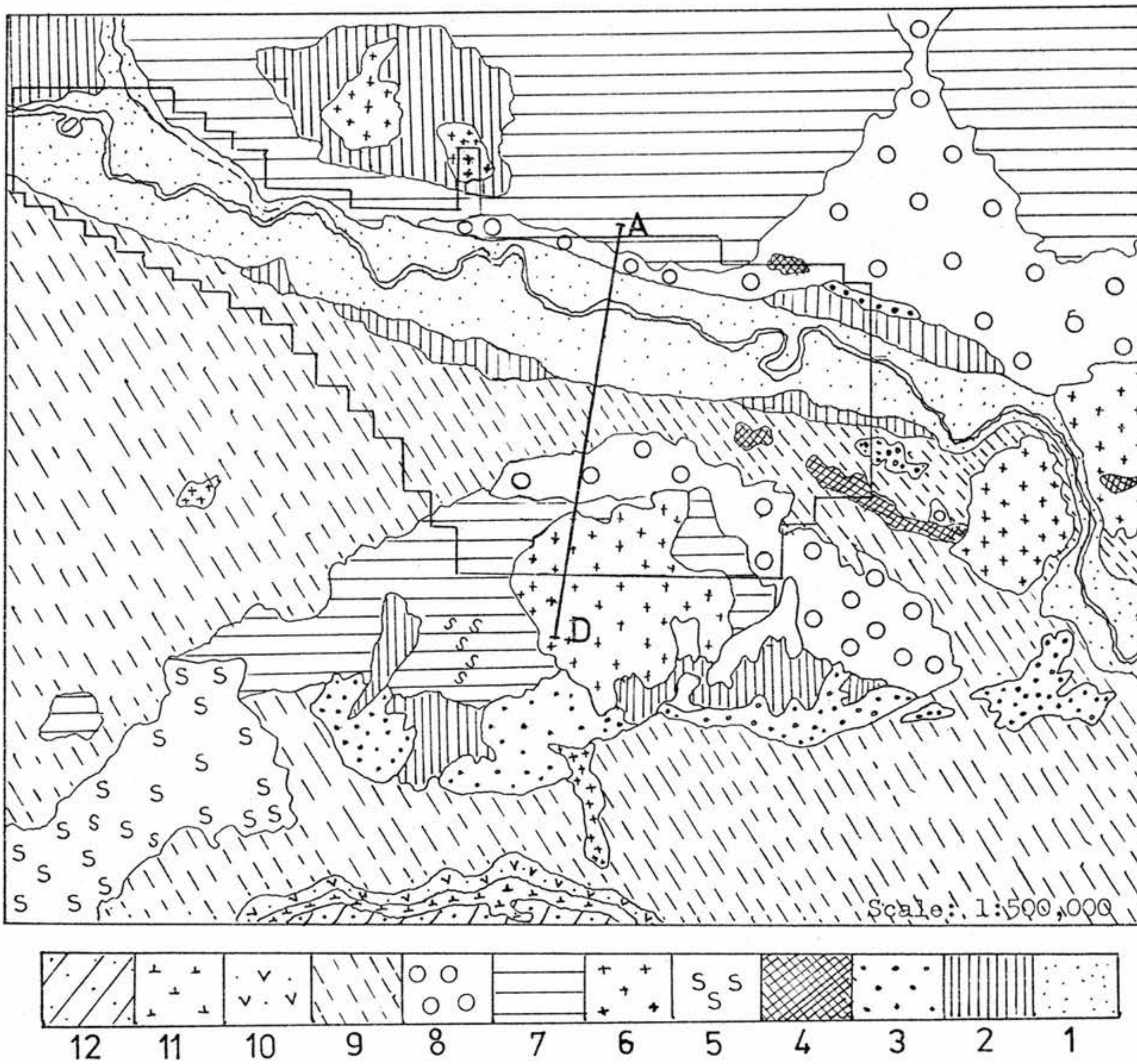
Terrace II
- Old sandy river bed deposits 8
- Old river bed deposits 9
- Wadi fans 10

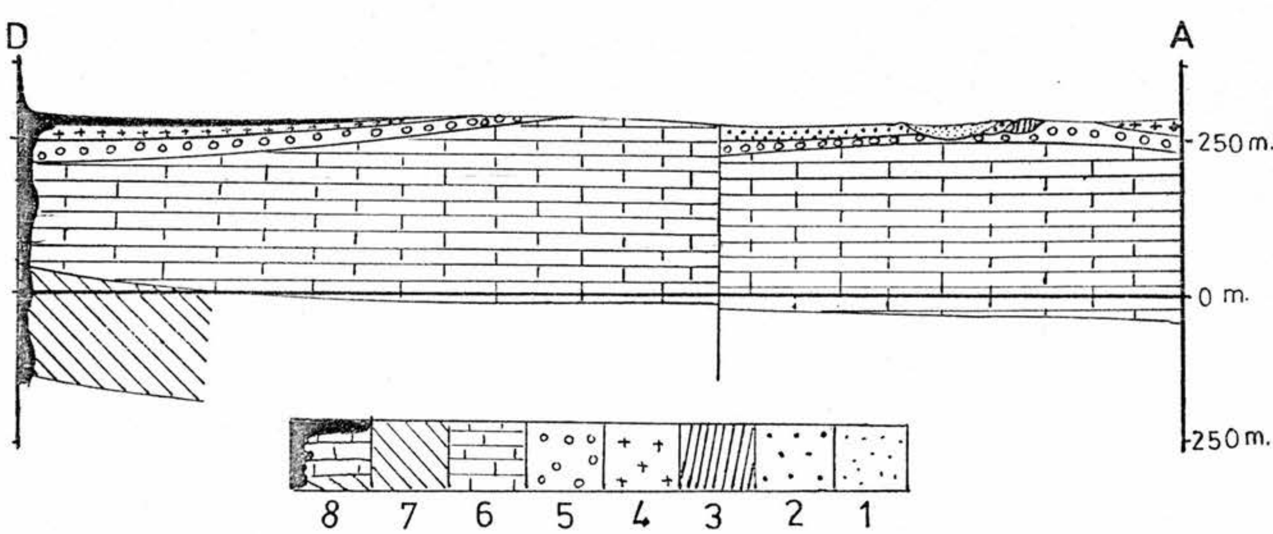
Terrace III
- Gullies formed by erosion, with shallow gypsiferous forms 11
- Gypsum powder and vertical gypsum plates 12

Terrace IV
- Gypsiferous materials 13

Source: Based on: Ministry of High Euphrates Dam, Damascus; Fieldwork, Zouzou, R., 1961-74.

Figure 3.1
GEOLOGY OF THE STUDY AREA





D - A   A GEOLOGICAL CROSS SECTION OVER THE STUDY AREA

Key overleaf

Key to Figure 3.1
GEOLOGY OF THE STUDY AREA

1. Recent Quaternary (flood plain and first terrace above the flood plain) deposits - sands, pebble beds, loams, clays, sandy loams; alluvial fans with pebble beds; aeolian sands, marine calcareous sandstones, sands, pebble beds.

2. Lower Quaternary deposits (the second terrace) - alluvial pebble beds and conglomerates, alluvial proluvial and proluvial pebble beds, conglomerates, loams, sandy loams; lacustrine clays and marls; marine calcareous sandstones, conglomerates.

3. Middle Quaternary deposits (the third terraces) - alluvial conglomerates and pebble beds; alluvial proluvial and proluvial conglomerates and pebble beds; marine calcareous sandstone, conglomerates; lacustrine gypsum and loams.

4. Upper Quaternary deposits (the fourth terrace) - alluvial conglomerates and pebble beds; alluvial proluvial and proluvial conglomerates; marine calcareous, sandstone and conglomerates.

5. Aeolian.

6. Basalts.

7. Pliocene deposits, clays, continental conglomerates, sandstone, limestone, marls; marine clays and tuff-breccia.

8. Upper Miocene deposits, clays, sandstone, marls, siltstones, gypsum (the Upper Fars formation) and basalts.

9. Tortonian (Upper and Lower) deposits (Middle Miocene), gypsum, limestones, marls, clays, sandstones, rock salts (the Lower Fars formation), gypsum, sandstone, silty clay.

10. Helvetian (Middle Miocene) deposits, limestone, conglomerates, sandstone and marls, and shell beds.

11. Lower Miocene deposits - continental quartz sands, marls, marine limestone, and shell beds.

12. Oligocene deposits, limestone, sandstone, and silty clay.

KEY TO GEOLOGICAL CROSS SECTION OVER THE STUDY AREA/

D - A A GEOLOGICAL CROSS-SECTION OVER THE STUDY AREA (between D (Tell Treb 473 m) and A 2 km north of Hammad Assaf village.
The vertical scale 1:13,000, the horizontal scale 1:200,000.

1. Recent. Pebbles and sands of flood plain and present stream of the Euphrates river.

2. Recent. Pebbles, sands, loams of the first terrace of the Euphrates river.

3. Lower Quaternary. Pebbles, sandy loam and boulders.

4. Pliocene, Lower part. Sands, sandstones, pebbles, clays and limestones.

5. Upper Miocene. Sandstones, siltstones, silty clays (Upper Fars formation).

6. Middle Miocene. Tortonian, Upper part. Gypsum, sandstones, silty clays (Lower Fars formation).

7. Middle Miocene. Tortonian, Lower part. Gypsum, marls, limestones, silty clays (Lower Fars formation).

8. Middle Quaternary. Basalts.

N.B. A MORE SPECIFIC INTERPRETATION OF THE GEOLOGICAL STRUCTURE OF THE STUDY AREA IS GIVEN IN STRUCTURE COLUMNS 3.1a and 3.1b./

STRUCTURE COLUMN 3.1a

QUATERNARY	QUATERNARY	0		Recent: F I Holocene		
				Upper II		
			35m	Middle III Pleistocene		
		35		Lower IV		
	PLIOCENE			Upper		Grey quartz sands, pebbles, sandstone and gravel
			80m	Lower		Grey sands, sandstones, pebbles, gravel, clay, and gypsum limestone
		115				
N E O G E N E	M I O C E N E		95m	Upper M	Upper Fars	Brown sandstone, silt stone, silty clay
			300m	Middle M Tortonian	Lower Fars	Upper part of Lower Fars, light gypsum, vari-coloured sandstones, silt clays
			260m	Middle M Tortonian		Lower part of Lower Fars, light grey gyspum, marls, limestone, silty clay
			30m	Middle M Helvetian		Light marls, limestones, shelly beds, and carbonate breccias
			50m	Lower M		Grey quartz sands, sandstones
PALEOGENE	OLIGOCENE	850				
		895	45m	Oligocene		Sandstone, limestone, silty clay, dolomites

Source: Department of Geology and Mineral Research, Damascus 1963.
Fieldwork, Zouzou, R., 1974.

STRUCTURE COLUMN 3.1b

Series	Subseries	Stage	Index	Thickness (m) Euphrates	Thickness (m) Balikh	The Age (years)	Climate
RECENT		Flood plain	Q	1-2	2-3	Contemporary	High evaporation
HOLOCENE		Subatlantic				After 500 BC	Arid, slightly moist
		Sub-boreal				2500- 500 BC	Extremely arid
		Atlantic	Q_1	3-5	3-7	5600-2500 BC	Moist, warm
		Boreal				6800-5600 BC	Aridity
		Pre-boreal				8500-6800 BC	Extremely arid
PLEISTOCENE	Upper	Upper Pleistocene	Q_2	12-15	12-22	100,000 BC	Post pluvial Günzglacial
	Middle	Middle Pleistocene	Q_3	25-35	30-50	475,000 BC	Interpluvial Mindelglacial
	Lower	Lower Pleistocene	Q_4	60-120	65	600,000 BC	Pluvial Würmglacial
PLIOCENE	Upper	Upper part of Pliocene	N_2^b	35		About 5,000,000 BC	Strong rainfall causing river and wadis, and warm climate
	Lower	Lower part of Pliocene	N_2^a	45			
MIOCENE	Upper	Upper Fars	N_1^3	95		About 19,000,000 BC	Climate moderate, and marine with fresh water deposits ($CaSO_4$), and salt rocks
	Middle (TORTONIAN)	Lower Fars	N_1^b	300			
	Middle (TORTONIAN)	Lower Fars	N_1^a	260			
	Middle	Helvetian	N_1^h	30			
	Lower	Lower Miocene	N_1^1	50			

Sources: Butzer, 1961; Department of Geological and Mineral Research, Damascus, 1963; Technoexport, 1963.

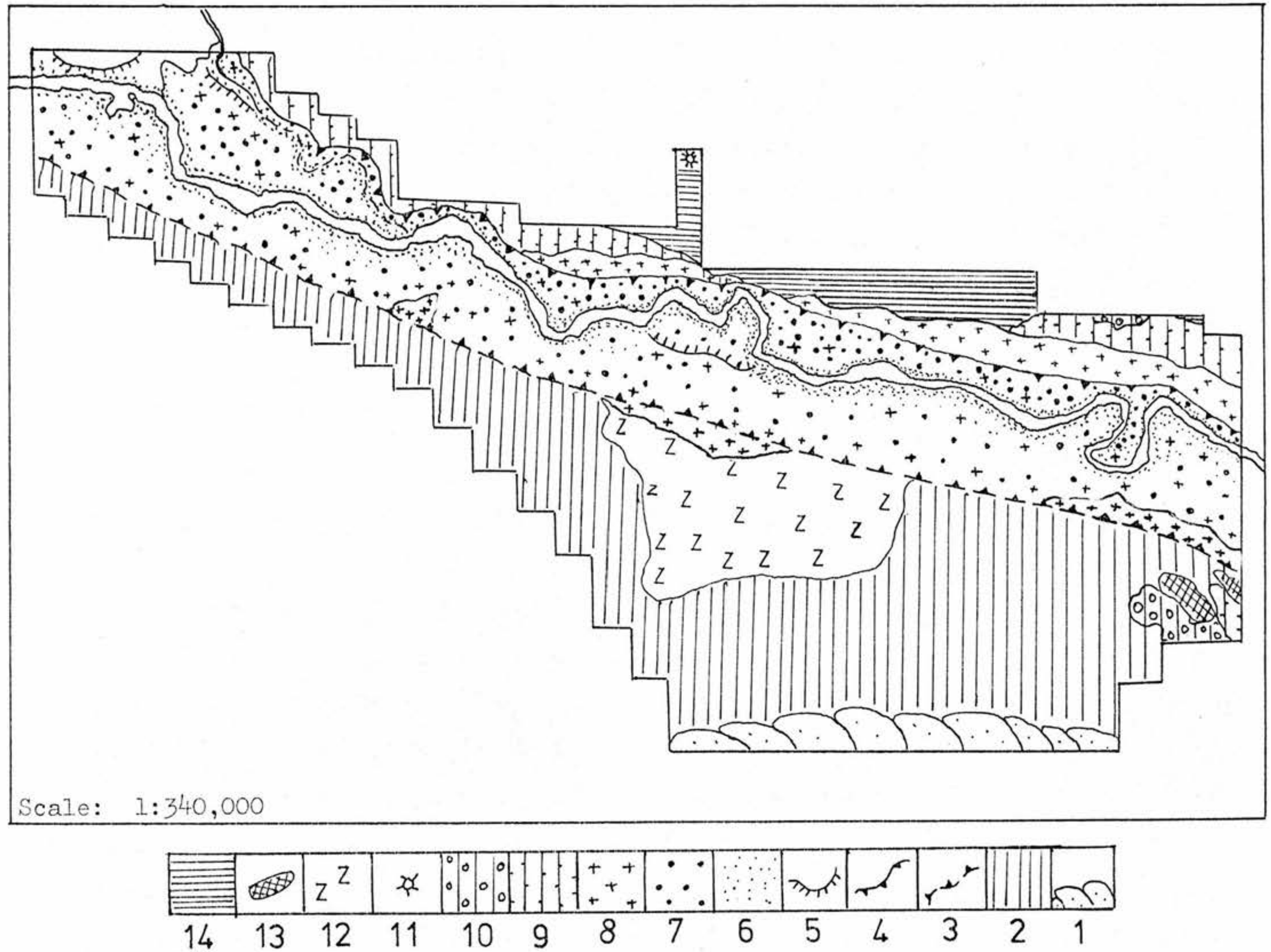


Figure 3.2
GEOMORPHOLOGY OF THE STUDY AREA

Key overleaf

Key to Figure 3.2
GEOMORPHOLOGY OF THE STUDY AREA

1. Upper Quaternary and recent alluvial fans
2. Gently undulating plains
3. Faults recognizable in the relief as scarps
4. Cusps of compound terraces
5. Cusps of aggradation terraces
6. Flood plain with the lacustrine saline plains
7. First terrace above the flood plain (Recent Quaternary deposits)
8. Second terrace above the flood plain (Lower Quaternary deposits)
9. Third terrace above the flood plain (Middle Quaternary deposits)
10. Fourth terrace above the flood plain (Upper Quaternary deposits)
11. Volcanoes extinct
12. Sloping plains
13. Karst formation
14. Undulating alluvial proluvial plains, with shallow erosion valleys

Source: Based on Department of Geology and Mineral Research, Damascus, 1964.
Applied to Fieldwork, Zouzou, R., 1961-74.

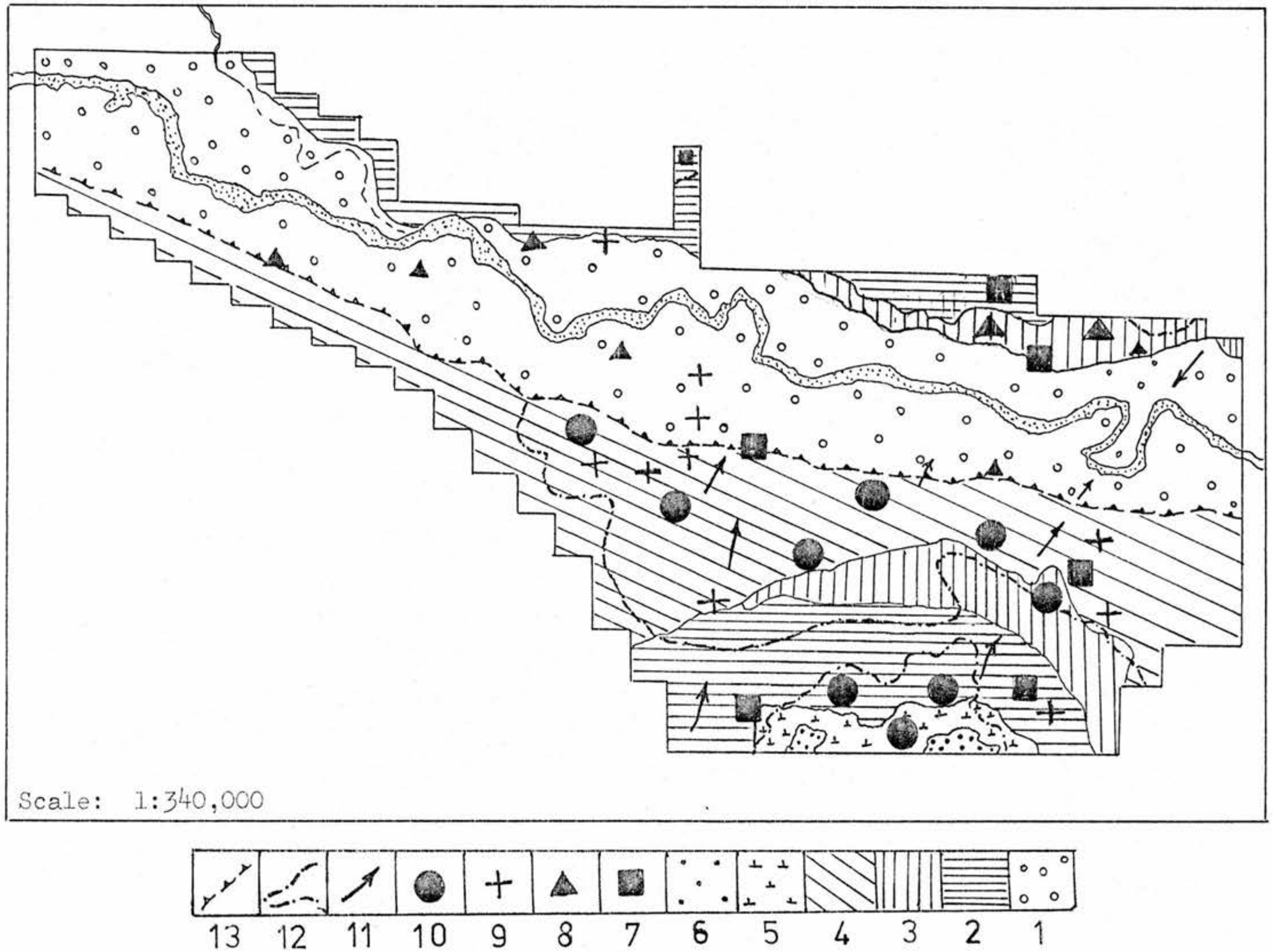


Figure 3.3
HYDROLOGY OF THE STUDY AREA

Key overleaf

Key to Figure 3.3
HYDROLOGY OF THE STUDY AREA

1. Quaternary alluvial deposits: pebbles, sands, sandy loams, loams.
2. Pliocene deposits: sands, sandstones, pebbles, conglomerates, marls.
3. Upper Miocene deposits: sands, sandstones, siltstones.
4. Middle Miocene deposits: sands, sandstones, sandy limestones.
5. Water with chloride anions.
6. Water with hydro-carbonate anions.
7. Where major anion is sulphate.
8. Less than 1 g/l.
9. From 1 - 3 g/l.
10. Over 3 g/l.
11. The main direction of water flow.
12. Contour line of the water table.
13. Faults.

Source: Based on Department of Geological and Mineral Research, Damascus, 1964. and fieldwork, Zouzou, R., 1961-74.

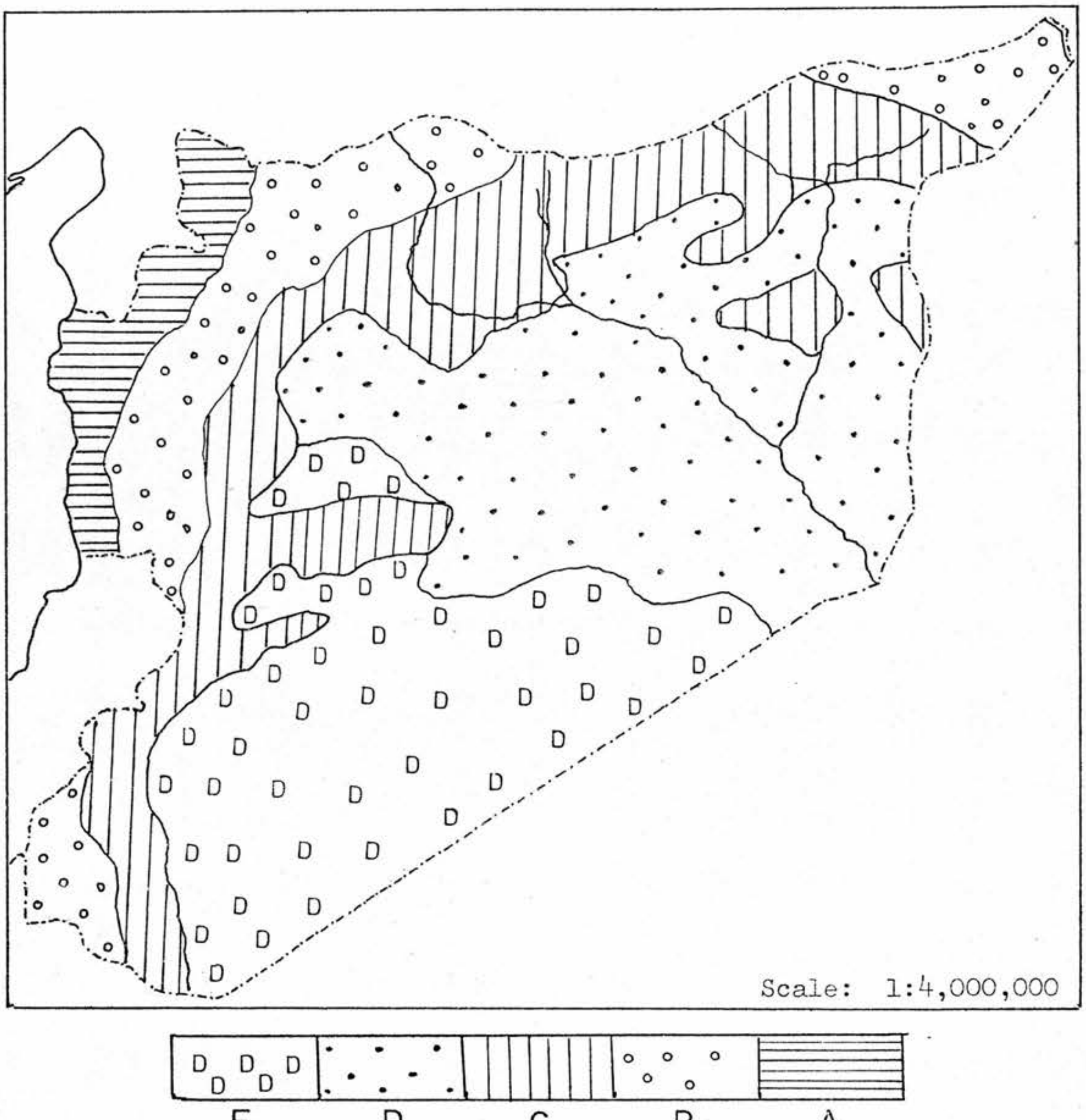


Figure 3.4
MAIN SOIL TYPES OF SYRIA

A Red Mediterranean soil

B Grumusol soil

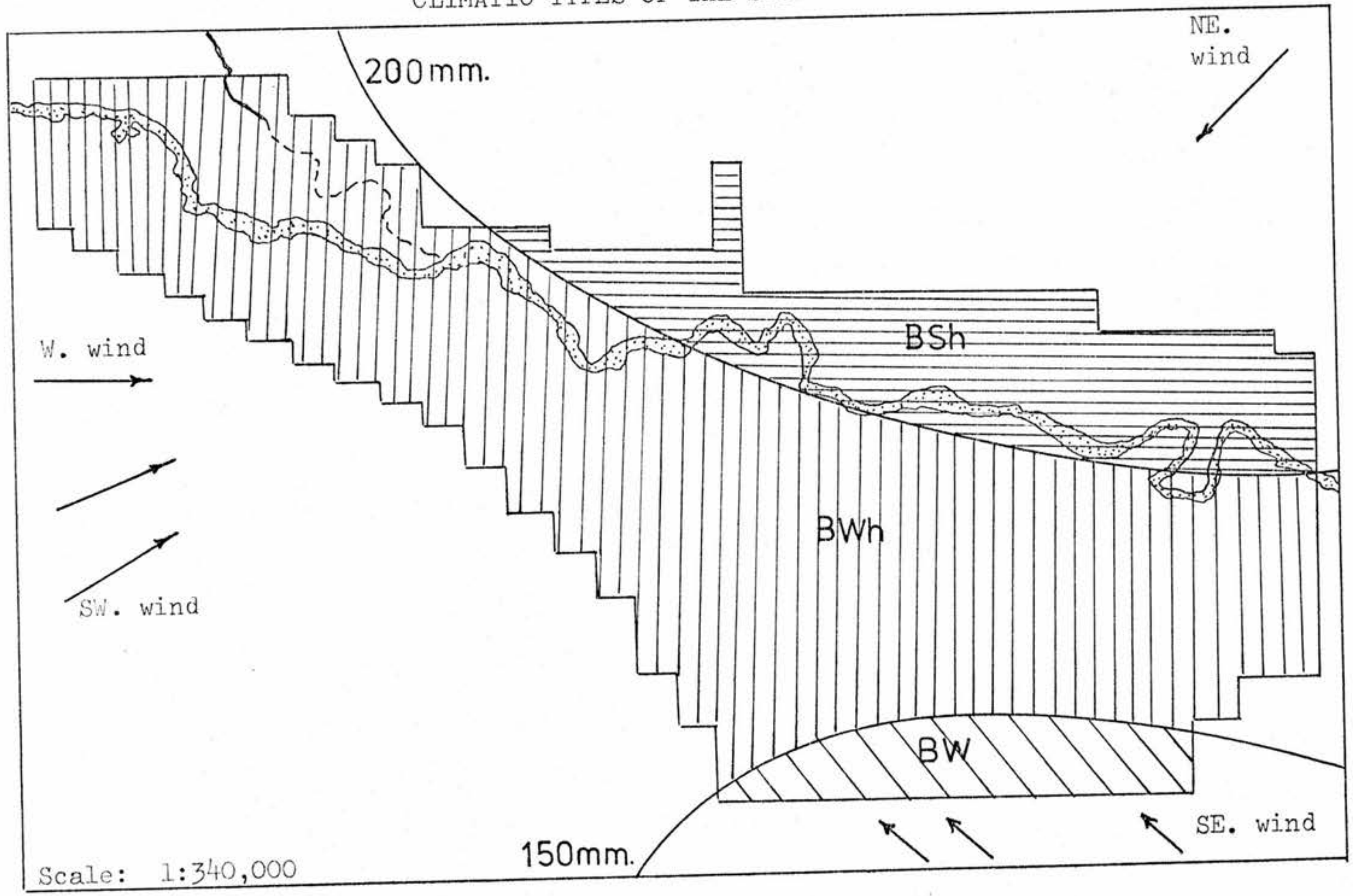
C Arid Brown soil

D Gypsiferous soil

E Grey desert soil

Source: After: van Liere, 1965;
Ministry of Agriculture, Damascus.

CLIMATIC TYPES OF THE STUDY AREA



BSh Semi-arid (average annual temperature over 18°C)

BWh Arid (average annual temperature over 20°C)

BW Desert or extremely arid (average annual temperature over 22°C)

Source: Based on Koppen's Classification.

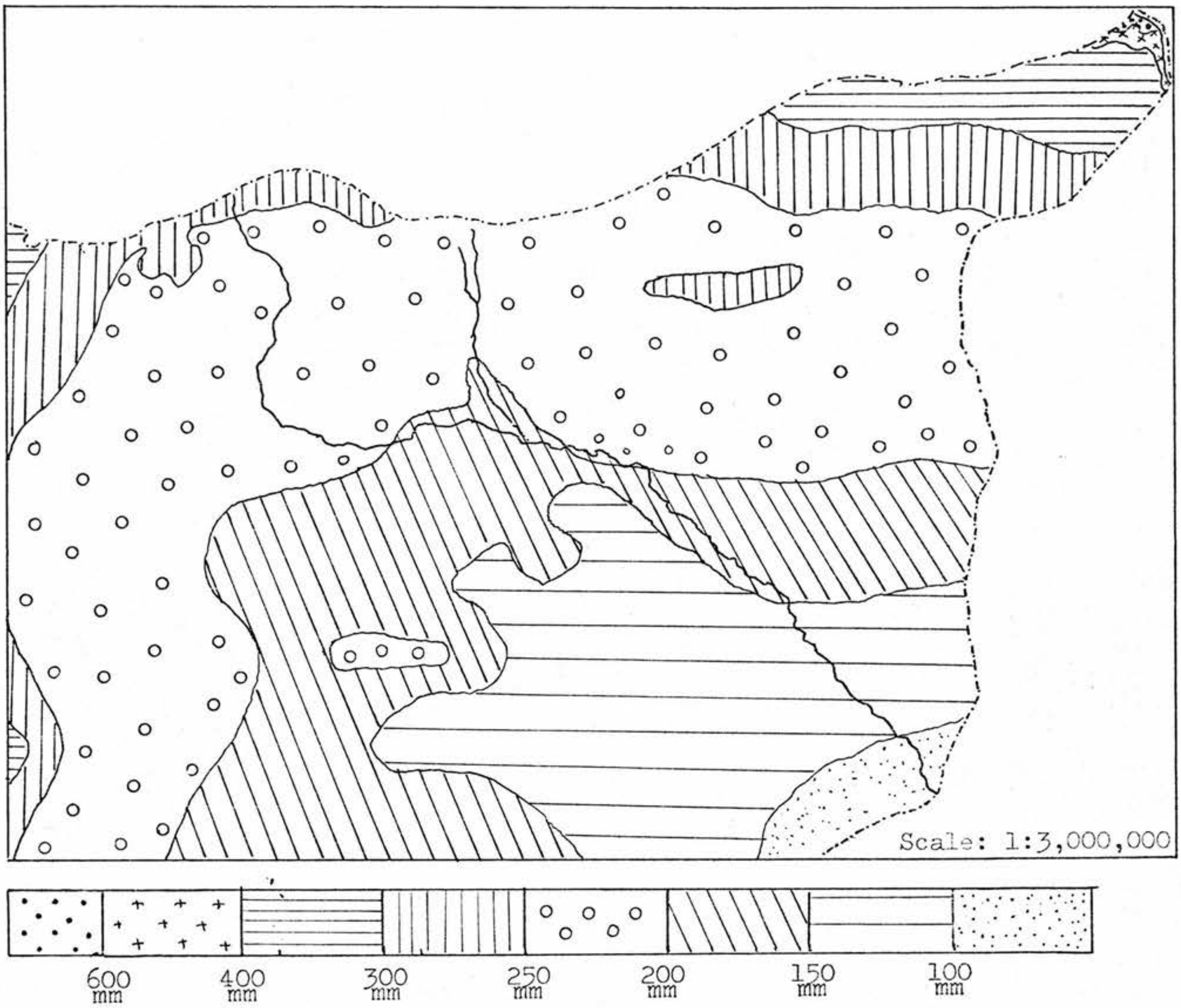


Figure 3.6
ISOHYETAL MAP OF THE STUDY AREA

Source: Based on: Ministry of Agriculture, Damascus;
Strebel, 1967.

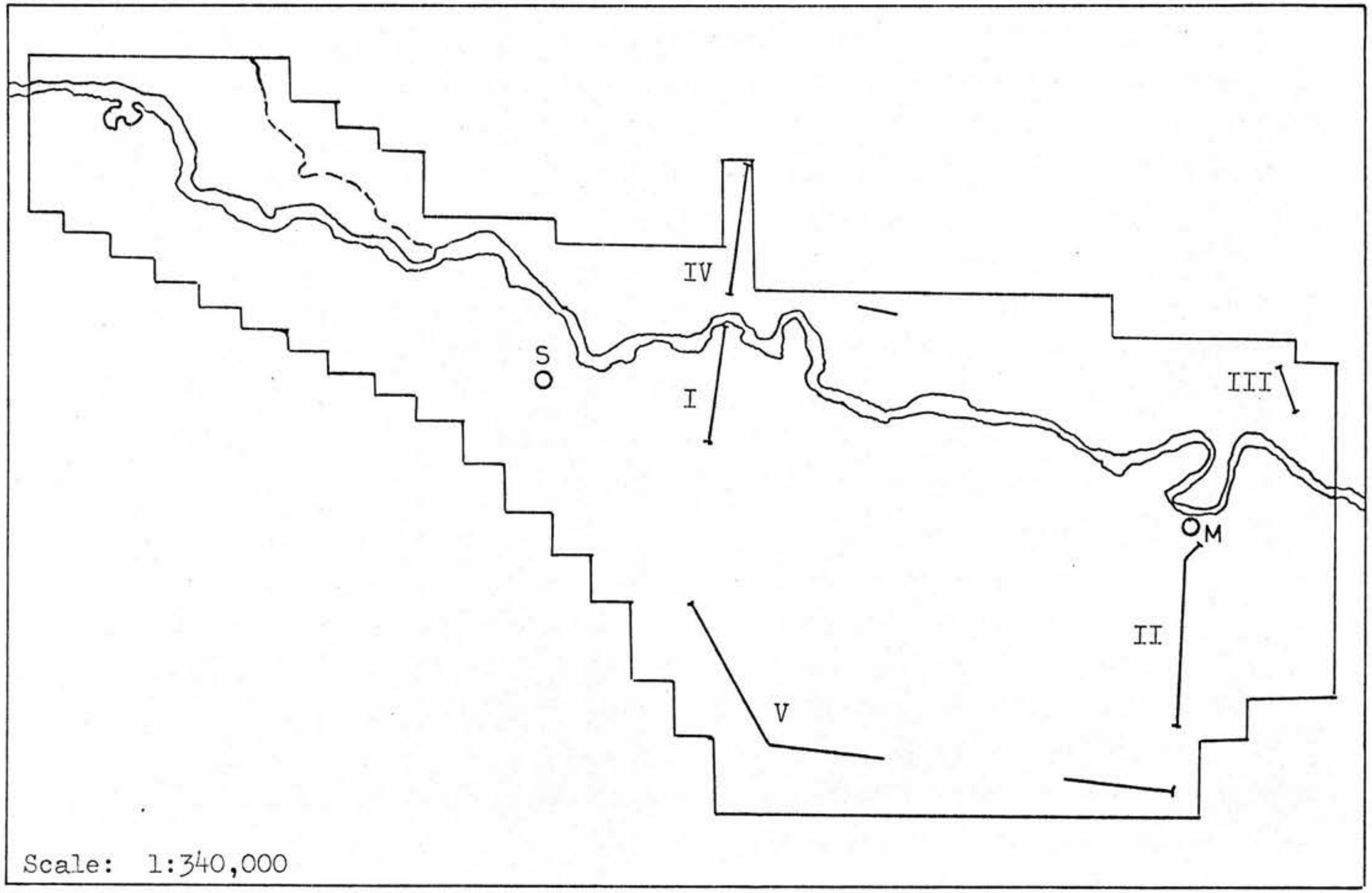


Figure 4.1
LOCATION OF VEGETATION TRANSECTS IN RELATION TO SOIL HABITATS OF THE STUDY AREA

Source: Fieldwork, Zouzou, R., 1961-74.

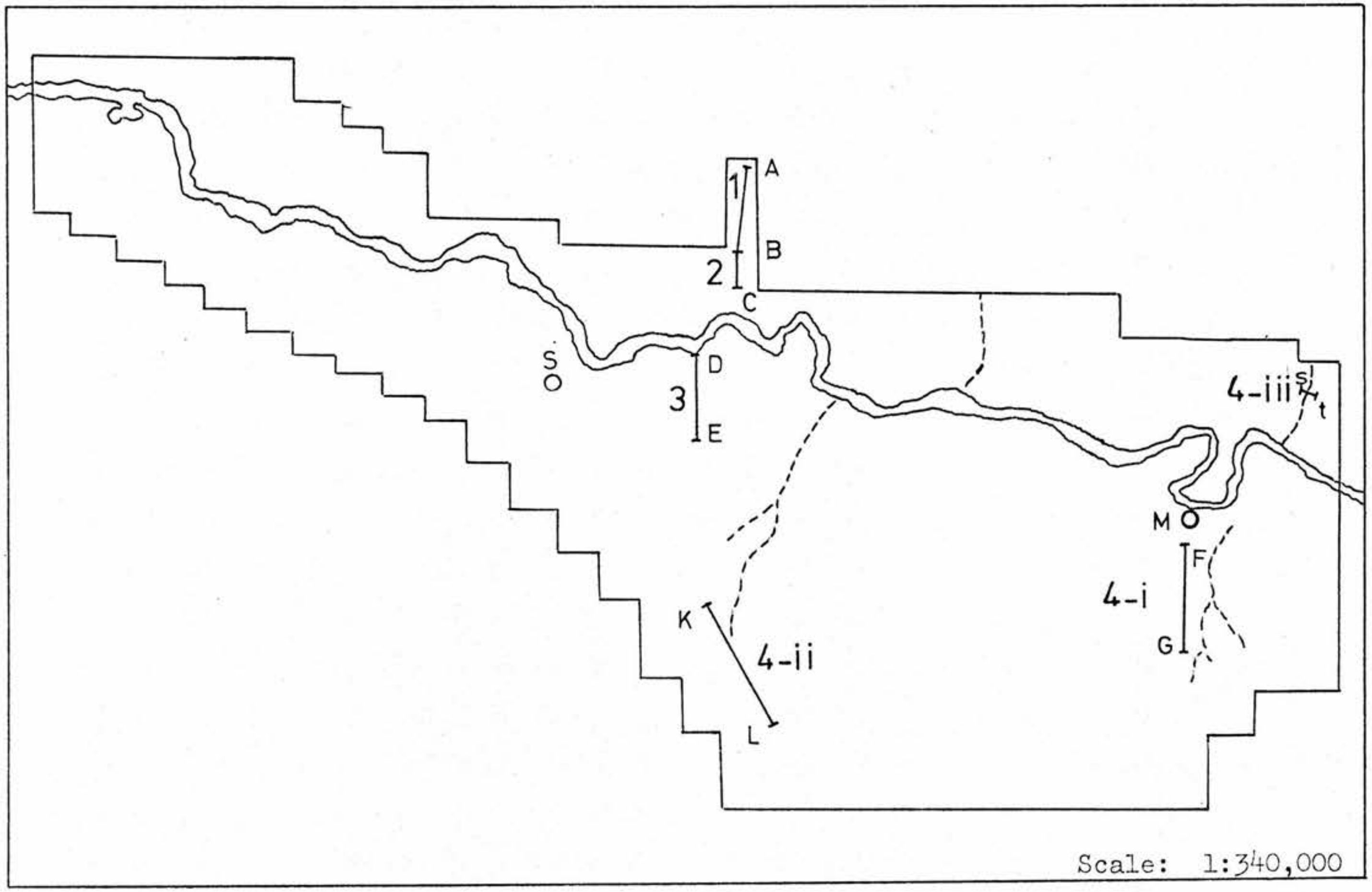


Figure 4.2
LOCATION OF VEGETATION TRANSECTS IN RELATION TO SOIL TYPES OF THE STUDY AREA

Source: Fieldwork, Zouzou, R., 1961-74.

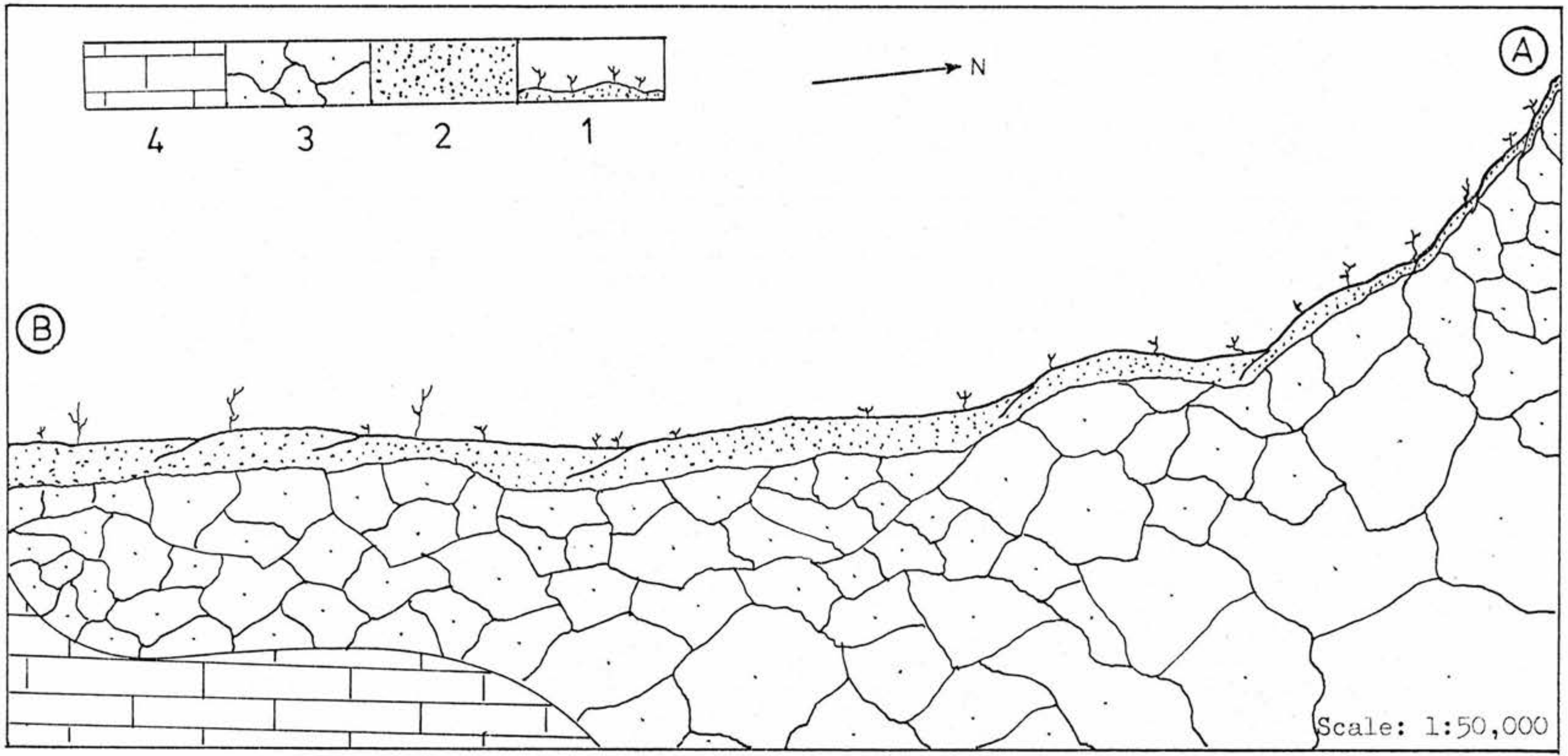


Figure 4.3
(1) CROSS-SECTION OF THE VEGETATION ALONG THE LAPILLI TRANSECT

1. Vegetation 2. Soils 3. Basalt 4. Limestone.

Source: Fieldwork, Zouzou, R., 1961-74.

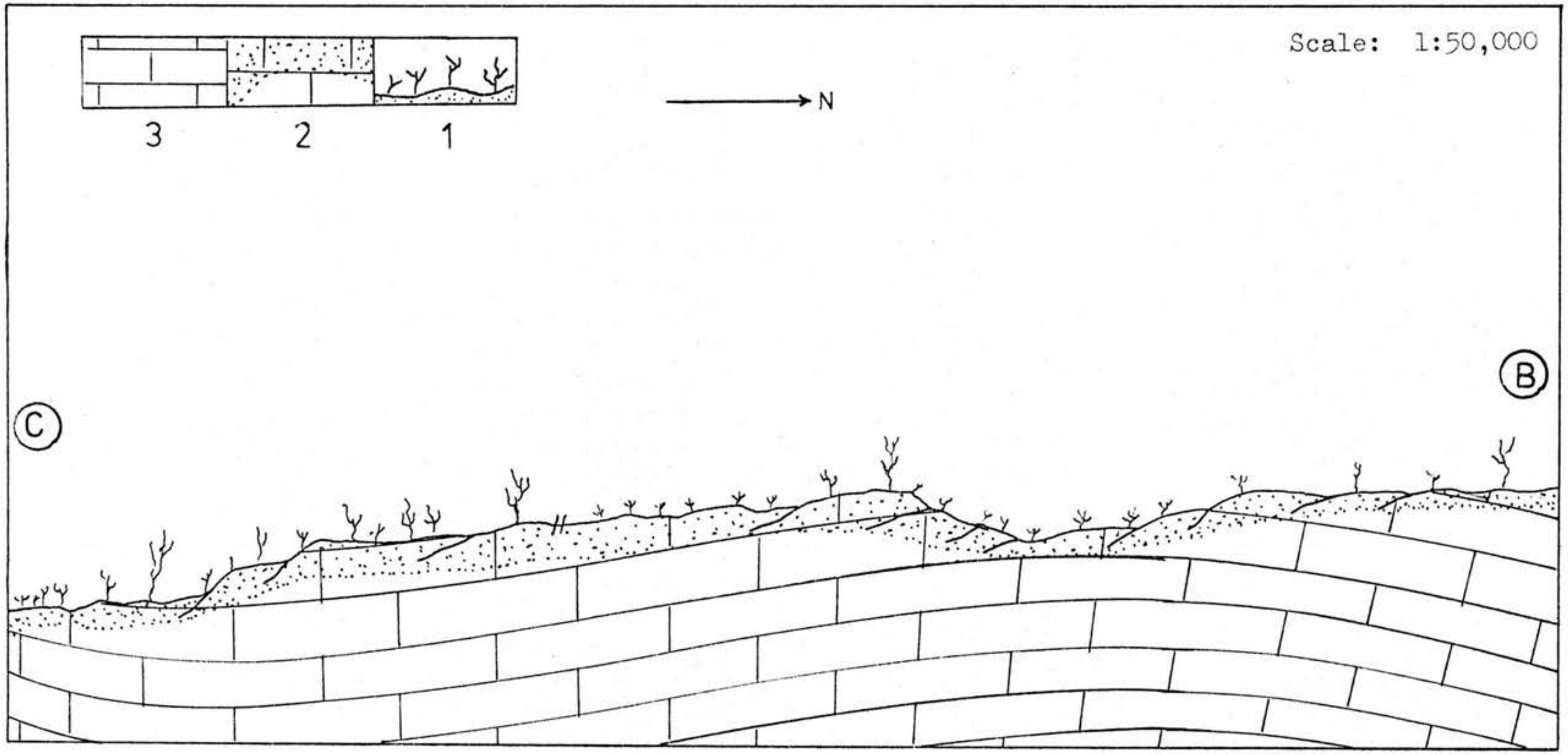


Figure 4.4
(2) CROSS-SECTION OF THE VEGETATION ALONG THE CALCAREOUS TRANSECT

1. Vegetation 2. Soils 3. Bed rocks (Limestone)

Source: Fieldwork, Zouzou, R., 1961-74.

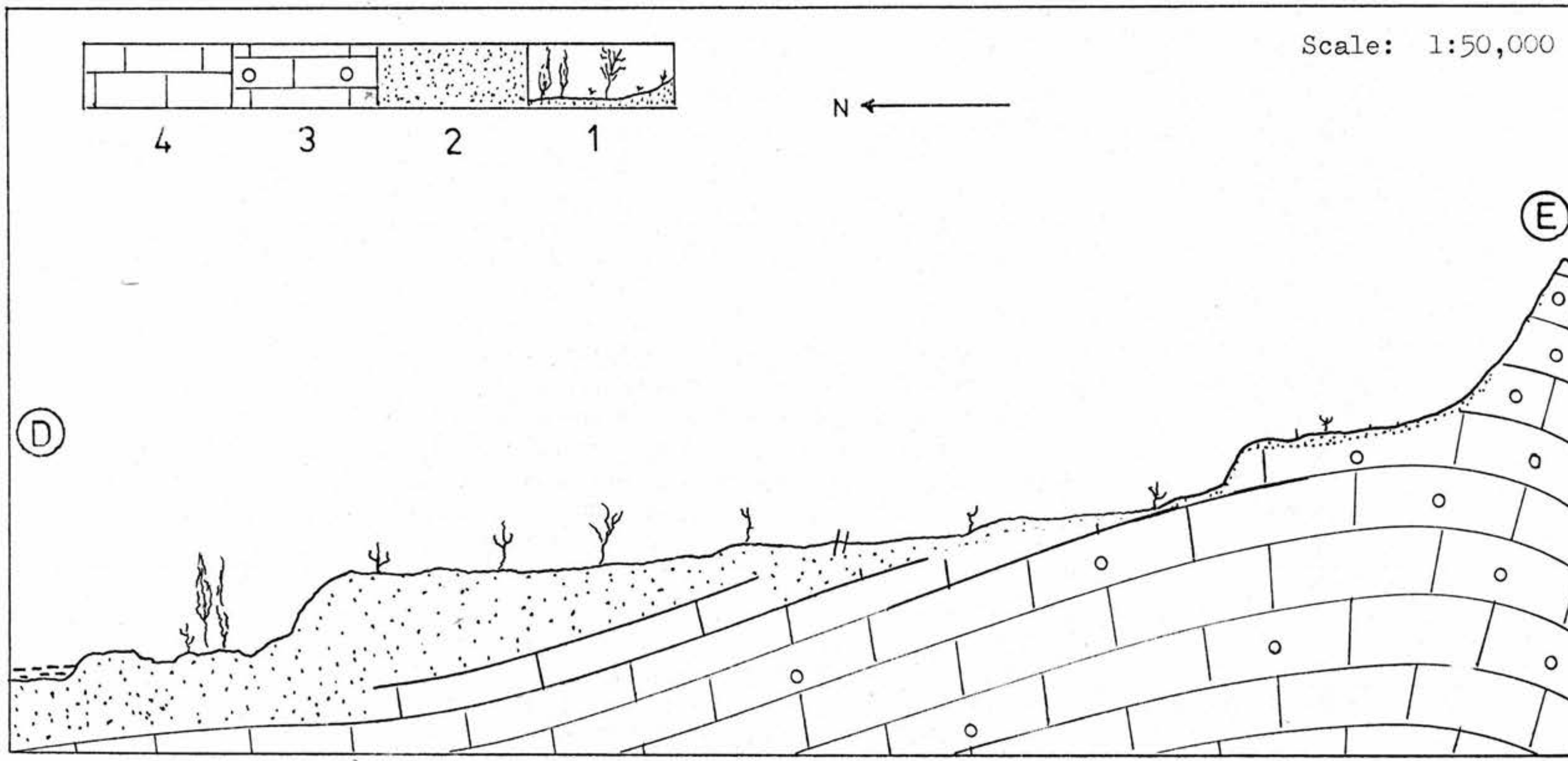


Figure 4.5
(3) CROSS-SECTION OF THE VEGETATION ALONG THE ALLUVIAL TRANSECT

1. Vegetation 2. Soils 3. Gypsum 4. Limestone

Source: Fieldwork, Zouzou, R., 1961-74

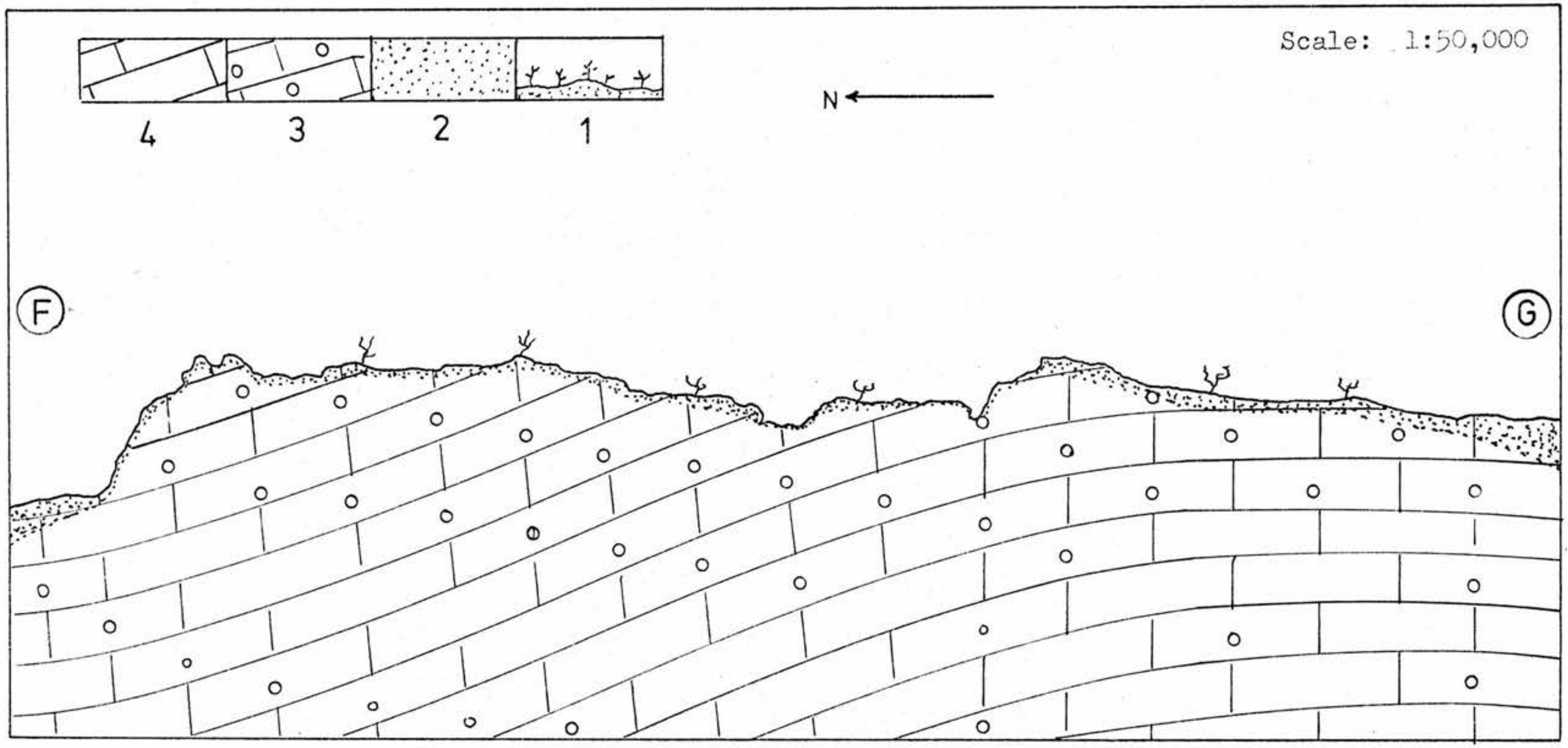


Figure 4.6
(4-i) CROSS-SECTION OF THE VEGETATION ALONG THE GYPSIFEROUS TRANSECT

1. Vegetation 2. Soils 3. Gypsum 4. Limestone

Source: Fieldwork, Zouzou, R., 1961-74

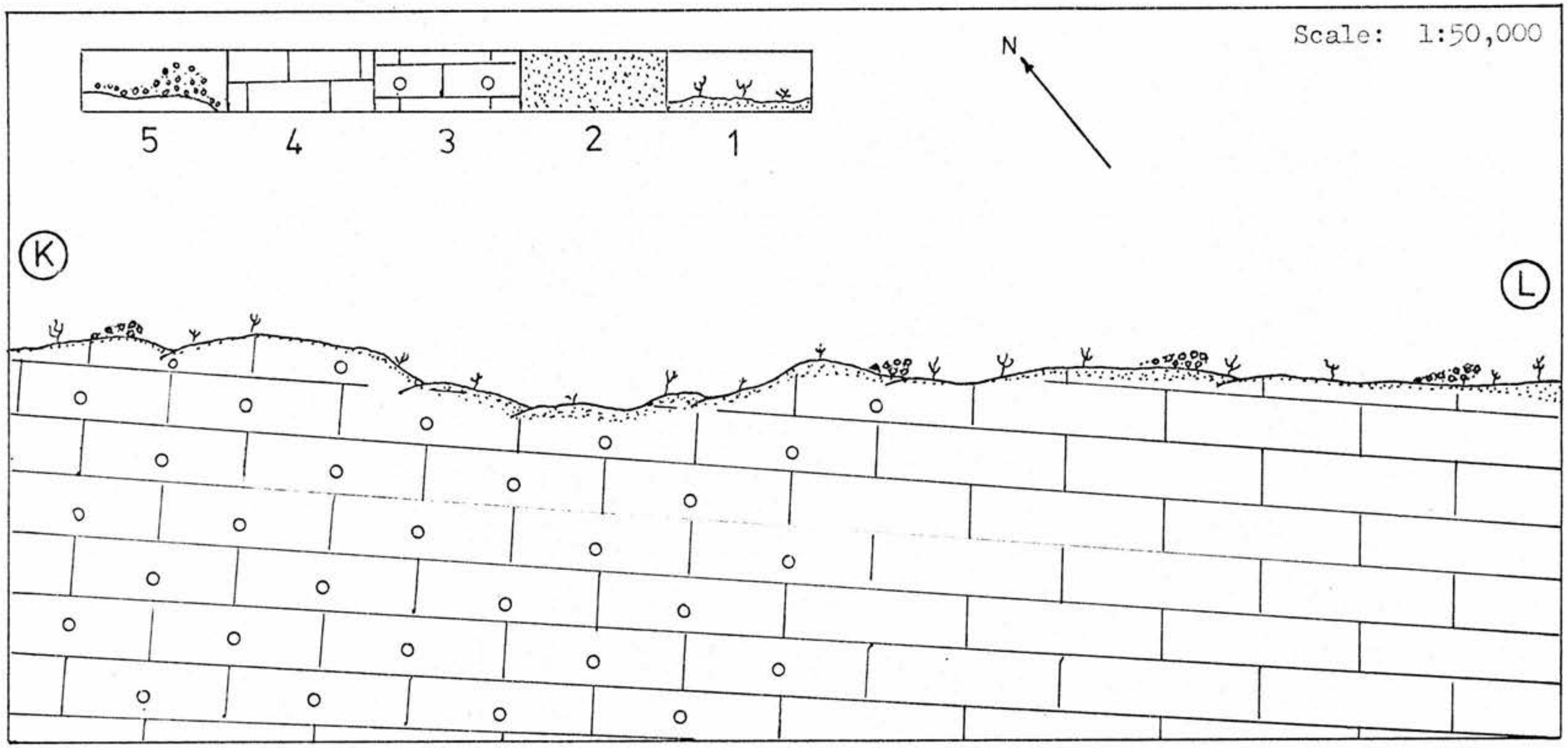


Figure 4.7
(4-ii) CROSS-SECTION OF THE VEGETATION ALONG THE GYPSIFEROUS TRANSECT

1. Vegetation 2. Soils 3. Gypsum 4. Limestone 5. Sand dunes

Source: Fieldwork, Zouzou, R., 1961-74

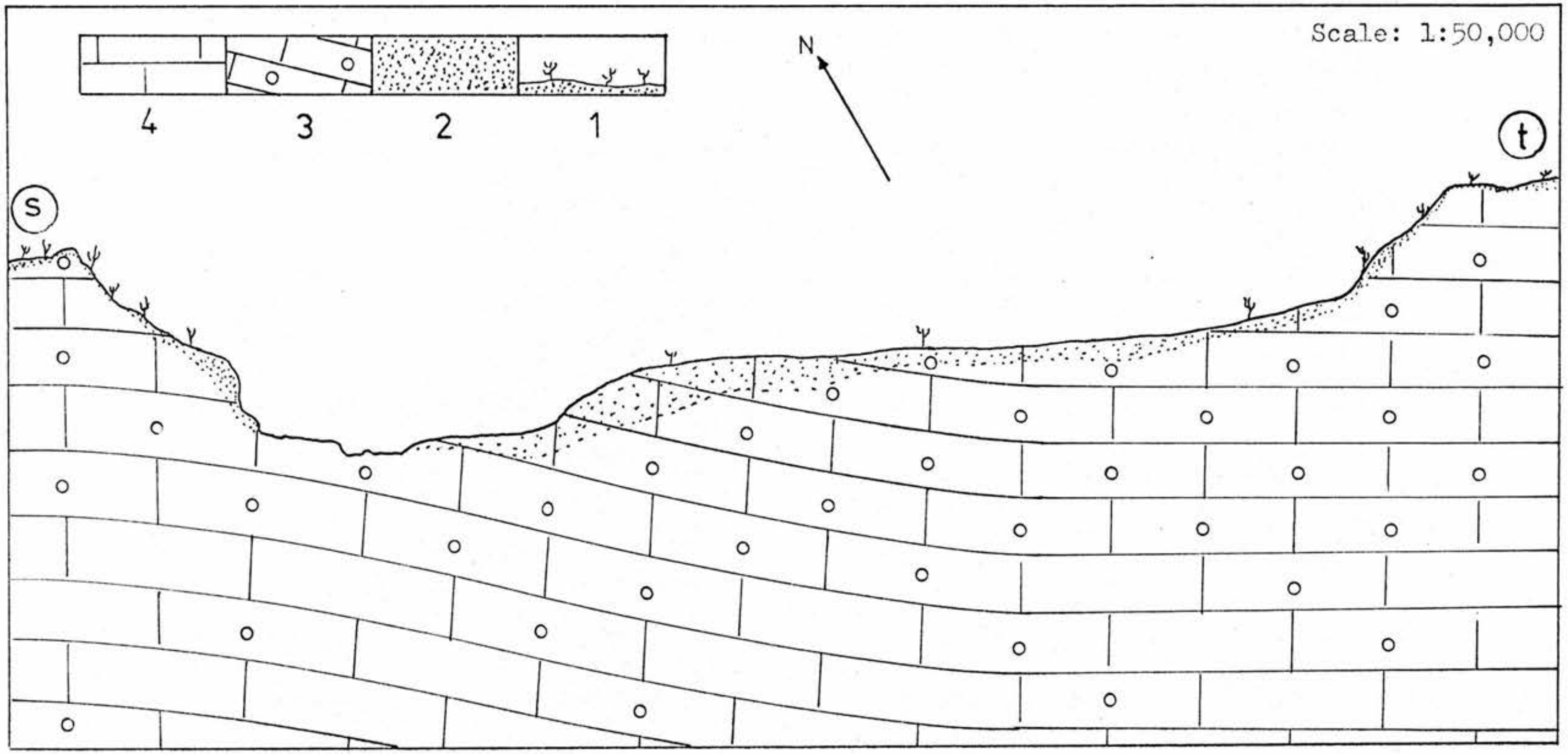


Figure 4.8
(4-iii) CROSS-SECTION OF THE VEGETATION ALONG THE GYPSIFEROUS TRANSECT

1. Vegetation 2. Soils 3. Gypsum 4. Limestone

Source: Fieldwork, Zouzou, R., 1961-74.

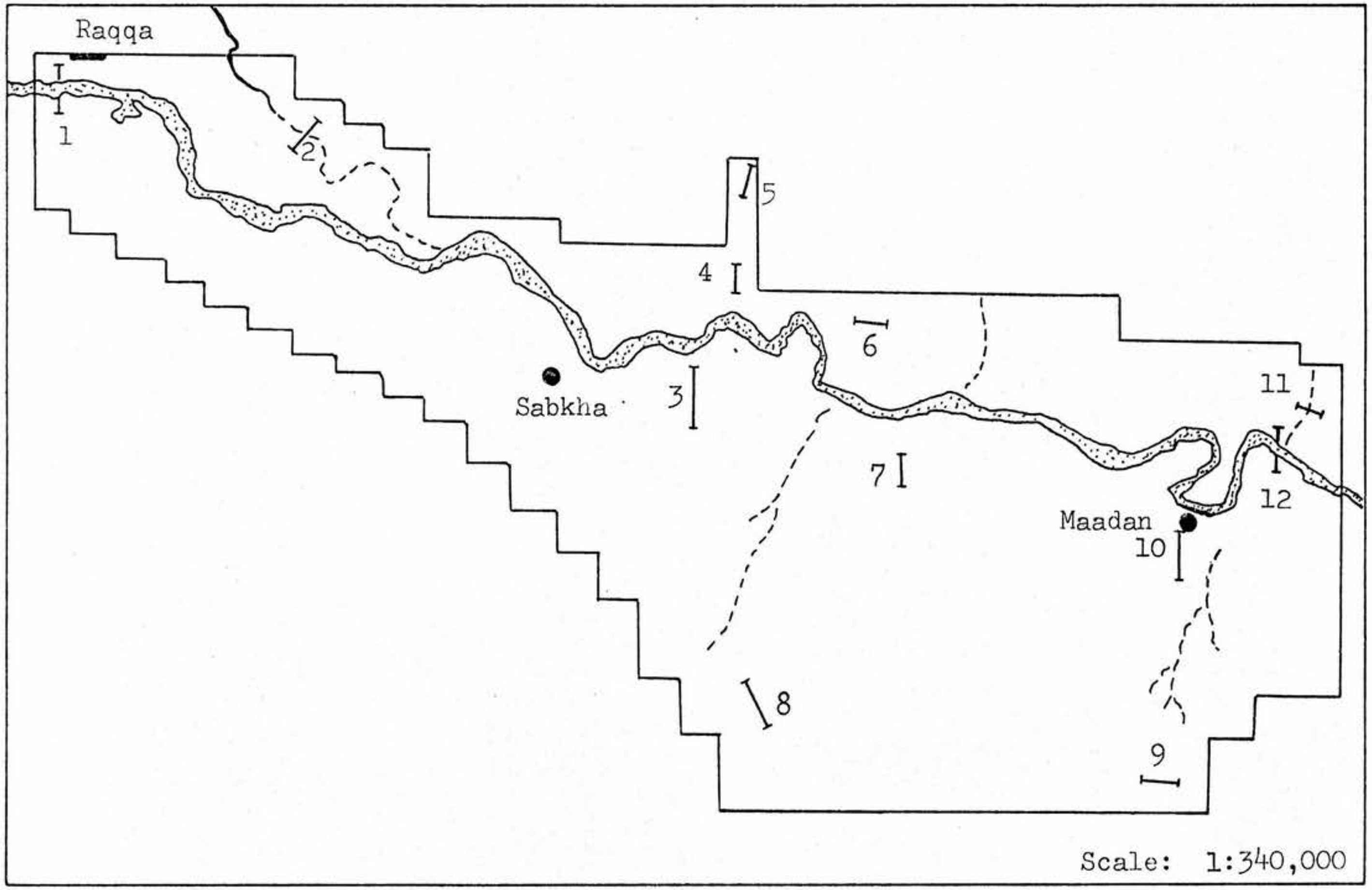
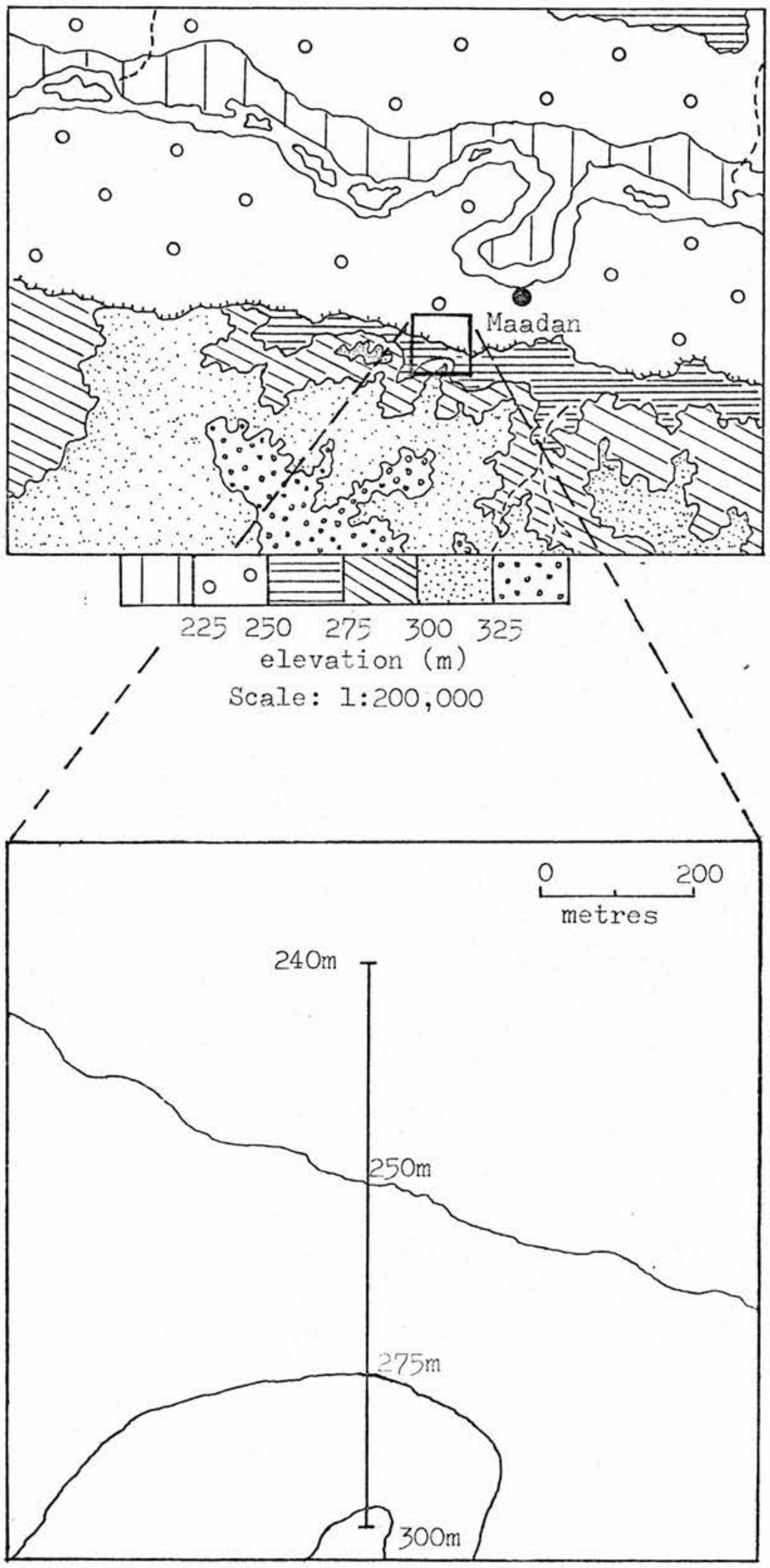


Figure 5.1
LOCATION OF TRANSECTS WITHIN THE STUDY AREA

Source: Fieldwork, Zouzou, R., 1961-74.

Figure 5.2
LOCALITY OF THE TRANSECT NO. 10



Source: Fieldwork, Zouzou, R., 1961-74.

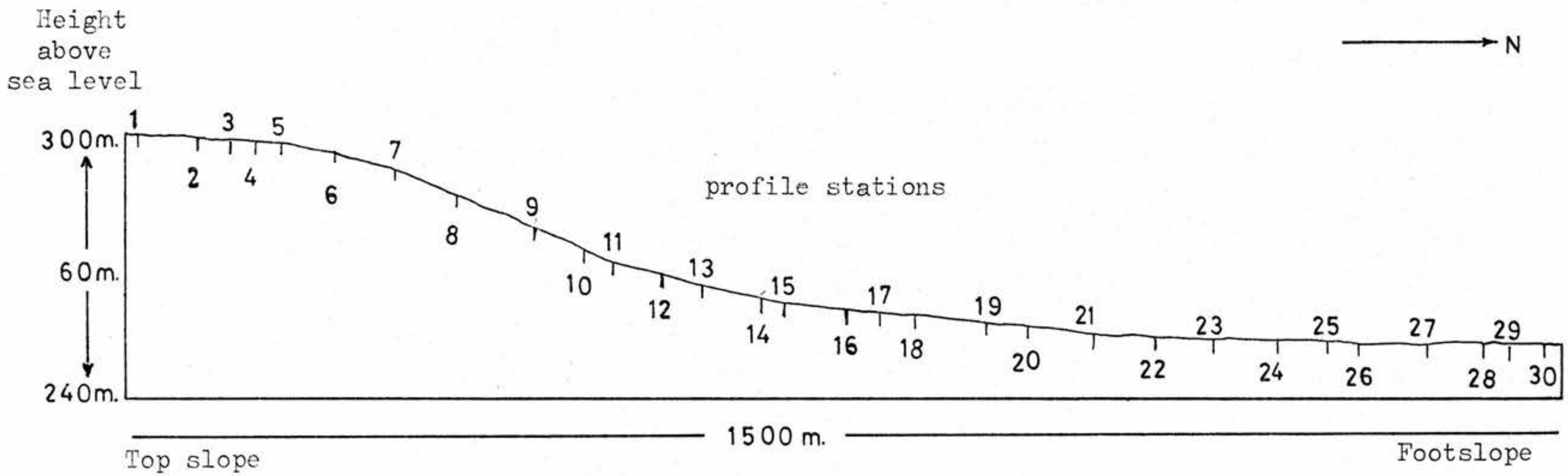
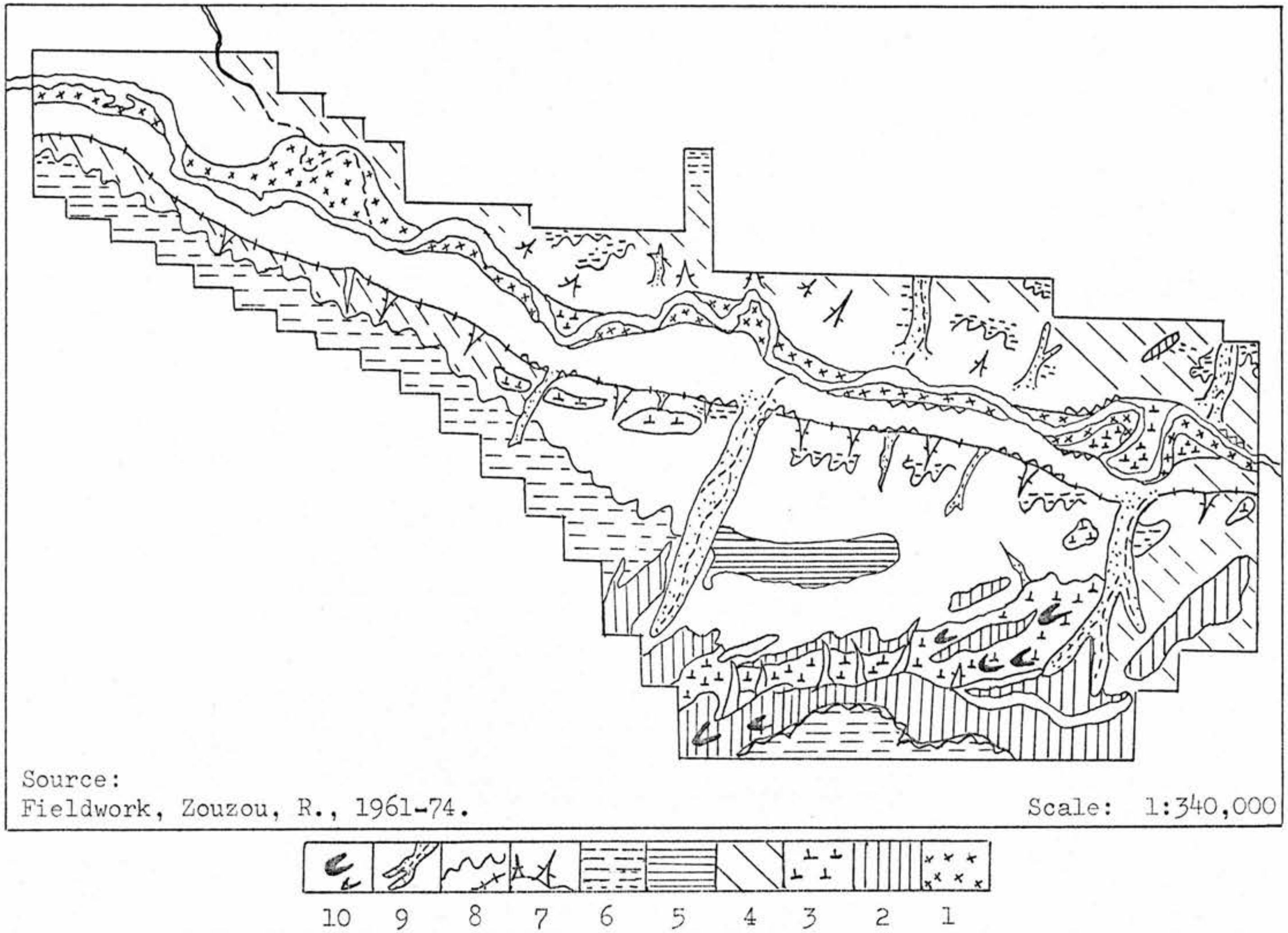


Figure 5.3
MORPHOLOGICAL FEATURE OF TRANSECT 10

Source: Fieldwork, Zouzou, R., 1961-74.

THE INCIDENCE OF EROSION WITHIN THE STUDY AREA



(1) Area suffering at present from severe erosion damage by water; (2) Area suffering at present from severe erosion damage by wind; (3) Area suffering at present from an intermediate level of wind and water erosion (over gravel hills and gravel terraces); (4) Area with little or no erosion problems; (5) Salt pan area; (6) Area with a little erosion damage at present; (7) Area suffering at present from violent rain storm damage; (8) Area suffering at present from mass movement over slopes; (9) Gully erosion and mass movement; (10) Dunes.

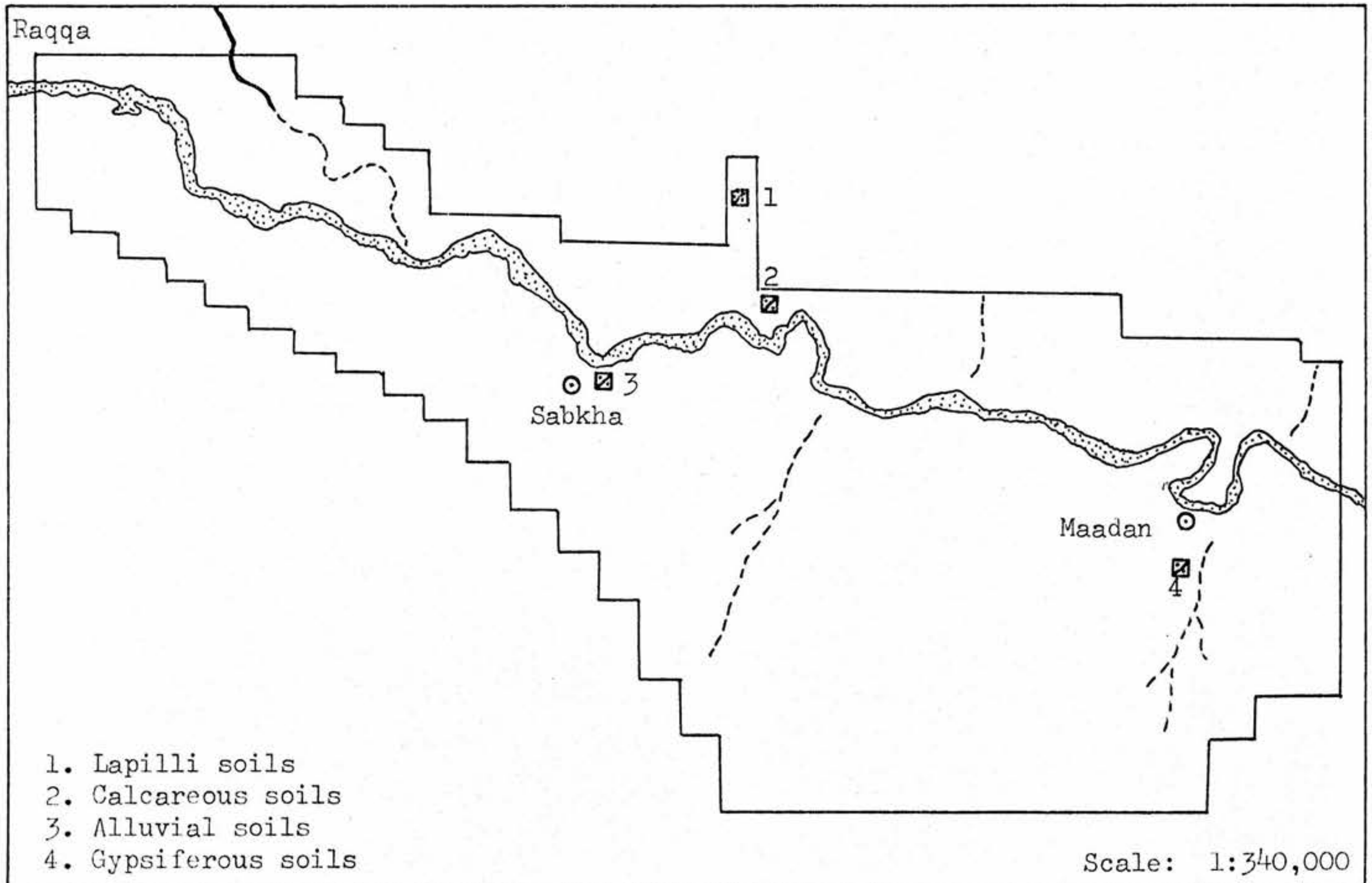
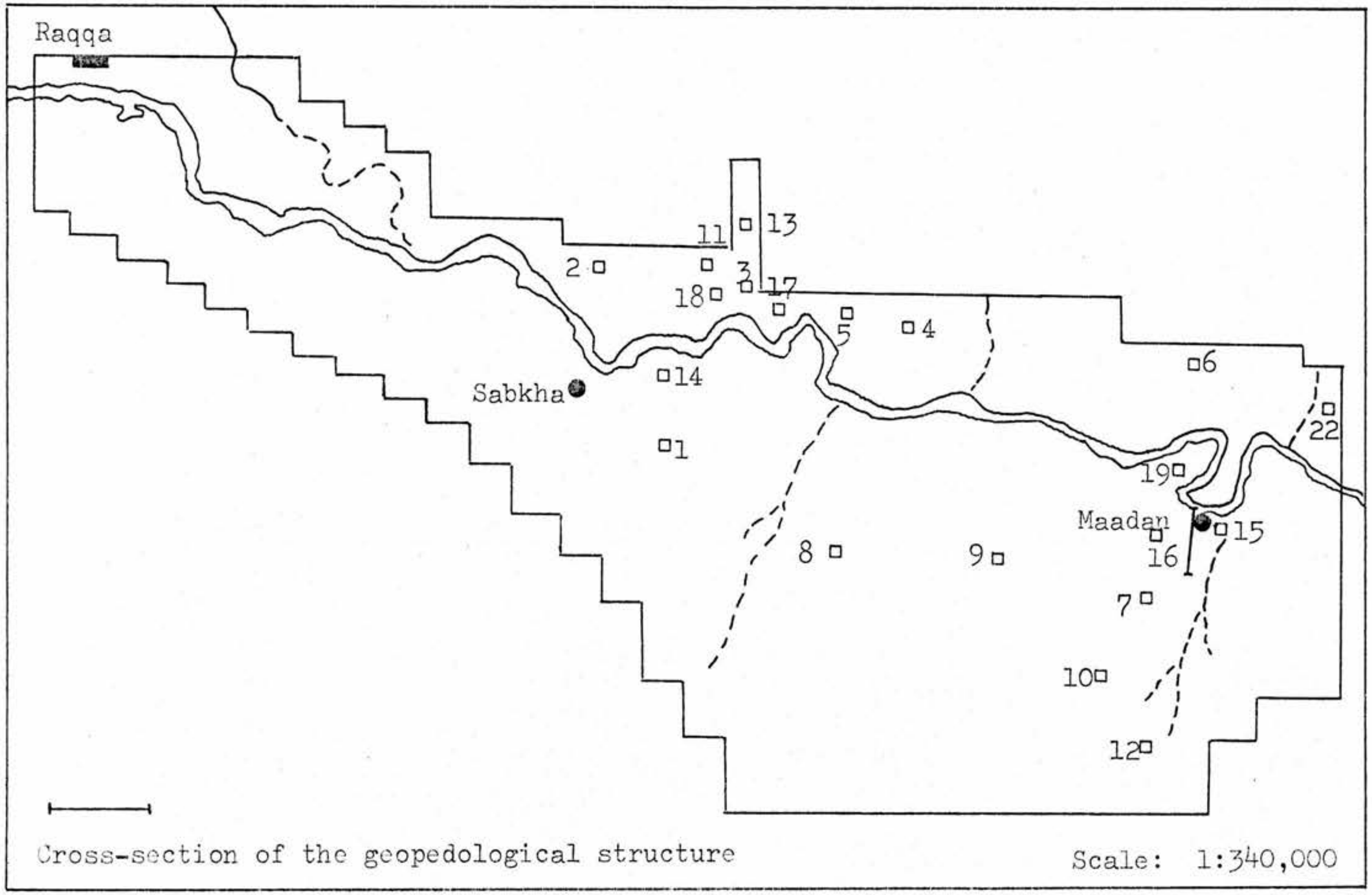


Figure 6.1
LOCATION OF THE REPRESENTATIVE PROFILES OF VARIOUS SOIL GROUPS

Source: Fieldwork, Zouzou, R., 1961-74.

Figure 7.1
LOCATIONS OF REPRESENTATIVE PROFILES OVER VARIOUS SOIL GROUPS AND FAMILIES

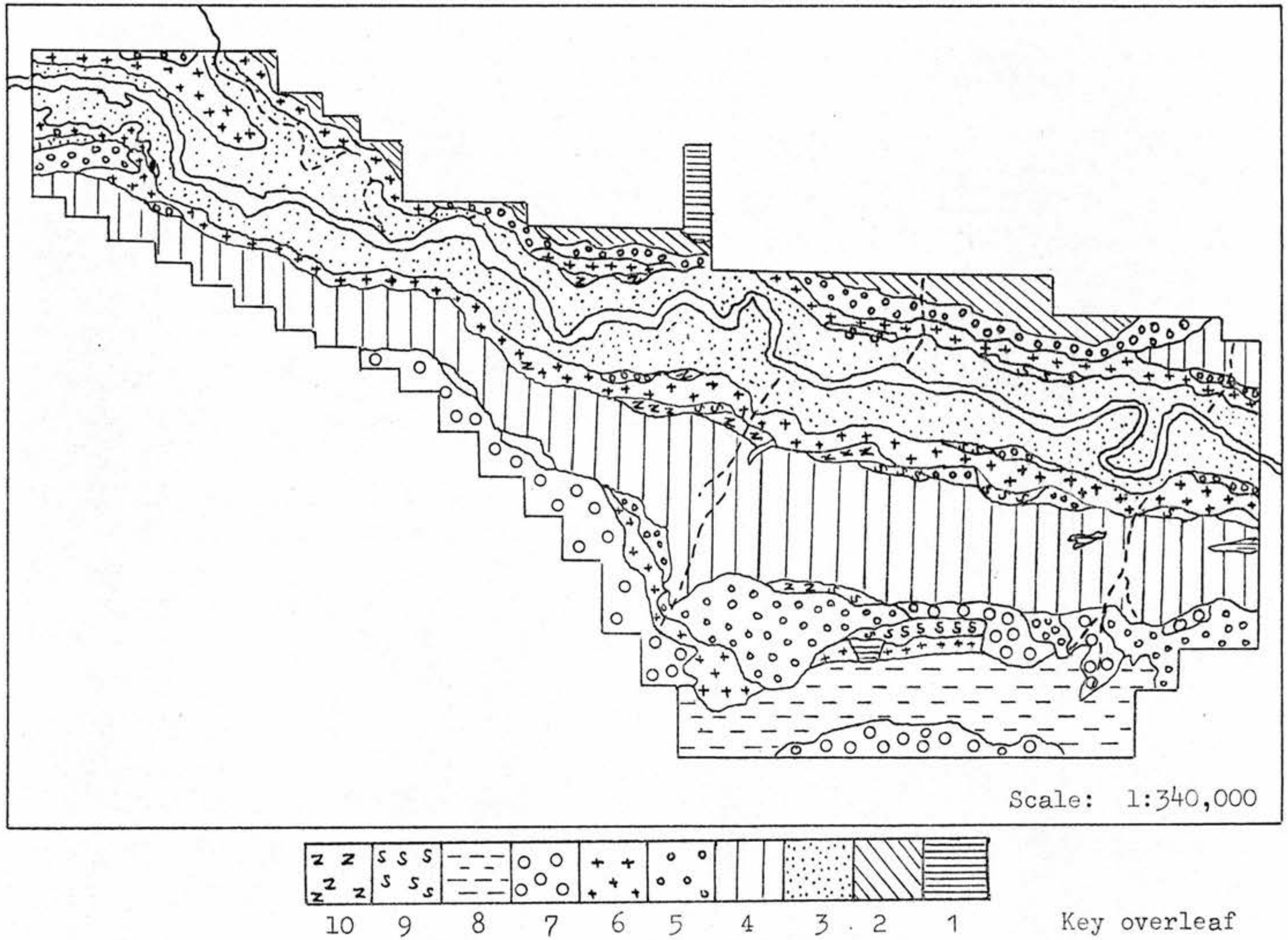


(1) Solonetz soils; (2) - (6) Calciorthids with calcic horizon; (7) - (10) Calciorthids with gypsic horizon (Gypsiorthids); (11) Salorthids (Solonchak soils); (12) Camborthids (red desert soils); (13) Camborthids (lapilli soils); (14) Torrifluvents; (15) Ustifluvents; (16) Vertic Ustifluvents; (17) Torriorthents; (18) Torripsamments; (19) Ustipsamments; and (22) Gypsic horizon formed by drainage water.

Source: Fieldwork, Zouzou, R., 1961-74.

Figure 7.2

A MAP SHOWING THE TENTATIVE DISTRIBUTION OF SOIL GROUPS WITHIN THE STUDY AREA



Source: U.S.D.A. Classification, 1961, 1967; and FAO, Unesco, 1974.
Based on Fieldwork, Zouzou, R., 1961-74. (Drawn up 1976)

KEY TO FIGURE 7.2

1. (Lapilli soils): from basic volcanic rocks, on slightly to moderately dissected rolling plains (texture similar to Calcareous soils).

2. (Calcareous soils): sandy, on level to undulating plains with Lithosols from limestone on level to undulating plains. Fine to coarse textured with enough salts to affect plant growth.

3. (Alluvial soils): Medium and fine texture deposits on level alluvial plain. Saline and coarse-textured, calcareous in association.

4. (Gypsiferous soils): from sedimentary rocks, on dissected plateaux with undulating plateau remnants, on undulating to rolling plains with high proportion of bare rock. Calcareous alluvial soils in wadi bottoms, and with sandy red desert soils on level to undulating plains.

5. (4 + 2): Mixed Gypsiferous and Calcareous materials.

6. (4 + 3): Mixed Gypsiferous and Alluvial materials.

7. (Red desert - Sierozem soils) : sandy, on level to undulating plains with Lithosols from sedimentary rocks on steep undulating terrain complexes.

8. (Red desert - Sierozem soils) Gravelly, on level to undulating plains with shifting sand dunes. Sandy on level to undulating plains with Solonchak, on lowland plains as complexes and associates.

9. (Solonchak soils): with saline Alluvial and Calcareous soils on lowland and in the basins, consisting of soil with gray, thin, salty crust on the surface and fine granular mulch underlying the surface, with poor drainage. Solonchak forms under sparse growth of halophytic plants.

10. (Solonetz soils): with saline-alkaline Alluvial and Gypsiferous soils on level land and in the basins. The surface soils are underlain by a dark, hard layer usually highly alkaline. Solonetz forms under subhumid to arid conditions; they are better drained than Solonchaks. Solonetz forms under vegetation of halophytic plants.

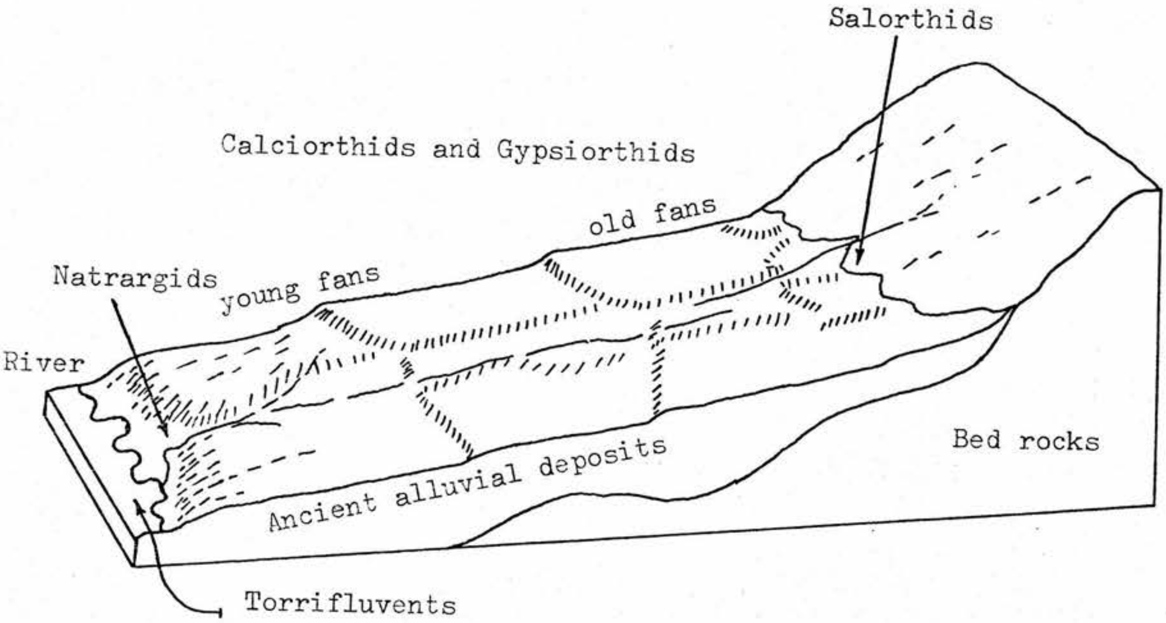


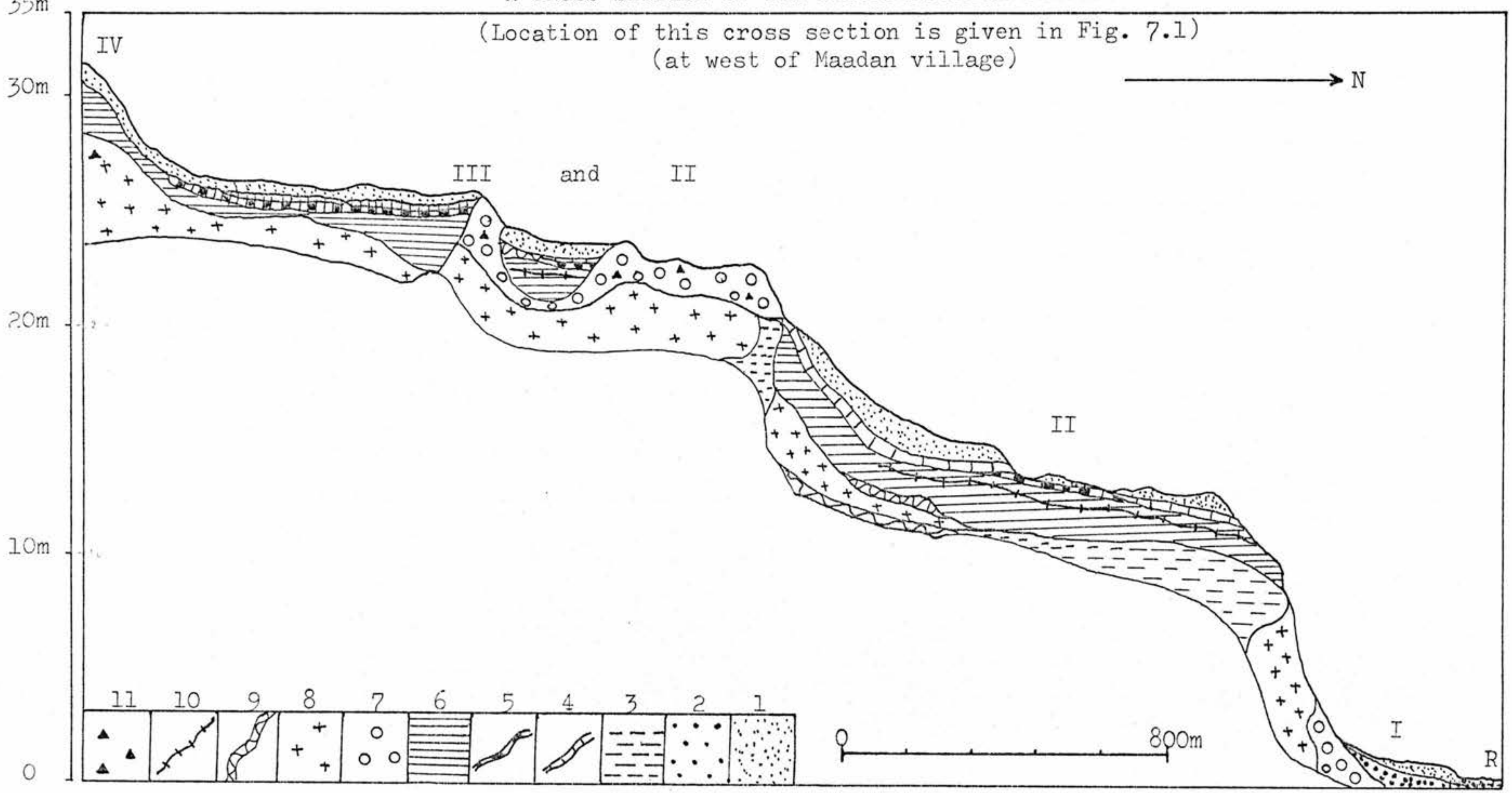
Figure 7.3a
A REPRESENTATIVE BLOCK DIAGRAM OF THE GEOPEDOLOGICAL STRUCTURE

Block diagram showing position of some major kinds of Aridisols and Entisols with their associates which have been identified within the study area.

Source: Adapted from S.W. Buol, Soil Genesis and Classification, 1973.
Applied to Fieldwork, Zouzou, R., 1974.

Figure 7.3b

A CROSS SECTION OF THE GEOPEDOLOGICAL STRUCTURE



(1) Loams; (2) Clay; (3) Loamy with clay; (4) Calcic horizon; (5) Gypsic horizon; (6) Gypsum materials; (7) Sandy gypsum mixed with gravel and loam; (8) Powder and sandy gypsum; (9) Hard gypsum crust; (10) Mottled formation; (11) Some lapilli formations with loam.

Source: Fieldwork, Zouzou, R., 1961-74.

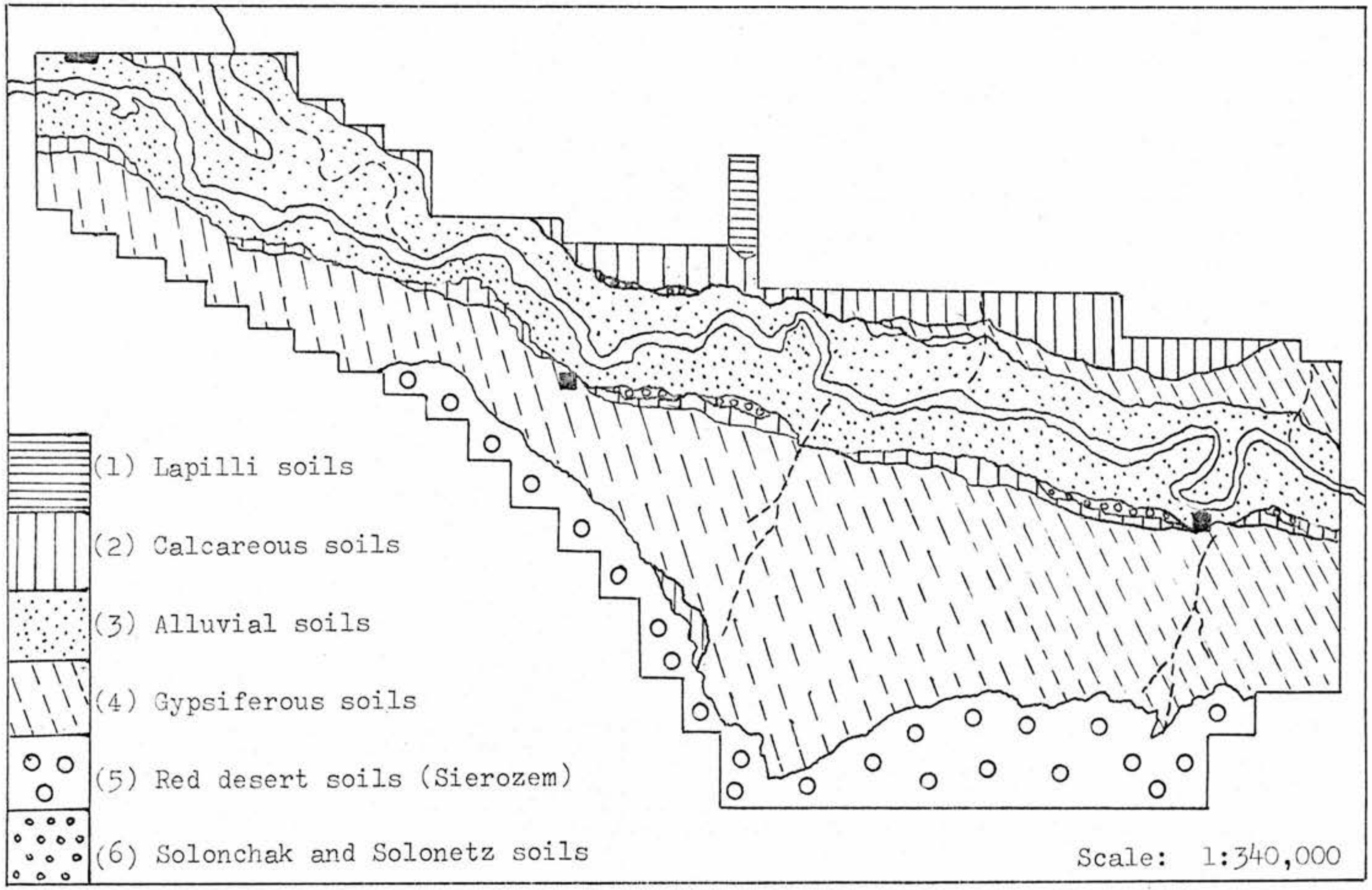


Figure 7.4
MAIN SOIL GROUPS OF THE STUDY AREA

Source: Fieldwork, Zouzou, R., 1961-74.

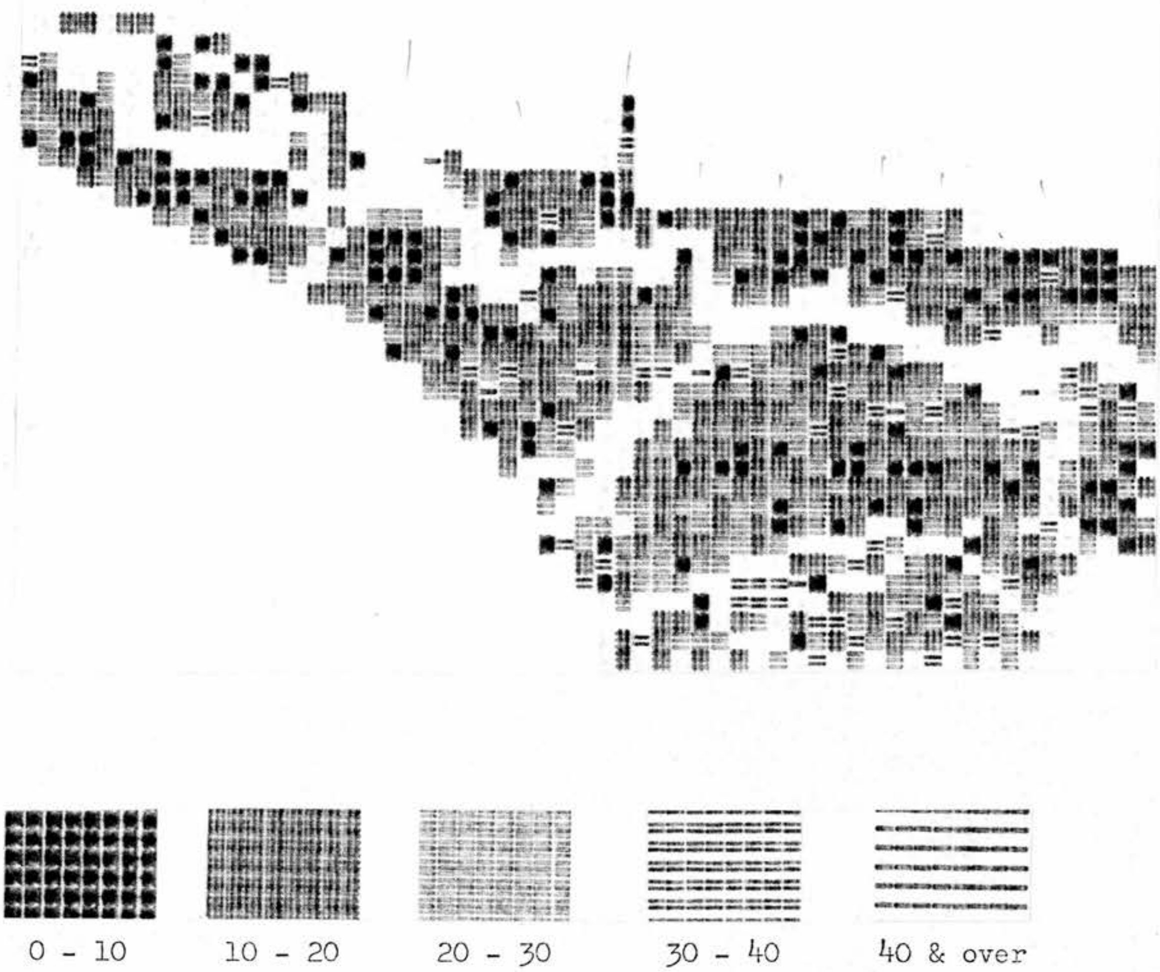


Figure 7.5a
DISTRIBUTION OF THE CLAY SIZED FRACTION
(Computer Map)

Soil texture is controlled mainly by clay particles; the greater the content, the more sticky and plastic together with a greater base exchange capacity. The clay content is closely associated with the agricultural potential.

This map shows the proportions of clay; ranges between 10-30% are dominant in both plateaux. The level of 30-40% and over is mainly found close to and within the valley and wadis. Levels of less than 10% occur mainly within shallow and very shallow soils particularly in the east and south plateau.

Source: This computer map is based on results of fieldwork, Zouzou, R., 1961-74.

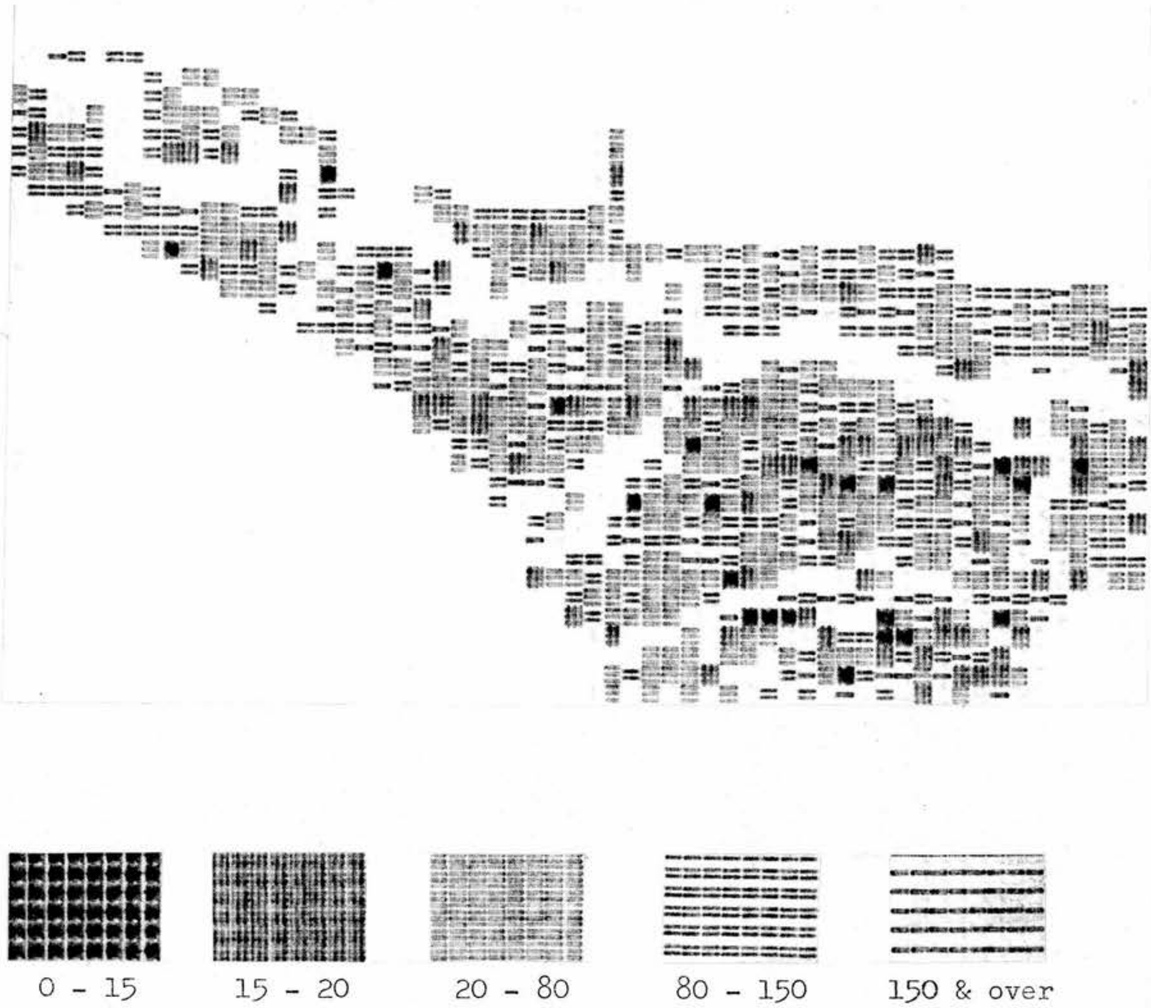


Figure 7.5b
DISTRIBUTION OF SOIL DEPTH VARIATIONS
(Computer Map)

Soil depth clearly relates to agricultural productivity since it is closely related to the potential rooting volume. The majority of deep and medium depth soils can be found mainly in the valley. They consist of brown soils or reddish brown soils or intergrades between Calciorthids and Sierozem soils. The shallow soils are mostly stony brown soils, Lithosols and Sierozem soils.

The map shows that the depths of the soil between 20-80 cm occupies a large part of the area over both plateaux; while the depth of the soil between 80-150 cm (or more) occurs mainly within and close to the Euphrates valley and wadis. In addition the very shallow soils (less than 80 cm) have been found close to and within the stony brown soils or Lithosols or Sierozem soils.

Source: This computer map is based on results of Fieldwork, Zouzou, R., 1961-74.

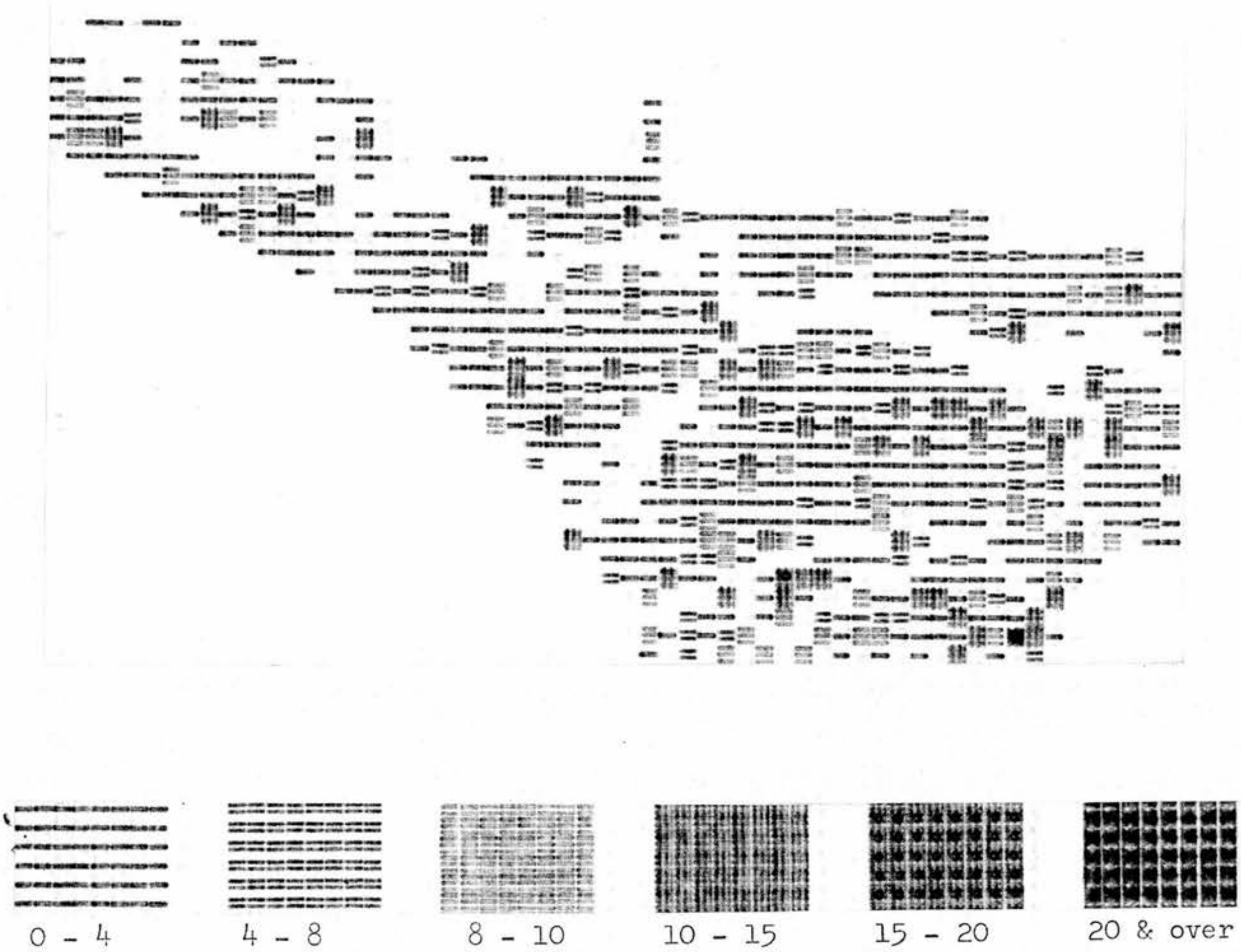


Figure 7.5c
DISTRIBUTION OF THE WATER SOLUBLE SALT CONTENT
(Computer Map)

In the weathering of parent material many soluble elements are formed in the soil body. The abundance of salts in the soil solution makes plant growth difficult; in this situation the root hairs will fail to make normal growth because they are unable to absorb soil moisture; at this stage, artificial leaching is required.

The map shows that levels of water soluble salts less than 4 meq/100 g soils cover most of the study area, particularly within and around the Euphrates valley. These results may be subdivided into theee levels:

Continued/

(i) Represents the top 20 cm, consisting of up to 2 meq/100 g soils and occupying 65% of the surface horizon.

(ii) Represents the second 5 cm, consisting of up to 3 meq/100 g soils and occupying 15% of the surface horizon.

(iii) Represents the lower 5 cm, consisting of up to 4 meq/100 g soils and occupying 20% of the surface horizon.

Levels of 4-8 meq/100 g soils are mainly found in the south plateau. In addition the level of 8-10 meq/100 g soils (or more) occurs further south due to the parent material and the extreme aridity of the area. High levels of water soluble salts can be found in the valley and wadi 'bottom lands' in places close to the surface such as in Solonchak and Natrargid soils.

Source: This computer map is based on results of Fieldwork, Zouzou, R., 1961-74.

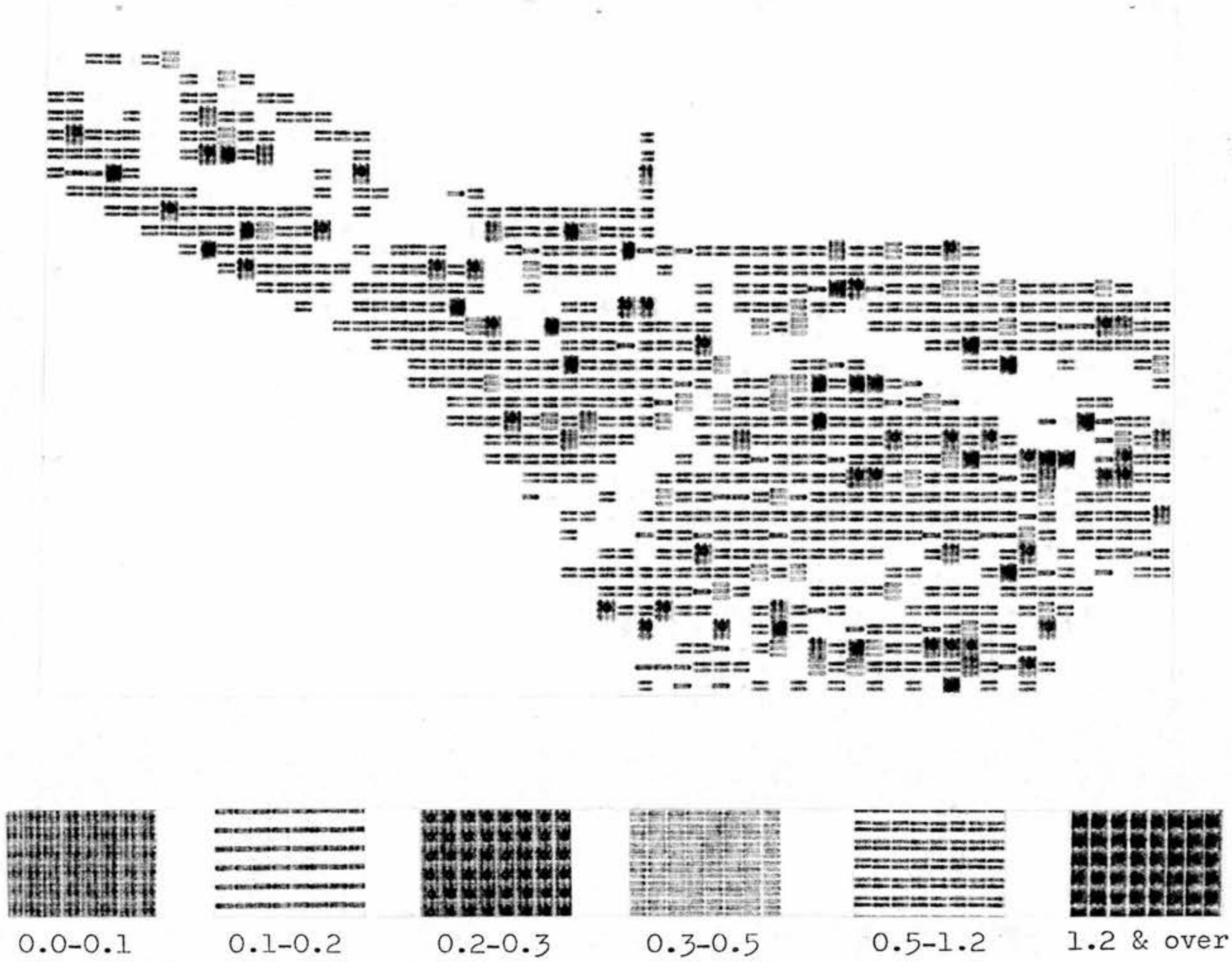


Figure 7.5d
DISTRIBUTION OF ORGANIC CARBON
(Computer Map)

In an aerated soil the organic matter undergoes oxidation and decomposition under the influence of soil micro-organisms such as bacteria, fungi and protozoa, which lead mainly to formation of carbon dioxide, water, ammonia, nitrogen compounds; these in turn will affect soil structure. The organic carbon is one of the most important chemical elements in the soil and the chief constituents of living tissue (carbohydrates ($C_6H_{12}O_6$), and carbon dioxide (CO_2).

The map shows that levels of 0.50% - 1.20% are dominant in the study area related closely to the vegetation cover; but this distribution may be subdivided into three parts.

Continued/

(i) Represents the area within the Euphrates valley and the (I-II) terraces of the river, consist of up to (1.0-1.20%), and occupying 30% of the area.

(ii) Represents the second part, consisting of up to (0.7-1.0%) and occupying 25% of the area in the plateaux around and within the third and fourth terraces.

(iii) Represents the third part, consisting of up to (0.5-0.7%) and occupying 45% of the area particularly in the south plateau.

Levels greater than 1.20 occur within the first terrace; and levels less than 0.50% occur mainly where outcrops, sand dunes, high salt content, high aridity and the lack of water are dominant.

Source: This computer map is based on results of Fieldwork, Zouzou, R., 1961-74.

Figure 7.6
DIVISION OF LAND POTENTIAL, LAND SUITABILITY AND CAPITAL INPUTS FOR EACH MAP CELL

Figure 7.6a

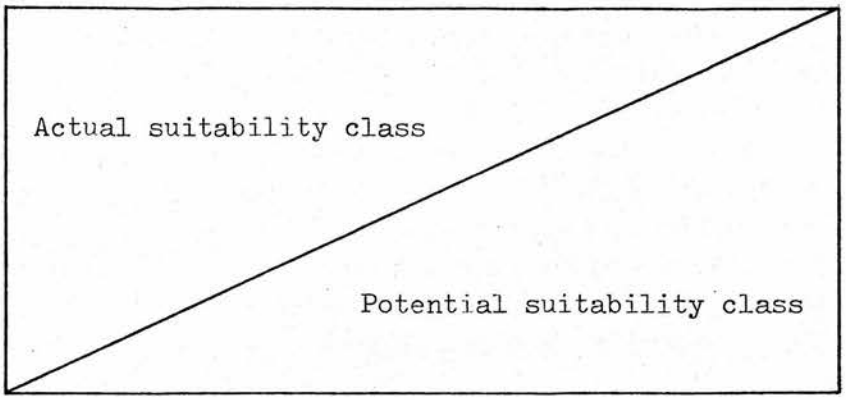
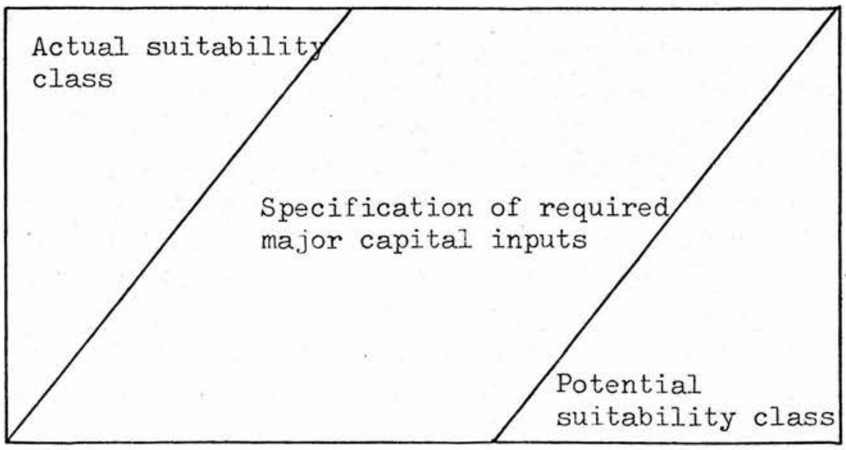
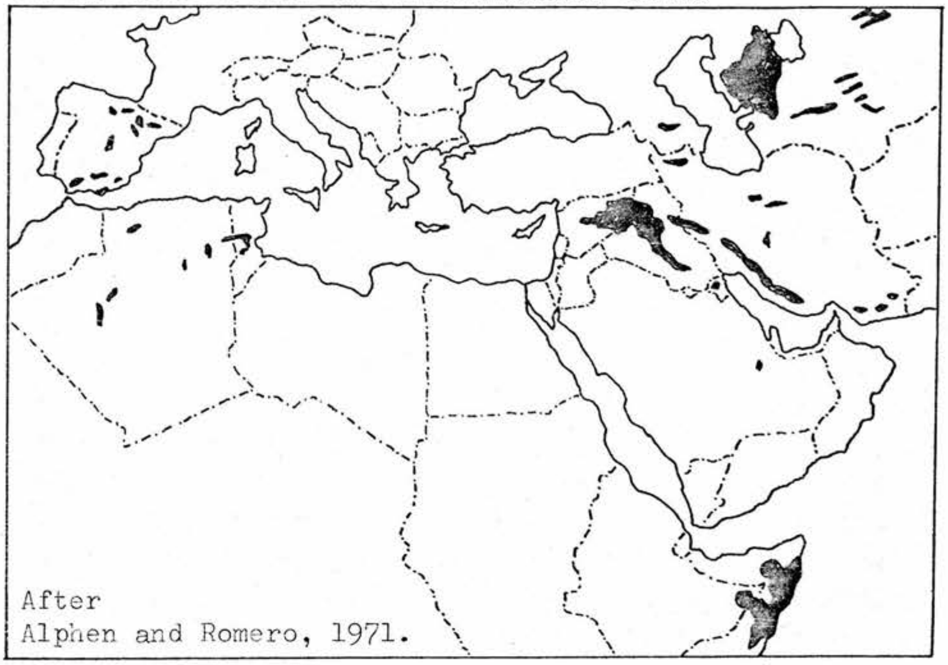


Figure 7.6b



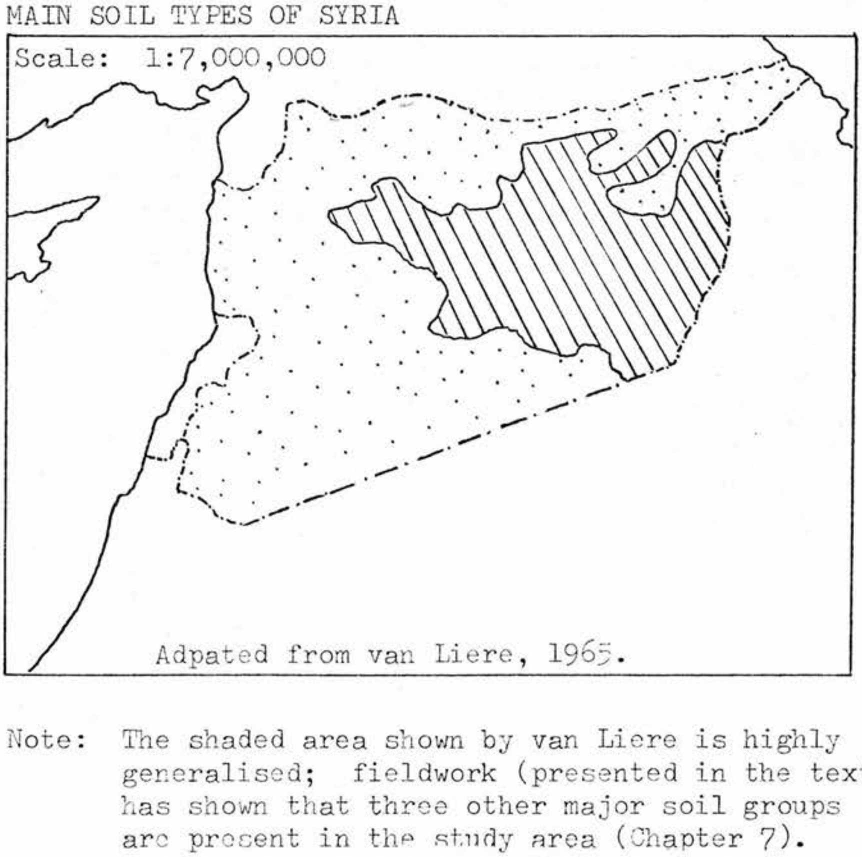
Source: Adapted from Brinkman and Smyth, 1973.
Applied to Fieldwork, Zouzou, R., 1961-74.

Figure 8.1a
DISTRIBUTION OF GYPSIFEROUS SOILS
IN THE MIDDLE EAST AND MEDITERRANEAN AREAS



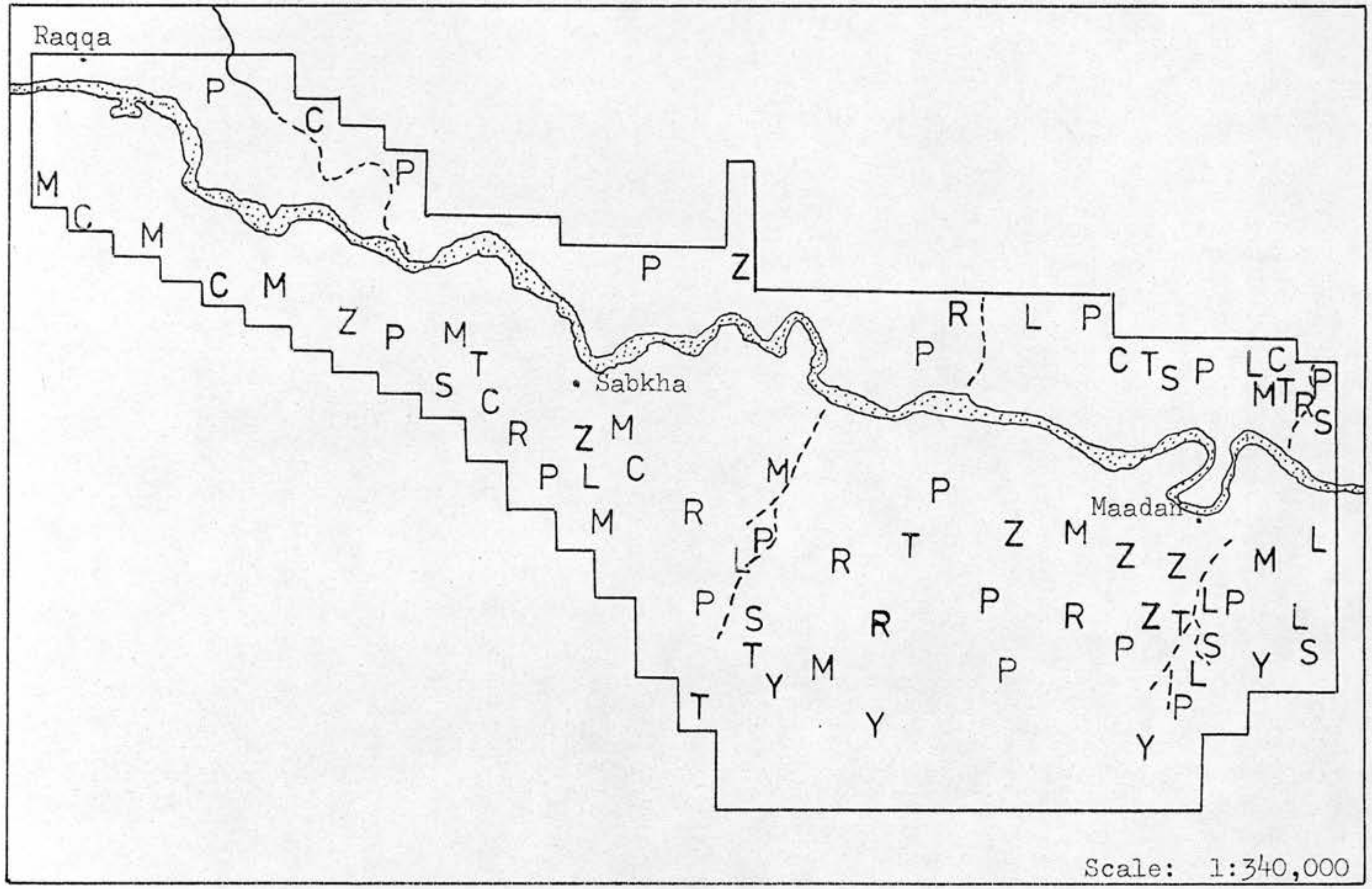
Scale: 1:60,000,000

Figure 8.1b
MAIN SOIL TYPES OF SYRIA



Note: The shaded area shown by van Liere is highly generalised; fieldwork (presented in the text) has shown that three other major soil groups are present in the study area (Chapter 7).

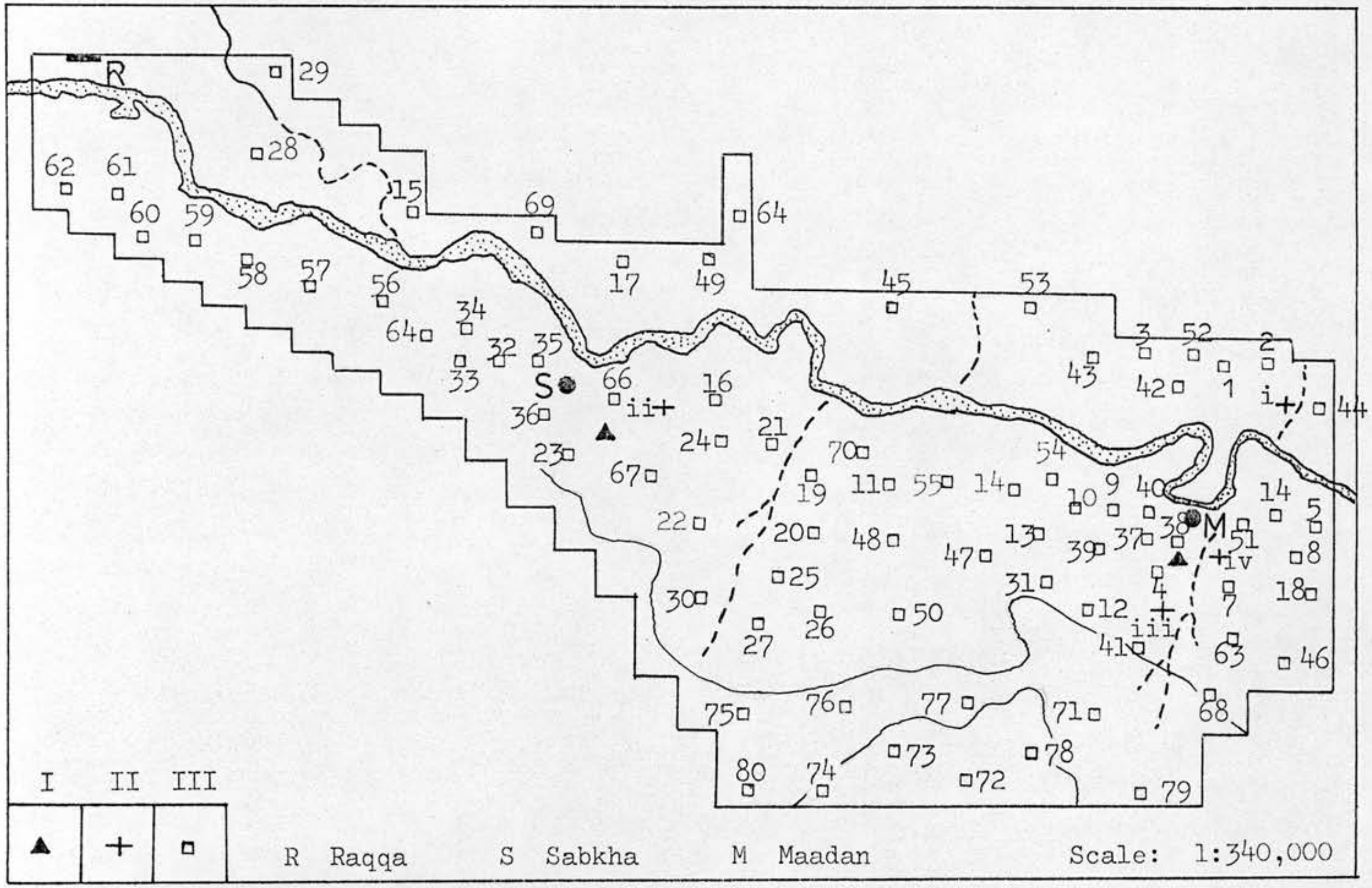
Figure 8.2
FORMS OF GYPSUM DEPOSITS



M (i) massive deposits of gypsum anhydrite; R (ii) gypsum crystals; P (iii) gypsum powder;
C (iv) Gypsum cement; L (v) gypsum plates; T (vi) Gypsum crust; Z (vii) gypsum in brown loam;
S (viii) gypsum stones; Y (ix) gypsum crystals of ground water.

Source: Department of Geology and Mineral Research, Damascus.
Based on : Fieldwork, Zouzou, R., 1961-74.

Figure 9.1
LOCATION OF GROUND WATER SAMPLES



I Representative profile of medium and deep soils in gypsiferous areas
II Representative ground water samples in various geological structures within the gypsiferous area related to Graphs 9.2 a-d.
III Representative ground water samples at various levels related to Table 9.1 and Appendix IX.

Source: Department of Geology and Mineral Research, Damascus, 1967.
Fieldwork, Zouzou, R., 1961-1974.

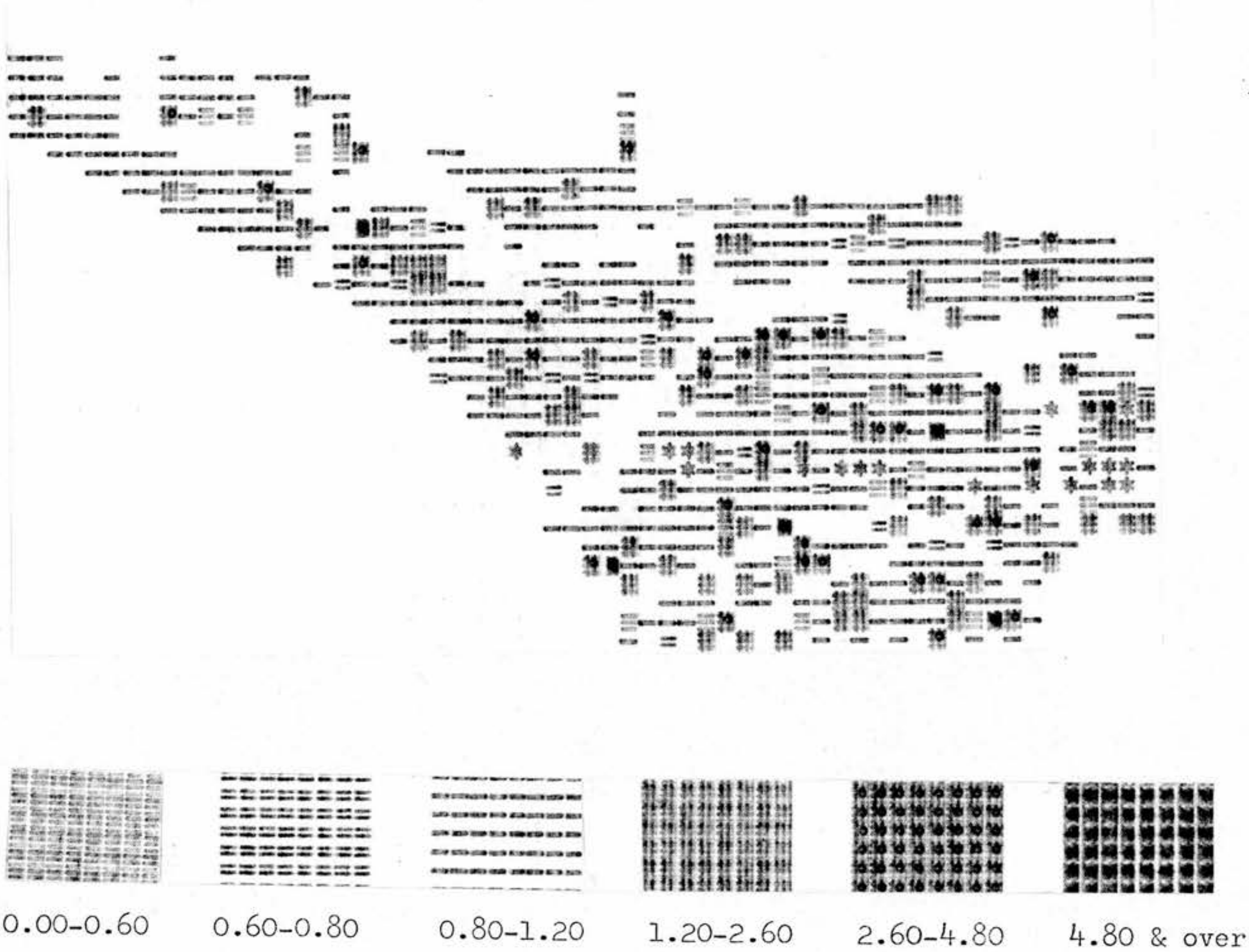


Figure 9.2a
ELECTRICAL CONDUCTIVITY (EC_5) - SURFACE
(Computer Map)

This map shows the high level of electrical conductivity occurring in the soils of the south plateau (0.8 - 1.2 mmhos/cm), particularly in the east. This results from the fairly high proportion of gypsum. In addition there is high salinity due to high concentrations of soluble anions and cations.

Source: This computer map is based on results of Fieldwork, Zouzou, R., 1961-74.

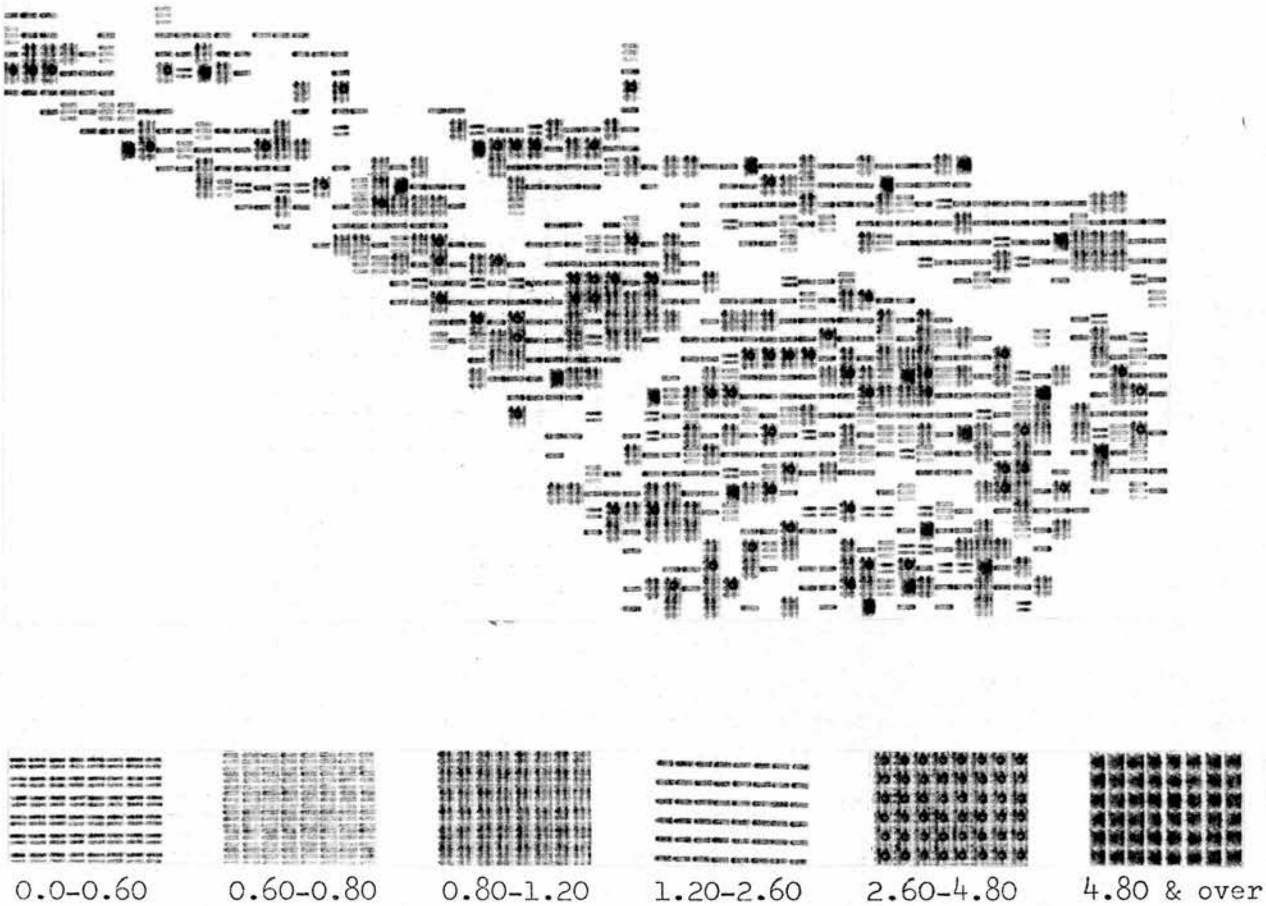


Figure 9.3a
ELECTRICAL CONDUCTIVITY (EC_5) - SUBSURFACE
(Computer Map)

This map shows the higher levels of electrical conductivity (EC_5 1.2 - 2.6 mmhos/cm) in the subsurface. These levels extend over the southern plateau and can be found in the north. Even higher figures (EC_5 4.8 mmhos/cm) have been recorded to the east and south of the area.

Source: This computer map is based on results of Fieldwork, Zouzou, R., 1961-74.

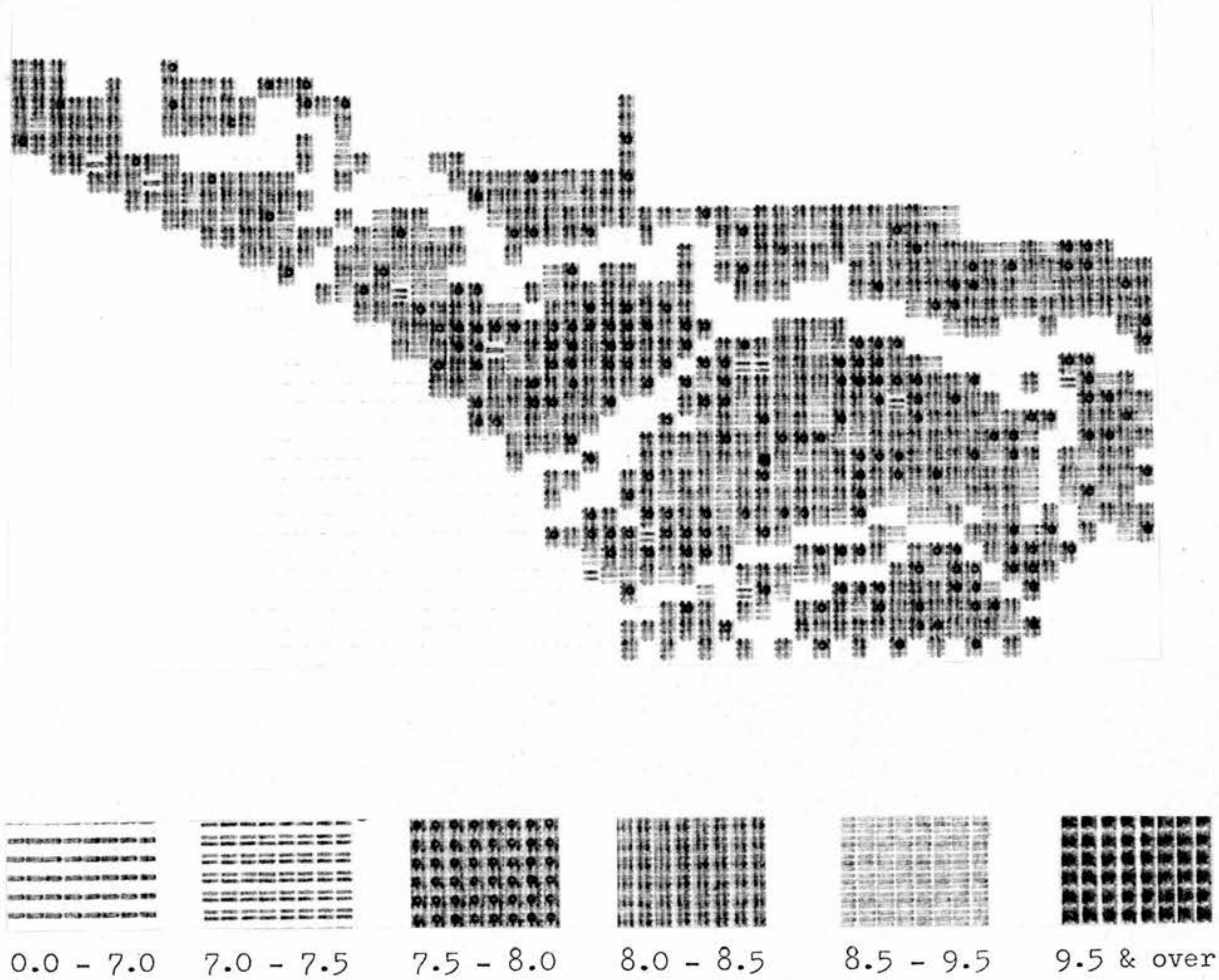


Figure 9.2b
pH VALUES - SURFACE
(Computer Map)

This map shows high pH values (7.5 - 8.5) mainly in south plateau. The high values coincide with a fairly high cation exchange capacity, particularly exchangeable sodium.

Source: This computer map is based on results of Fieldwork, Zouzou, R., 1961-74.

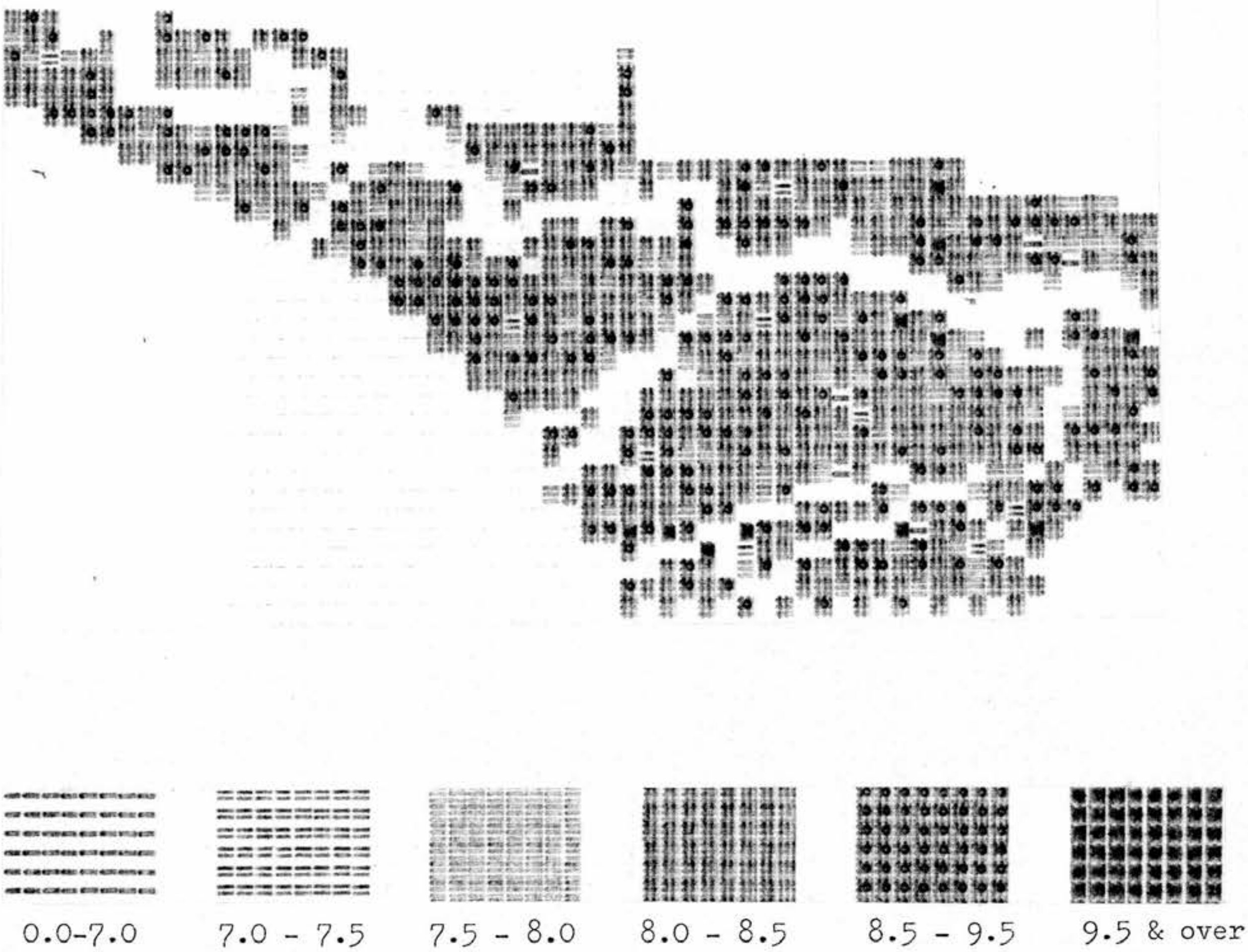


Figure 9.3b
pH VALUES - SUBSURFACE
(Computer Map)

This map shows the increased pH values (8.0 - 9.5) with depth. This trend is emphasised particularly in the centre and north plateau of the area and to the east.

Source: This computer map is based on results of Fieldwork, Zouzou, R., 1961-74.

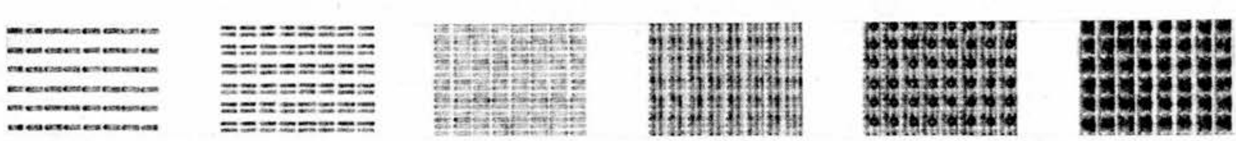


Figure 9.2c
CALCIUM CARBONATE ($CaCO_3$) - SURFACE
(Computer Map)

This map shows fairly high contents of calcium carbonate (12.0% - 25%) over the area, with even higher levels (over 24%) in the north plateau and to the centre. These figures are related to calcareous soils particularly the high content of calcium carbonate derived mainly from limestones, silt stones and calcareous silty clays.

Source: This computer map is based on results of Fieldwork, Zouzou, R., 1961-74.

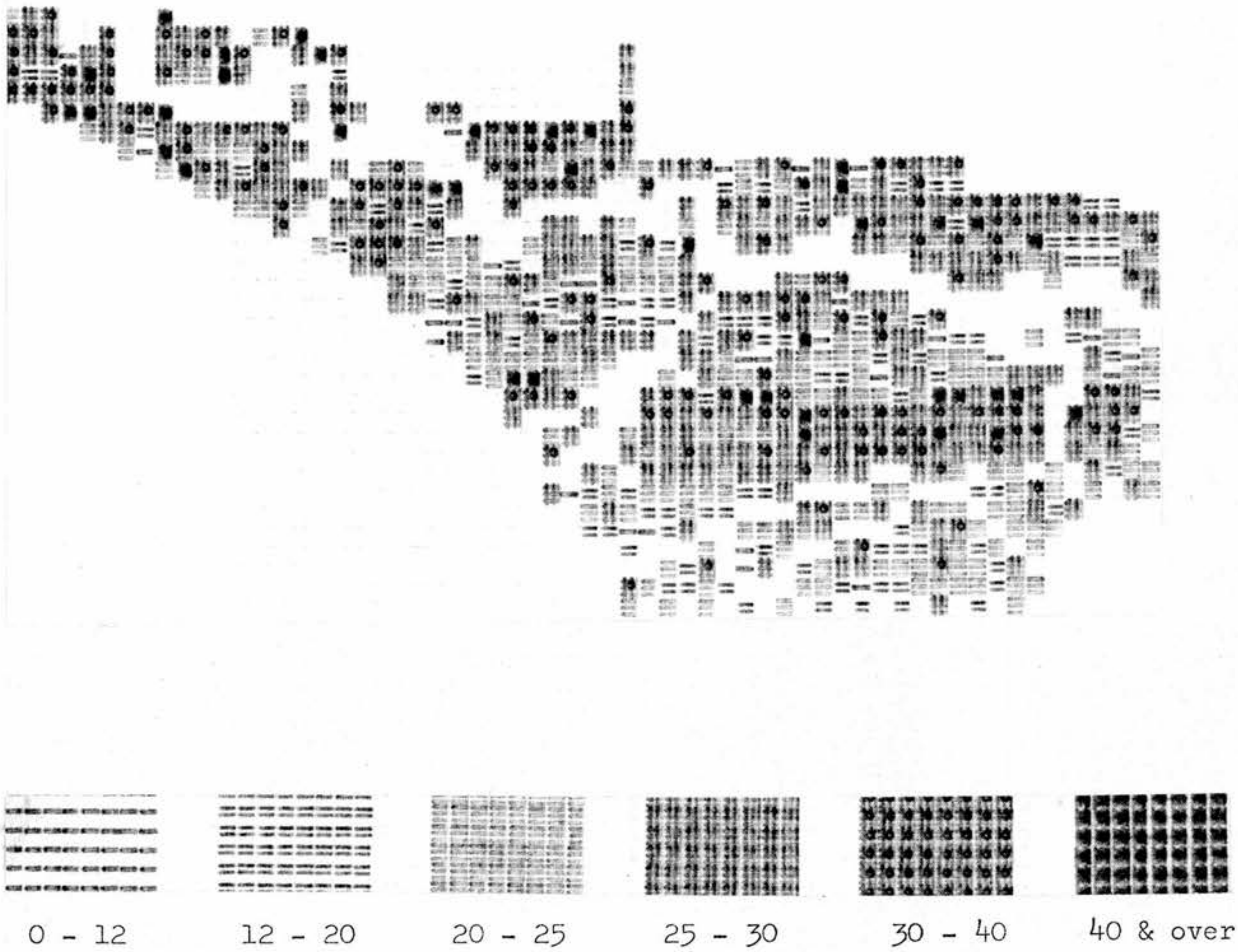


Figure 9.3c
CALCIUM CARBONATE ($CaCO_3$) - SUBSURFACE
(Computer Map)

This map shows the increased level of calcium carbonate with depth (20% - 40%). These higher levels of carbonate react with sulphate to give higher gypsum levels in the subsurface horizons.

Source: This computer map is based on results of fieldwork, Zouzou, R., 1961-74.

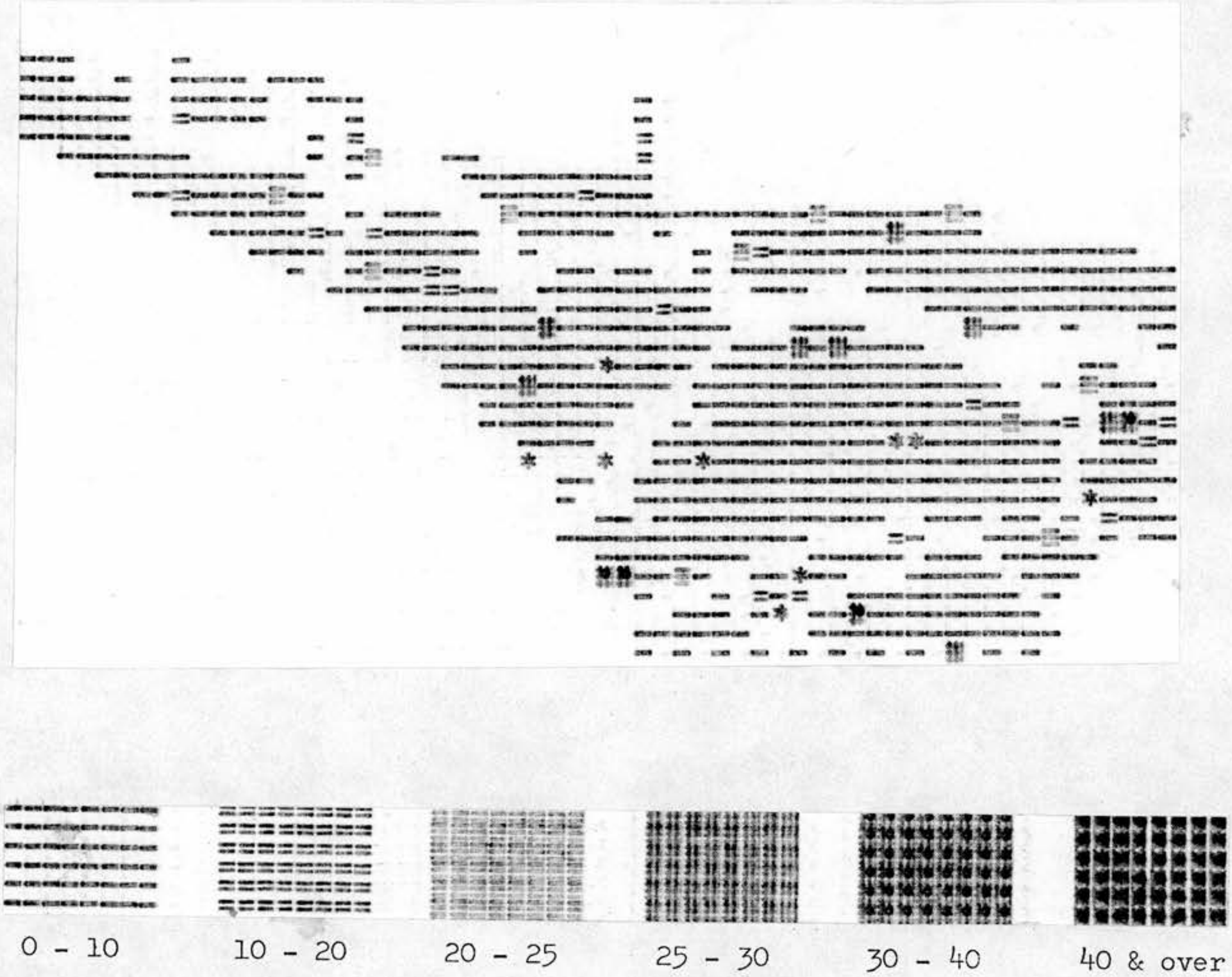


Figure 9.2d
CALCIUM SULPHATE ($CaSO_4$) - SURFACE
(Computer Map)

This map shows that most of the soils have gypsum contents in the surface horizon of between 0 - 10 per cent. The surface horizons (0-30 cm) may be subdivided into three depth classes:

(i) Represents the top 20 cm, consisting of up to 1.5% gypsum, and occupying 62% of the surface horizon.

(ii) Represents the second 5 cm, consisting of up to 5% gypsum, and occupying 21% of the surface horizon.

(iii) Represents the lower 5 cm, consisting of up to 10% gypsum, and occupying 17% of the surface horizon.

The high gypsum content (over 1.5% of gypsum) leads to the formation of 'gypsiferous soils'.

Source: This computer map is based on results of Fieldwork, Zouzou, R., 1961-74.

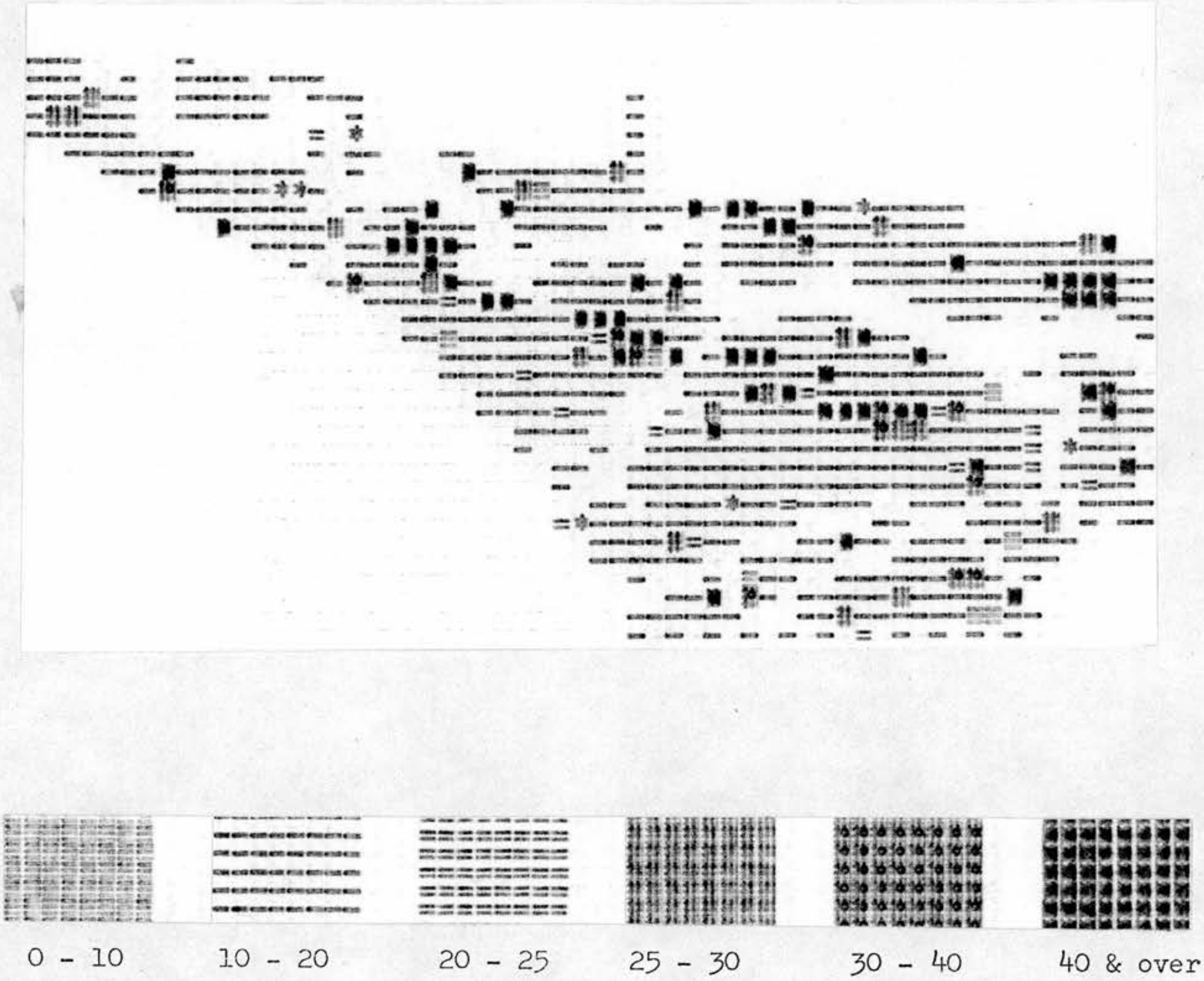


Figure 9.3d
CALCIUM SULPHATE ($CaSO_4$) - SUBSURFACE
(Computer Map)

This map shows high gypsum contents (10% - 20%) in the subsurface horizons rising to 40% or even more in soils derived from the Upper and Lower Fars formation.

The high gypsum levels lead to the formation of "gypsiferous soils" and high salinity. Such levels significantly affect agricultural development in the area.

Source: This computer map is based on results of fieldwork, Zouzou, R., 1961-74.

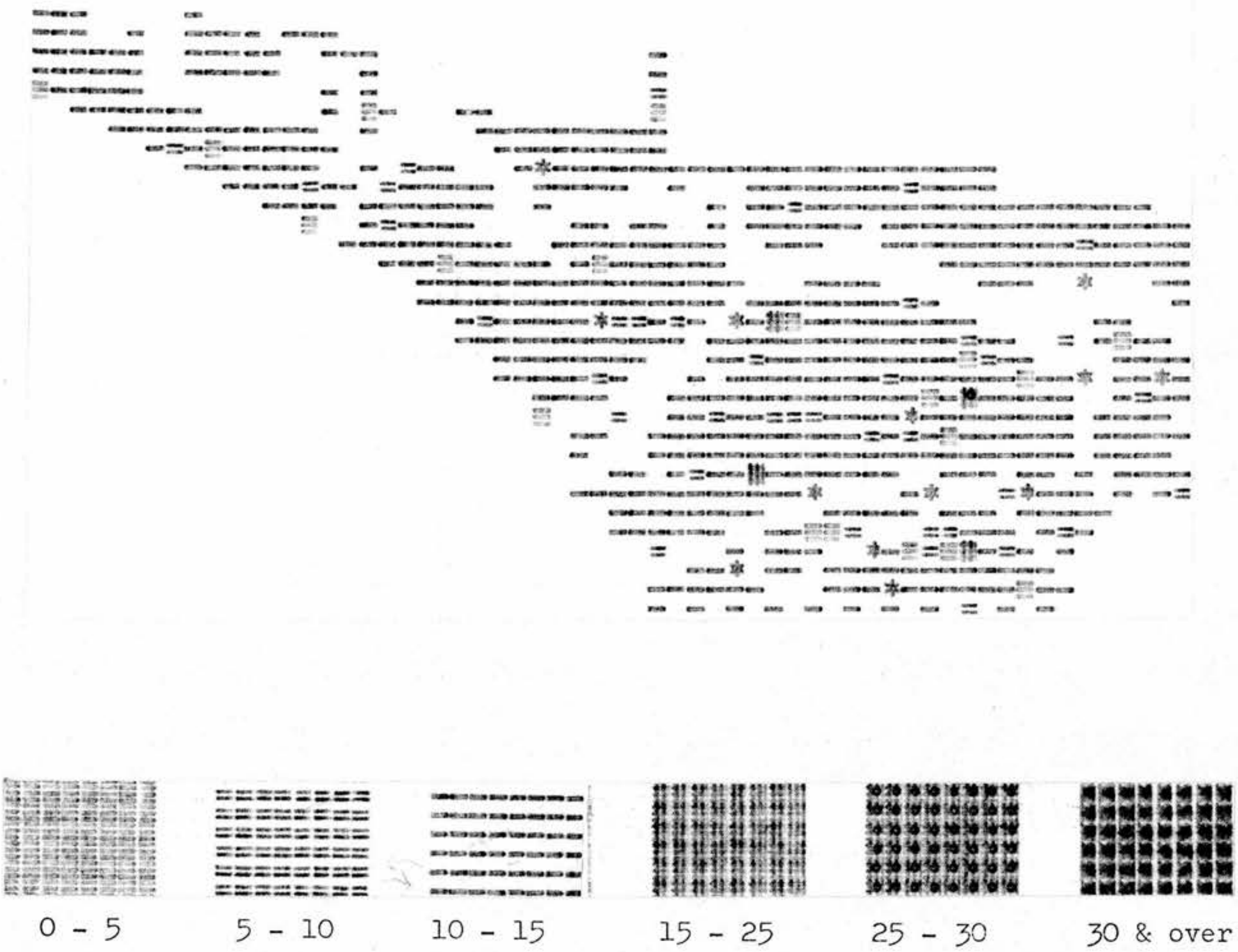
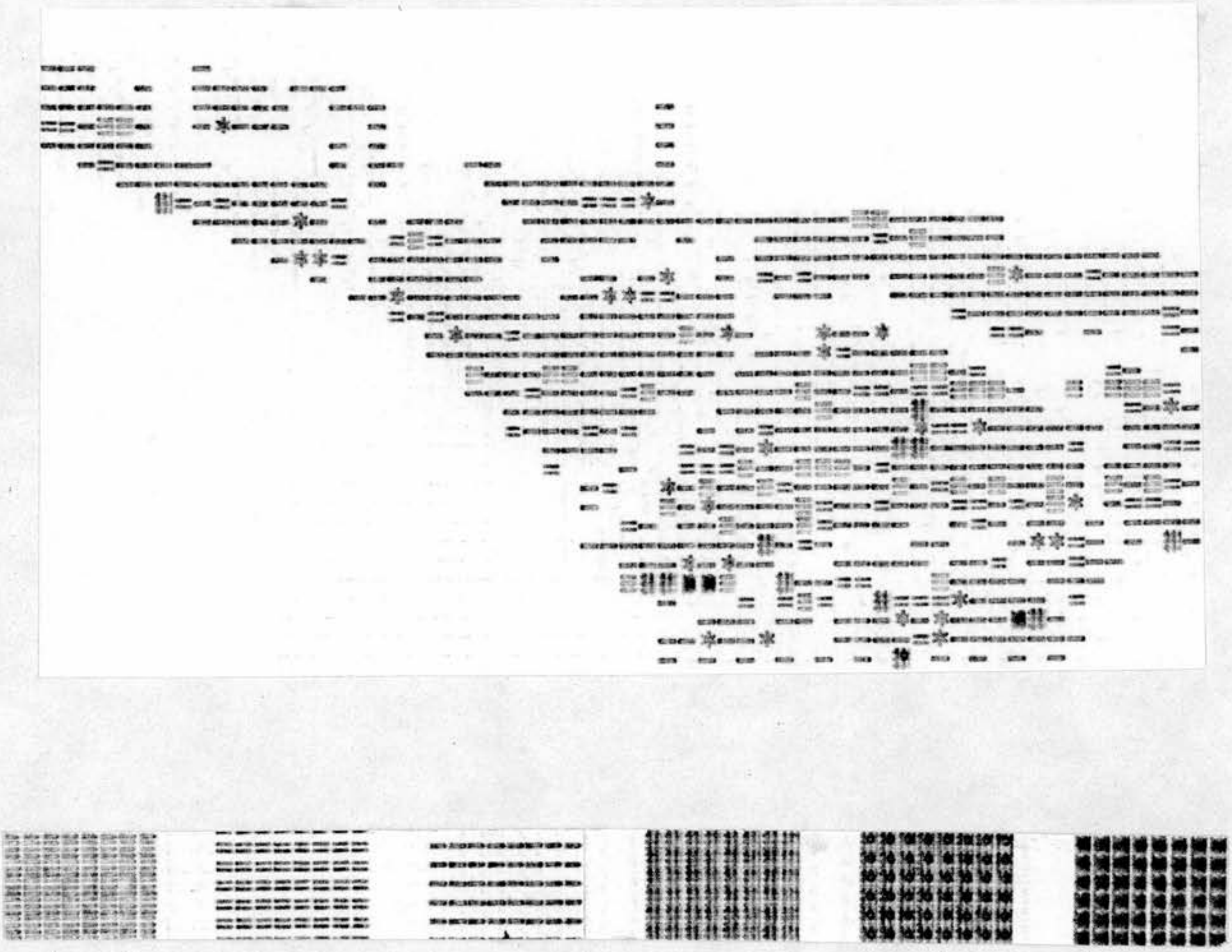


Figure 9.2e
EXCHANGEABLE SODIUM PERCENTAGE (ESP) - SURFACE
(Computer Map)

This map shows widespread alkalinity due to fairly high ESP values (10% - 15%), particularly in the east and southern plateau. This causes interference with plant growth without artificial leaching.

Source: This computer map is based on results of Fieldwork, Zouzou, R., 1961-74.



5 - 10 | 10 - 15 | 15 - 25 | 25 - 30 | 30 - 40 | 40 & over

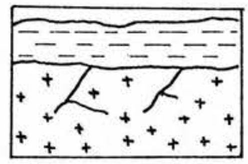
Figure 9.3e
EXCHANGEABLE SODIUM PERCENTAGE (ESP) - SUBSURFACE
(Computer Map)

This map shows the high level of exchangeable sodium (15% - 25%) in the subsurface, rising to more than 25% in the east. Such alkalinity affects the soil permeability, and tends to disturb stable irrigation structures and limits plant growth.

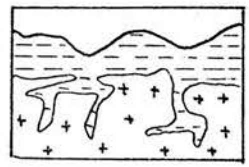
Source: This computer map is based on results of fieldwork, Zouzou, R., 1961-74.

Figure 9.4
REACTION OF WATER ON GYPSIFEROUS SOILS

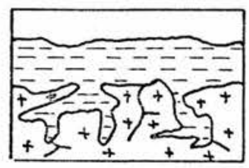
Gypsiferous soils before irrigation
(hardly any reaction)



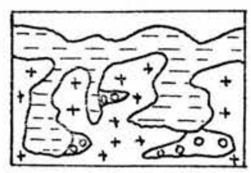
Gypsiferous soils after irrigation
(slow reaction)



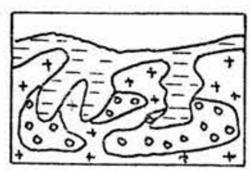
Levelled land after first irrigation
(more reaction because of the penetration
of water)



Second irrigation causes more activity
in the gypsiferous soils



Levelling after second irrigation increases
the activity of gypsiferous soils

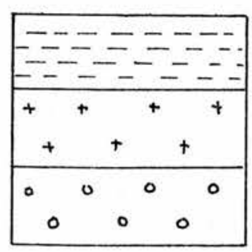


Key

Surface soil without gypsiferous material

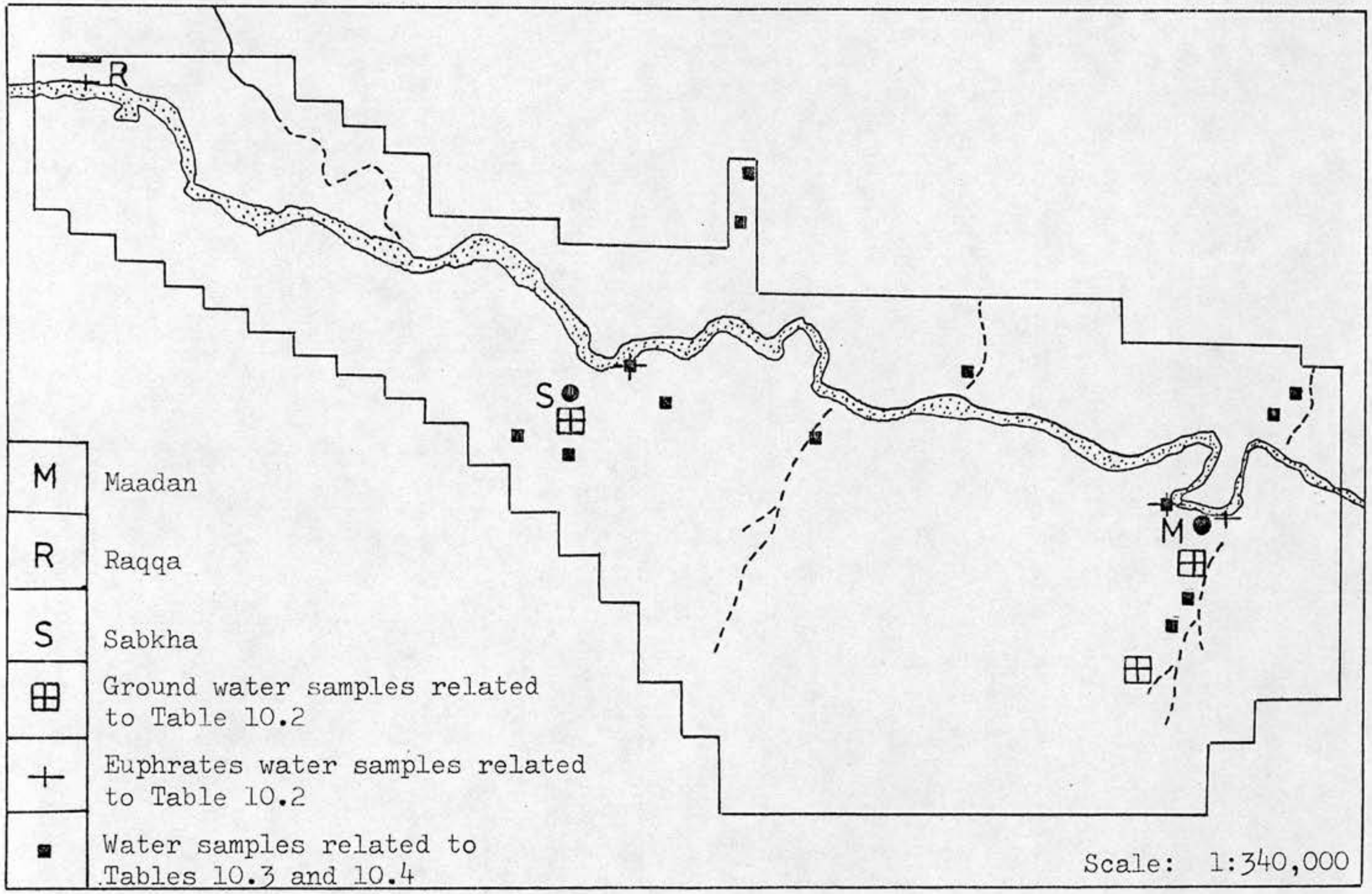
Subsoil with gypsum

Hollows and small caves in the gypsum



Source: Based on Alphen and Romero, 1971.
Fieldwork, Zouzou, R., 1961-1974.

Figure 10.1
LOCATION OF WATER SAMPLES



Source: Fieldwork, Zouzou, R., 1961-74.
Limited additions from Department of Geology and Mineral Research, Damascus.

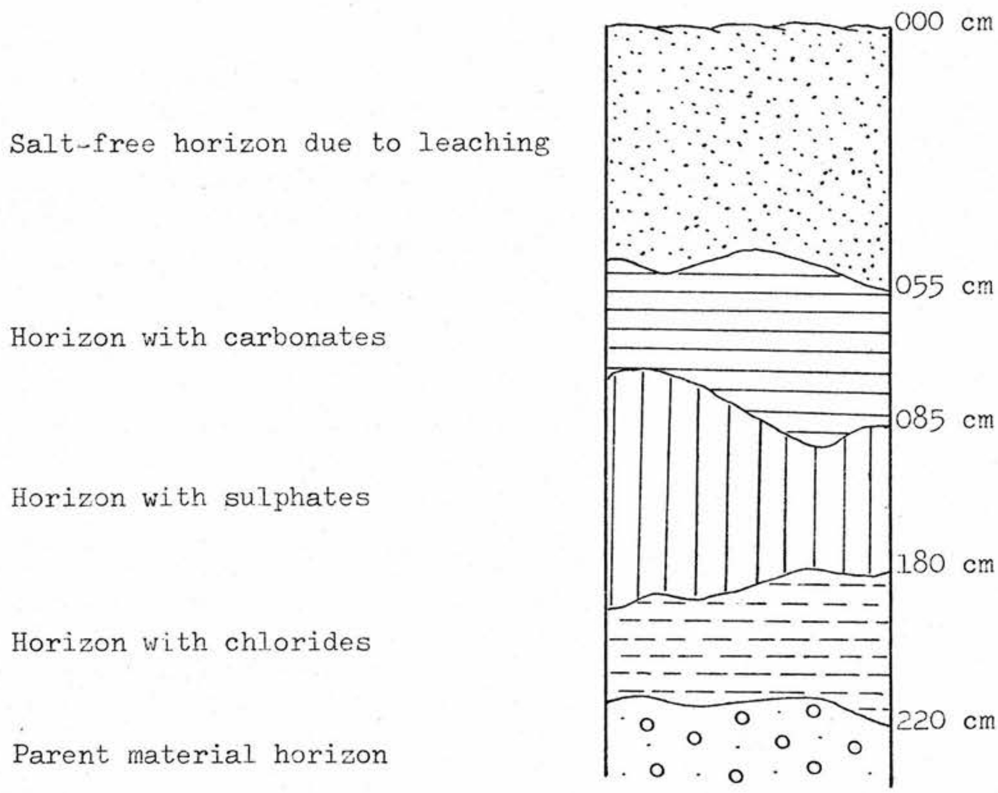


Figure 10.2
DISTRIBUTION OF SALTS DUE TO LEACHING IN THE SOIL PROFILE
(Location: 1 km south of Maadan village)

Explanation: The distribution of salts in the sub-surface horizons is correlated with the frequency of wetting of the soils and the relative solubilities of the salts. Due to frequent wetting of the surface and immediate sub-surface horizons, the salts move downwards. Their distribution as evidenced in the soil profile is shown above.

Source: Fieldwork, Zouzou, R., 1961-74.

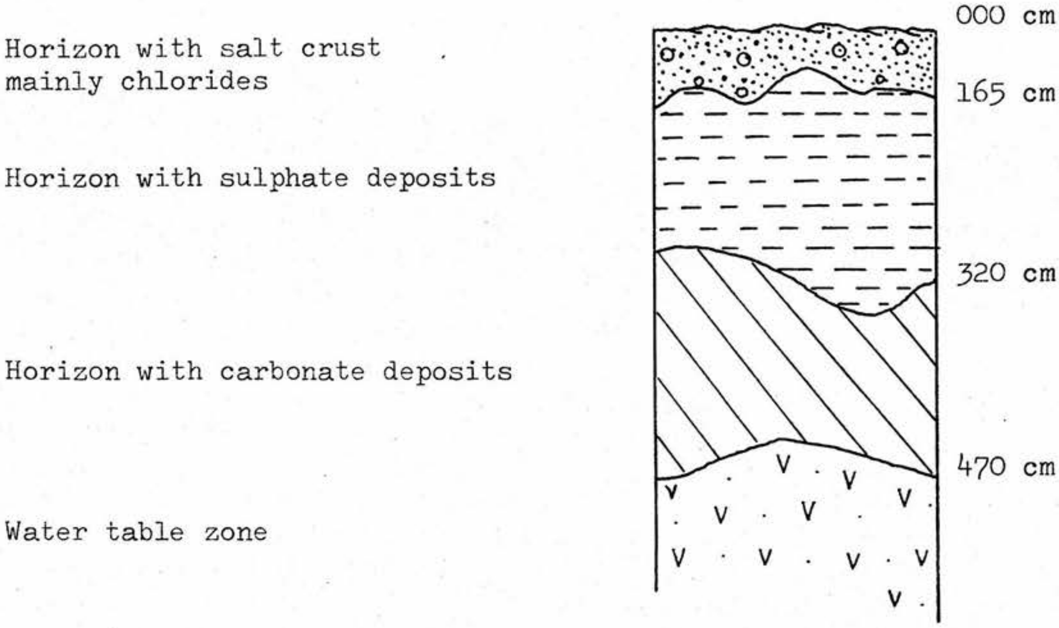
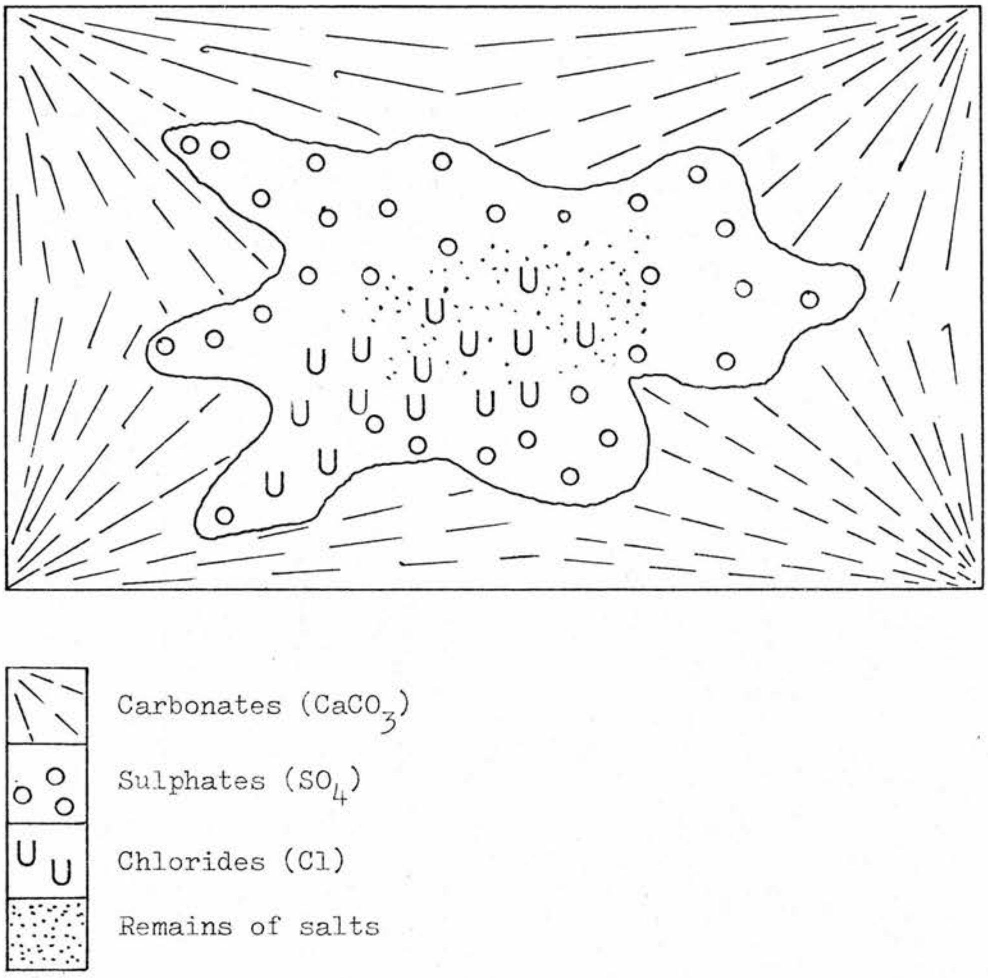


Figure 10.3
DISTRIBUTION OF SALTS AS A RESULT OF THE ACTIVITY OF CAPILLARY FRINGE IN THE SOIL PROFILE
(Location: 2 km south-east of Maadan village)

Explanation: The distribution of salts rising due to capillary action above the shallow water table as observed in the Profile (shown above).

Source: Fieldwork, Zouzou, R., 1961-74.

Figure 10.4
SPATIAL DISTRIBUTION OF SALTS IN SALT PAN
(Location: 5 km east of Tell Kharar)



Explanation: During rainy period, the area is flooded by rainy water from the bordering areas. This water brings in dissolved form a large amount of salts and these salts are deposited in the central parts within the area. As the flood water evaporates, these salts are left behind. The least soluble salts are: (i) carbonates which were the first to crystallize, (ii) sulphates, and (iii)chlorides (shown above in the key).

Source: Fieldwork, Zouzou, R., 1961-74.

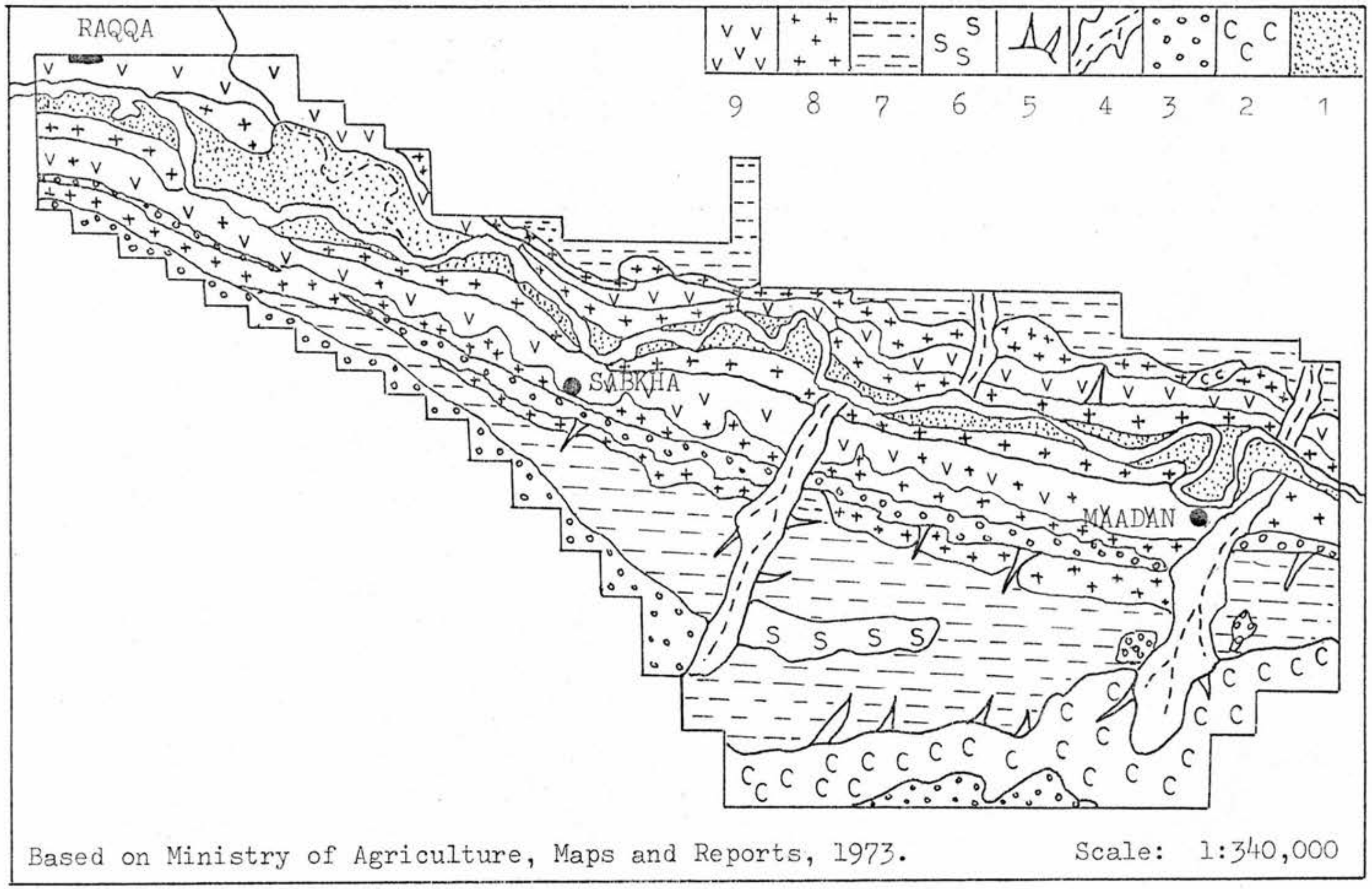


Figure 11.1
PRESENT LAND USE PATTERN

(1) Area under water erosion; (2) Area under wind erosion; (3) Outcrops of bare rock;
(4) Wadis; (5) Gullies; (6) Salt pans; (7) Rough vegetation and bare land;
(8) Cereal crops (wheat, barley, chickpeas, tomatoes); (9) mainly cotton and field crops.

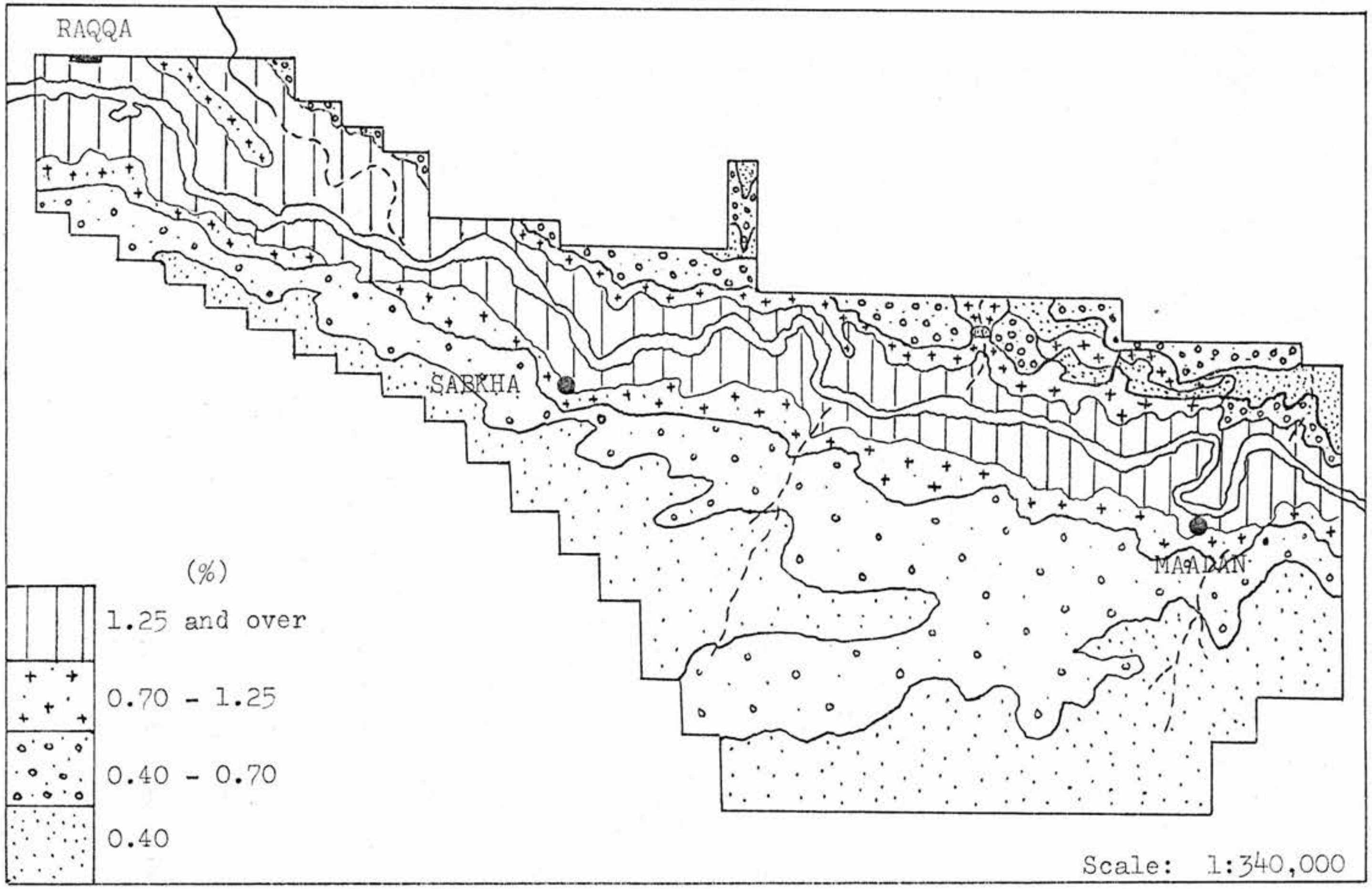


Figure 11.2
GENERALISED MAP SHOWING THE DISTRIBUTION OF THE ORGANIC MATTER LEVELS (%)

Source: Fieldwork, Zouzou, R., 1961-74.

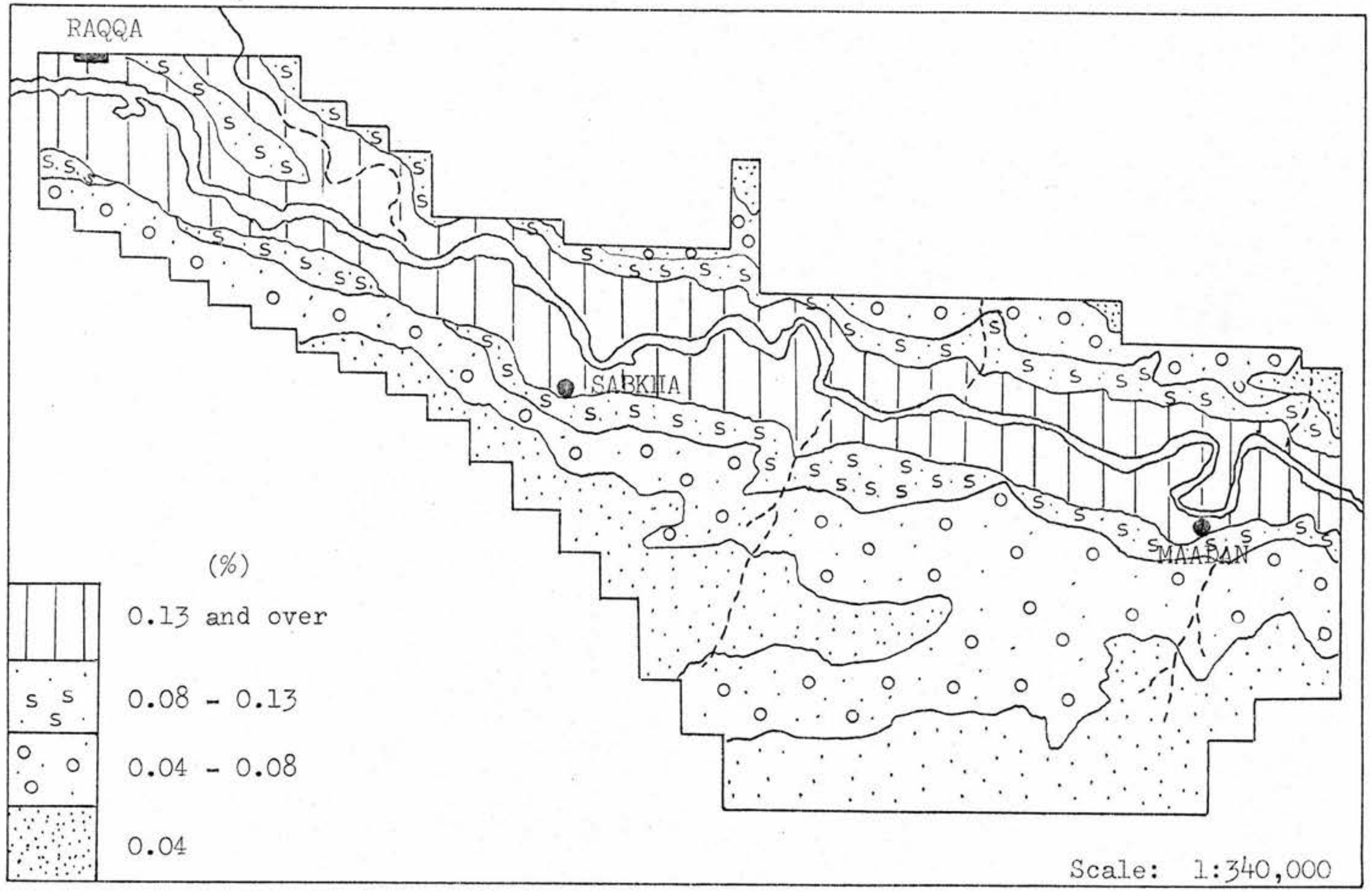


Figure 11.3
GENERALISED MAP SHOWING THE DISTRIBUTION OF TOTAL NITROGEN (%)

Source: Fieldwork, Zouzou, R., 1961-74.

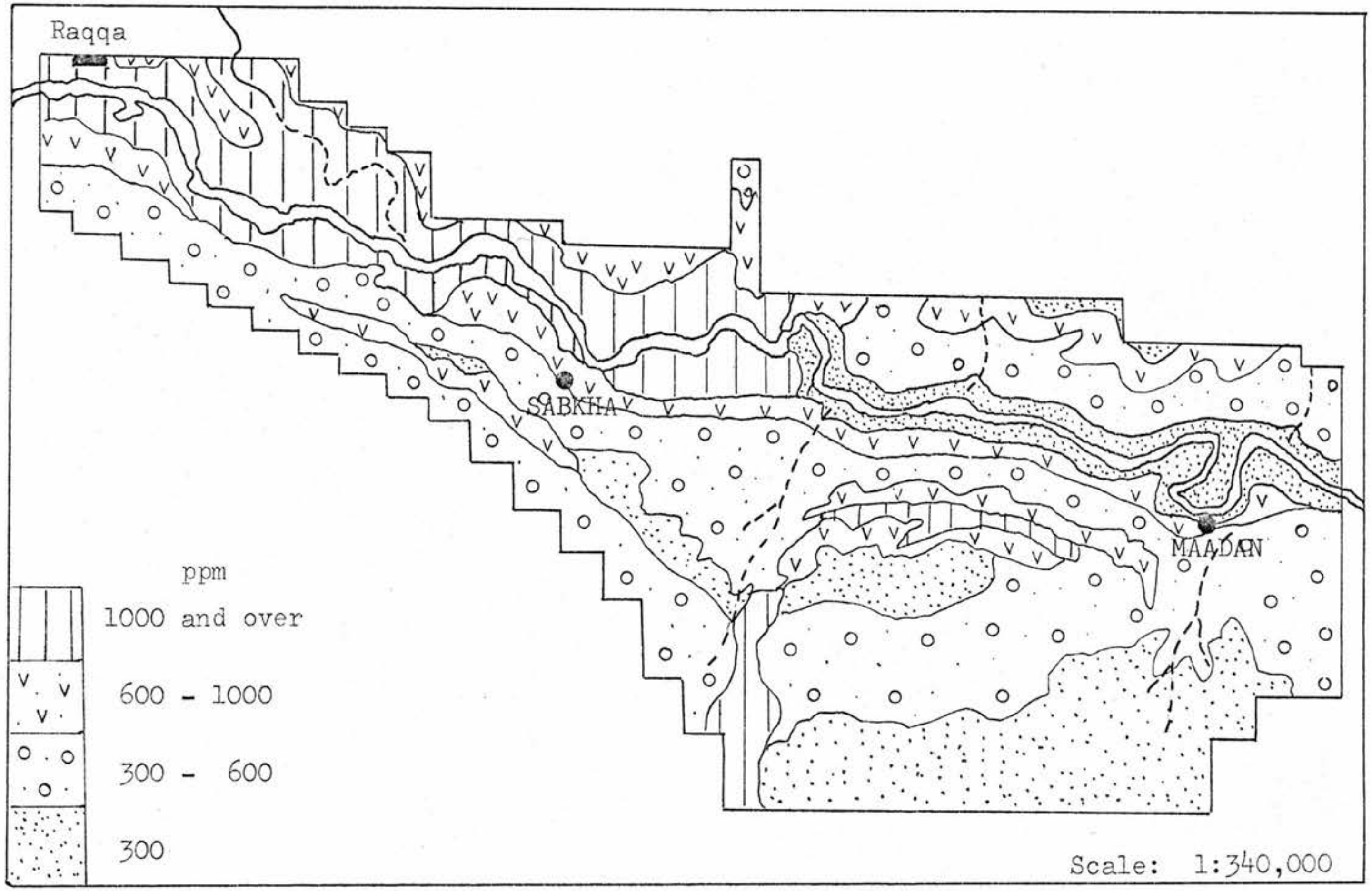


Figure 11.4
GENERALISED MAP SHOWING THE DISTRIBUTION OF THE AVAILABLE PHOSPHATE LEVELS

Source: Fieldwork, Zouzou, R., 1961-74.

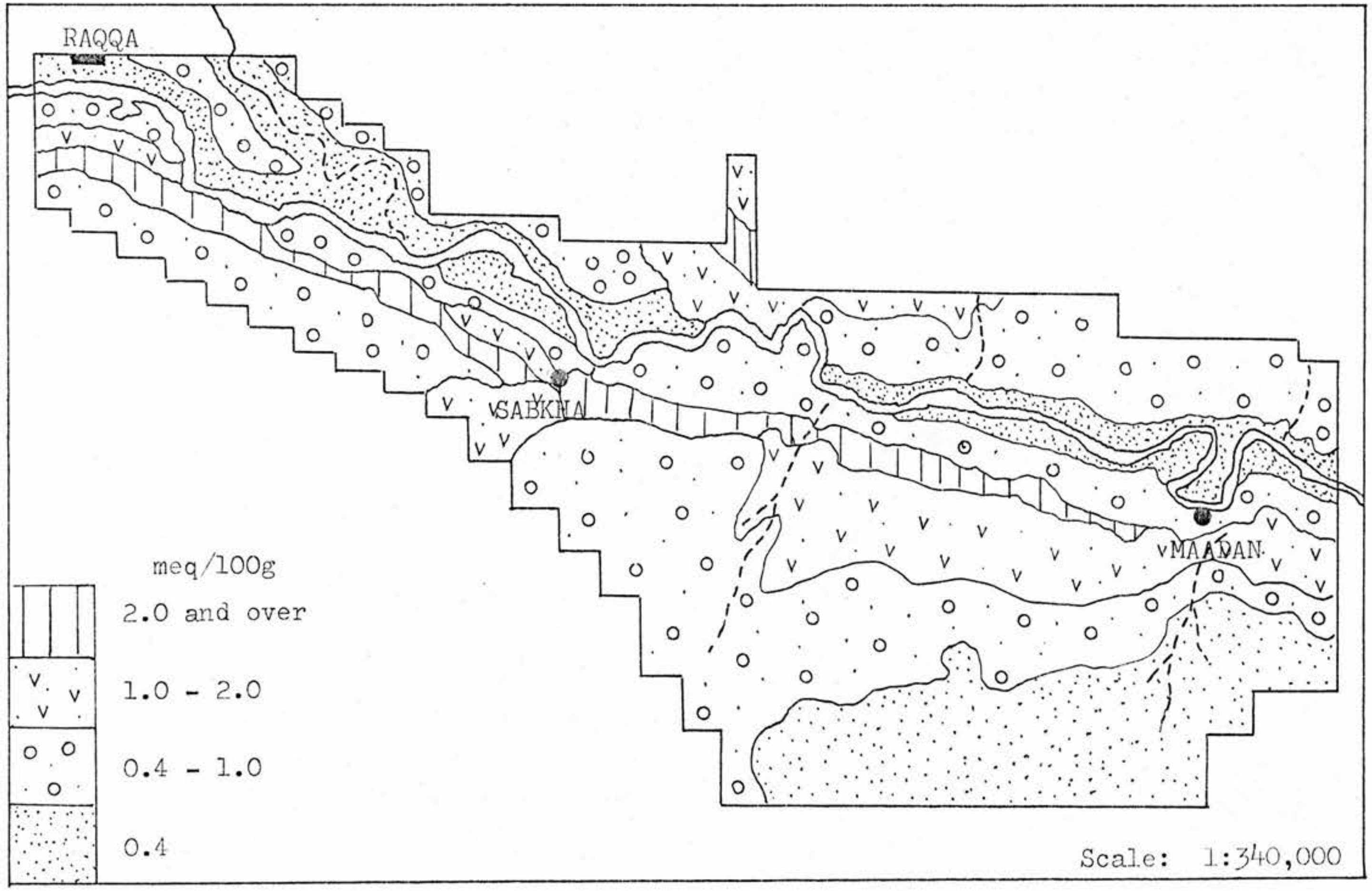
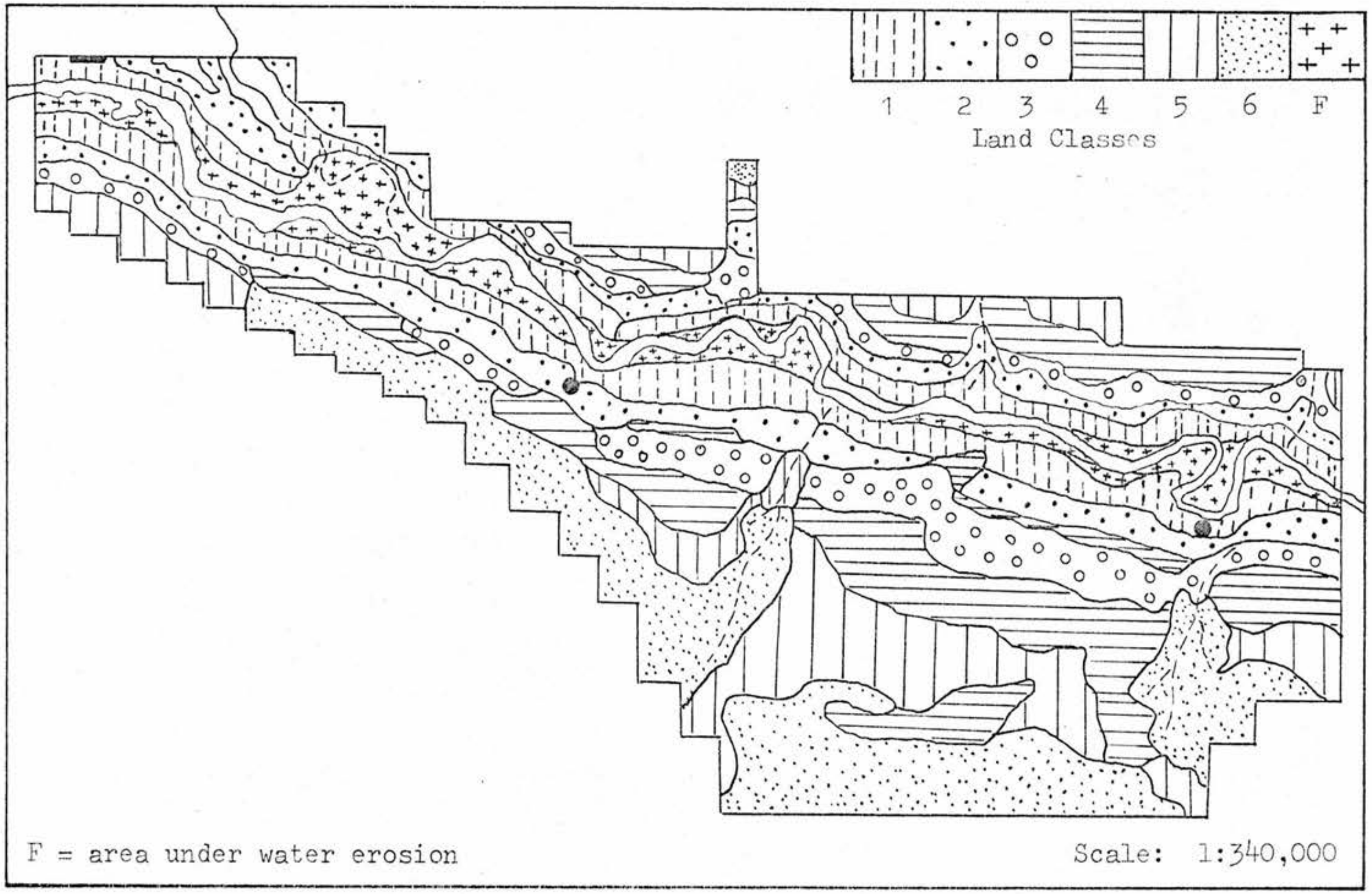


Figure 11.5
GENERALISED MAP SHOWING THE DISTRIBUTION OF THE LEVELS OF POTASSIUM

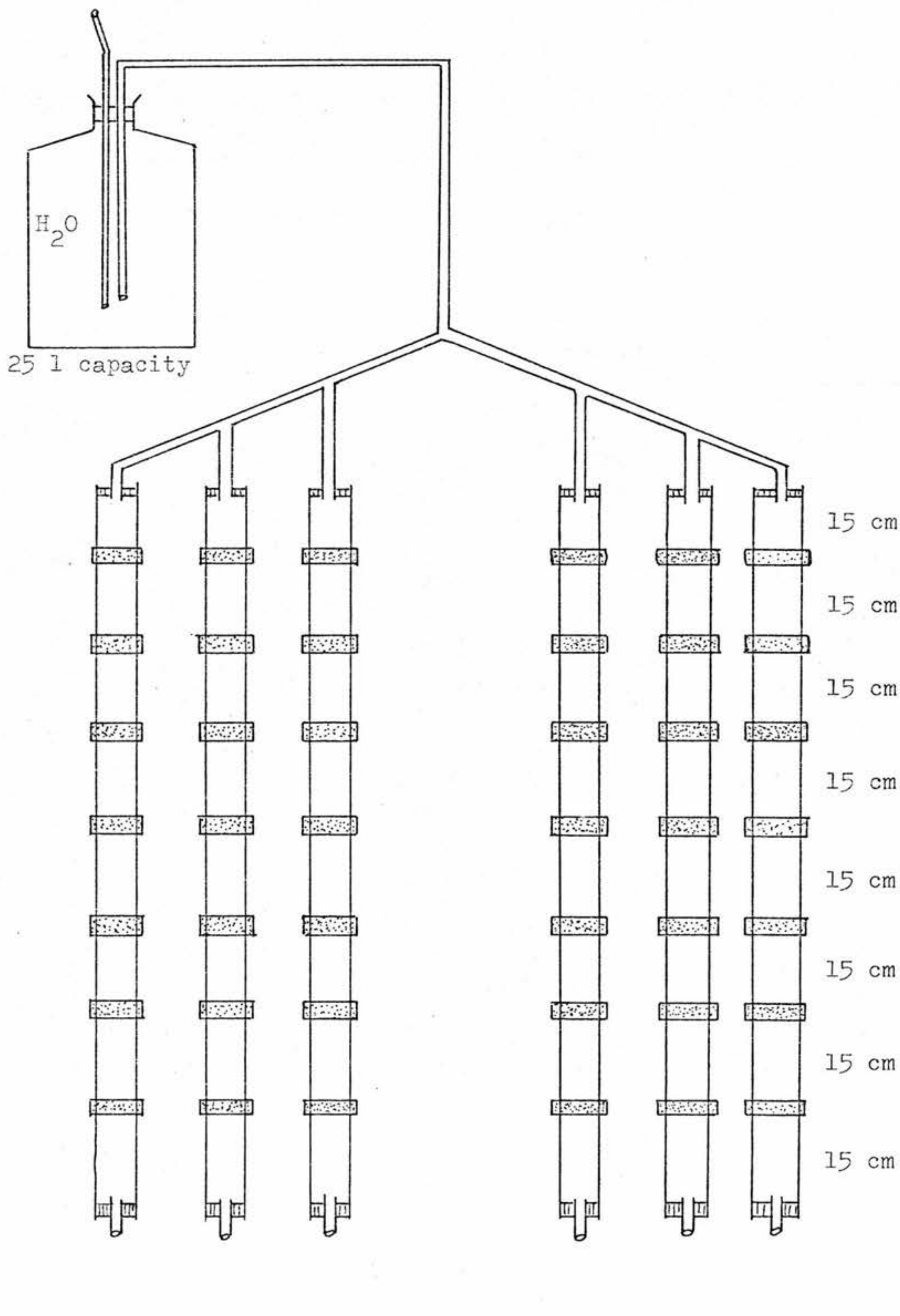
Source: Fieldwork, Zouzou, R., 1961-74.

Figure 11.6
A TENTATIVE MAP SHOWING THE DISTRIBUTION OF VARIOUS LAND CLASSES WITHIN THE STUDY AREA



Source: This map is based on land classes and capability classes (see Appendix X), according to the U.S. Bureau of Reclamation, 1953 (Land Classification Report).
Applied to Fieldwork, Zouzou, R., 1961-74. (Drawn up 1976)

Figure 12.1
LEACHING APPARATUS USED IN LABORATORY TRIALS



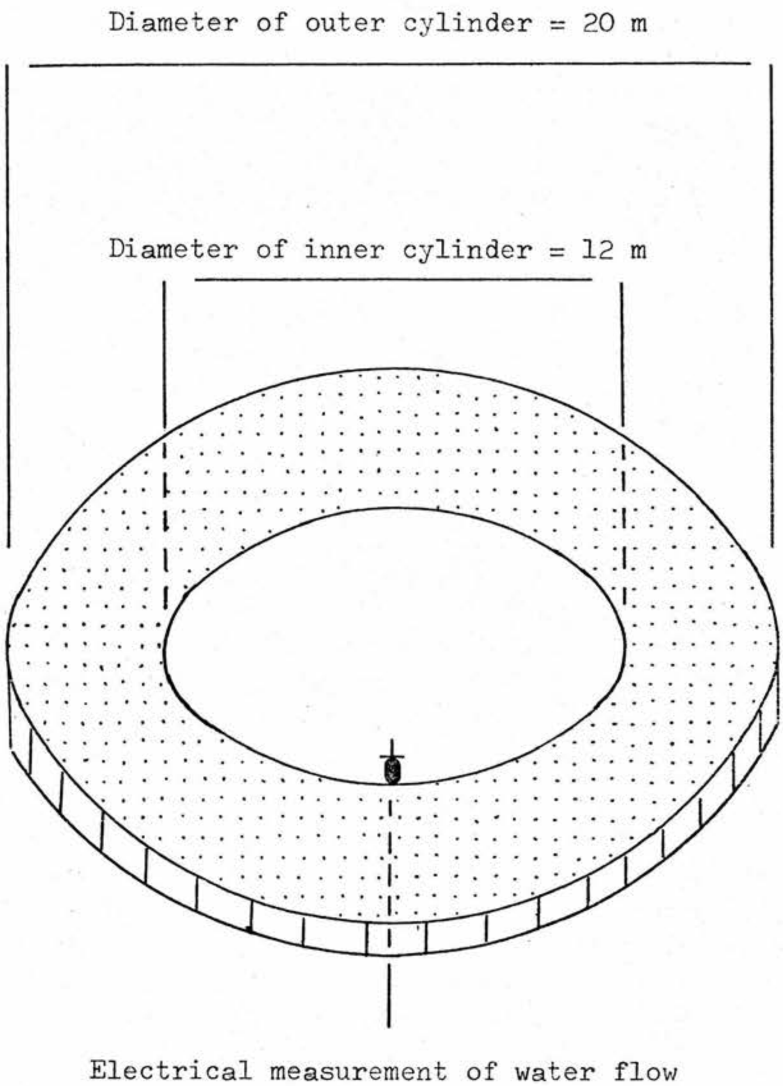


Figure 12.2
FIELD LEACHING APPARATUS

Source: Devised in consultation with Danish agronomists working under the Danish Experiment Station in Syria, 1952-68.

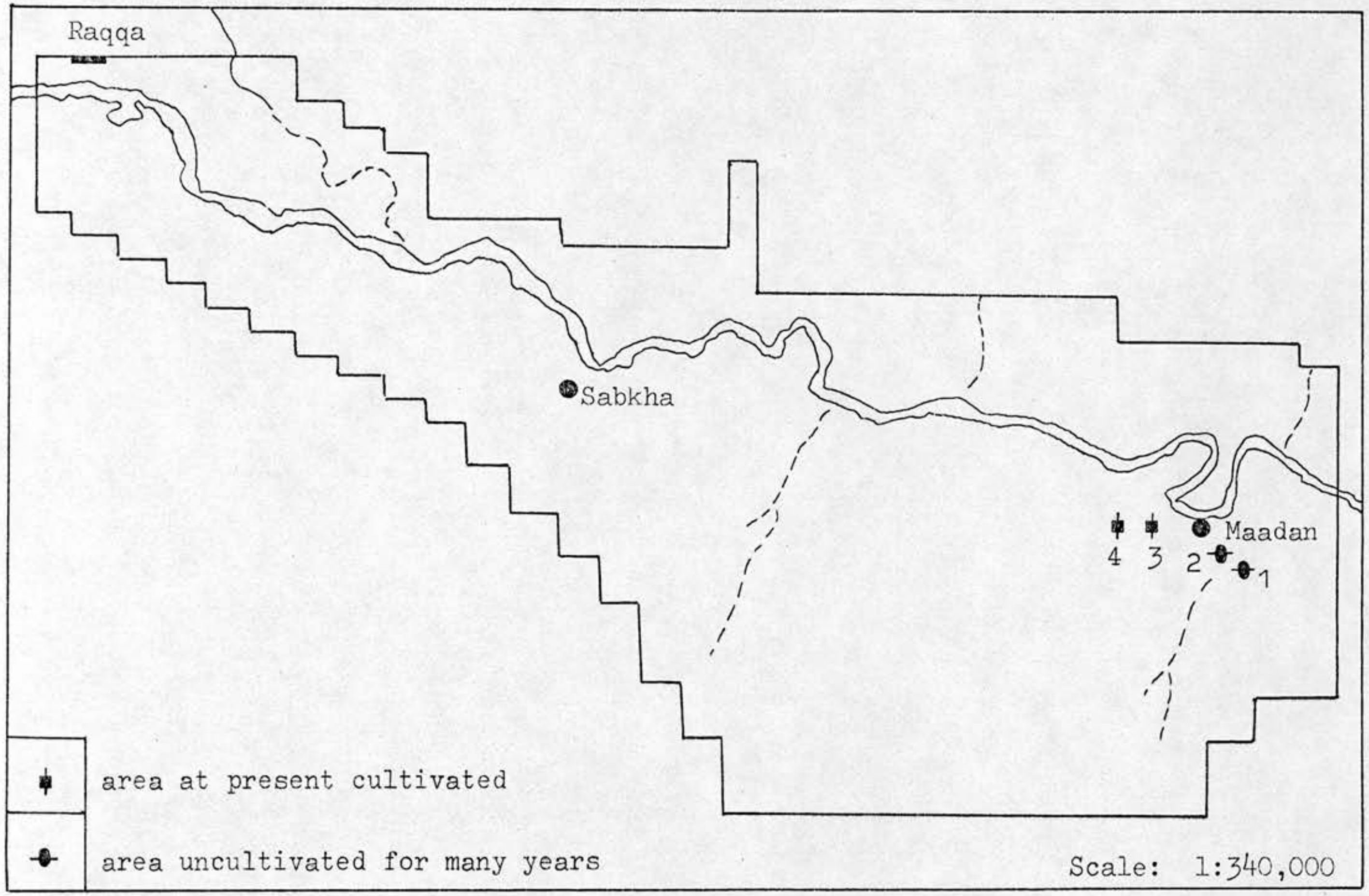
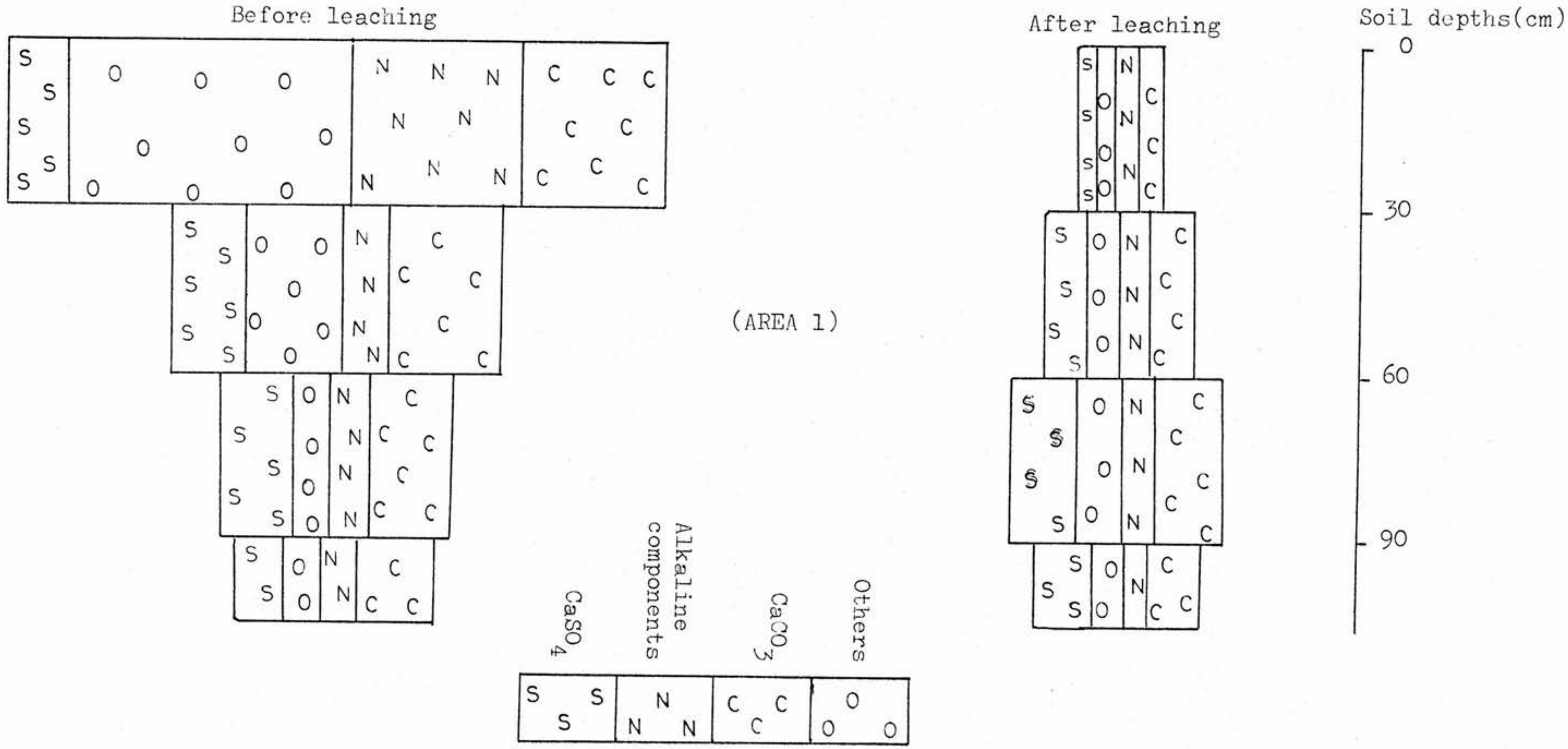


Figure 12.3
LOCATION OF THE FOUR EXPERIMENTAL APPLICATION AREAS FOR AGRICULTURAL DEVELOPMENT

Source: Fieldwork, Zouzou, R., 1961-74.

(1) area at 4.0 km south east of Maadan village
(2) area at 2.5 km south east of Maadan village
(3) area at 2.0 km west of Maadan village
(4) area at 3.0 km west of Maadan village

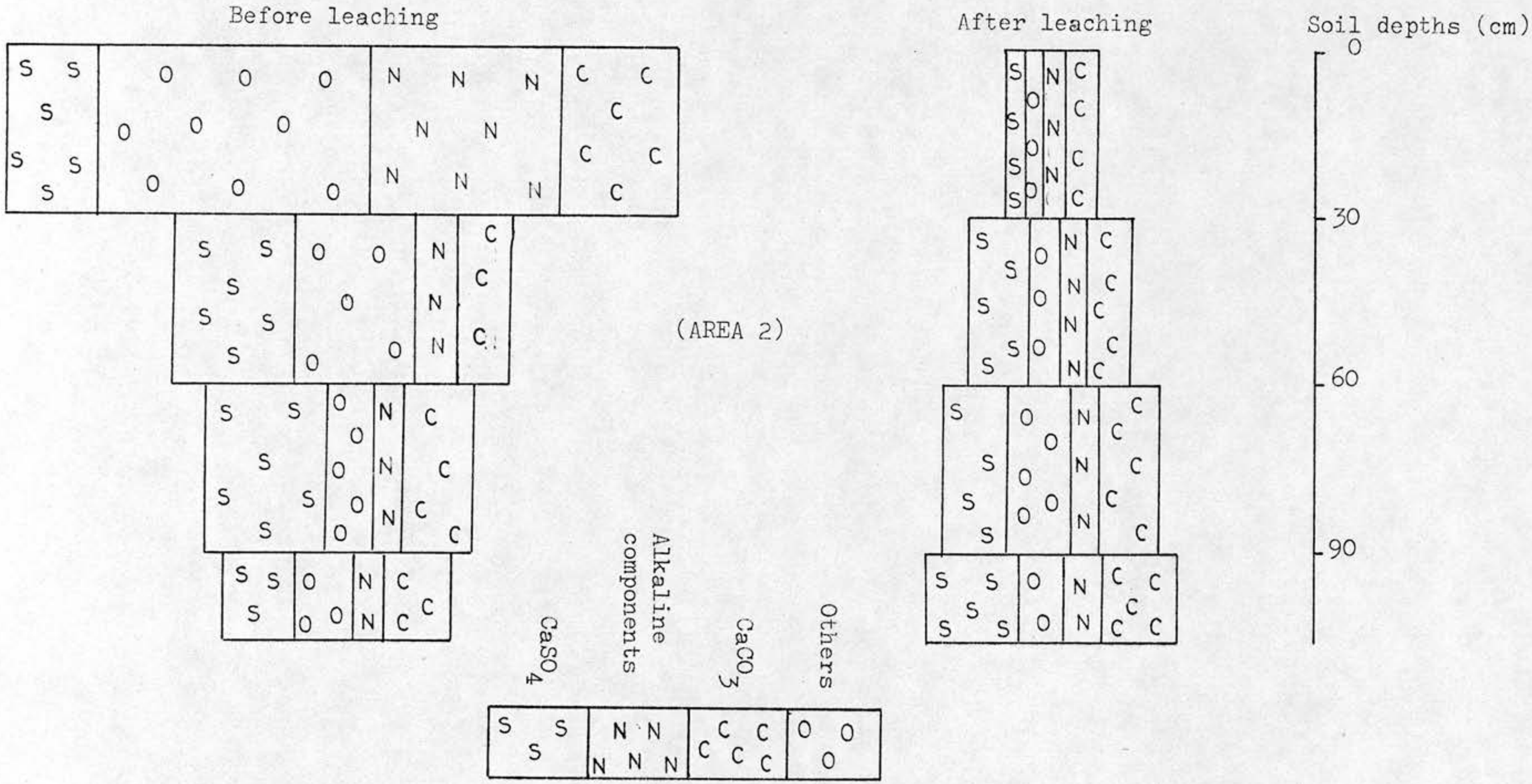
(3) area at 2.0 km west of Maadan village
(4) area at 3.0 km west of Maadan village



The values presented are the average of 25 samples from each horizon

Figure 12.4
THE EFFECTS OF EXPERIMENTAL LEACHING IN THE SALT CONCENTRATION

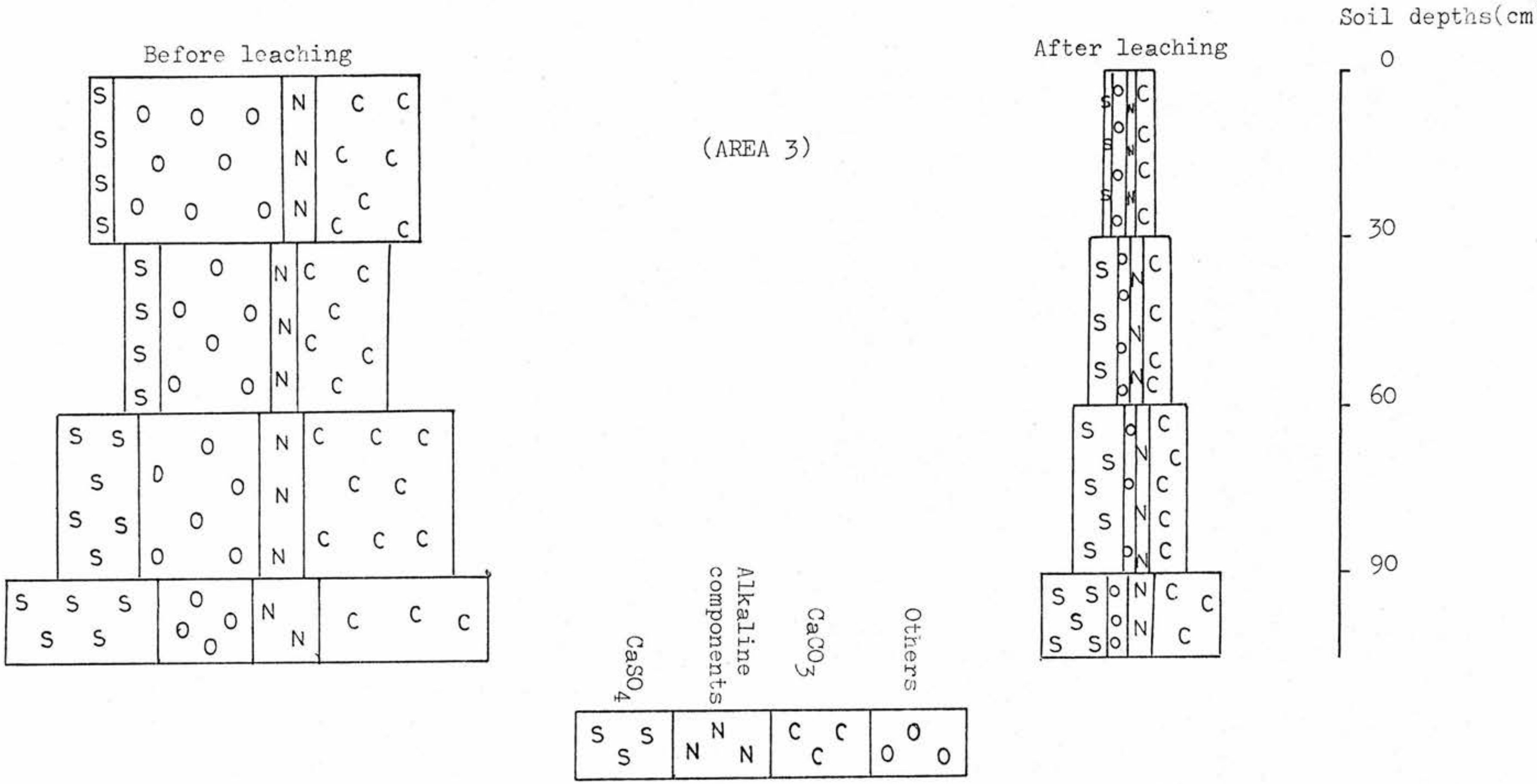
Source: Fieldwork, Zouzou, R., 1961-74.



The values presented are the average of 25 samples from each horizon

Figure 12.5
THE EFFECTS OF EXPERIMENTAL LEACHING IN THE SALT CONCENTRATION

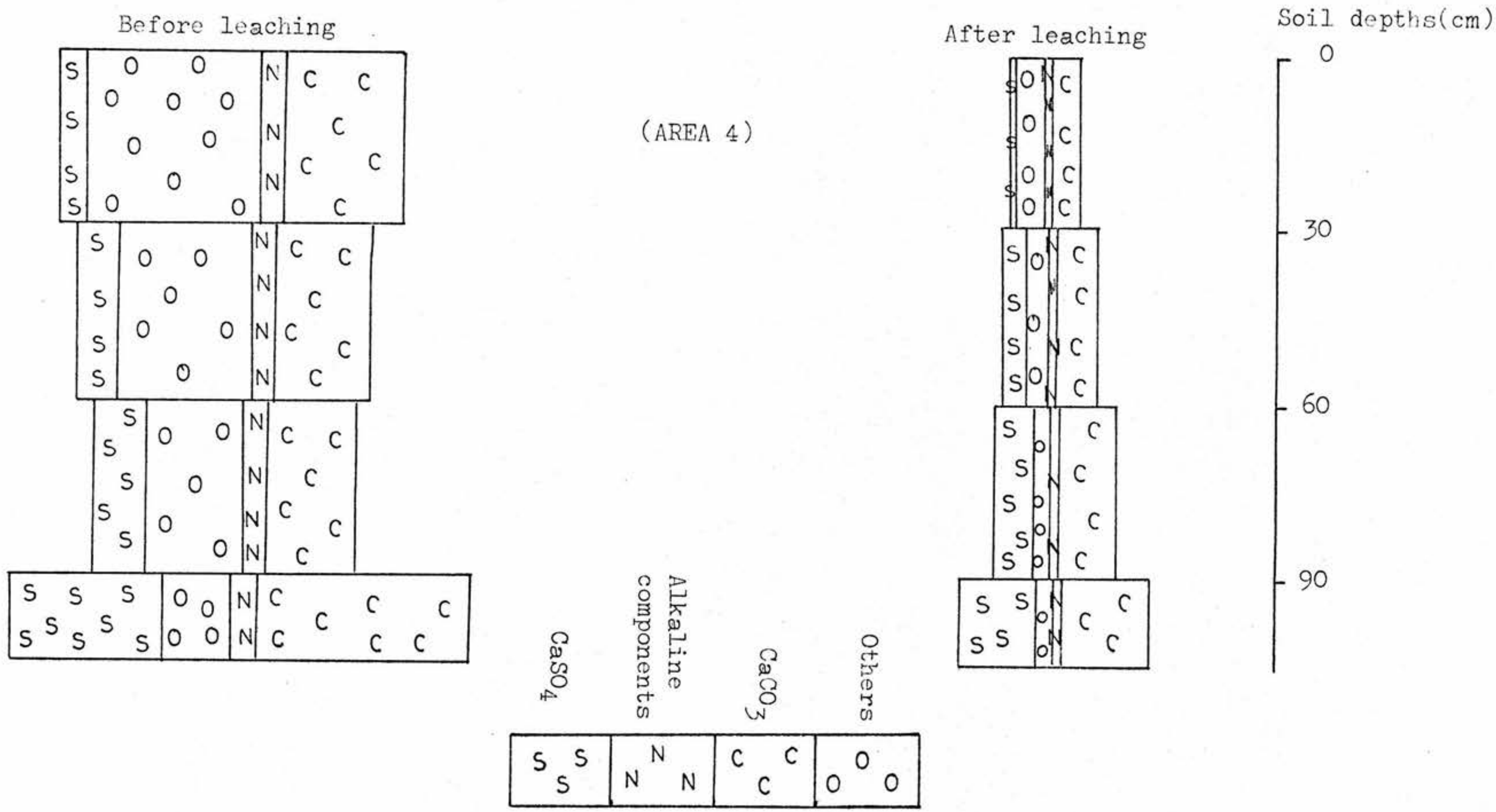
Source: Fieldwork, Zouzou, R., 1961-74.



The values presented are the average of 25 samples from each horizon

Figure 12.6
THE EFFECTS OF EXPERIMENTAL LEACHING IN THE SALT CONCENTRATION

Source: Fieldwork, Zouzou, R., 1961-74.

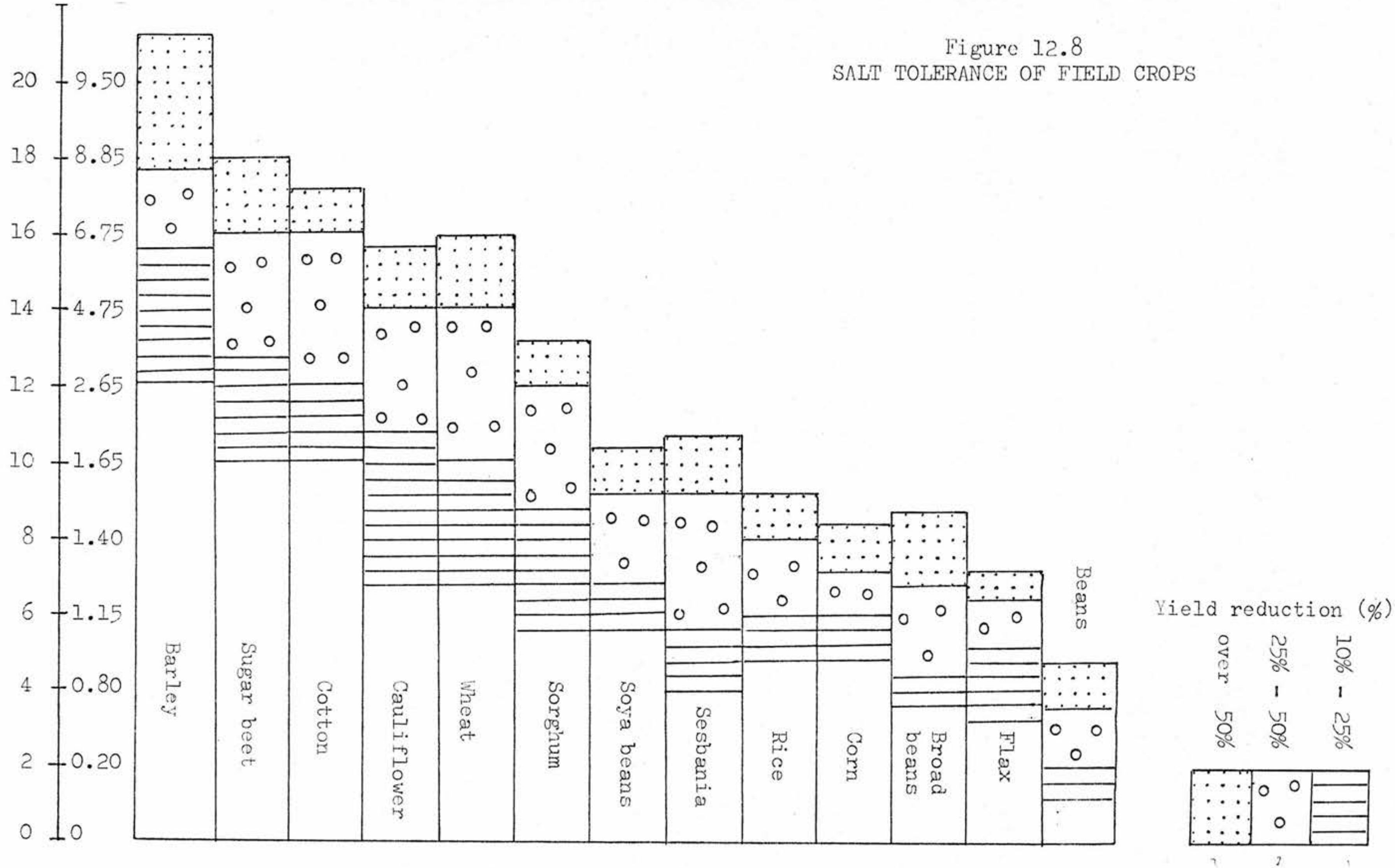


The values presented are the average of 25 samples from each horizon

Figure 12.7
THE EFFECTS OF EXPERIMENTAL LEACHING IN THE SALT CONCENTRATION

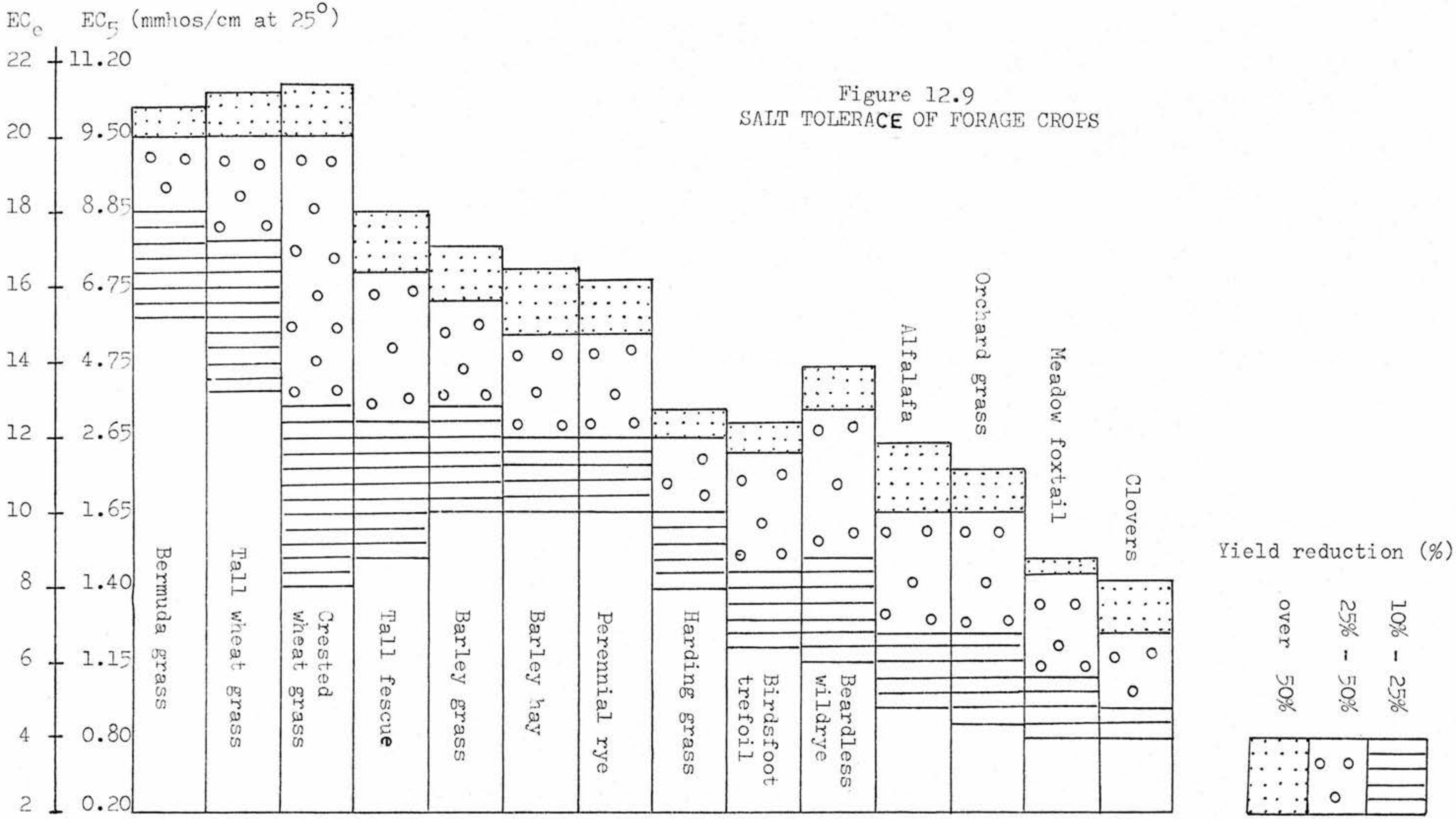
Source: Fieldwork, Zouzou, R., 1961-74

Figure 12.8
SALT TOLERANCE OF FIELD CROPS



Source: Based on: USDA, Diagnosis and Improvement of Saline and Alkali Soils (1969).
Applied to Fieldwork, Zouzou, R., 1961-74.

Figure 12.9
SALT TOLERACE OF FORAGE CROPS



Source: Based on: USDA, Diagnosis and Improvement of Saline and Alkali Soils (1969). Applied to Fieldwork, Zouzou, R., 1961-74.

Figure 13.1
LOCATION OF THE LAND RECLAMATION EXPERIMENTAL SITE

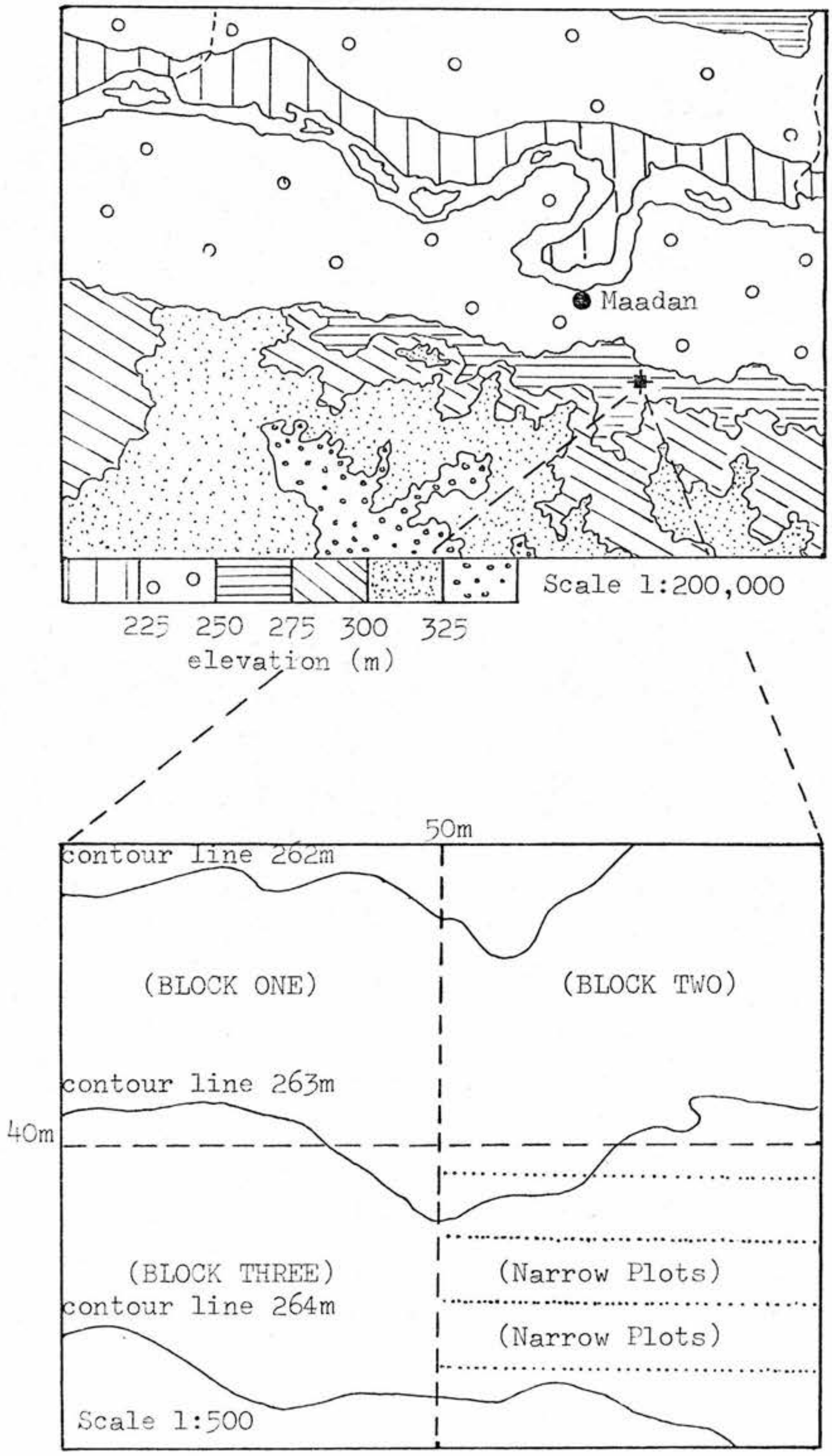
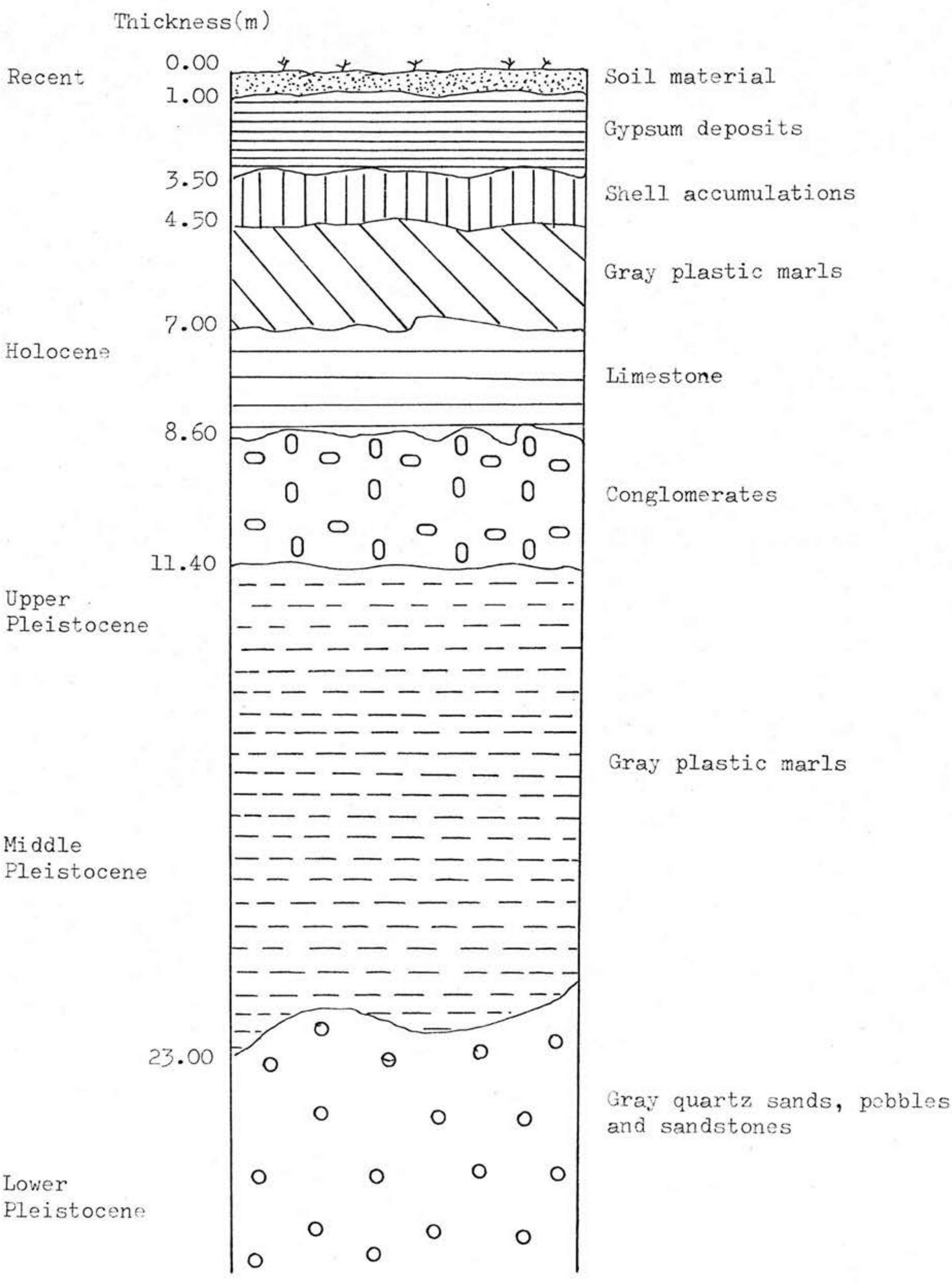


Figure 13.1a

Figure 13.1b

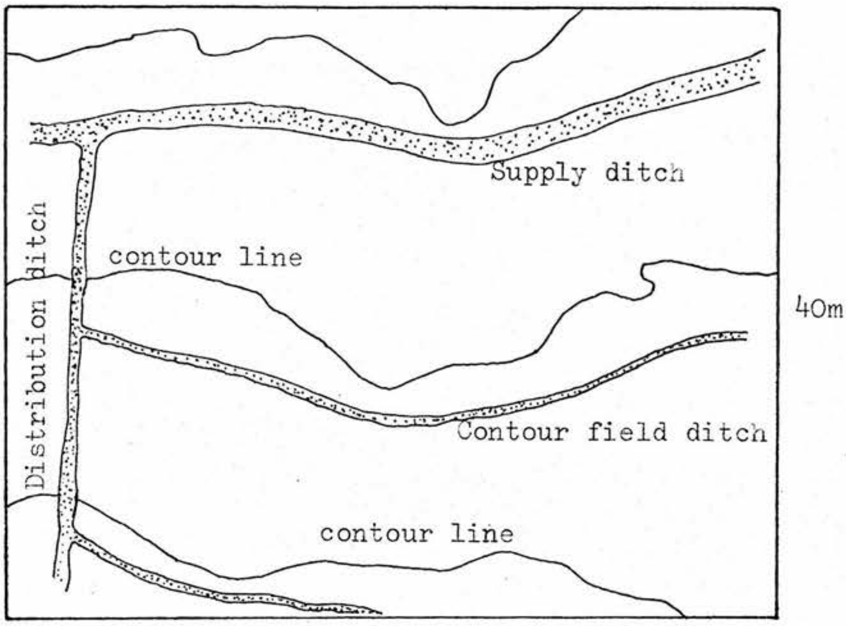
Source: Fieldwork, Zouzou, R., 1961-74.

Figure 13.2
STRUCTURES OF THE LAND RECLAMATION EXPERIMENTAL SITE



Sources: Department of Geology and Mineral Research, 1964.
Fieldwork, Zouzou, R., 1961-74.

Figure 13.3
THE FLOODING SYSTEM FROM FIELD DITCHES
OF THE LAND RECLAMATION EXPERIMENTAL SITE



Scale: 1:500

Method of: Lowndes, A.G. (1960), Spray Irrigation of pastures and fodder crops, Bank of New South Wales, Sydney.

Molnar, I. (1961), A Manual of Australian Agriculture, Heinemann, Melb.

Applied to Fieldwork, Zouzou, R., 1961-74.

Figure 13.4
THE ROTATION OF CROP DISTRIBUTIONS
AT THE LAND RECLAMATION EXPERIMENTAL SITE

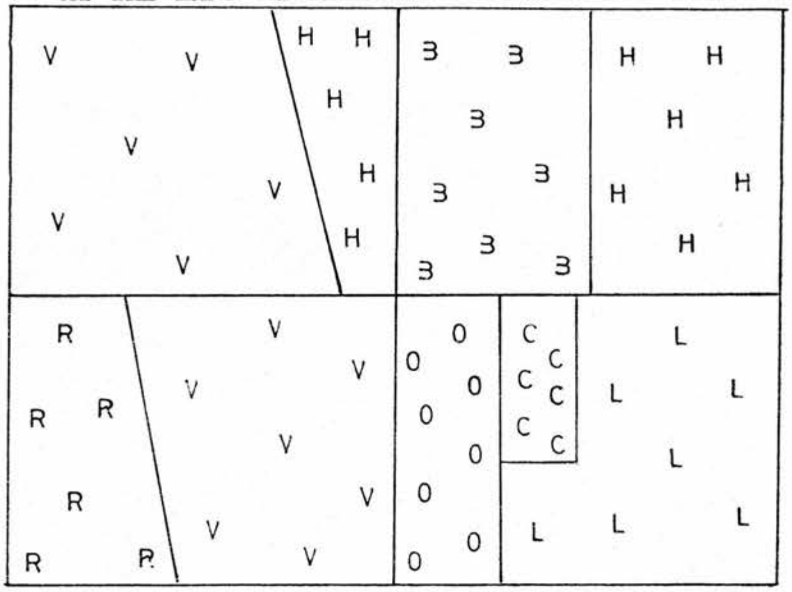


Figure 13.4a

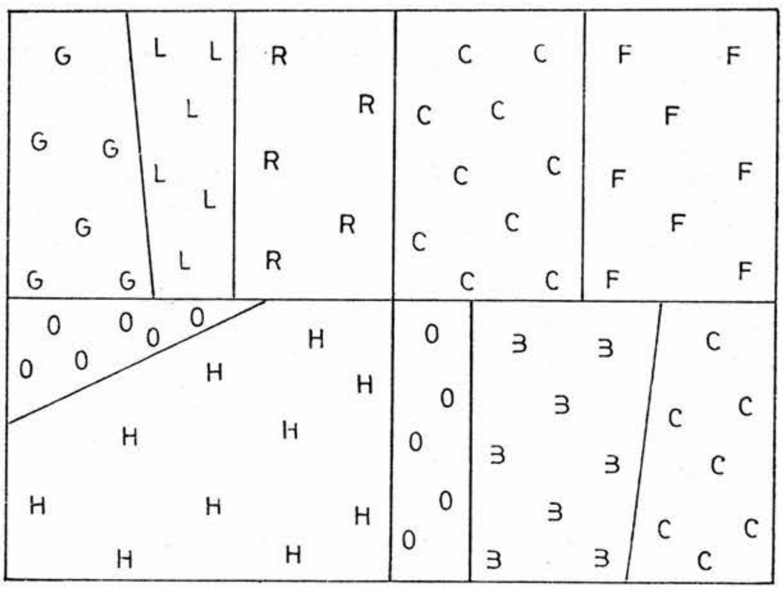


Figure 13.4b

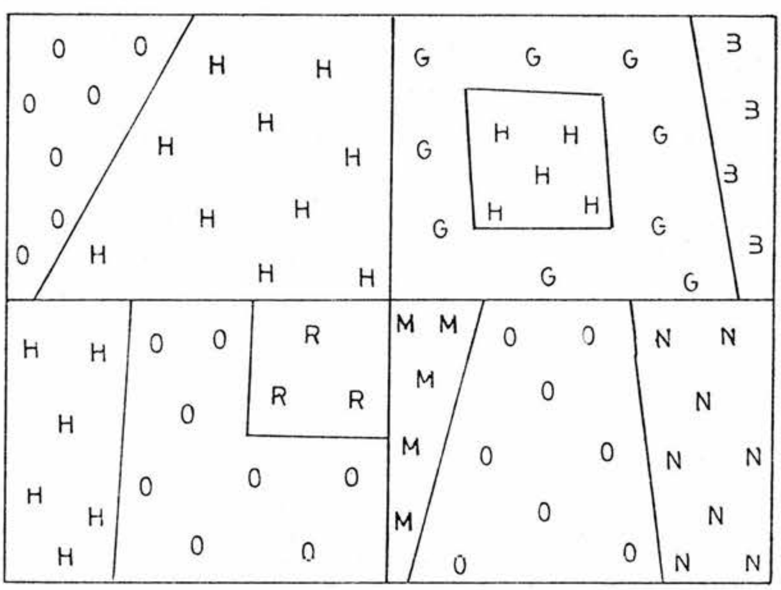


Figure 13.4c

continued/

Figure 13.4
THE ROTATION OF CROP DISTRIBUTIONS
AT THE LAND RECLAMATION EXPERIMENTAL SITE

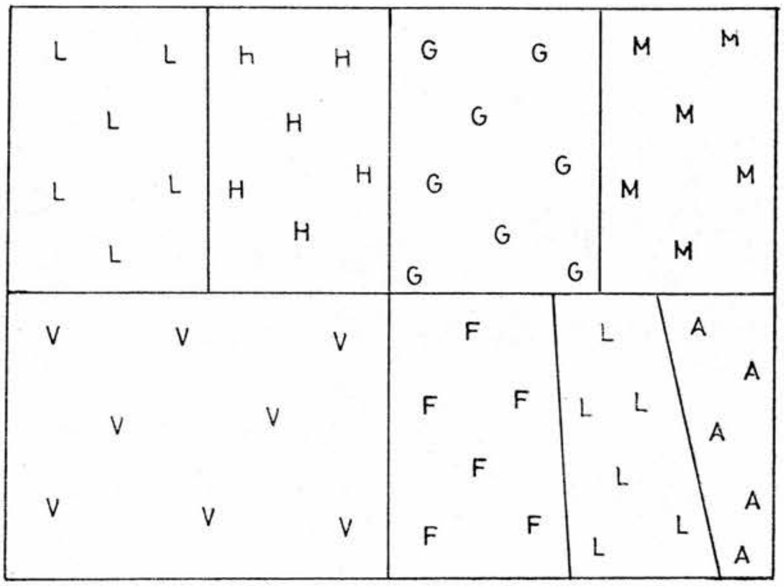


Figure 13.4d

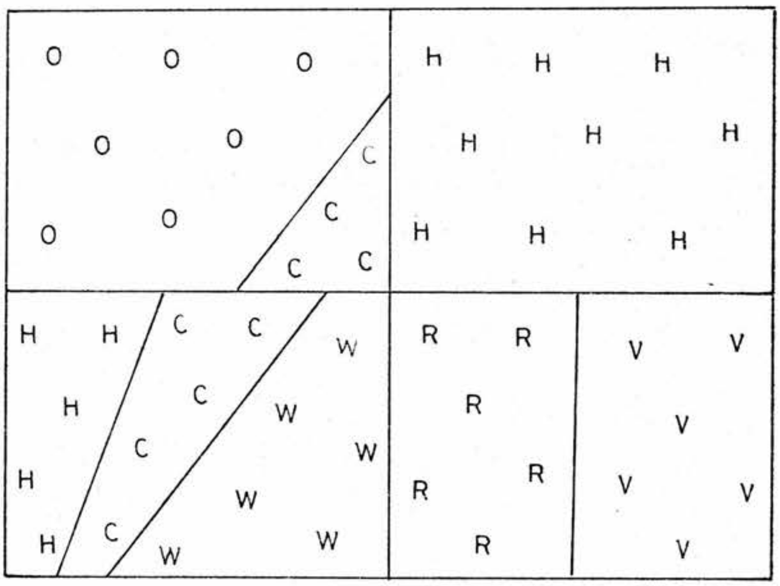


Figure 13.4e

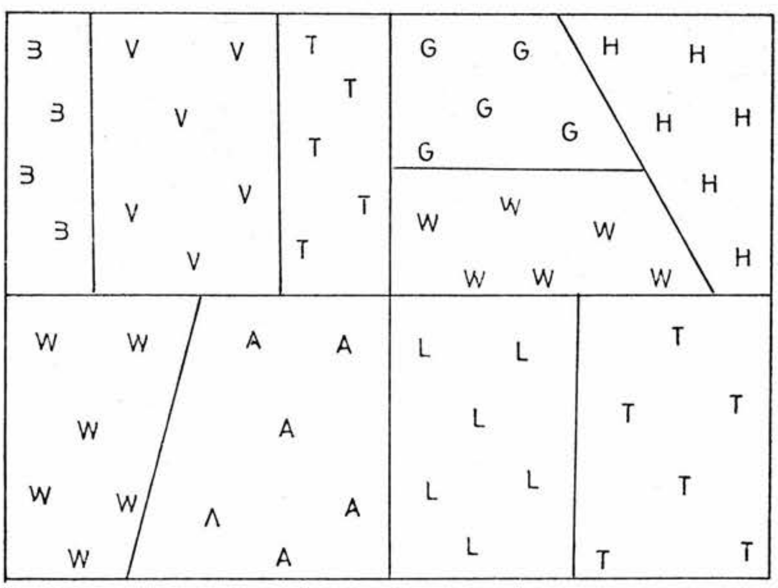


Figure 13.4f

continued/

Figure 13.4
THE ROTATION OF CROP DISTRIBUTIONS
AT THE LAND RECLAMATION EXPERIMENTAL SITE

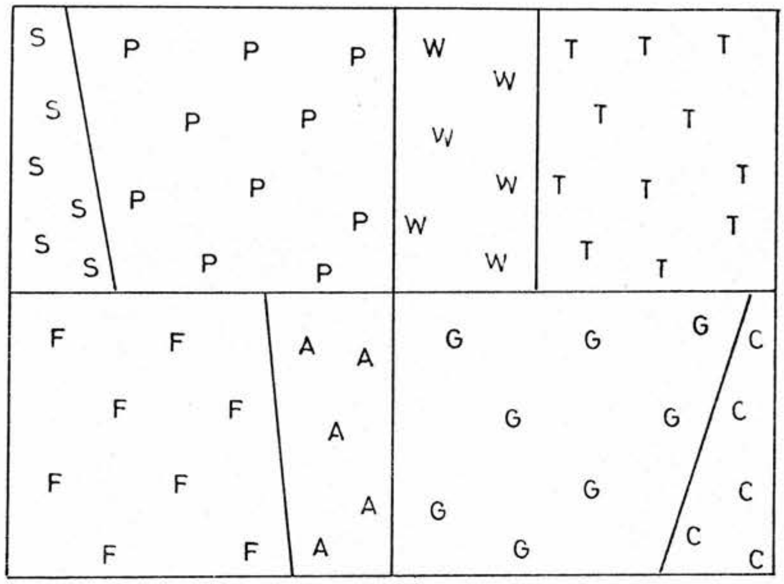


Figure 13.4g

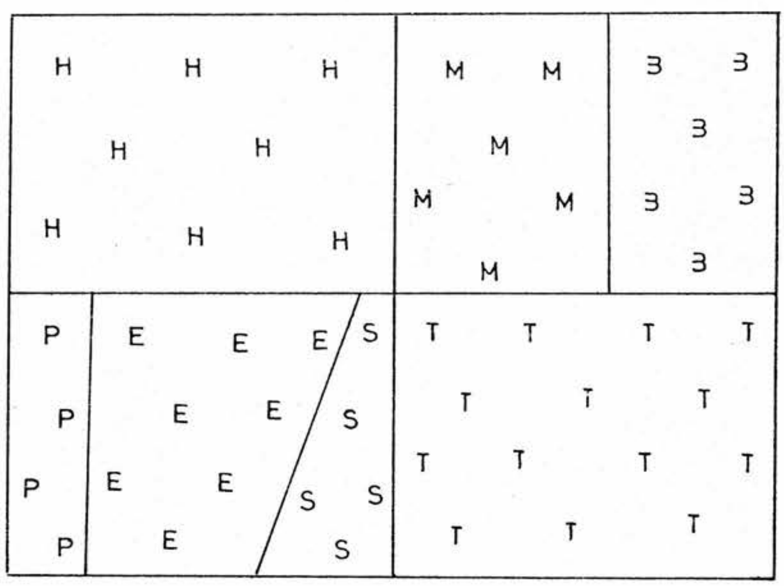
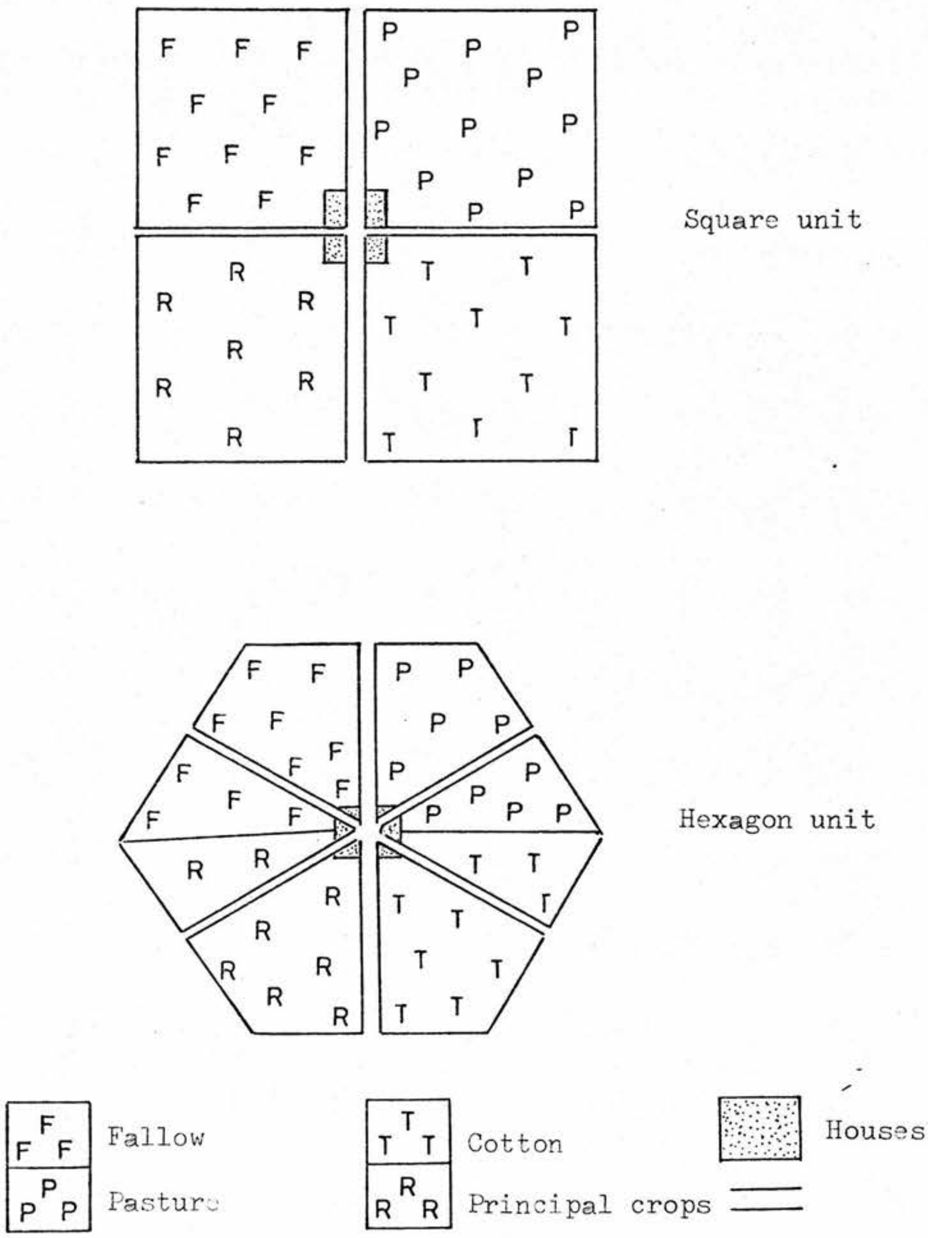


Figure 13.4h

H	wheat	G	green beans	P	potatoes
Ɛ	barley	T	cotton	S	spinach
O	oats	V	grass	M	tomatoes
R	berseem	W	onion	E	field beans
C	corn	A	cabbage	N	melon
F	alfalafa	L	salt grass	U	lettuce

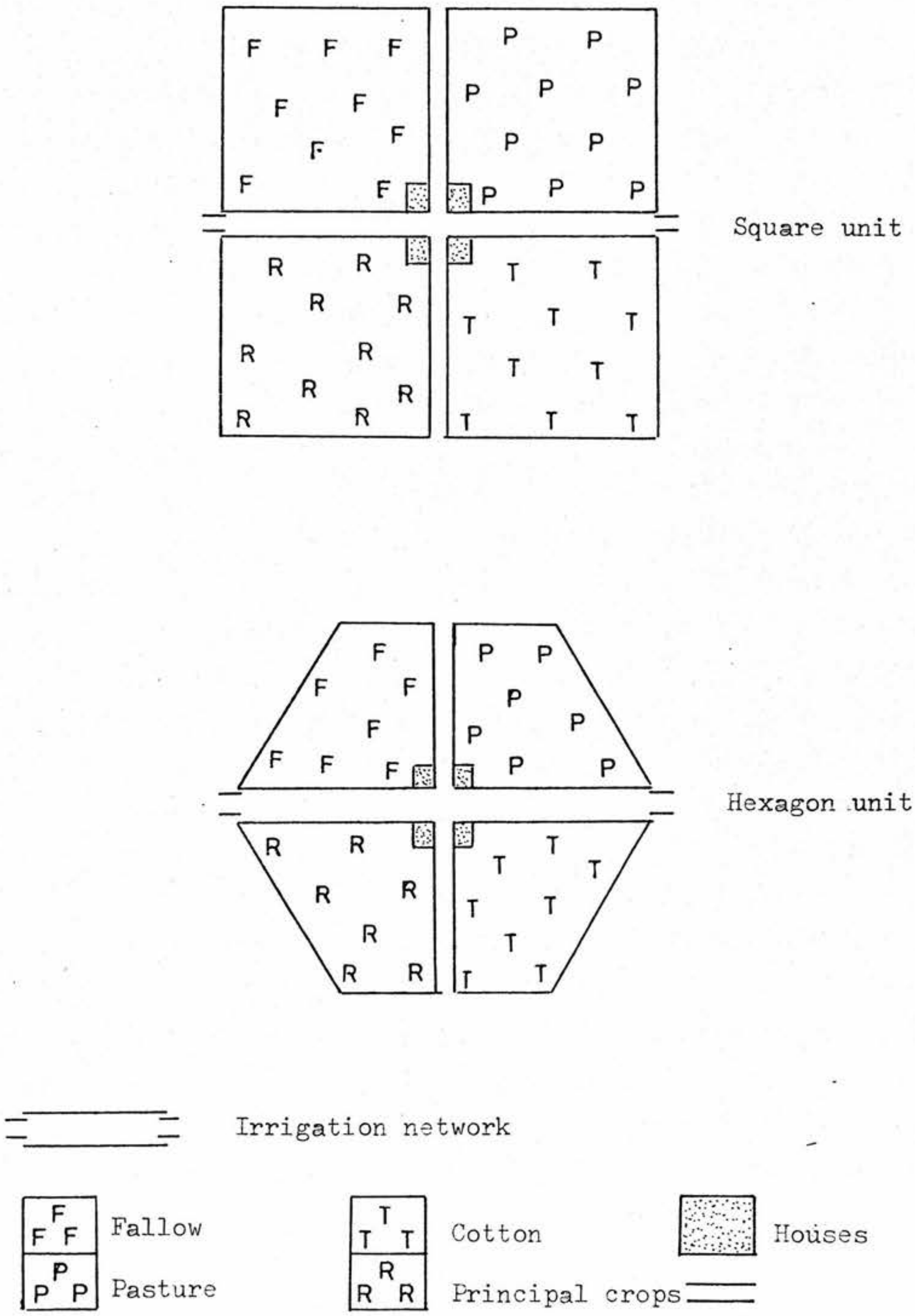
Source: Fieldwork, Zouzou, R., 1961-74.

Figure 14.1
THE PROPOSED PATTERN OF SETTLEMENT UNITS AND CROP DISTRIBUTION



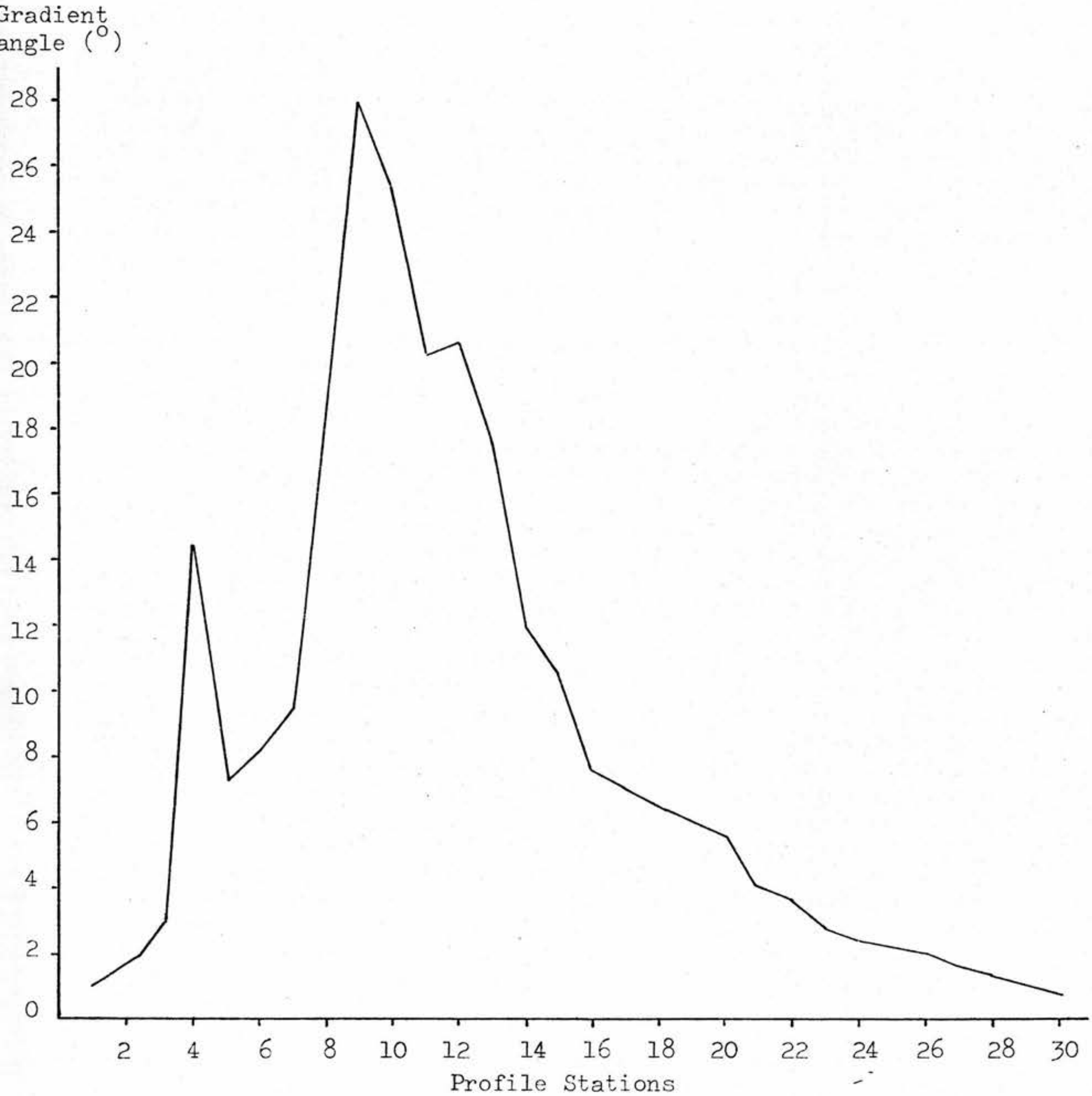
Based upon: ideas discussed in the following:
UN Economic Development in the Middle East, New York, 1955.
Field results from Danish Experimental Stations in Syria, 1952-68.

Figure 14.2
THE PATTERN OF THE IRRIGATION SYSTEM



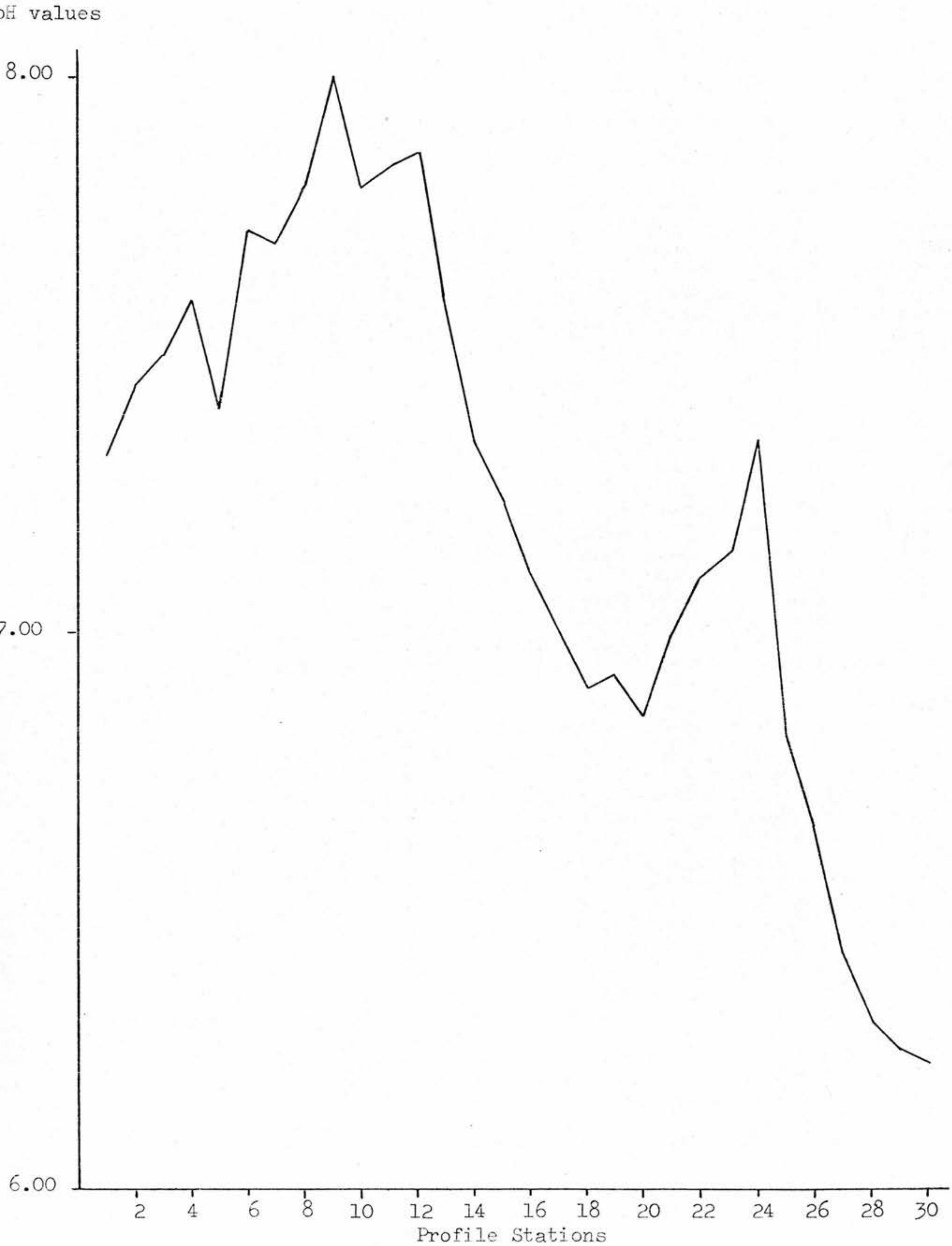
Based upon: ideas discussed in the following:
UN Economic Development in the Middle East, New York, 1955.
Field results from Danish Experimental Stations in Syria, 1952-68.

GRAPHS



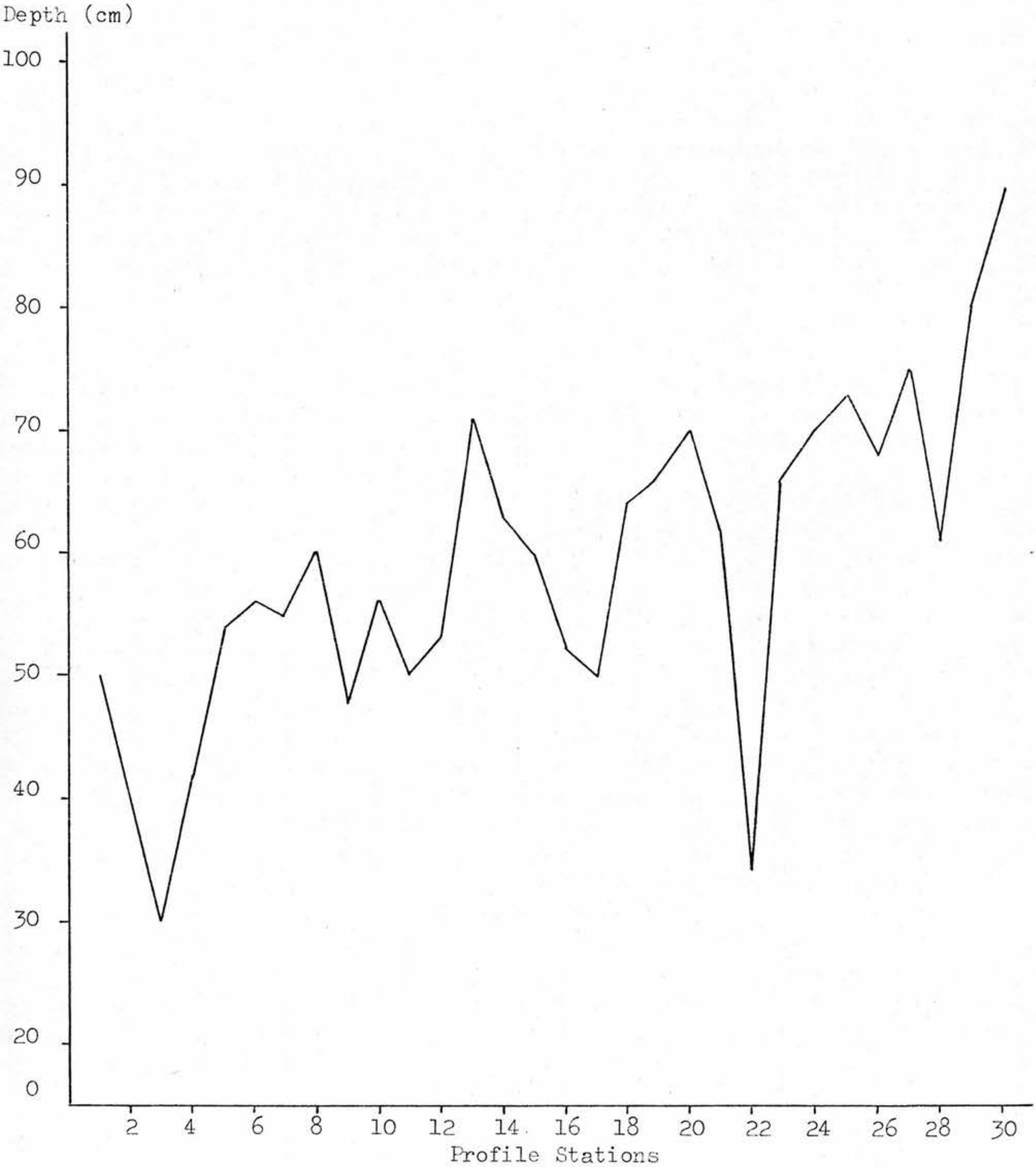
GRAPH 5.1

Source: Fieldwork, Zouzou, R., 1961-74.



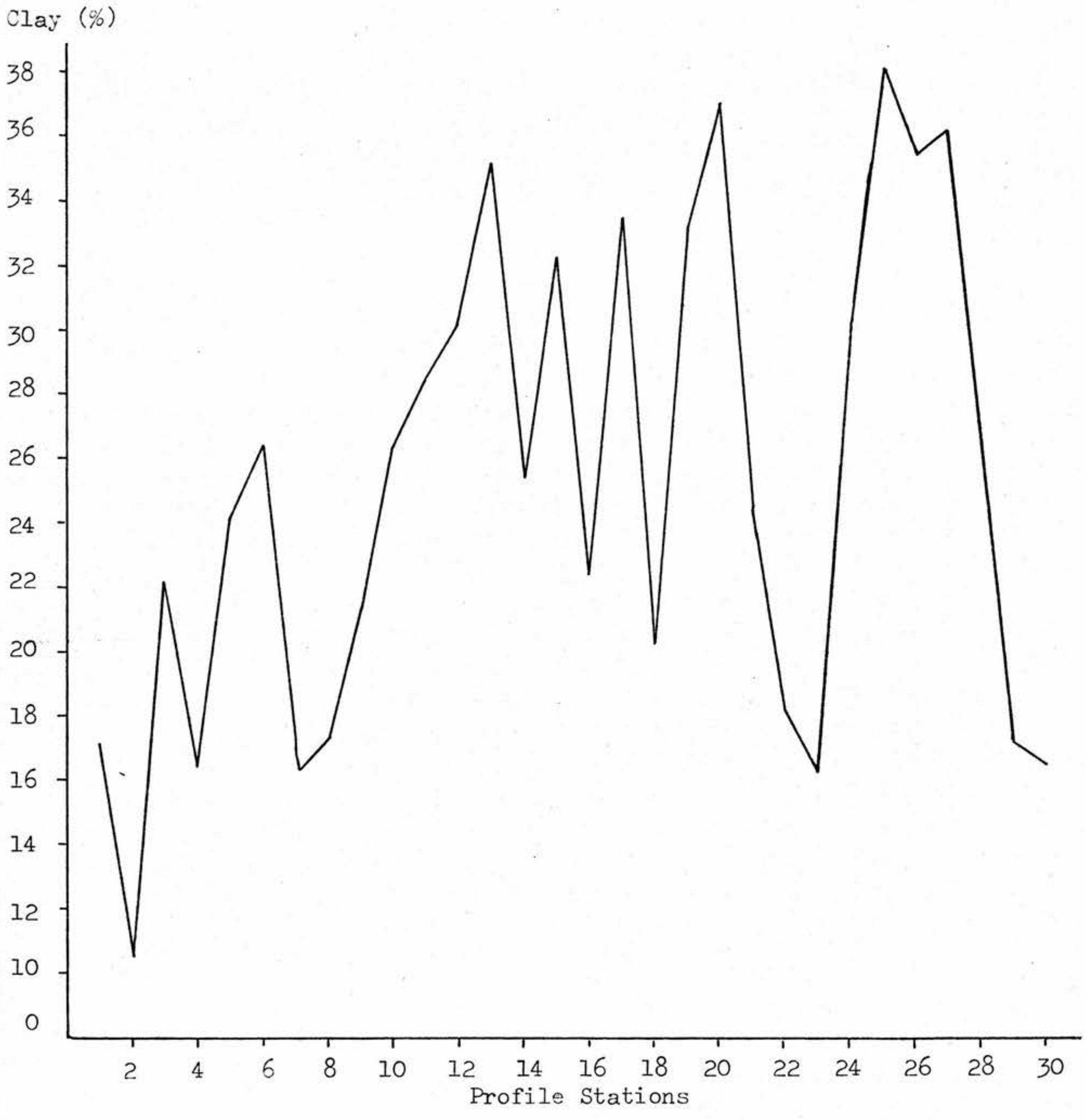
GRAPH 5.2

Source: Fieldwork, Zouzou, R., 1961-74.



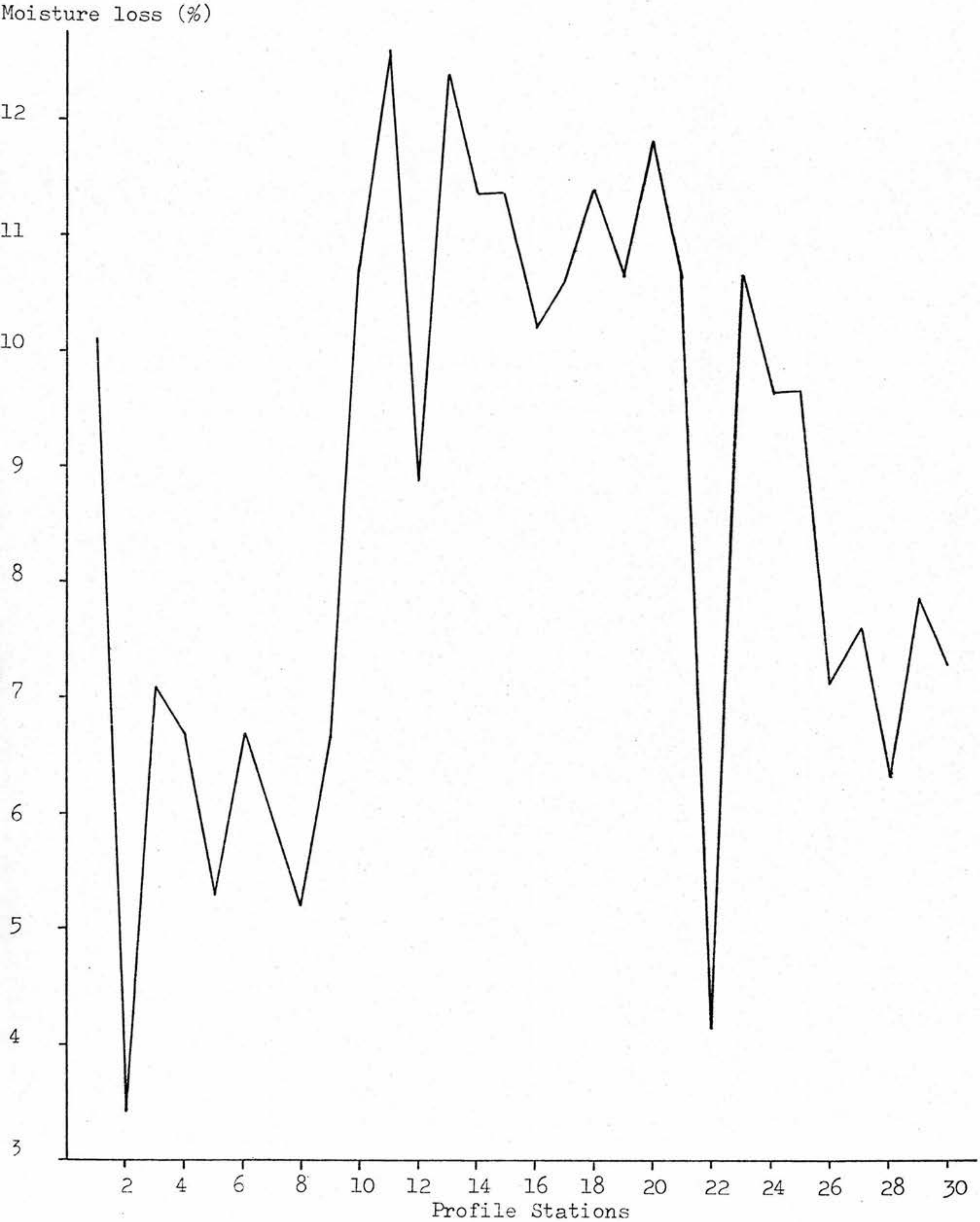
GRAPH 5.3

Source: Fieldwork, Zouzou, R., 1961-74.



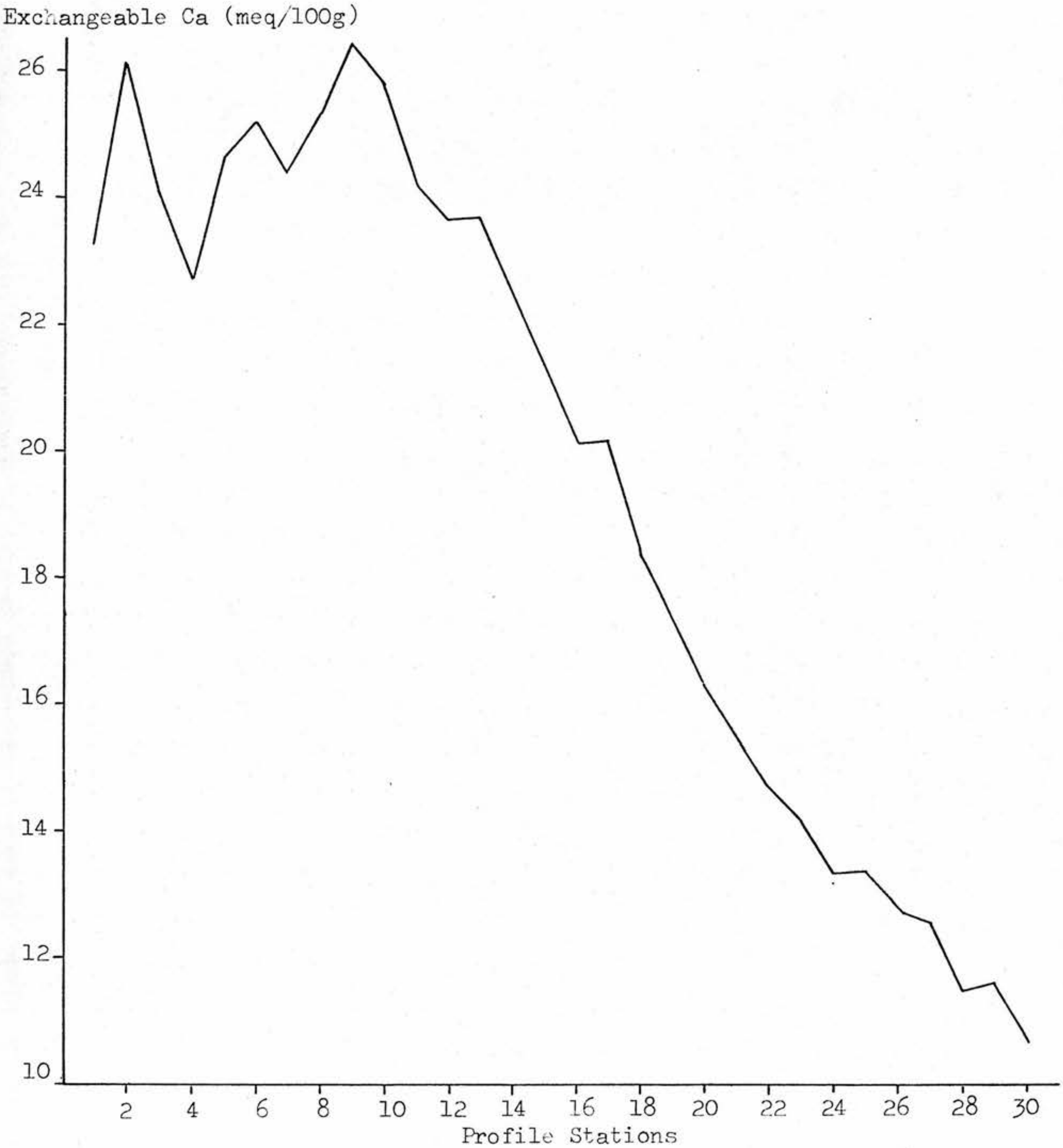
GRAPH 5.4

Source: Fieldwork, Zouzou, R., 1961-74.



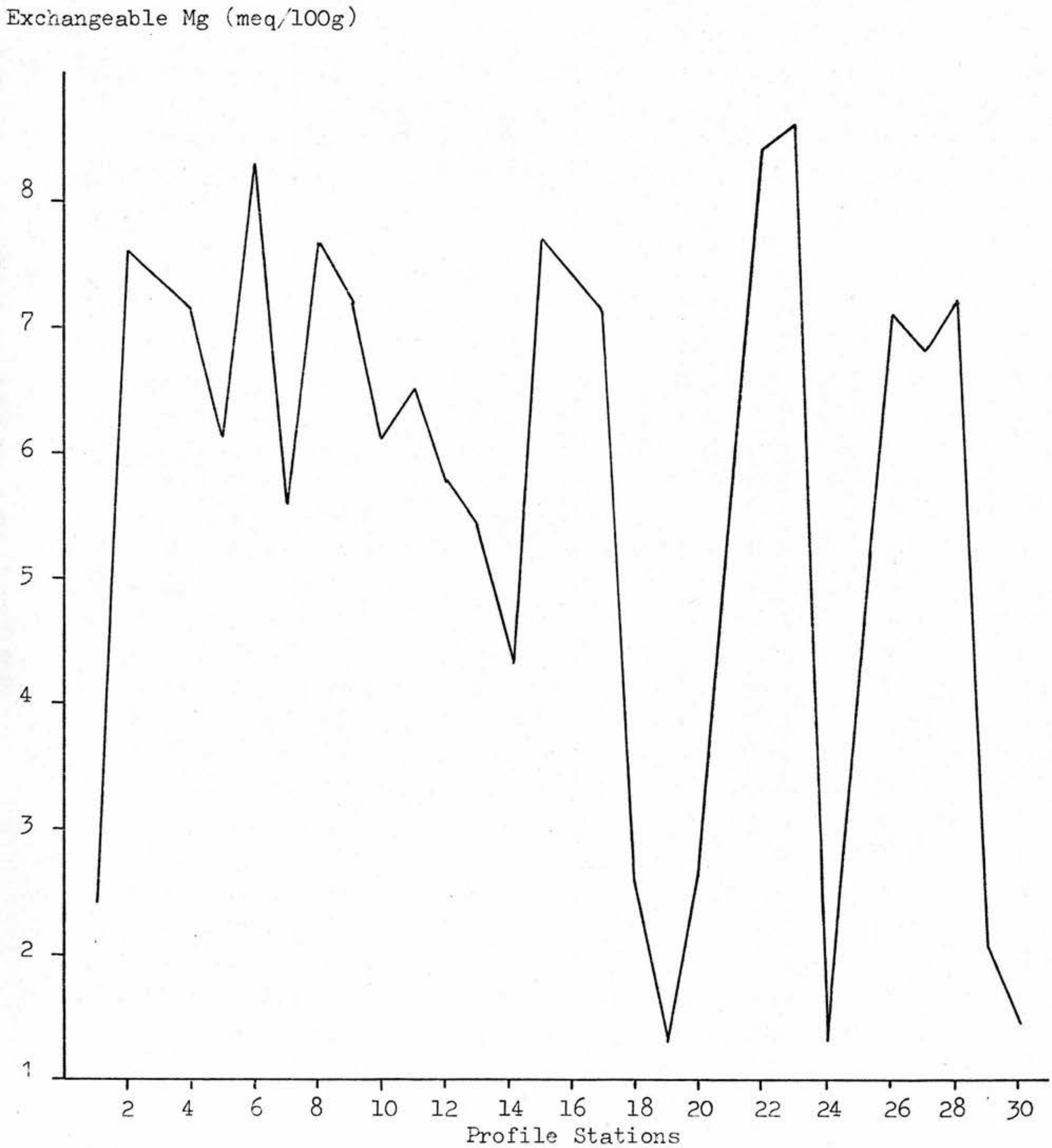
GRAPH 5.5

Source: Fieldwork, Zouzou, R., 1961-74.



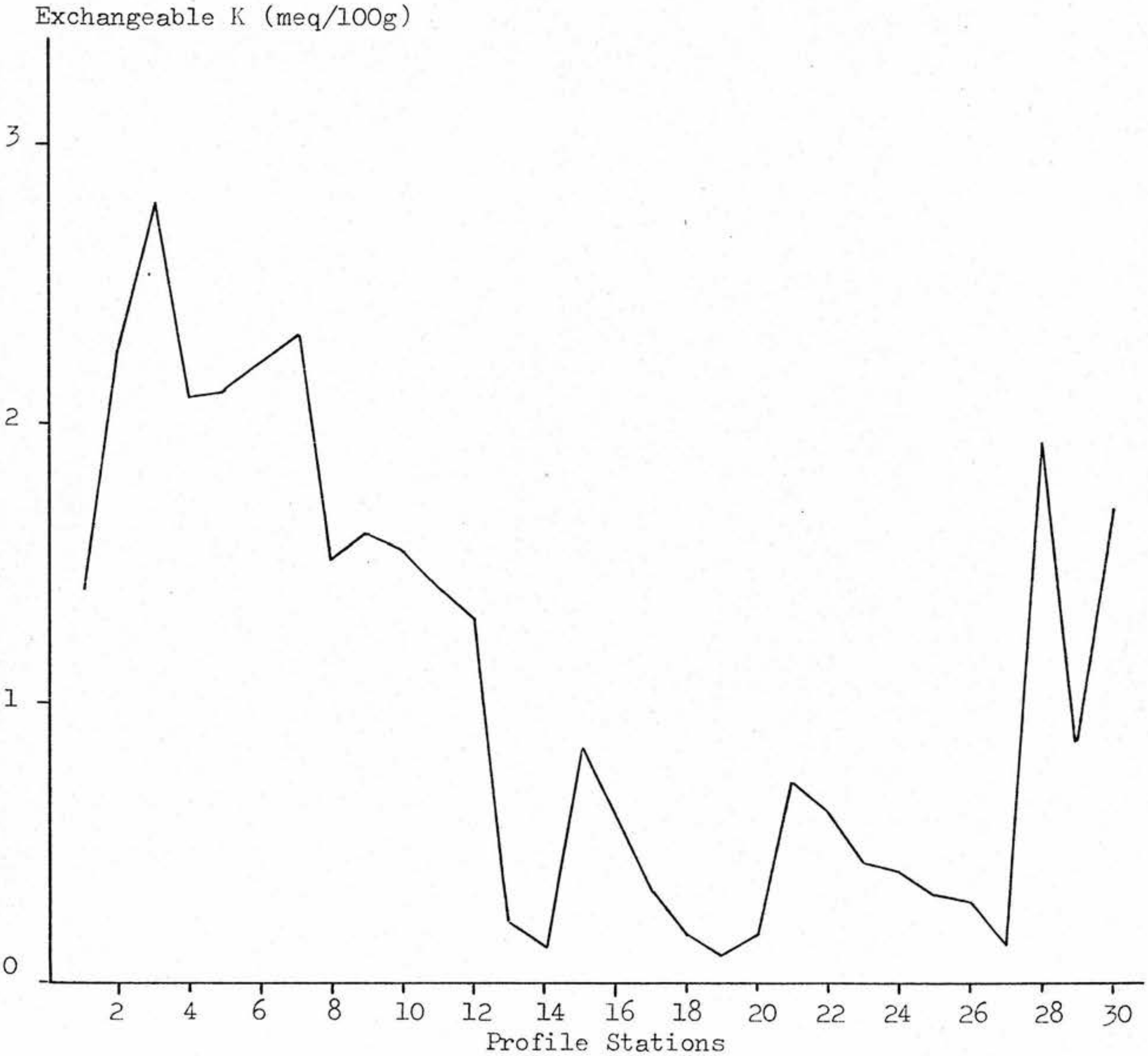
GRAPH 5.6

Source: Fieldwork, Zouzou, R., 1961-74.



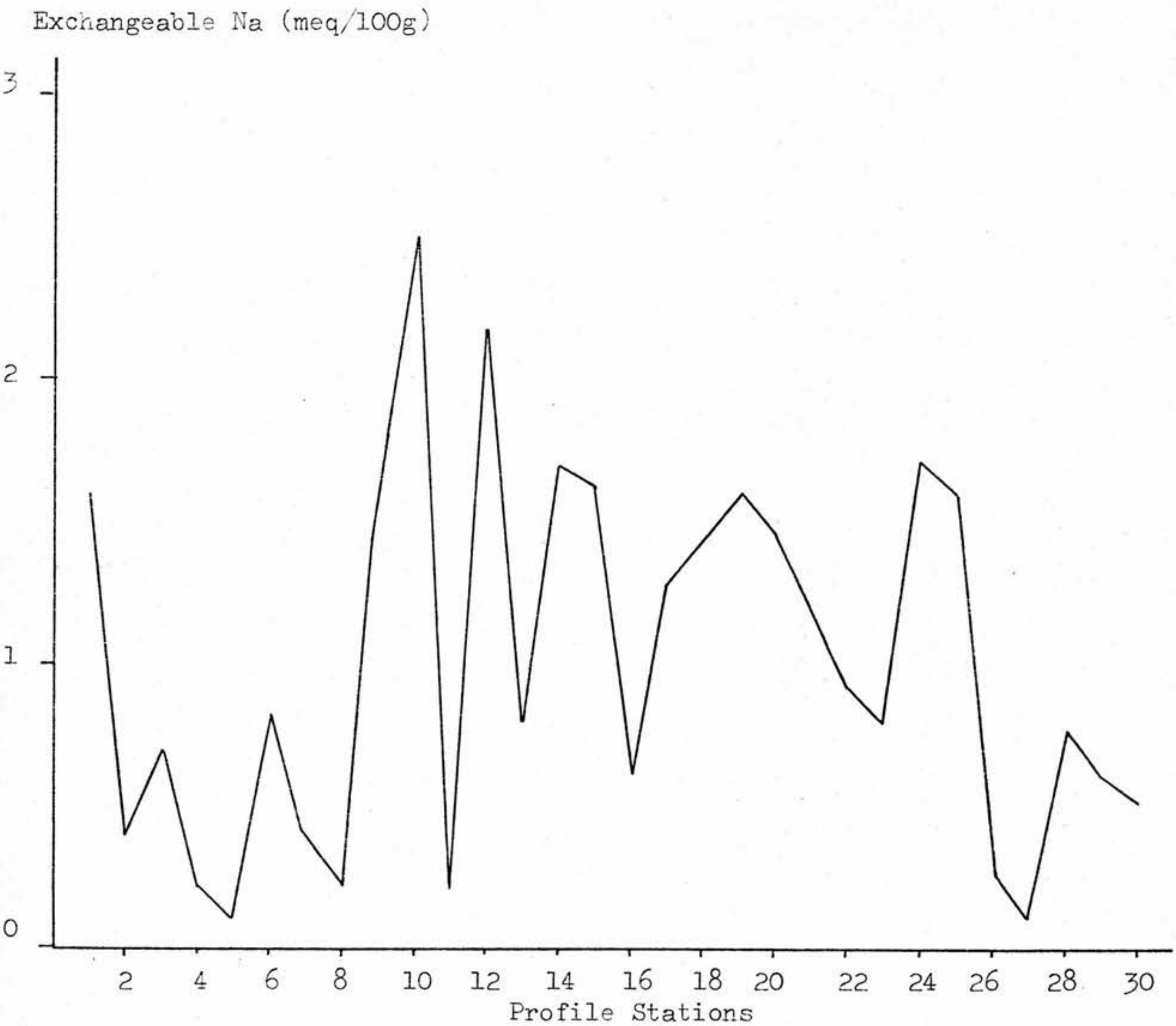
GRAPH 5.7

Source: Fieldwork, Zouzou, R., 1961-74.



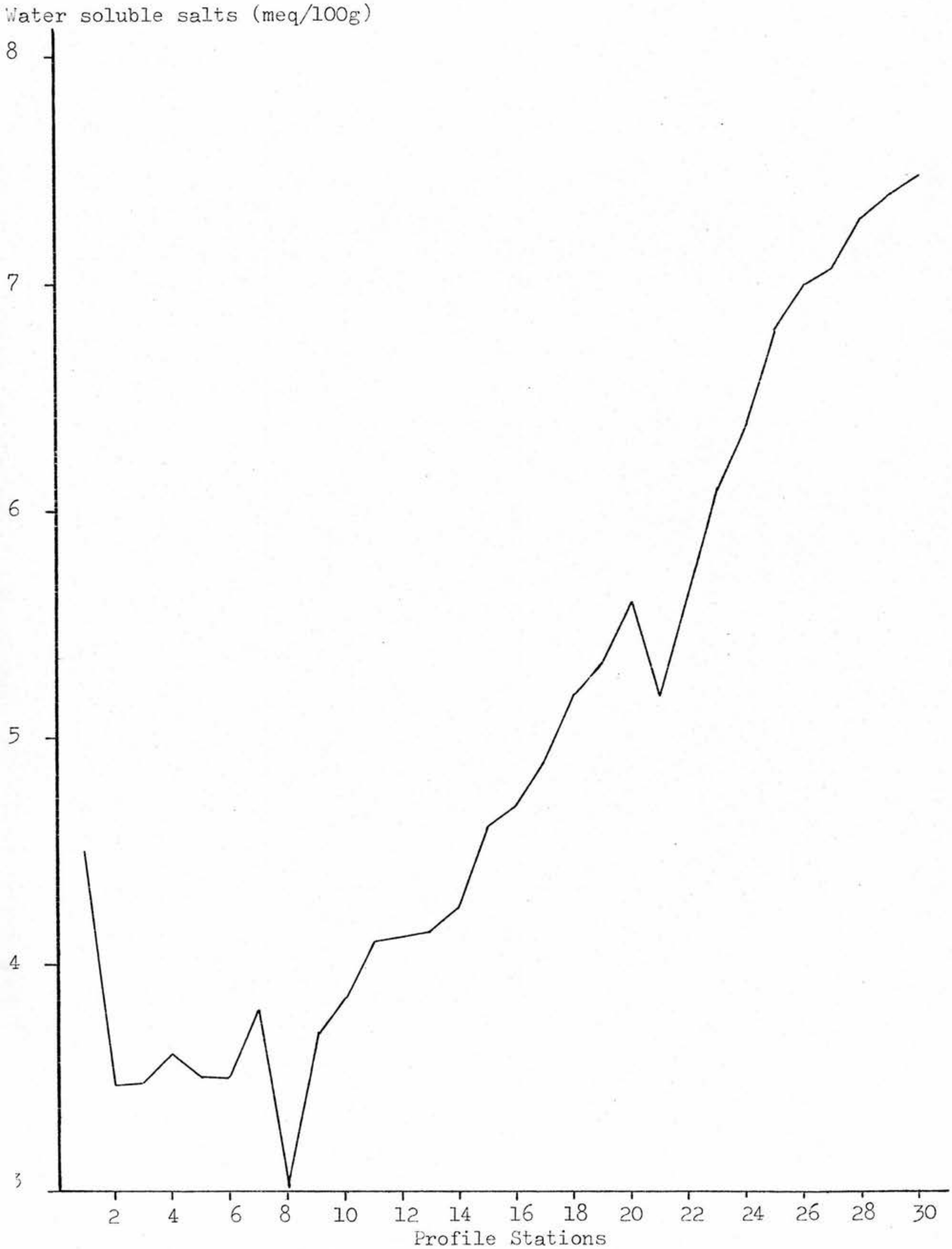
GRAPH 5.8

Source: Fieldwork, Zouzou, R., 1961-74.



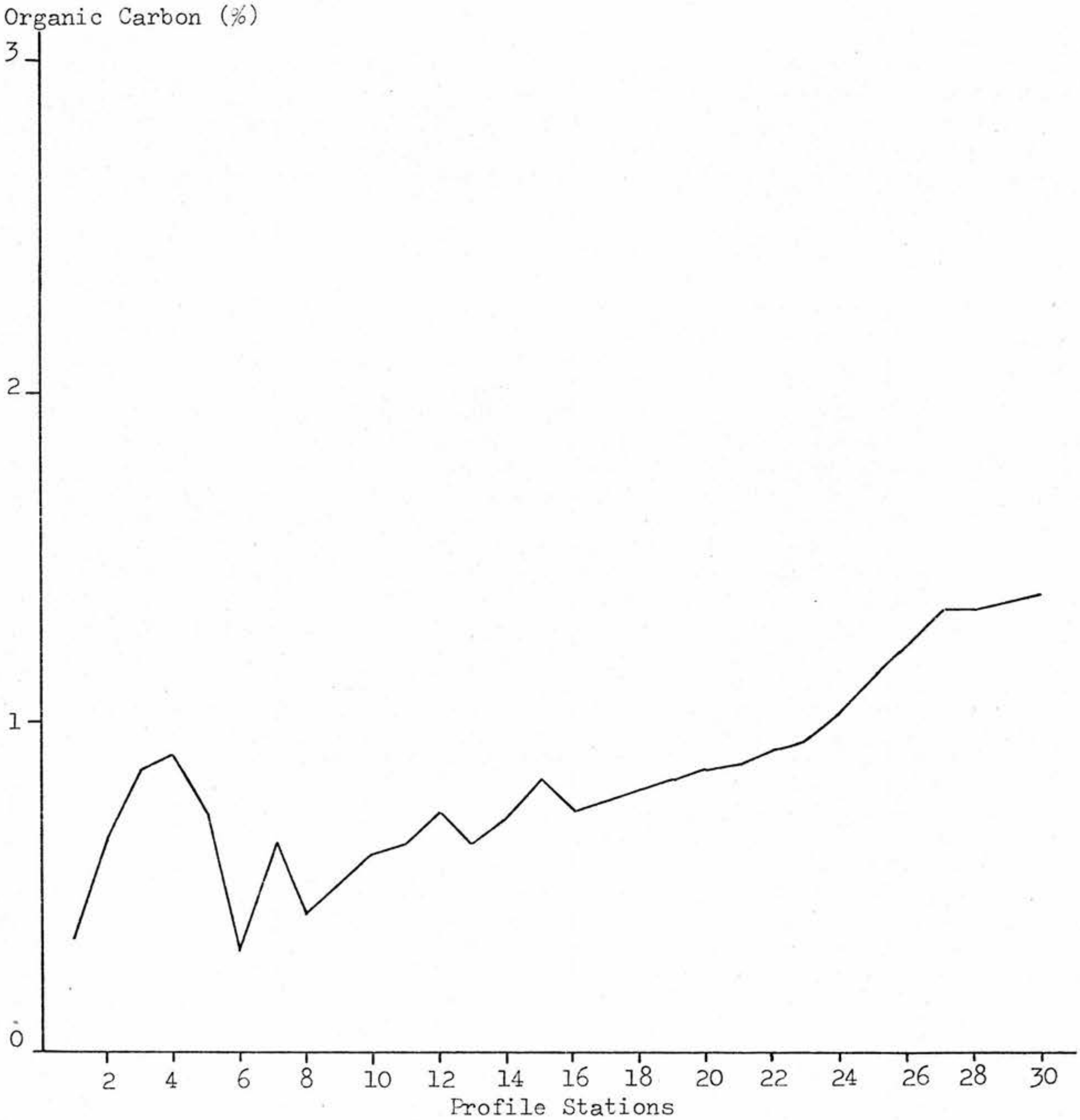
GRAPH 5.9

Source: Fieldwork, Zouzou, R., 1961-74.



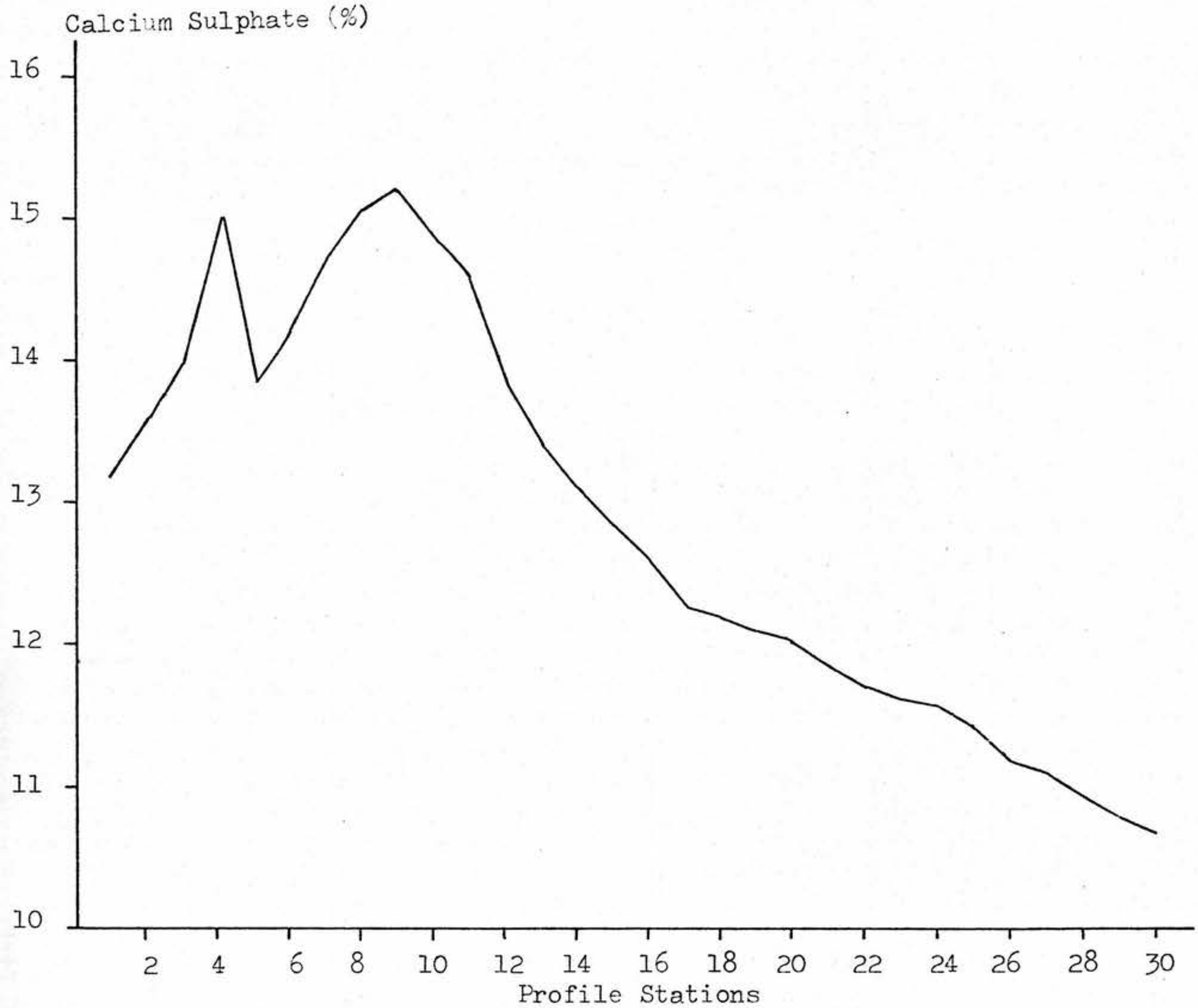
GRAPH 5.10

Source: Fieldwork, Zouzou, R., 1961-74.



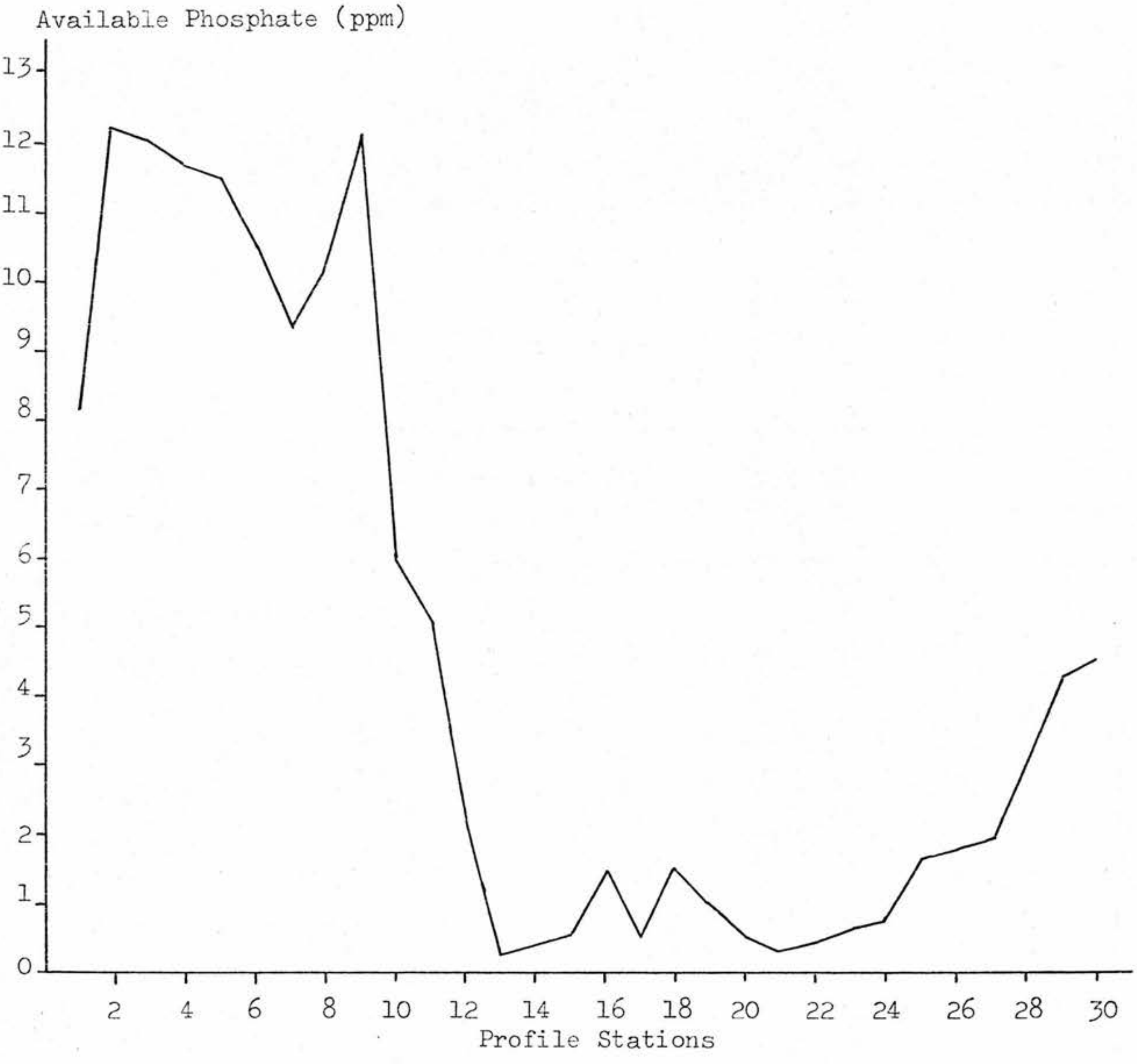
GRAPH 5.11

Source: Fieldwork, Zouzou, R., 1961-74.



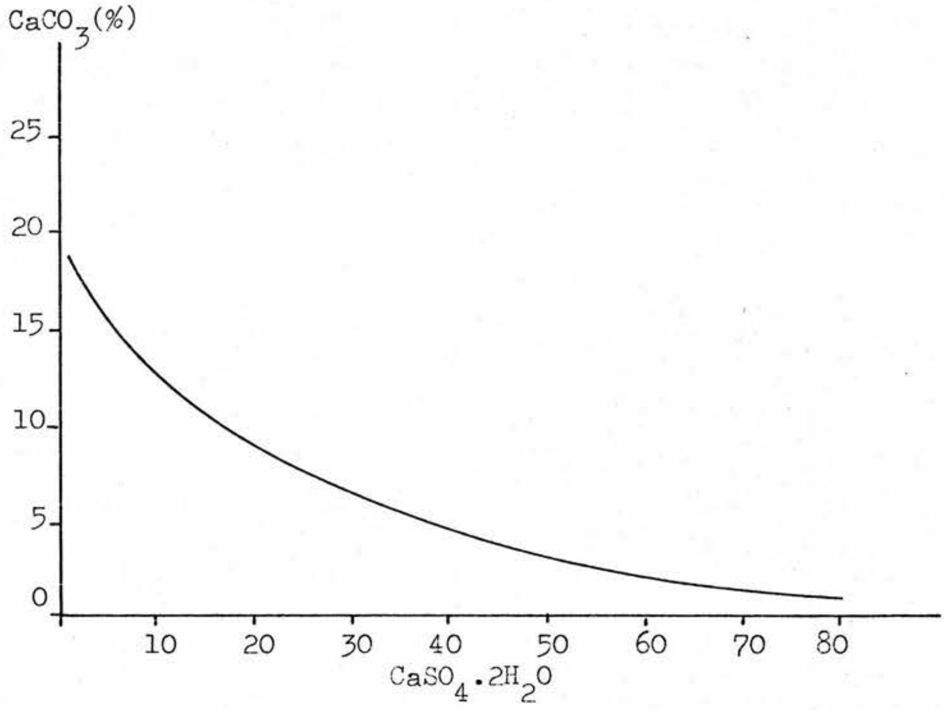
GRAPH 5.12

Source: Fieldwork, Zouzou, R., 1961-74.



GRAPH 5.13

Source: Fieldwork, Zouzou, R., 1961-74.



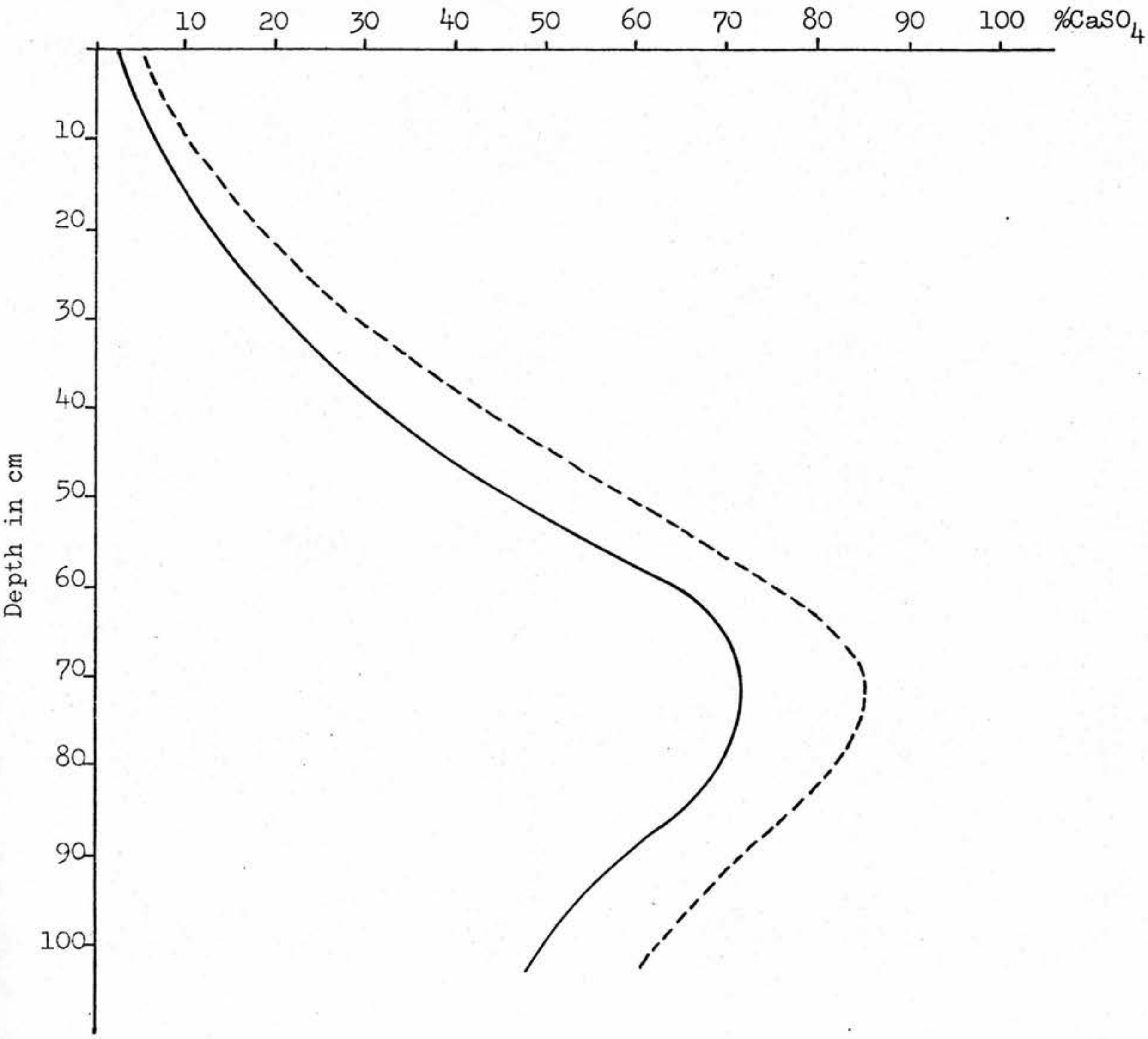
GRAPH 8.1

THE CONTENT OF THE CALCIUM CARBONATE IN RELATION TO CONTENT OF GYPSUM IN THE GYPSIFEROUS SOILS (ranging between 55 - 85 cm)

(Location: 10 km south of Sabkha village)

Source: Fieldwork, Zouzou, R., 1961-74.

Graph 9.1
GRAPH SHOWING THE AVERAGE CONTENT OF GYPSUM IN THE GYPSIFEROUS AREAS

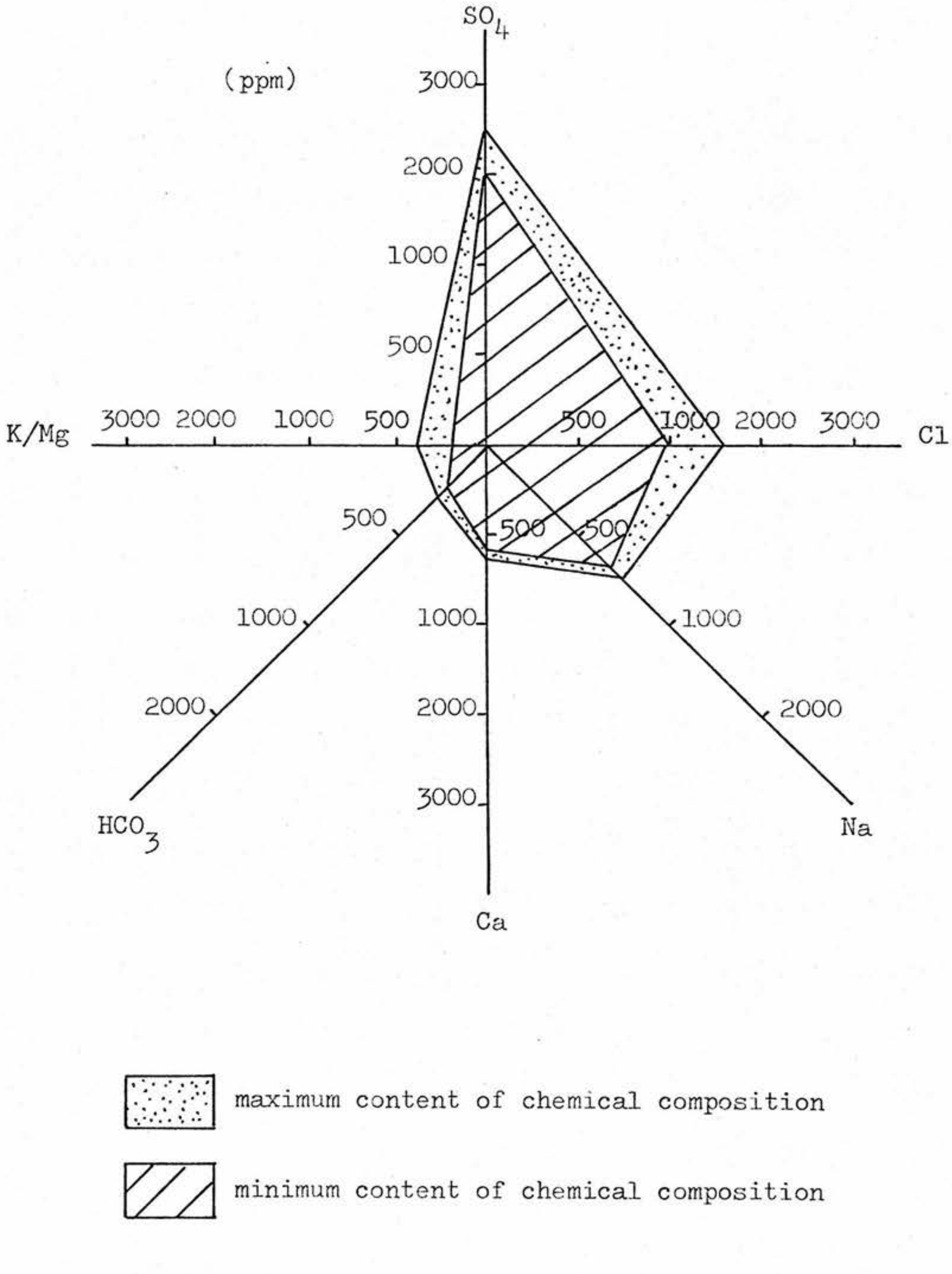


——— This curve represents the average content of gypsum in the profiles south of Sabkha village

– – – – – This curve represents the average content of gypsum in the profiles south of Maadan village

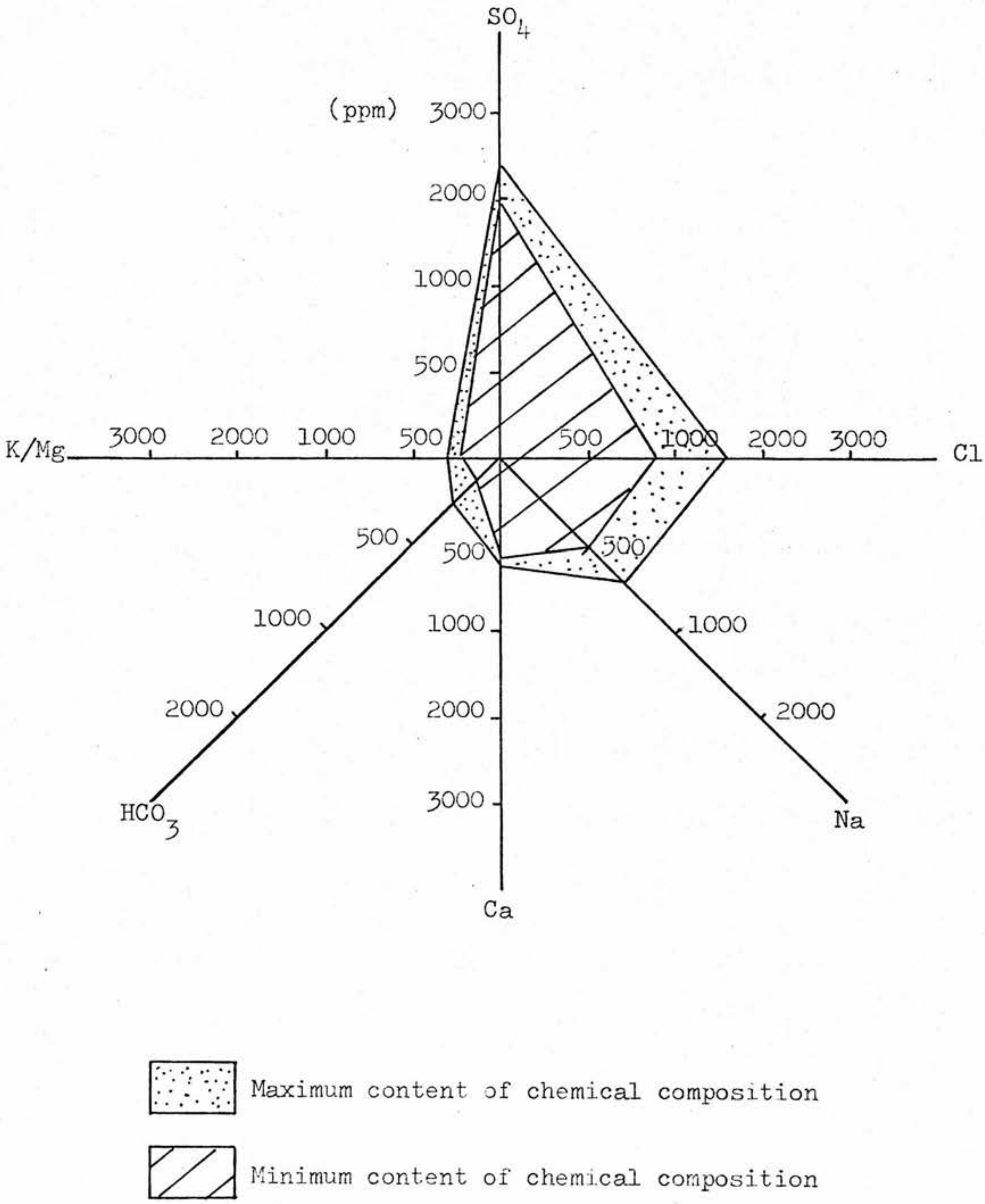
Source: Fieldwork, Zouzou, R., 1961-74.

Graph 9.2a
(i) MAJOR COMPONENTS OF THE CHEMICAL COMPOSITION OF GROUND WATER (TORTONIAN) AT WADI OGLA 5 km NORTH EUPHRATES RIVER



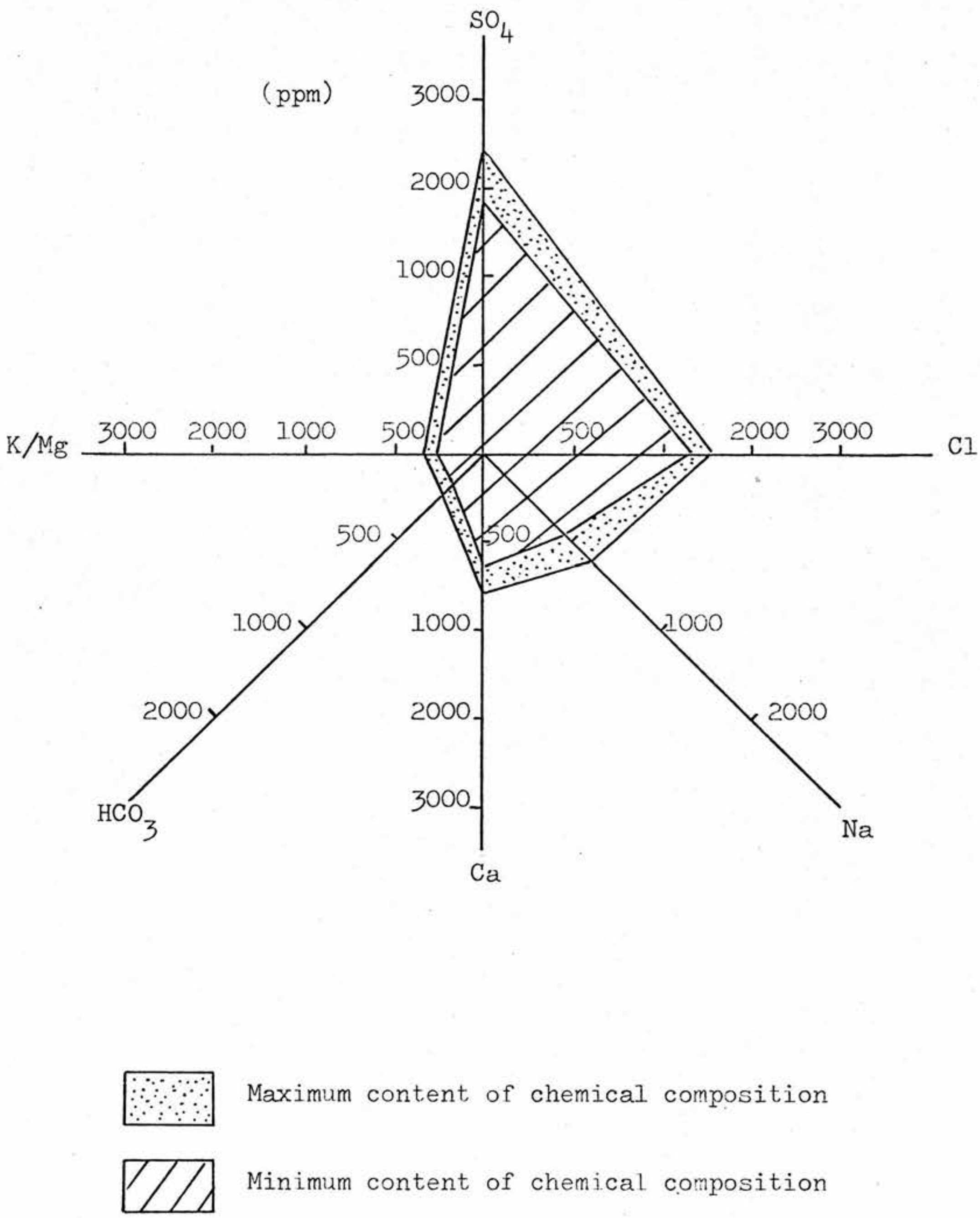
Source: Fieldwork, Zouzou, R., 1961-74.

Graph 9.2b
(ii) MAJOR COMPONENTS OF THE CHEMICAL COMPOSITION OF GROUND WATER (PLIOCENE) AT 7 km EAST SABKHA VILLAGE



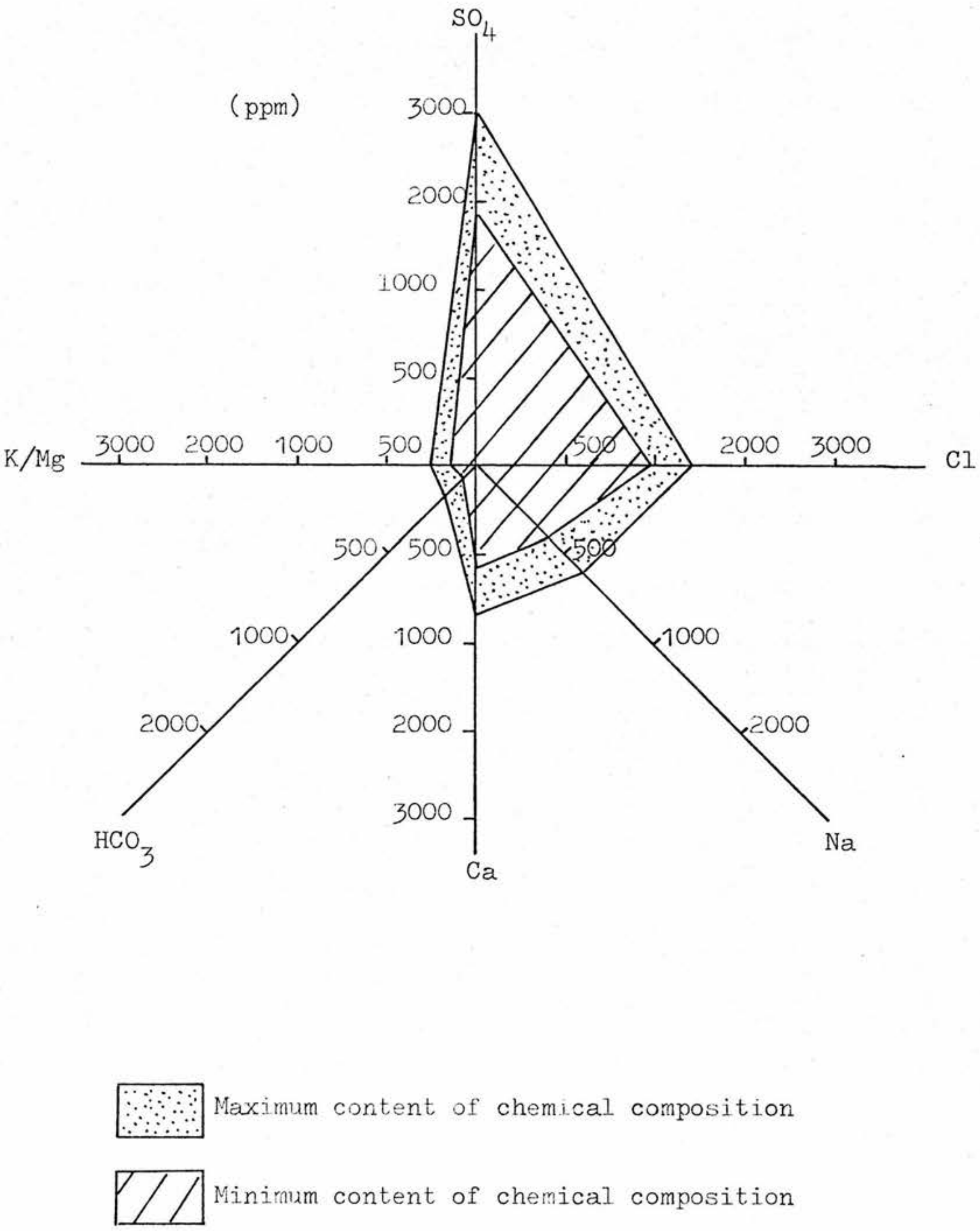
Source: Fieldwork, Zouzou, R., 1961-74.

Graph 9.2c
(iii) MAJOR COMPONENTS OF THE CHEMICAL COMPOSITION OF GROUND WATER
(LOWER PLEISTOCENE) AT 8 km SOUTH MAADAN VILLAGE



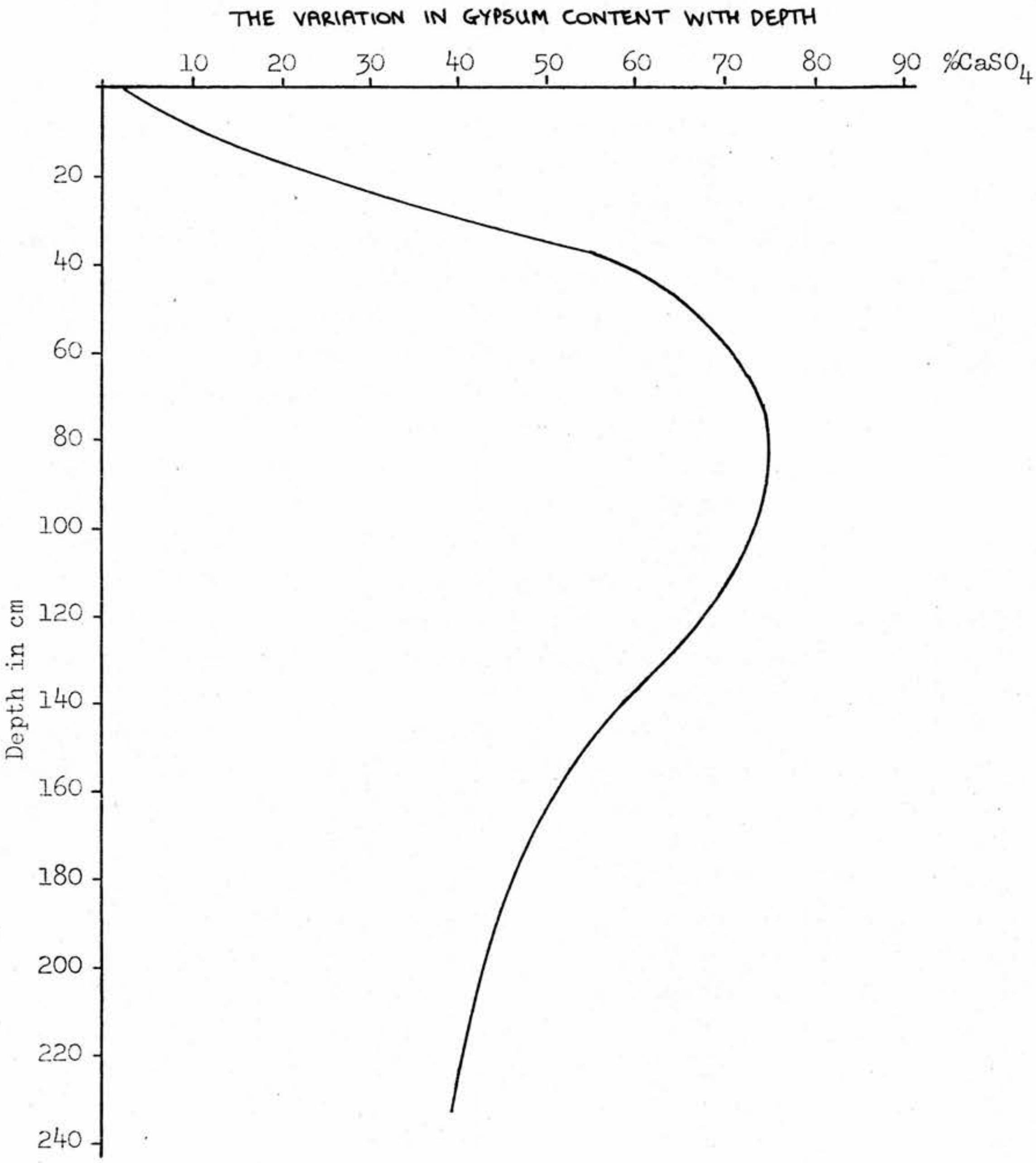
Source: Fieldwork, Zouzou, R., 1961-74.

Graph 9.2d
(iv) MAJOR COMPONENTS OF THE CHEMICAL COMPOSITION OF GROUND WATER, (UPPER PLEISTOCENE) AT 3 km SOUTH-EAST MAADAN VILLAGE



Source: Fieldwork, Zouzou, R., 1961-74.

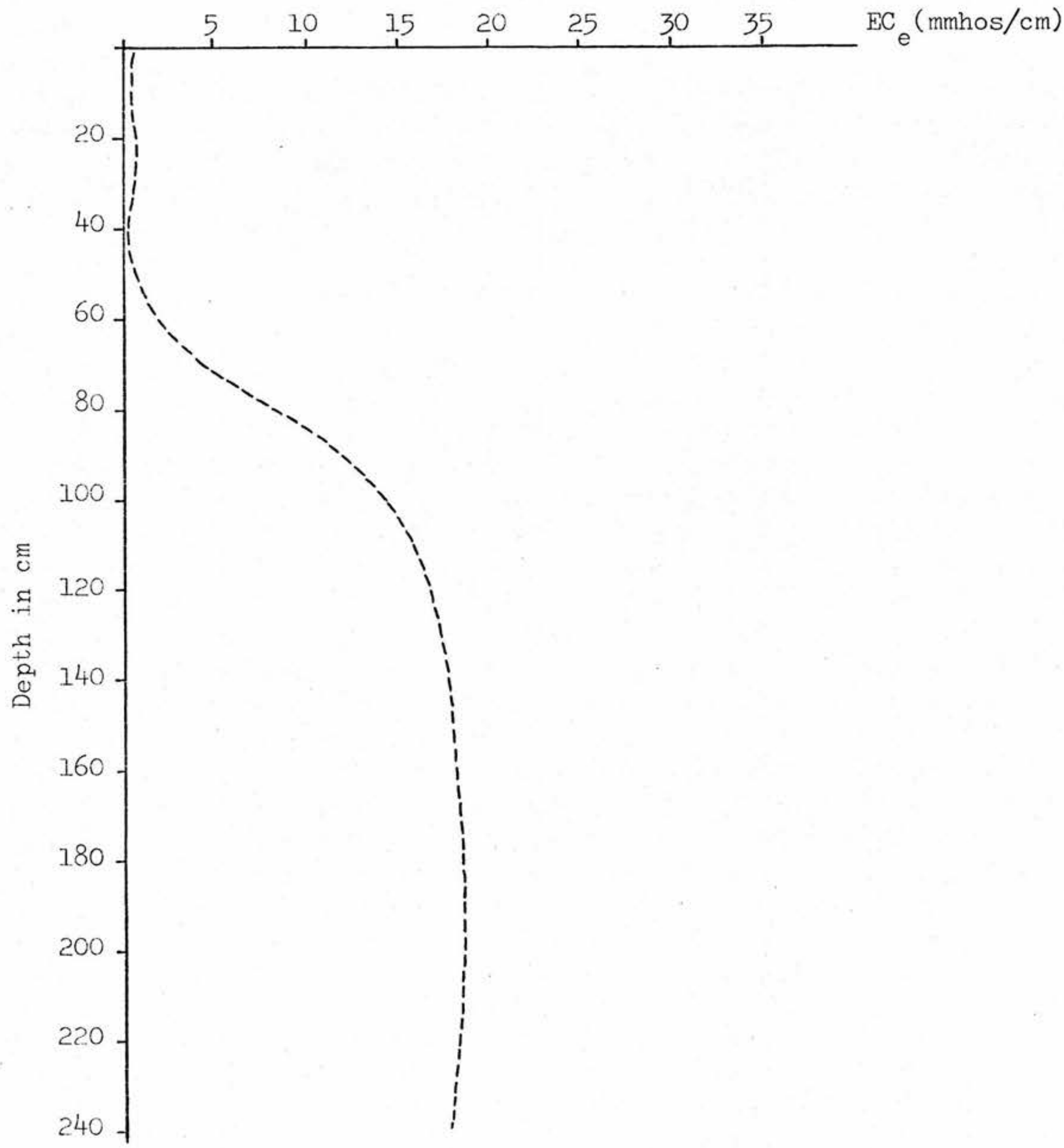
Graph 9.3



This graph represents the average figures for gypsum content in the soil profiles, and shows the increase in gypsum with depth.

Source: Fieldwork, Zouzou, R., 1961-74.

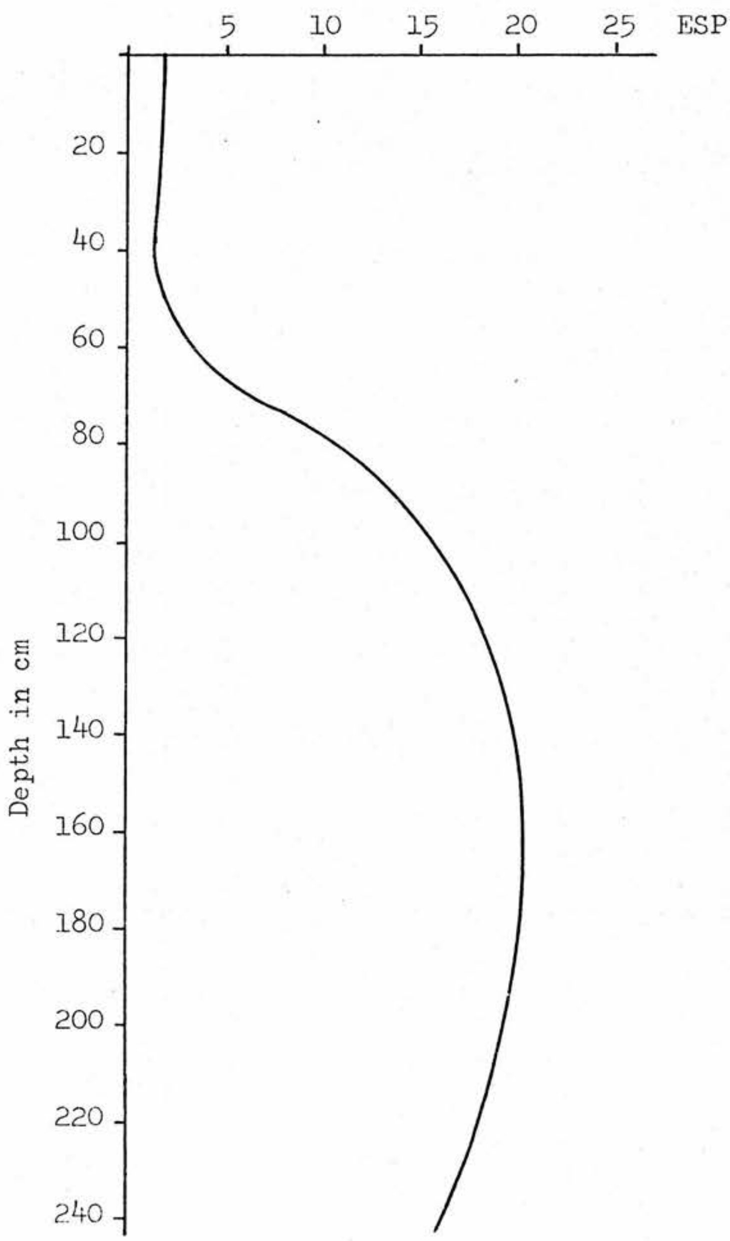
Graph 9.4
ELECTRICAL CONDUCTIVITY INCREASING WITH DEPTH



This graph represents average EC_e figures which show an increase with depth and also indicate increasing salinization of the soils.

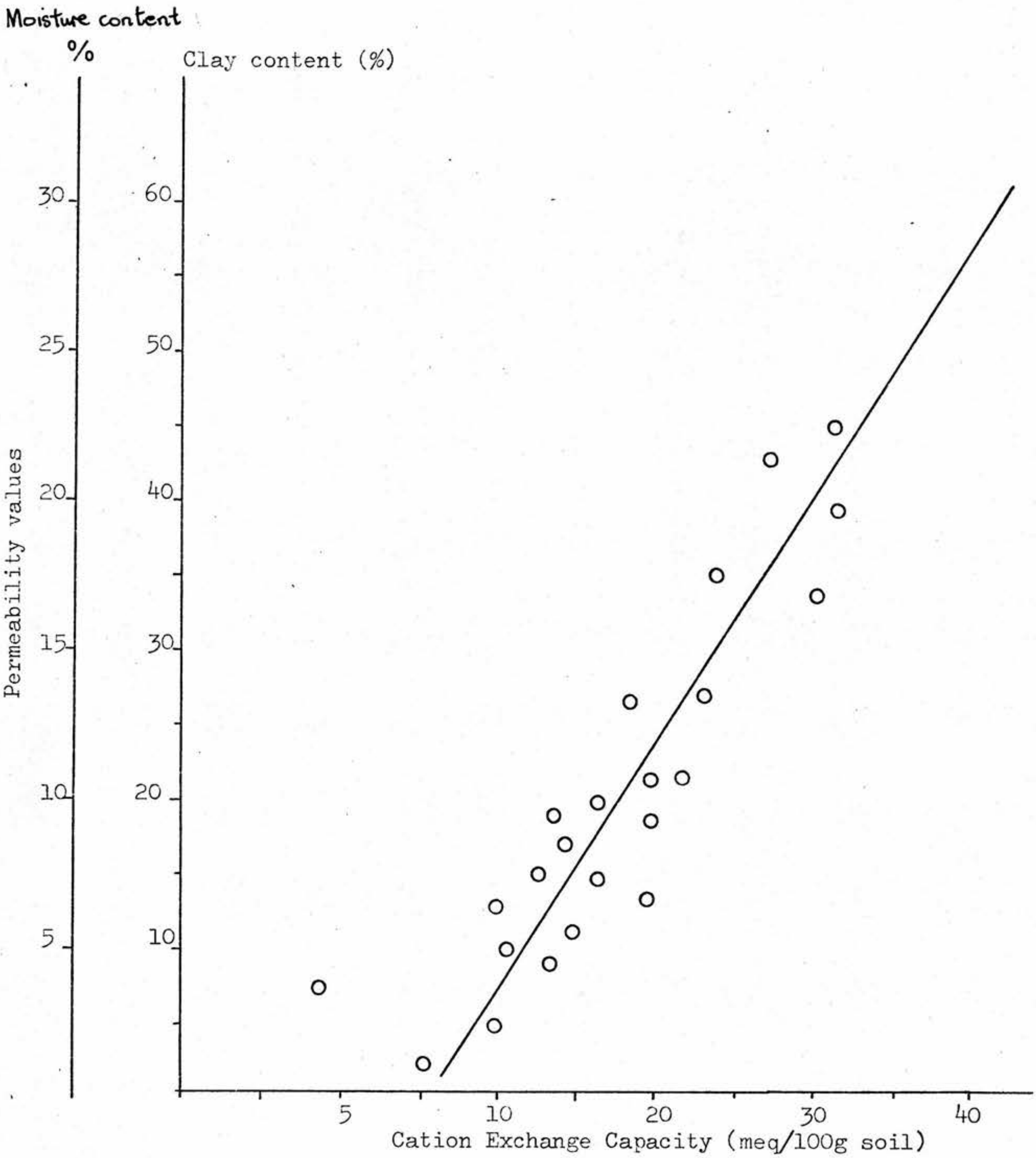
Source: Fieldwork, Zouzou, R., 1961-74.

Graph 9.5
EXCHANGEABLE SODIUM PERCENTAGE INCREASING WITH DEPTH



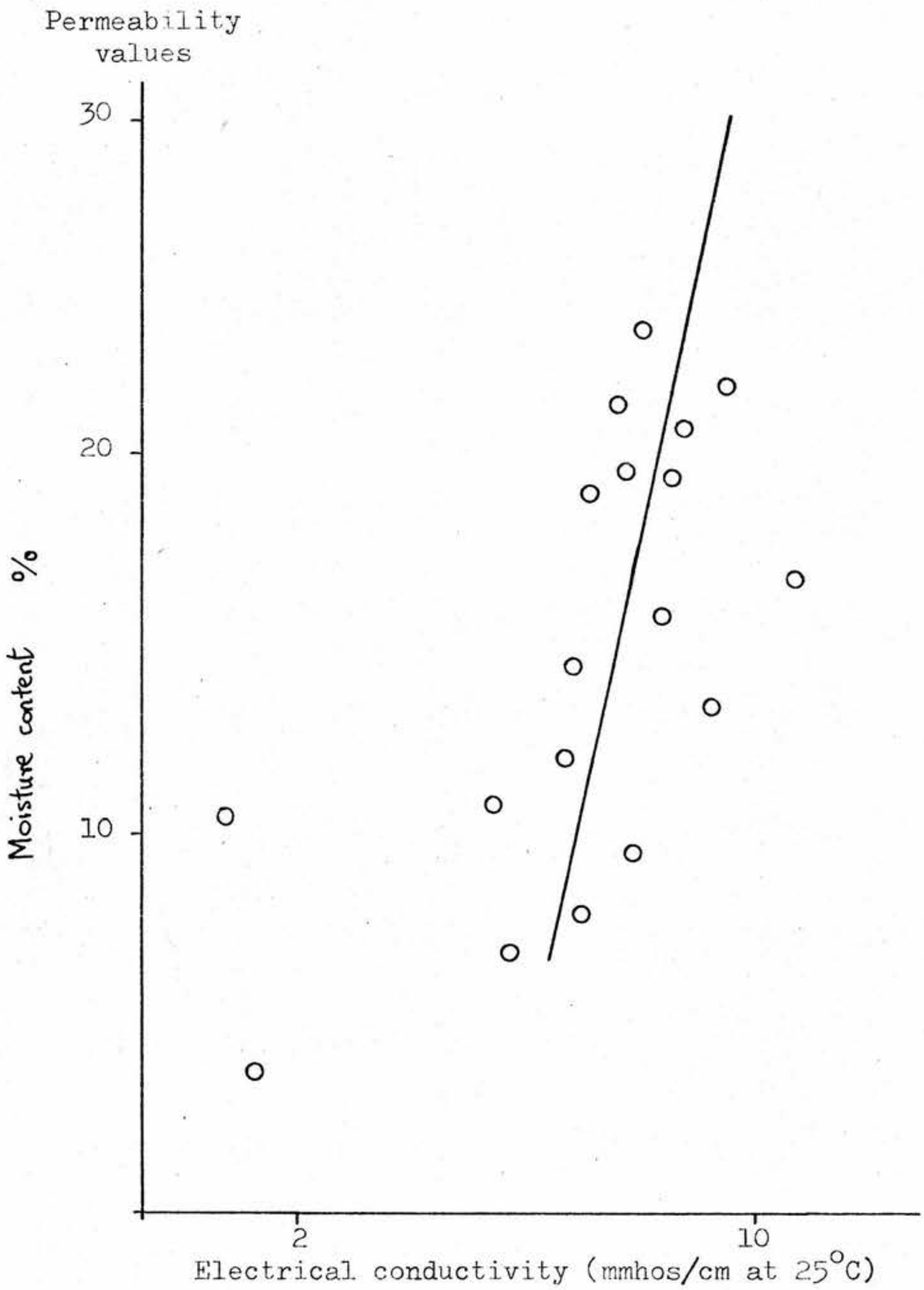
This graph represents average ESP figures in the study area which show an increase with depth.

Source: Fieldwork, Zouzou, R., 1961-74.



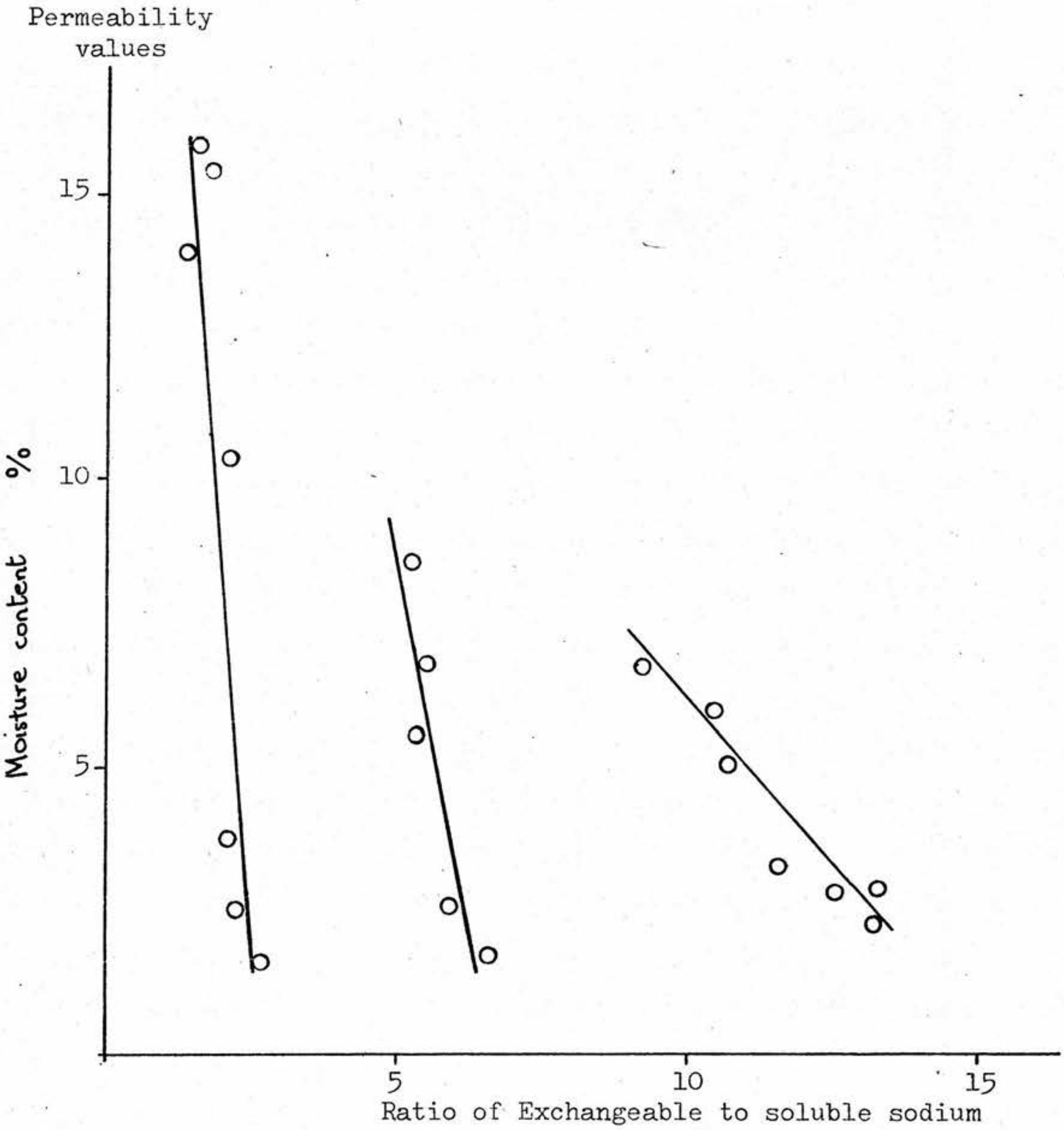
Graph 10.1
EXPERIMENTAL EVIDENCE ON THE RELATIONSHIP BETWEEN CATION EXCHANGE CAPACITY AND CLAY CONTENT ON SOIL PERMEABILITY

Source: Fieldwork, Zouzou, R., 1961-74.



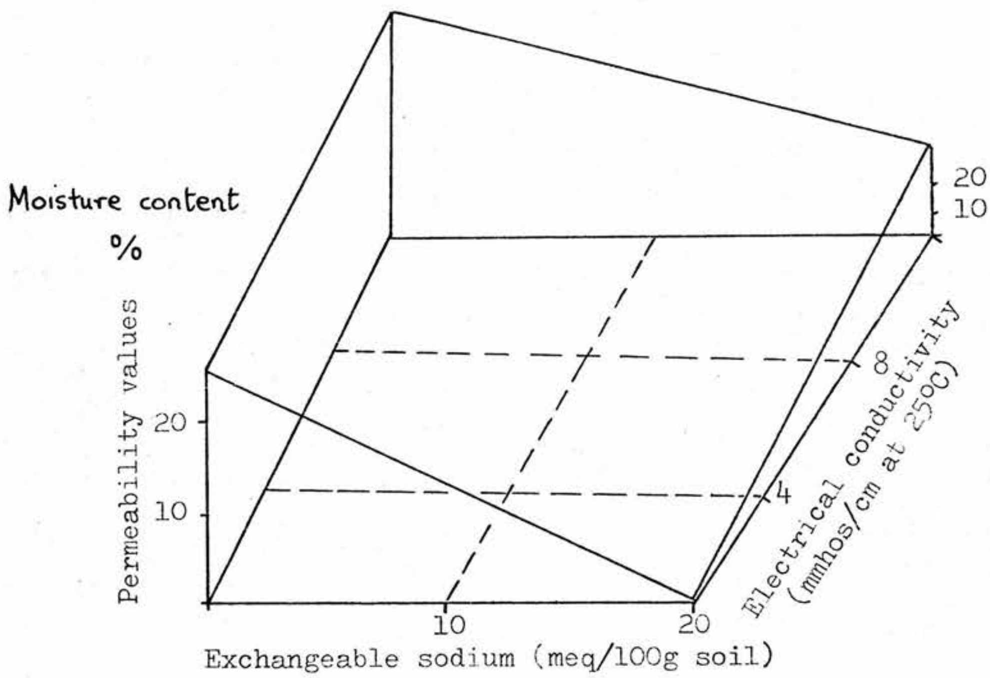
Graph 10.2
EXPERIMENTAL EVIDENCE ON THE RELATION BETWEEN
ELECTRICAL CONDUCTIVITY AND SOIL PERMEABILITY

Source: Fieldwork, Zouzou, R., 1961-74.



Graph 10.3
EXPERIMENTAL EVIDENCE ON THE RELATION BETWEEN RATIO OF EXCHANGEABLE TO SOLUBLE SODIUM FOR SALINE AND NON-SALINE SOIL ON SOIL PERMEABILITY
(See page 239)

Source: Fieldwork, Zouzou, R., 1961-74.

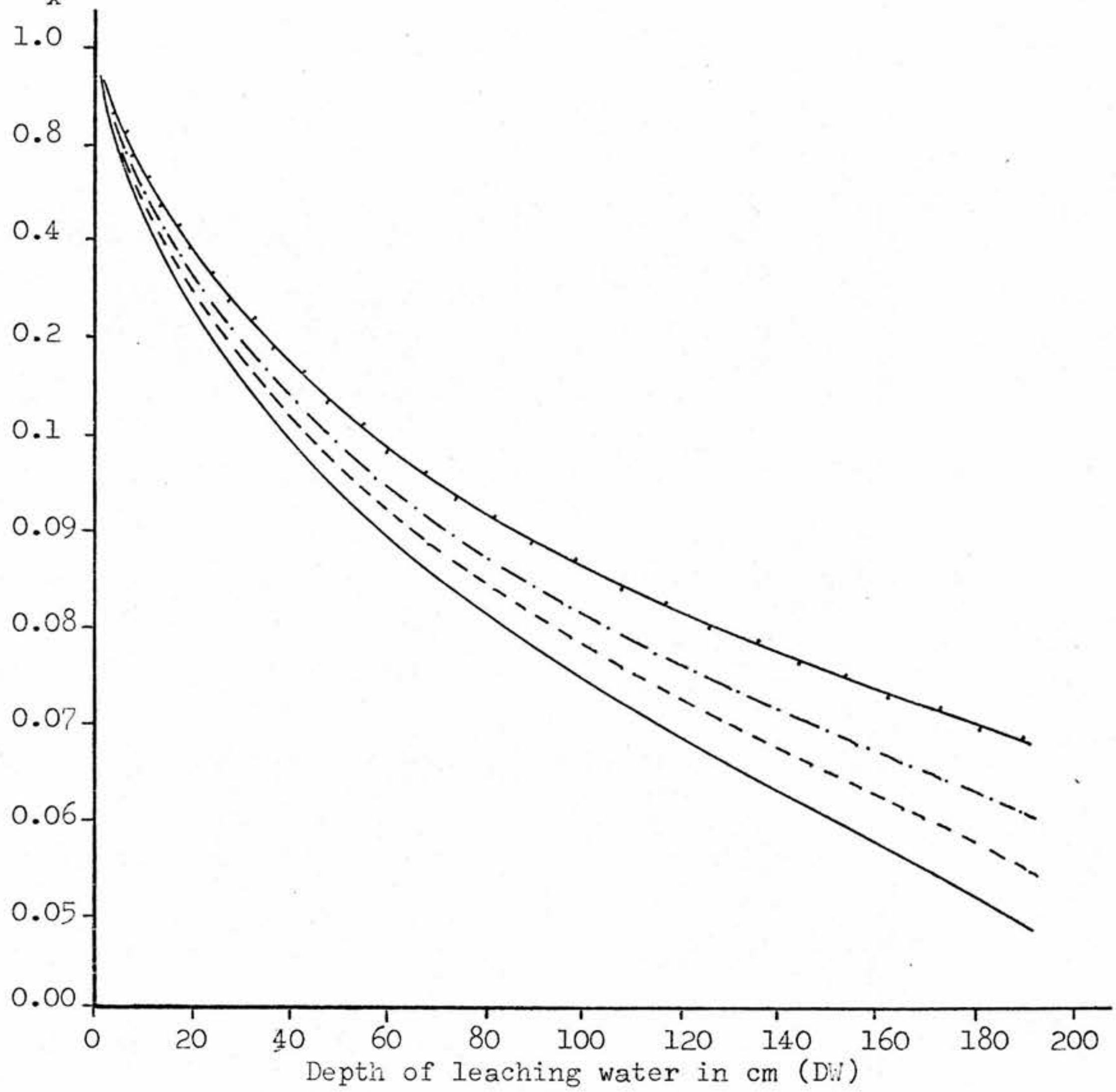


Graph 10.4
THE INFLUENCE OF DIFFERENT COMBINATIONS OF SALINITY AND EXCHANGEABLE SODIUM ON SOIL PERMEABILITY

Source: Fieldwork, Zouzou, R., 1961-74.

Graph 12.1

THE RELATIONSHIP BETWEEN SOIL SALINITY AND TOTAL DEPTH OF LEACHING WATER REPRESENTED BY LEACHING CURVES



EC = Electrical conductivity after leaching

EC_x = Electrical conductivity before leaching

——————— Curve of soil depths at 0 - 30 cm

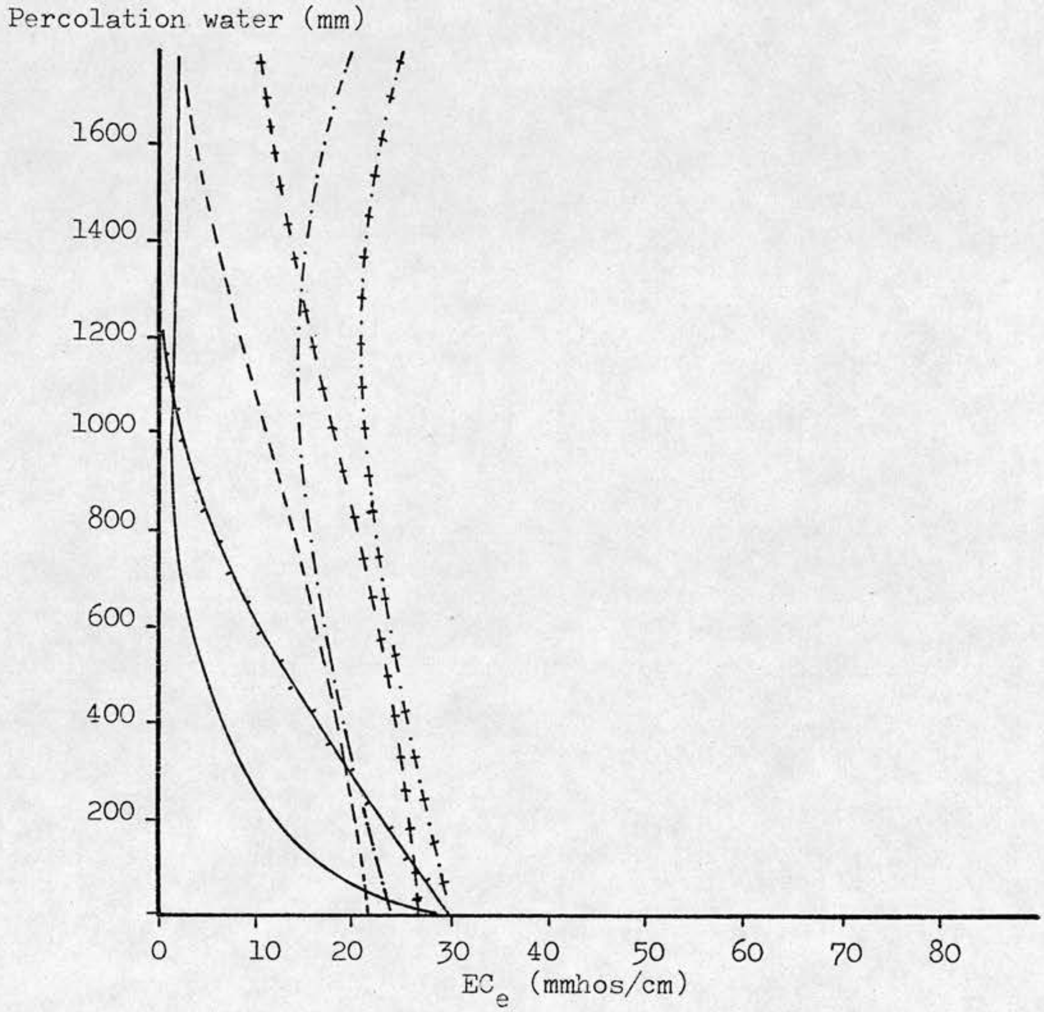
- - - - - - - - - - Curve of soil depths at 30- 55 cm

—·—·—·—·—· Curve of soil depths at 55- 90 cm

—'—'—'—'— Curve of soil depths at 90-120 cm

Source: Fieldwork, Zouzou, R., 1961-74.

Graph 12.2
LEACHING CURVES AT VARIOUS DEPTHS OF SOILS
BEFORE AND AFTER LEACHING



Electrical conductivity of the soil before leaching at depth 0 - 30 cm

Electrical conductivity of the soil after leaching at depth 0 - 30 cm

Electrical conductivity of the soil before leaching at depth 30 - 55 cm

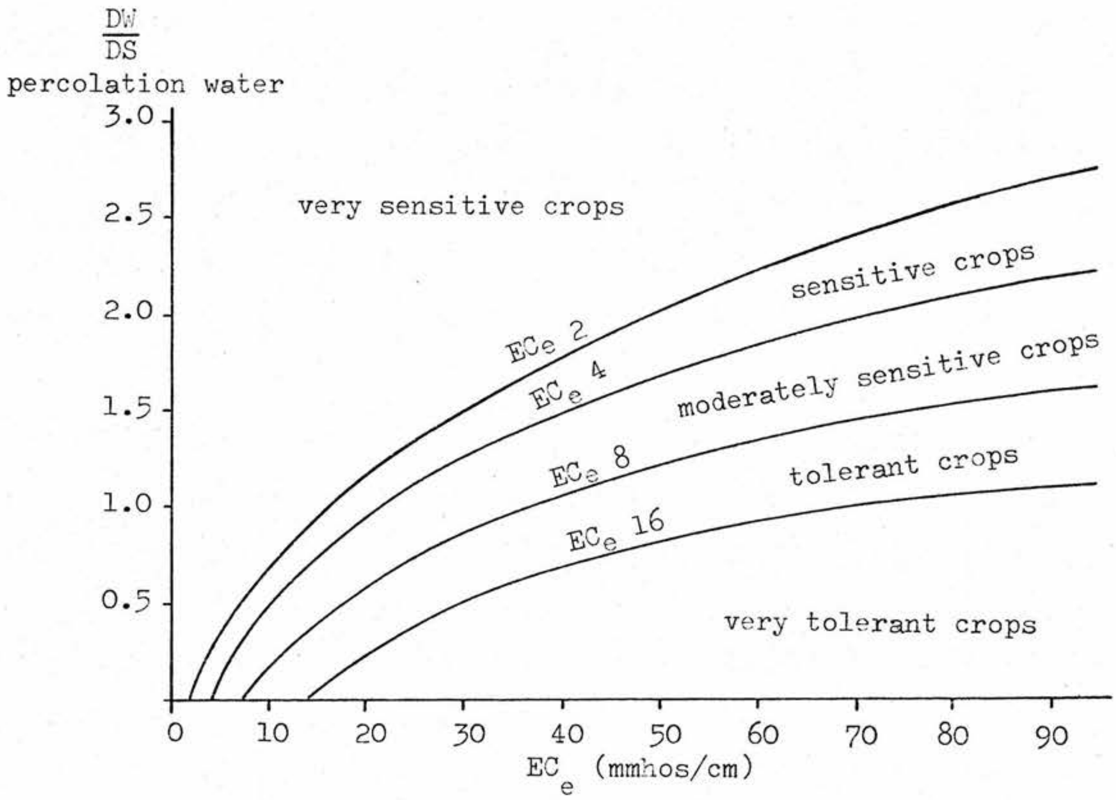
Electrical conductivity of the soil after leaching at depth 30 - 55 cm

Electrical conductivity of the soil before leaching at depth 55 - 90 cm

Electrical conductivity of the soil after leaching at depth 55 - 90 cm

Source: Fieldwork, Zouzou, R., 1961-74.

Graph 12.3
DEPTH OF PERCOLATION WATER BEFORE LEACHING
(for various field crops in relation to soil salinity)



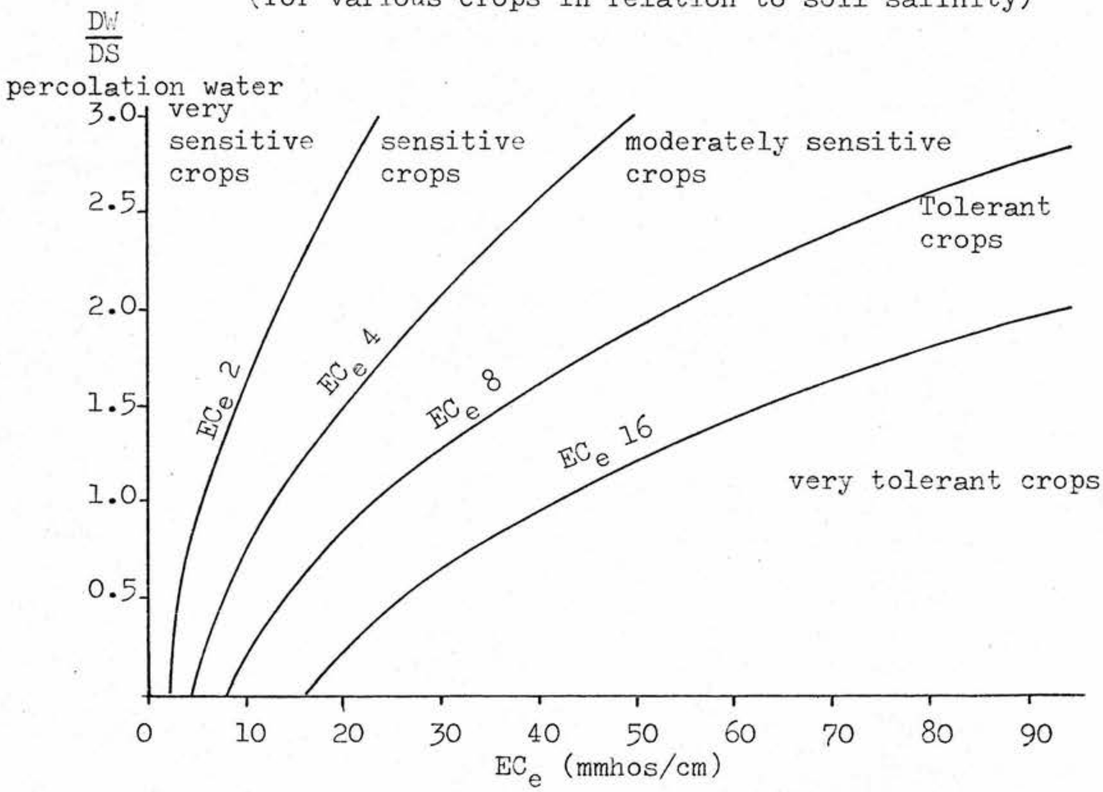
$\frac{DW}{DS}$ = Depth of leaching water per unit depth of soil (m)

Source: Based on U.S.D.A., Diagnosis and Improvement, Saline and Alkali Soils, 1969.

Dieleman, "Reclamation of Salt Affected Soils in Iraq, 1963.

Applied to Fieldwork, Zouzou, R., 1961-74.

Graph 12.4
DEPTH OF PERCOLATION WATER AFTER LEACHING
(for various crops in relation to soil salinity)



$\frac{DW}{DS}$ = Depth of leaching water per unit depth of soil (m)

Source: Based on U.S.D.A., Diagnosis and Improvement, Saline and Alkali Soils, 1969.

Dieleman, "Reclamation of salt affected soils in Iraq", 1963.

Applied to Fieldwork, Zouzou, R., 1961-74.

APPENDICES

A P P E N D I X   I

CLIMATOLOGICAL DATA

Source: Fieldwork, Zouzou, R., 1961-74
(with limited additions from
the Department of Meteorology,
Damascus)

APPENDIX I

TABLE 1

AVERAGE MONTHLY TEMPERATURE (in C°)

Month	Aleppo	Raqqa	Dier-ez-Zor	Hassakeh
January	8.1	7.0	7.5	6.1
February	8.2	7.8	9.0	6.7
March	10.0	11.3	11.3	11.4
April	16.2	18.1	19.3	16.2
May	22.0	23.0	24.2	23.0
June	27.0	27.4	29.6	27.5
July	28.1	29.3	32.5	30.5
August	29.2	30.1	31.8	30.2
September	25.0	24.6	26.4	25.5
October	17.5	19.4	20.2	19.1
November	13.1	13.0	12.3	12.4
December	9.7	7.7	8.1	7.5

Source: Fieldwork, Zouzou, R., 1961-74.

APPENDIX I

TABLE 2

AVERAGE MONTHLY PRECIPITATION (in mm)

Month	Aleppo	Raqqa	Dier-ez-Zor	Hassakeh
January	56.0	38.0	35.0	46.0
February	52.0	25.0	18.0	44.0
March	38.0	23.0	23.0	33.0
April	30.0	25.0	20.0	36.0
May	20.0	2.7	6.8	15.0
June	6.0	3.2	0.5	1.7
July	0.0	0.0	0.0	0.0
August	1.6	0.0	0.0	0.0
September	2.0	0.0	0.3	0.0
October	16.0	3.7	1.7	1.0
November	21.0	18.0	8.0	26.0
December	47.0	26.0	27.7	47.1

Source: Fieldwork, Zouzou, R., 1961-74.

APPENDIX I

TABLE 3

AVERAGE MONTHLY HUMIDITY (in per cent)

Month	Aleppo	Raqqa	Dier-ez-Zor	Hassakeh
January	62	55	55	60
February	60	55	51	53
March	55	51	47	48
April	43	38	34	37
May	35	31	28	31
June	30	37	26	27
July	26	23	21	22
August	25	20	18	21
September	32	24	22	26
October	38	28	27	33
November	44	35	33	47
December	56	47	42	51

Source: Fieldwork, Zouzou, R., 1961-74.

APPENDIX I

TABLE 4

AVERAGE MONTHLY WIND VELOCITY (in m/sec)

Month	Aleppo	Raqqa	Dier-ez-Zor	Hassakeh
January	3.6	2.7	2.6	1.4
February	3.5	3.2	1.9	2.6
March	3.7	4.8	1.7	2.3
April	4.1	4.6	2.6	2.5
May	4.5	4.1	2.8	3.1
June	5.8	5.3	3.6	3.1
July	6.1	6.6	4.2	2.7
August	5.8	6.0	3.4	2.4
September	4.3	5.8	2.7	2.2
October	3.5	4.2	1.5	2.6
November	3.0	3.8	1.6	1.8
December	2.5	3.1	1.2	1.3

Source: Fieldwork, Zouzou , R., 1961-74.

APPENDIX I

TABLE 5

RELATIVE DURATION OF SUNSHINE (in per cent)

Month	Aleppo	Raqqa	Dier-ez-Zor	Hassakeh
January	45	57	61	55
February	66	69	80	74
March	65	73	73	71
April	70	74	71	68
May	85	81	76	77
June	95	94	90	84
July	98	96	92	93
August	98	96	89	91
September	94	94	93	90
October	92	93	95	88
November	67	74	75	65
December	56	64	68	68

Source: Fieldwork, Zouzou, R., 1961-74.

APPENDIX I

TABLE 6

AVERAGE MONTHLY DEGREE OF CLOUDINESS (/8)

Month	Aleppo	Raqqa	Dier-ez-Zor	Hassakeh
January	4.9	4.3	4.2	4.1
February	4.0	3.6	2.9	2.7
March	4.1	4.2	3.5	3.3
April	3.8	2.8	3.7	2.4
May	2.7	2.6	2.4	1.7
June	0.9	0.8	0.7	0.5
July	0.4	0.3	0.2	0.1
August	0.6	0.5	0.0	0.0
September	0.9	0.2	0.4	0.0
October	2.1	1.9	1.2	0.8
November	3.6	3.0	2.2	2.8
December	4.5	3.8	3.5	3.6

Source: Fieldwork, Zouzou, R., 1961-74.

APPENDIX I

TABLE 7

SUMMARY OF CLIMATIC CONDITIONS

Stations	Altitude (meters)	Average temperature (C°) January min.	Average temperature (C°) January max.	Average temperature (C°) August max.	Average temperature (C°) August min.	Number of rainy days	Months of heavy rain	Annual rainfall (mm)	Average winter temperature (C°)
Aleppo	437	-1.6	11.0	37.7	22.3	59	December-January	365	11.2
Raqqa	272	-2.0	10.5	38.0	20.0	45	December-January	195	10.5
Dier-ez-Zor	213	-1.0	10.0	40.1	24.5	40	February-March	150	9.0
Hassakeh	315	-2.2	10.8	36.2	21.2	42	February-March	250	11.6

Source: Fieldwork, Zouzou, R., 1961-74.

APPENDIX I

TABLE 8

EVAPORATION AND SUNSHINE AT MAADAN

Month	Average monthly temperature	Free water surface evaporation in mm: Average daily	Average monthly	Total percentage	Average total hours of actual sunshine	Average percentage of sunshine
January	7.2	1.4	43	1.7	157.8	54
February	9.4	2.2	62	2.5	172.9	60
March	12.8	4.3	133	5.4	237.4	68
April	18.6	6.3	189	7.6	257.8	70
May	24.1	8.6	267	10.8	322.7	81
June	29.7	13.2	396	16.0	361.0	92
July	32.6	14.3	443	17.9	382.6	96
August	32.4	12.2	378	15.3	366.1	93
September	27.8	8.4	252	10.2	332.7	92
October	21.6	5.3	164	6.6	276.2	85
November	13.6	3.0	90	3.6	214.4	74
December	8.3	1.9	59	2.4	158.0	55
Years of record	12	12	12	12	12	12
Period of record	1963 - 1974					

The evaporation in the regions seems to be uniform from a comparison of the figures of Maadan; it is high, with a maximum of 12 to 14 mm, mainly during the summer period. The data on sunshine show a very long duration of sunshine during the warm half of the year.

Source: Fieldwork, Zouzou, R., 1961-74.

APPENDIX I

TABLE 9

DUST STORMS AND WIND VELOCITY AT MAADAN

Month	Average monthly precipitation in mm	Average number of wet days	Maximum fall in 24 hours in mm	Monthly average number of days with sand/dust storms	Average monthly wind velocity in m/sec
January	33.2	8.9	35.8	0.6	2.6
February	27.4	7.5	27.3	1.0	2.7
March	19.5	7.3	18.8	2.0	3.4
April	20.7	7.1	35.2	1.8	3.3
May	6.0	2.5	31.0	2.2	3.7
June	1.2	0.2	2.0	2.6	4.9
July	0.0	0.0	0.0	2.7	6.0
August	0.0	0.0	0.0	0.5	4.8
September	0.3	2.0	25.7	1.0	3.6
October	5.7	2.4	35.0	1.1	2.2
November	20.5	4.0	20.0	1.1	2.0
December	22.9	7.5	24.6	0.3	2.4
Years of record	12	12	12	12	12
Period of record	1963-1974				

The period with morefrequent dust storms is in summer when the soil surface is dry and locally heavy wind occurs in the hot desert-like region with an extensive area of uniform pressure. In addition to the dust storms a large number of dust whirlwinds can be observed locally. In summer the average velocity will be influenced by short periods of squalls.

Source: Fieldwork, Zouzou, R., 1961-74.

APPENDIX I

TABLE 10

MONTHLY SOIL TEMPERATURE AT MAADAN

Month	Average monthly temperature of the soil at various depths				Range of extreme temperatures of the soil at depth 10 cm	
	10 cm	20 cm	50 cm	100 cm	Maximum	Minimum
January	8.2	9.0	10.1	14.8	8.4 - 14.8	-0.6 - 8.9
February	10.5	11.0	12.0	14.1	11.7 - 17.5	2.0 - 11.6
March	14.4	14.7	15.5	15.7	17.6 - 23.4	1.8 - 13.8
April	20.6	20.7	20.4	19.3	21.3 - 30.4	10.4 - 19.0
May	27.7	27.5	26.4	23.9	30.3 - 39.1	16.7 - 24.9
June	33.9	33.5	32.3	29.2	40.5 - 45.0	22.8 - 32.9
July	35.8	35.6	34.6	31.5	42.4 - 47.6	25.3 - 34.6
August	35.6	35.6	35.9	32.6	39.9 - 41.2	24.5 - 34.5
September	30.4	31.3	31.7	31.1	33.2 - 37.8	19.9 - 29.9
October	23.2	24.2	26.1	27.6	24.4 - 31.9	8.6 - 20.8
November	16.2	17.4	19.9	23.1	15.9 - 26.4	3.3 - 15.4
December	10.6	11.6	14.2	18.2	12.0 - 16.9	2.3 - 10.3

Years of record 12

Source: Fieldwork, Zouzou, R., 1961-1974
Department of Agriculture, Raqqa
(limited additions for the top 10 cm)

APPENDIX I

TABLE 11

MONTHLY SOIL TEMPERATURE AT RAQQA

	Average monthly temperature of the soil at various depths				Range of extreme temperatures of the soil at depth 10 cm	
Month	10 cm	20 cm	50 cm	100 cm	Maximum	Minimum
January	8.0	8.8	10.9	14.6	8.4 - 14.8	-0.6 - 8.9
February	10.3	10.8	11.8	13.9	11.7 - 17.5	2.0 - 11.6
March	14.2	14.5	15.3	15.6	17.6 - 23.4	1.8 - 13.8
April	20.4	20.5	20.2	19.1	21.3 - 30.4	10.4 - 19.0
May	27.5	27.3	26.2	23.7	30.3 - 39.1	16.7 - 24.9
June	33.7	33.3	32.1	29.0	37.5 - 41.0	22.8 - 32.0
July	35.6	35.4	34.4	31.3	36.4 - 42.6	25.3 - 34.6
August	35.4	35.4	34.7	32.4	29.9 - 41.2	24.5 - 34.5
September	30.2	31.1	31.5	30.9	33.2 - 37.8	19.9 - 29.9
October	23.0	24.0	25.9	27.4	24.4 - 31.9	8.6 - 20.8
November	16.0	17.2	19.7	22.9	15.9 - 26.4	3.3 - 15.4
December	10.6	11.4	14.0	18.0	12.0 - 16.9	2.3 - 10.3

Years of record: 12

Source: Fieldwork, Zouzou, R., 1961-1974
Department of Agriculture, Raqqa
(limited additions for the top 10 cm)

A P P E N D I X II

MAJOR SPECIES OF BIRDS FOUND IN THE STUDY AREA

Source: Fieldwork, Zouzou, R., 1961-74

APPENDIX II

MAJOR SPECIES OF BIRDS FOUND IN THE STUDY AREA

Common Names	Scientific Names
Farmyard duck	Anas platyrhynchos
Juvenile pigeon	Columba livila
Hawfinch	Coccothraustes
Goshawk	Accipter gentilis
Black headed gull	Larus ridibundus
Griffon vulture	Gyps fulvus
Swallow	Hirundo rustica
Oystercatcher	Haematopus ostrlegus
Barnowl	Tyto alba
Green woodpecker	Picus viridis
Marabou stork	Leptotilus crumeniferus
Rook	Corvus frugilegus
House sparrow	Passer domesticus

These bird species were identified by The Royal Society for the Protection of Birds - The Lodge Sandy Bedfordshire - to whom the author expresses his thanks. Thanks are also expressed to Dr. W.W. Newey of the Geography Department at Edinburgh University for his assistance in identifying these species.

A P P E N D I X III

MAPS

Applied to Fieldwork, Zouzou, R., 1961-74

APPENDIX III

MAPS

Topographical maps of Syria

Scale 1 : 50,000	Service Geographique de l'Armee en Paris 1940.
Scale 1 : 200,000	Service Geographique de l'Armee en Paris 1945.
Scale 1 : 15,000	General administration for the development of the Euphrates basin, Raqqa, 1974.
Scale 1 : 50,000	Department of Geology and Mineral Research, Ministry of Industry, Damascus, 1964. (made by V.O. Technoexport - Moscow)

Geological maps of Syria

Scale 1 : 500,000	Louis Dubertret, Beyrouth, 1942.
Scale 1 : 1,000,000	Louis Dubertret, Beyrouth, 1945.
Scale 1 : 200,000	Department of Geology and Mineral Research, Ministry of Industry, Damascus, 1964. (made by V.O. Technoexport - Moscow)
Scale 1 : 500,000	Department of Geology and Mineral Research, Ministry of Industry, Damascus, 1964. (made by V.O. Technoexport - Moscow)
Scale 1 : 1,000,000	Department of Geology and Mineral Research, Ministry of Industry, Damascus, 1964. (made by V.O. Technoexport - Moscow)

Other maps and illustrations

Tectonic map scale 1 : 1,000,000, Department of Geology and Mineral Research, Ministry of Industry, Damascus, 1964. (Made by V.O. Technoexport - Moscow)

Geomorphological map scale 1 : 1,000,000, Department of Geology and Mineral Research, Ministry of Industry, Damascus, 1964.
(made by V.O. Technoexport - Moscow)

Schematic map of the first-below-the-surface water-bearing formation of Syria, scale 1 : 1,000,000, Department of Geology and Mineral Research, Ministry of Industry, Damascus, 1964.
(made by V.O. Technoexport - Moscow)

Schematic map of Quaternary sediments of Syria, scale 1 : 1,000,000, Department of Geology and Mineral Research, Ministry of Industry, Damascus, 1964.
(made by V.O. Technoexport - Moscow)

Photo mosaics scale 1 : 10,000, General Organization of the Euphrates Dam, Ministry of the Euphrates Dam, Damascus, 1964.

Air photographs scale 1 : 8,000, General Organization of the Euphrates Dam, Ministry of the Euphrates Dam, Damascus, 1964.

Soil maps of Syria

Soil groups of Syria, scale 1 : 200,000, Directorate of Soils, Ministry of Agriculture, Damascus, 1953.

Great soil groups of Syria, scale 1 : 500,000, Directorate of Soils, Ministry of Agriculture, Damascus, 1958.

Map of land suitability in the Euphrates and its tributary, scale 1 : 100,000, Ministry of the Euphrates Dam, 1963. (Nedeco - Netherlands)

Map of land classification of the Balikh basin, scale 1 : 50,000, General administration for the development of the Euphrates basin, Raqqa, 1967. (Gibb, A., and partners - England)

Soil map of the Balikh basin, scale 1 : 50,000, Mulders, Rotterdam, 1969.

Soil groups map of Syria and Lebanon, Walpart, Berlin, 1967.

Soil map of north-east Syria, scale 1 : 800,000, Van Liere, Rome, 1965.

A P P E N D I X IV

ANALYTICAL FIELD METHODS

Applied to Fieldwork, Zouzou, R., 1961-74.

APPENDIX IV

ANALYTICAL FIELD METHODS

All the profiles were described in relation to topography, lithology, vegetation, and human activity.

(i) The locality and the age of the land were considered in assessing the site characteristics of each profile, this included consideration of the surface of landscape, elevation, slope, flat, bare, grasses, salt and drainage conditions.

(ii) The profiles were dug to between 40-400 cm deep enabling the various soil horizons and root zonation to be identified and the soil type to be assessed.

(iii) Samples were taken at various depths from horizons of changing colour, structure, constitution, organic matter content, horizon with roots and without roots. Samples were taken from the base of the profiles to study the nature of parent material and mineral content. The size of the samples were taken considering the type and nature of the soil (soft, mud, hard crust, stony, salty or mixed materials). The weight of the samples ranged from 1000-3000 g and sometimes upto 6000 g. Some of the samples were packed in wax-covered cloth and numbered. Other samples were collected and stored in polythene bags.

(iv) To obtain the field observation data of each profile, the following points were recorded: locality, date, mean annual temperature and rainfall, topographical position, field crops (recent yield or last one), vegetation cover, elevation and parent material, depth, depth of each horizon, colour, structure, texture, depth of roots, depth of watertable, moisture and water conditions, and organic content.

(v) Colour was determined on the basis of Munsell colour charts (1971), and also Rock-colour charts (1951), in the field as well as in the laboratory when the samples were wet and dry.

(vi) The infiltration rates were determined by using the cylinder method of Musgrove (U.S.D.A., 1955). Experiments were conducted continuously for 36 hours for each of the tests (expressed in mm per time or cm/day).

(vii) The field capacity was determined by drying and weighing the soil samples taken in the infiltration tests at a depth of 10 cm. The field capacity is the moisture content of soil in the field two or three days after rain or irrigation, and is expressed as moisture percentage - dry weight basis (U.S.D.A., 1969).

(viii) Soil horizons. The following soil horizons have been identified in the profiles of the study area:

Surface horizons

A	dark surface layers mainly rich in plant nutrients.
Ai	normally occur at the surface under wet conditions, though they may be buried at a shallow depth. It is a thin organic horizon if virgin lands; if ploughed, it has a very high organic matter content which results from the mixture of fauna and flora environment.
Aii	occurred under long continued farming that involved large additions of organic matter and supplemented by nitrogen and phosphate.

Aiii light pale in colour, very low in organic carbon, it is hard and massive when dry, and does not include fresh sediments.

Subsurface horizons

B are alluvial in nature with silicate clays, free from carbonates; loamy and very fine particles.

Bi are alluvial horizons of clay and humus formed under cultivation by mixing the surface and subsurface materials. It is found below the plough level in fields in which clay and humus have accumulated as thick dark coating on bed surface and wormholes.

Bs intermediate horizon with salts which affect the loamy soils. They possess high exchangeable sodium contends.

Bii are altered horizons with a coarse texture of sands and loamy sands with very few loamy clay particles.

Deep horizons

C are horizons of parent soil materials.

Cg parent soil material with gypsum.

Cc parent soil material with calcium carbonate.

Variable horizons. Some horizons can be formed in either the surface or subsurface of the soils.

G the gypsum horizons are formed by precipitation of calcium sulphate by the downward movement of the soil water.

S the saline horizons have a second enrichment of soluble salts such as NaCl, MgCl, Na, $MgSO_4$.

Ca calcium horizons, secondary carbonate accumulated as concretions and as soft powder by precipitation from the downward movement of soil water. This horizon contains high lime accumulation in the soils, ranging between 15-30 per cent.

Sp pan horizon occurring in the soils of the arid climates which exist in the central and south of the study area. This horizon is largely dry. It might exist in the lapilli soils.

(ix) Grid units. Within each 1 km^2 grid unit, two profiles were dug (one from each 1000 x 500 m sub-unit). Each profile was analysed for EC, ESP, pH, SO_4, $CaCO_3$; one profile (1000 x 500 m sub-unit) was analysed for the full range of soil properties.

A P P E N D I X V

VEGETATION SAMPLING METHOD

Applied to Fieldwork, Zouzou, R., 1961-74

APPENDIX V

VEGETATION SAMPLING METHOD

The following procedure was adopted in the vegetation sampling method in the field:

(i) Vegetation sample plots were marked 4 x 4 m, located along the transections.

(ii) For details of plant species the investigations were carried out in a quadrat system 1 x 1 m. This is considered to be useful especially where environmental changes disturb the plots.

(iii) The 1 x 1 m quadrats have been used to record data especially of halophytic groups.

(iv) Species and the form of plant life have been recorded according to Zohary (1973).

(v) Profiles were drawn of the natural plant communities in the survey area. These have not been included in the present thesis but are available.

(vi) Species were pressed and dried in the field using the method as described by Davis and Heywood (1963).

(vii) Valuable assistance in plant identification was obtained from Dr. Davis of the Royal Botanical Garden, Edinburgh.

(viii) The zonation of vegetation was very marked on the transects due to hydrological, climatological and soil conditions.

A P P E N D I X VI

ANALYTICAL LABORATORY METHODS

Applied to Fieldwork, Zouzou, R., 1961-74

APPENDIX VI

ANALYTICAL LABORATORY METHODS

To analyse the soil samples, the following laboratory tests were conducted:

(i) Moisture loss (moisture equivalent): The soil samples were heated in an electrical oven at 110^{o}C, until constant weight was reached. The loss of weight was determined and calculated as percent of dry air soil.

(ii) Particle size: The international pipette method was used to separate the coarse sand, fine sand, silt and clay fractions (U.S.D.A., 1969). The soil sample was mixed without any pretreatments with a dispersing agent containing 44.00 g sodium pyrophosphate ($Na_4.P_2O_7$ + $10H_2O$) and 4.00 g sodium carbonate (Na_2CO_3) per litre. The soil paste was left 12 hours and then was poured into cylinders of 500 ml. Then 500 ml of water was added and stirred mechanically. After waiting for 85 seconds the suspensions were checked for dispersion. The well dispersed suspensions were stirred once more mechanically for one minute and after 5 hours the clay fraction is pipetted from an appropriate depth (at 20^{o}C). The pipette fraction was evaporated after drying at 110^{o}C. The weight of the clay fraction was then determined. The soil particles in the cylinders were sieved through a 50 micron sieve and were washed till free of the fractions smaller than 50 micron. The fraction on the sieve represented coarse and fine sand. After drying, these were weighed. The results were calculated on an oven dry percentage basis.

(iii) Soil reaction: The soil acidity and alkalinity were expressed as pH values and were determined electrometrically (glass electrode) in a soil water extract with a ratio 1:5 (Schofield, R.K., and Taylor, J., 1955).

(iv) Calcium carbonate was determined by calcimeter (Black, 1965). The soil samples were treated with hydrochloric acid, and the volume of CO_2 gas was measured. The results were calculated as a percentage of $CaCO_3$, and the total carbonates were determined by Collin's calcimeter.

(v) Total soluble salts: Na and K were determined by a flame-photometer in a soil-water extract (ratio of 1:1). Ca and HCO_3 and Cl were determined by titration: Ca was precipitated as calcium oxalate, which was then dissolved in perchloric acid; titration follows with ammonium hexanitrate cerate; HCO_3 was titrated with sulphuric acid; Cl was titrated with silver nitrate and also by the chloride counter apparatus. NO_3 was determined by distillation as well as colorimetrically. The total soluble salt content represents the amount of salts determined by weighing the residue of a grains volume of a 1:1 extract after evaporation (Black, 1965). The SO_4 content was determined gravimetrically by precipitation as barium sulphate. Mg was precipitated as magnesium ammonium phosphate and determined colorimetrically. P was determined colorimetrically (Hesse, 1971).

(vi) CeC (cation exchange capacity) was determined according to a leaching technique; with ammonium nitrate for Na and K; and sodium chloride for Ca and Mg (Black, 1965).

(vii) ESP (exchangeable sodium percentage) was calculated from the formula:

$$\frac{Na}{CeC} \times 100$$

(viii) EC_5 (electrical conductivity of water extract 1:5) was measured with an electric conductivity meter, the result being expressed in mmhos/cm^2 at 25°C (U.S.D.A., 1969).

(ix) Gypsum content ($CaSO_4$) was determined by the method described in Black (1965). The gypsum in the soil was dissolved in the soil extract SO_4 was precipitated by barium chloride ($BaCl_2$) and measured gravimetrically; Ca was determined titrimetrically by precipitation as calcium oxalate (Black, 1965), and also by a second method where the soil sample was first shaken with water for 30 minutes. Normally a ratio of 1:1 or 1:2 was used, but in samples with high gypsum content a ratio of up to 1:5 was required to dissolve all gypsum. In the extract the gypsum was separated from other sulphates by precipitation with acetone. The precipitate was then washed from other sulphates and redissolved in water. The conductivity of the solution was measured and compared with that of standard solution of gypsum of known concentration (U.S.D.A., 1969).

(x) Organic carbon (C) was determined according to Walkley's (1947) method, modified Walkley-Black (Metson, A.J., 1961).

(xi) Nitrogen (N) was determined according to Kjeldahl's method (1935), modified micro-Kjeldahl (Yuen, S.H., and Pollard, A.G., 1953).

(xii) Available phosphates (P) was determined by means of extraction with citric acid. The total phosphate content in some samples was determined colorimetrically with molybdenum-blue (Hesse, 1971).

(xiii) X-ray analysis of the clay fraction was determined by Fluorescence Apparatus (PW 1540, PW 1051, PW 1010). The samples were fused with lithiumborate (soil lithiumborate = 1:5) into a glass. At the end of the fusion the melt was poured into an aluminium ring placed on a polished plate of graphite at 450°C. A copper weight was placed on the melt in order to frame a glass button. A well-sized glass button weighed 4.5 - 5.0 grams. The applied dilution with lithiumborate should not be more than ten times (Reynders, 1964).

Another method was also used for this analysis. The samples were treated to be free both from calcium carbonate and iron oxides. The room temperature photographs were taken using the Unicam 9 cm (type of powder camera). The specimens were in the form of thin rods of about 0.45 mm in diameter, by using filtered cobalt radiation at high tension 35 K.V. and 30 current M.A. The time of exposure ranged between 7-10 hours (Brown, 1961).

(xiv) For further water and soil analyses a DR-El/24 instrument (Hach Chemical Company, U.S.A.) has been used (photometric tests with meter scales indicated by manual methods).

(xv) Classes of salinity and alkalinity adopted: The following classes were adopted for salinity and alkalinity:

(a) Salinity classes*

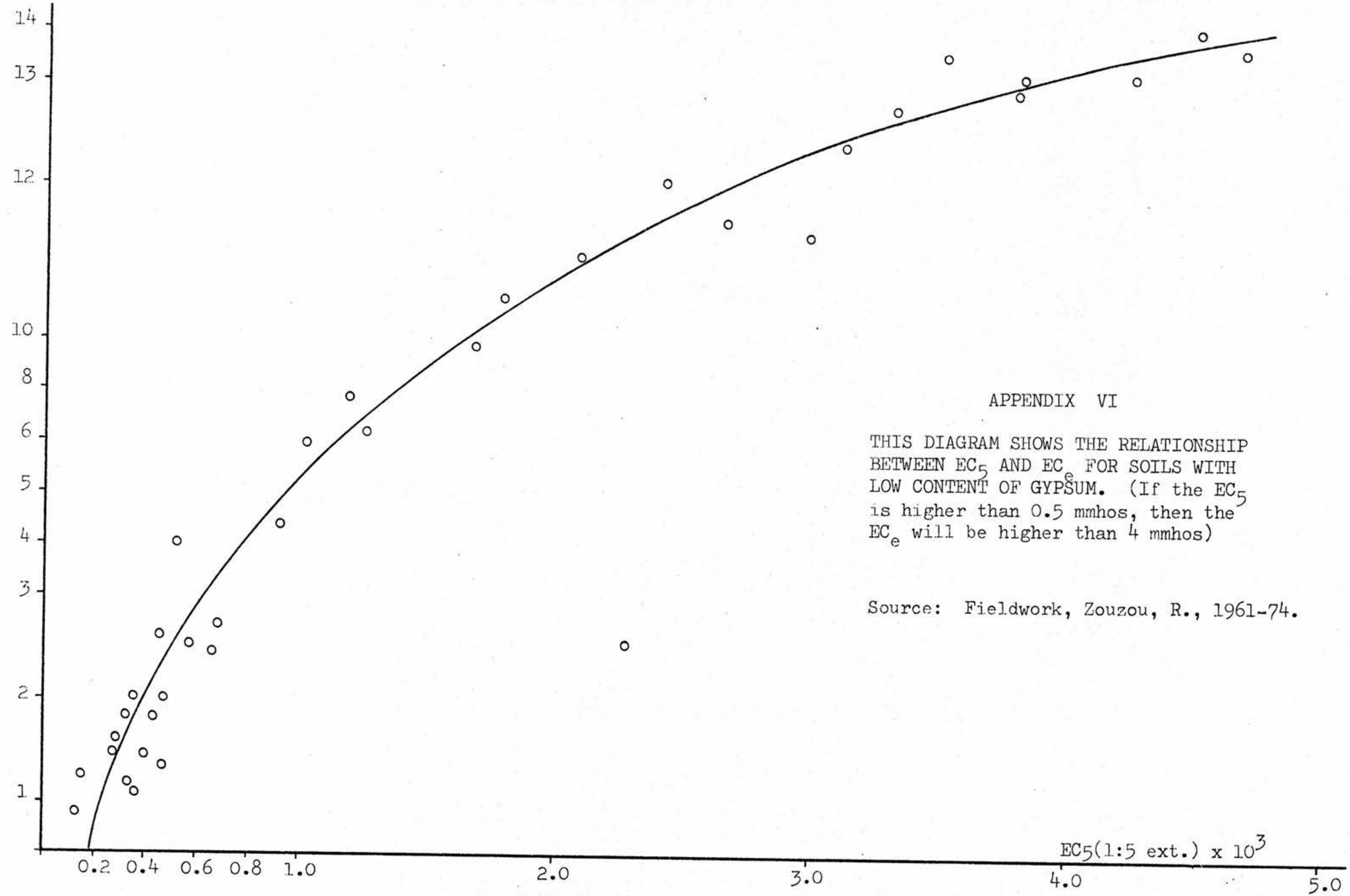
Class	EC_e in mmhos/cm[2]	EC_5	Assessment of soil
0	0 - 3	0.60	salt free
	3 - 4	0.80	weakly affected
I	4 - 8	0.80 - 1.20	slightly affected
II	8 - 12	1.20 - 2.60	moderately affected
III	12 - 14	2.60 - 4.80	strongly affected
	over 14	over 4.80	very strongly affected

(b) Alkalinity classes*

Class	ESP	pH	Assessment of soil
0	0 - 5	under 7	alkalinity free
	5 - 10	7.00 - 7.50	slightly affected
I	10 - 15	7.50 - 8.00	moderately weakly affected
II	15 - 25	8.00 - 9.00	moderately affected
III	25 - 30	9.00 - 9.50	moderately strongly affected
IV	30 - 40	9.50 - 10.00	strongly affected
	over 40	over 10.00	very strongly affected

* Source: adapted from U.S.D.A. Agriculture Handbook No. 60, 1969.

(xvi) The relationship between ECe and EC_5 for soils with low content of gypsum: illustration graphs overleaf.

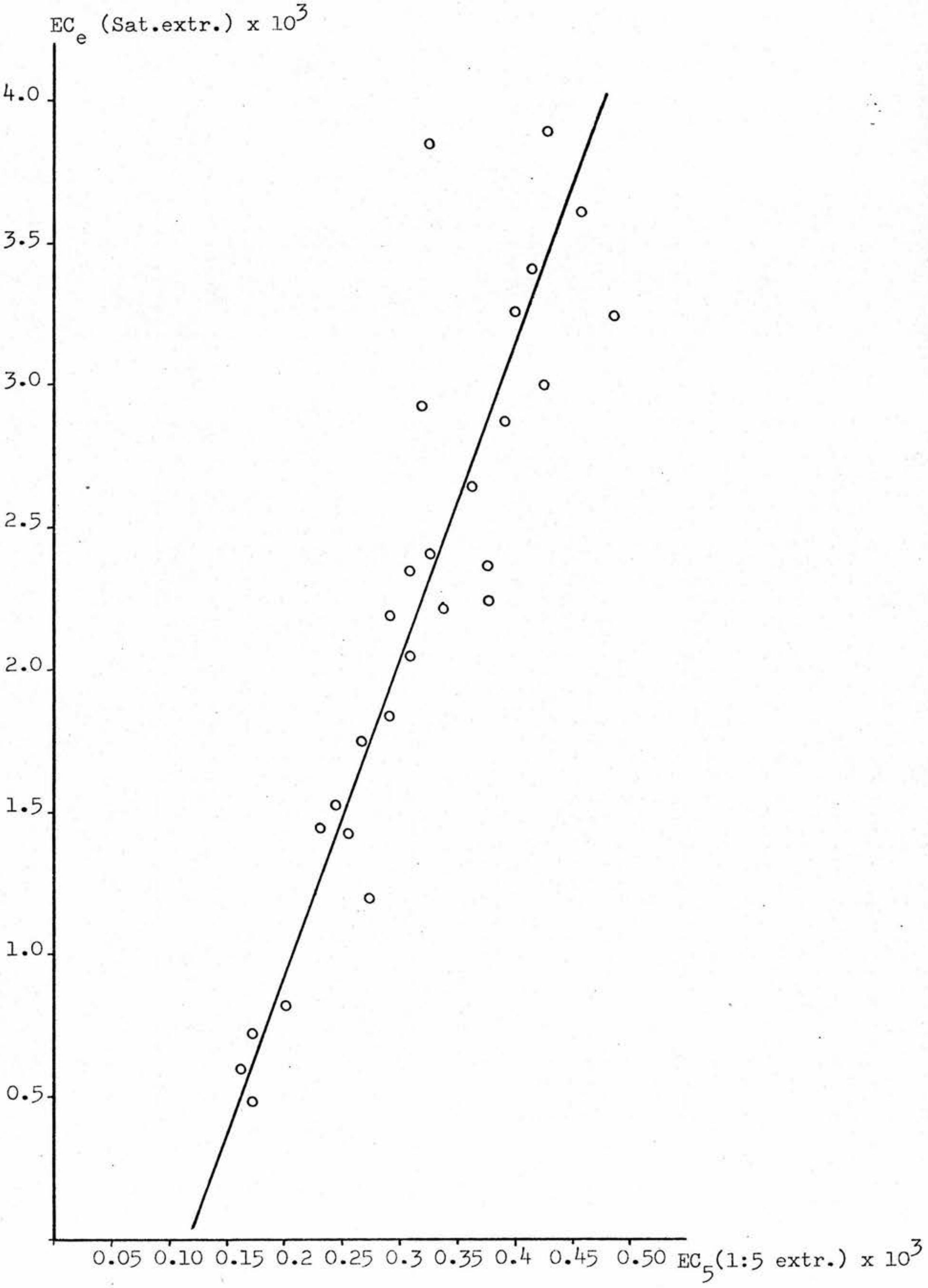


APPENDIX VI

THIS DIAGRAM SHOWS THE RELATIONSHIP BETWEEN EC_5 AND EC_e FOR SOILS WITH LOW CONTENT OF GYPSUM. (If the EC_5 is higher than 0.5 mmhos, then the EC_e will be higher than 4 mmhos)

Source: Fieldwork, Zouzou, R., 1961-74.

APPENDIX VI



THIS DIAGRAM SHOWS THE RELATIONSHIP BETWEEN THE EC_5 AND EC_e FOR SOILS WITH LOW CONTENT OF GYPSUM. (If the EC_5 is below 0.5 mmhos then the EC_e is lower than 4 mmhos)

Source: Fieldwork, Zouzou, R., 1961-74.

A P P E N D I X VII

LIST OF PLANT SPECIES COLLECTED

Source: Fieldwork, Zouzou, R., 1961-74

APPENDIX VII

LISTS OF PLANT SPECIES COLLECTED

(1) SELECTED VEGETATION COVER OF LAPILLI TRANSECT

Group	Family	No.	Species
Liliales	Liliaceae	1.	Crocus sp.
Ranunculales	Ranunculaceae	2.	Adonis autumnalis L.
		3.	Ceratocephala falcata (L.) Pers.
Rosales	Fagaceae	4.	Astralagus russellii Banks et Solander

(2) SELECTED VEGETATION COVER OF CALCAREOUS TRANSECT

Group	Family	No.	Species
Apiales	Apiaceae	1.	Bupleurum glaucumrobill & Cast ex. D.C.
		2.	Caucalis tenella Del.
Asterales	Asteraceae	3.	Senecio coronapifolius Desf.
Brassicales	Papaneraceae	4.	Hypecoum procumbens L.
Caryophyllales	Caryophyllaceae	5.	Minuartia picta (Sibth et Cm.) Bornm.
		6.	Spergularia diandra (Guss) Heldr. et Sart.
Geraniales	Geraniaceae	7.	Erodium cicutarium (L.) L: Her.
		8.	Erodium moschatum (L.) L: Her.
Poales	Poaceae	9.	Koeleria phleoides (Vill.) Pers.
Ranunculales	Ranunculaceae	10.	Adonis palaestina Boiss.
Rosales	Fagaceae	11.	Onobrychis crista-galli (L.) Lam.
Rutales	Rutaceae	12.	Haplophyllum longifolium Boiss.
Solanales	Boraginaceae	13.	Arnebia decumbens (Vent.) Coss. et Kral.
		14.	Convolvulus pilosellifolius Desr.

(3) SELECTED VEGETATION COVER OF ALLUVIAL TRANSECT

Group	Family	No.	Species
Apiales	Apiaceae	1.	*Hippomarathrum boissieri* Rent. & Hausk ex Boiss.
Asterales	Asteraceae	2.	*Achillea santolina* L.
		3.	*Asternisia herbia-alba* Asso
		4.	*Gondelia Tournefortii* L.
		5.	*Launaea spinosa* (Forsk) Sch. Bip.
		6.	*Matricaria aurea* (Loepl) Sch. Bip.
		7.	*Matricaria chamomilla* L.
Brassicales	Brassicaceae	8.	*Capsella bursa-pastoris* (L.) Medik.
		9.	*Diplotaxis acris* (Forsk) Boiss.
		10.	*Moricandia nitens* (Viv.) Dur & Bart.
		11.	*Sisymbrium septulatum* D.C.
		12.	*Sterigmostemum sulphureum* (Banks & Solander) Bornm.
	Resedaceae	13.	*Reseda luteola* L.
Caryophyllales	Caryophyllaceae	14.	*Dianthus sultipunctalus* Sek
		15.	*Spergula pentandra* L.
Geraniales	Geraniaceae	16.	*Erodium cicutarium* (L.) L:Her.
Liliales	Liliaceae	17.	*Muscaria racemosum* (L.) Mill.
Plantaginales	Plantaginaceae	18.	*Plantago notata* Lag.
Rutales	Rutaceae	19.	*Haplophyllum Buxbaumii* (Poir.) Boiss.
Solanales	Convolvulaceae	20.	*Convolvulus stachydifolius* Choisy
	Lamiaceae	21.	*Salvia palaestina* Benth.
		22.	*Salvia spinosa* L.
		23.	*Teucrium polium* var album (Mill.) Fiori.

(4) SELECTED VEGETATION COVER OF GYPSIFEROUS TRANSECTS

(a further list of species collected on these transects is given after Section 4 - iii)

(4 - i) SELECTED VEGETATION COVER OF GYPSIFEROUS TRANSECT

Group	Family	No.	Species
Asterales	Asteraceae	1.	Evax anatolica Boiss et Heldz
		2.	Koelpinia linearis pall.
		3.	Achillea santolina L.
		4.	Leontodon arabicus Boiss.
		5.	Senecio coronopifolius Desf.
Brassicales	Brassicaceae	6.	Alyssum seniocoides Boiss.
		7.	Arabidopsis pumila (stepk) Busch.
		8.	Capsella bursa-pastoris (L.) Medik.
		9.	Descurainia sophia (L.) Prantl.
		10.	Malcolmia africana (L.) R. Br.
		11.	Malcolmia torulosa (Desf.) Boiss.
		12.	Sisymbrium irio L.
		13.	Sisymbrium achimperi Boiss.
		14.	Sisymbrium septulatum D.C.
	Papaneraceae	15.	Hypecoum procumbens L.
Caryophyllales	Caryophyllaceae	16.	Minuartia picta (Sibth et Sm) Bornm.
		17.	Silene coniflora Nees ex. Otth.
Geraniales	Geraniaceae	18.	Erodium ciconium (L.) L:Her.
		19.	Erodium cicutarium (L.) L:Her.

(4 - ii) SELECTED VEGETATION COVER OF GYPSIFEROUS TRANSECT

Group	Family	No.	Species
Liliales	Liliaceae	1.	*Muscari longipes* Boiss.
Plantaginales	Plantaginaceae	2.	*Plantago ovata* Forsk.
Poales	Poaceae	3.	*Alopecurus myosuroides* Hunds.
Polygonales	Polygonaceae	4.	*Polygonum aniculare* L.
Primulales	Primulaceae	5.	*Ancrosace maxima* L.
Ranunculales	Ranunculaceae	6.	*Adonis aestivalis* L.
Rosales	Fagaceae	7.	*Ornithopus compressus* L.
Solanales	Boraginaceae	8.	*Arnebia decumbens* (Vent.) Coss et. Kral.
		9.	*Zisiphora tenuior* L.
	Orobanchaceae	10.	*Cistanche salsa* (C.A.Mey.) G. Beck.
	Scrophulariaceae	11.	*Veronica didyma* Ten.
Thymeleales	Eleagnacea	12.	*Eleagnus angustifolia*
	Moraceae	13.	*Morus alba* L.

(4 - iii) SELECTED VEGETATION COVER OF GYPSIFEROUS TRANSECT

Group	Family	No.	Species
Brassicales	Brassicaceae	1.	*Diplotaxis crucoides* (Torner) D.C.
		2.	*Lepidium draba* (L)
		3.	*Malcolmia arenaria* D.C.
Caryophyllales	Chenopodiaceae	4.	*Salsola villosa* Del.
		5.	*Suaeda baccata* Forsk ex. J.F. Gmel
Cistales	Tamaricaceae	6.	*Tamarix tetandra* Guebh ex Bunge
Plantaginales	Plantaginaceae	7.	*Plantago ovata* Forsk.
Poales	Fagaceae	8.	*Alhagi maurorum* Medik.
		9.	*Medicago polymorpha* L.
		10.	*Vicia palaestina* Boiss.
Solanales	Convolvulaceae	11.	*Cressa cretica* L.
	Solanaceae	12.	*Lycium arabicum* Schwinf.
Brassicales	Brassicaceae	13.	*Arabidopsis pumila* (Stepk.) Busch.

APPENDIX VII

LIST OF PLANT SPECIES COLLECTED
with relation to the Gypsiferous areas additional
to those shown on the lists relating to each transect

1. Pinus brutia Ten. or P. halepensis Miller
2. Spergularia diandra (Guss.) Heldr. & Sart.
* 3. Schimpera arabica Hochst. et Steud.
* (also unidentified Compositae near Tripleurospermum)
4. Cardaria draba (L.) Desv. s.l.
5. probably Hypecoum procumbens L.
* 6. Anthemis haussknechtii Boiss. & Reut.
* 7. Torularia torulosa (Desf.) O.E. Schulz
* 8. Roemeria hybrida (L.) DC. subsp. dodecandra (Forssk.) Maire
9. Prosopis stephaniana (Willd.) Kunth.
*10. Cardaria draba (L.) Desv. subsp. draba
*11. Reseda alba L.
12. Tripleurospermum sp.
*13. Erucaria hispanica (L.) Druce
14. Erucaria bornmuelleri O.E. Schulz & descr.
*15. mostly Roemeria hybrida (L.) DC. subsp. dodecandra (Forssk.) Maire (also a small Papaver rhoeas L.)
16. Papaver rhoeas
17. Adonis aestivalis L.
*18. Senecio glaucus L. (S. desfontainei Druce)
*19. Achillea wilhelmsii C. Koch (S. santolina auct.)
*20. Arnebia tubata (Bertol) Samuels
21. Convolvulus ? (immature)
22. Gypsophila (immature)
*23. Rhagadiolus angulosus (Jaub. & Spach.) Kupicha
24. Peganum harmala L.
*25. Silene coniflora Nees.
*26. Valerianella dufresnia Bunge ex Boiss.
*27. Koelpinia linearis Pall.
28. Muscari sp.
*29. Peganum harmala L.
30. Eruca sativa Miller

*31. Centaurea pallescens Del. var. hyalolepis Boiss.
32. Carthamus sp. (immature)
*33. Carduus getulus Pomel
34. Onopordum sp. (immature)
35. Alhagi sp. (immature)
*36. Cornulaea setifera Moq. (named from description)
*37. Cynoden dactylon (L.) Pers.
*38. Lolium rigidum Gand.
*39. Hordeum leporinum Link
*40. Bromus danthoniae Trin.
*41. Lophochloa phleioides (Vill.) Reichb.
42. Bromus tectorum L.
43. Lycium sp. (immature)
*44. Pimpinella olivieri Boiss.
45. Anchusa strigosa Lab.
46. Arnebia decumbens (Vent.) Coss. & Kral.
47. Silene longipetala Vent.
48. Artemisia herba-alba ? (inadequate material)

* Those marked with an asterisk have been placed in the collection of the Royal Botanic Garden Herbarium, Edinburgh.

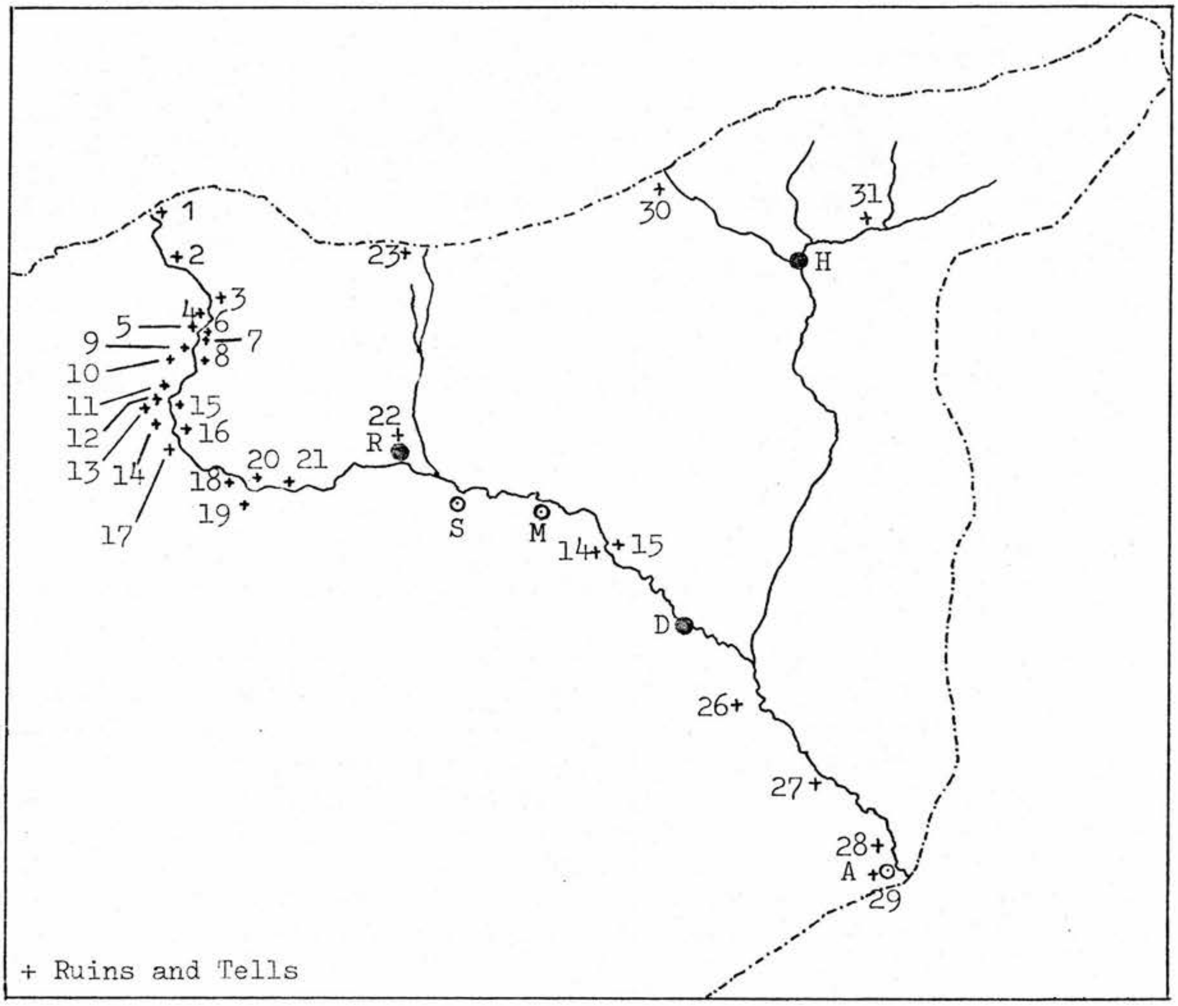
A P P E N D I X VIII

THE LOCATION OF VARIOUS TELLS AND RUINS ALONG THE EUPHRATES VALLEY

Source: Fieldwork, Zouzou, R., 1961-1974

APPENDIX VIII

THE LOCATION OF VARIOUS TELLS AND RUINS ALONG THE EUPHRATES VALLEY



1. Jerablas. 2. Tell Ahmar. 3. Qalaat Nejm. 4. Tell Soueihat/Rmaleh. 5. Tell Hadidi. 6. Tell Abd. 7. Tell Mumbapa. 8. Tell Cheikh Hasan. 9. Ataas. 10. Tell Al-Haj. 11. Tell Habuba Kebira. 12. Tell Habuba. 13. Tell Kannas. 14. Tell Solenkahieh. 15. Site of Halameh. 16. Tell Moreibet. 17. Meskeneh/Balis. 18. Dibsi Faraj/Athis. 19. Abou Houreira. 20. Tell Fray. 21. Qalaat Ja-bar. 22. Raqqa. 23. Arslan Tash. 24. Halabiye. 25. Zalabiye. 26. Kalaat Rabah. 27. Salhie/Dora Euphrates. 28. Tell Hariri/Mari. 29. Abu-Khamal. 30. Tell Halaf. 31. Tell Braq.

A	Abu-Kamal	D	Dier-ez-Zor	S	Sabkha
H	Hassakah	R	Raqqa	M	Maadan

Source: Fieldwork, Zouzou, R., 1961-74.

APPENDIX IX

THE CHEMICAL COMPOSITION OF GROUND WATER SAMPLES IN THE STUDY AREA

Source: Fieldwork, Zouzou, R., 1961-1974
(with limited additions from the
General Administration for the
Development of the Euphrates basin)

APPENDIX IX

THE CHEMICAL COMPOSITION OF THE GROUND WATER SAMPLES

No.	Depth	Cations meq/l				Anions meq/l				EC	pH
		Ca	Mg	K	Na	Cl	SO_4	HCO_3	CO_3		
1	3.97	6.5	9.5	0.40	7.5	12.09	38.0	2.9	0.0	3.8	7.25
2	6.22	3.5	3.5	0.56	4.5	6.12	30.0	2.8	0.0	3.25	7.25
3	18.91	0.0	9.0	0.22	4.0	10.35	25.0	2.4	0.0	2.85	7.35
4	5.30	0.5	2.5	0.23	12.5	15.12	36.0	3.8	0.0	3.6	7.50
5	10.55	2.5	7.5	0.21	3.0	5.76	22.0	2.3	0.0	2.7	7.50
6	10.53	1.5	4.0	0.04	0.9	0.90	0.94	3.8	0.0	0.60	7.65
7	19.57	1.4	2.3	0.03	1.4	0.96	0.64	3.2	0.0	0.55	7.65
8	31.00	0.5	3.0	0.02	0.95	0.90	0.74	2.8	0.0	0.55	7.75
9	12.18	5.0	1.0	0.68	12.5	14.94	56.0	4.7	0.0	4.15	7.50
10	9.85	5.5	0.5	0.14	5.5	8.37	9.0	2.7	0.0	2.0	7.50
11	5.40	9.5	7.5	1.00	30.0	42.84	46.0	2.7	0.0	7.9	7.25
12	27.60	9.2	5.8	0.15	10.5	12.51	40.0	1.3	0.0	3.6	7.55
13	29.69	2.3	8.0	0.30	24.0	23.04	46.0	3.1	0.0	4.6	7.60
14	14.41	5.0	3.0	0.11	0.8	0.63	4.0	3.2	0.0	0.80	7.70
15	18.79	5.0	4.0	0.13	1.25	1.89	4.0	3.1	0.0	0.90	7.10
16	18.68	8.0	8.0	0.74	7.5	2.97	28.0	5.2	0.0	2.15	6.80
17	27.32	3.5	2.5	0.90	20.0	25.02	34.0	6.3	0.0	4.75	7.35
18	25.10	8.5	7.5	1.30	17.5	21.15	34.0	7.7	0.0	4.50	7.45
19	26.35	3.0	3.0	0.56	21.5	22.59	41.0	1.6	0.0	4.60	6.85
20	11.84	8.0	9.0	1.20	22.5	31.63	50.0	3.9	0.0	6.45	7.50

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APPENDIX IX

THE CHEMICAL COMPOSITION OF THE GROUND WATER SAMPLES (contd)

No.	Depth	Cations meq/l				Anions meq/l				EC	pH
		Ca	Mg	K	Na	Cl	SO_4	HCO_3	CO_3		
21	17.78	6.0	4.0	1.18	25.0	20.16	40.0	1.4	0.0	4.50	6.95
22	10.15	8.0	7.0	0.98	29.5	26.28	53.0	1.1	0.0	4.80	7.20
23	13.18	6.0	7.0	0.80	32.5	44.00	40.0	6.8	0.0	4.75	7.30
24	25.55	8.5	0.5	0.38	30.0	14.76	68.0	1.8	0.0	3.85	7.15
25	14.11	3.0	2.0	0.03	0.35	1.49	0.4	2.7	0.0	0.45	7.90
26	10.00	5.5	6.0	0.26	9.5	9.45	14.0	6.2	0.0	2.12	7.65
27	16.39	2.0	4.7	0.06	2.2	2.50	2.4	2.7	0.0	0.62	7.15
28	10.20	3.0	8.0	0.48	17.0	26.64	42.0	1.2	0.0	4.85	6.85
29	2.33	1.5	5.4	0.42	32.0	41.58	50.0	2.4	0.0	5.90	7.40
30	6.72	9.0	2.2	0.90	42.0	49.32	52.0	3.2	0.0	6.90	6.80
31	9.40	5.0	3.2	0.66	30.0	26.19	46.0	2.9	0.0	4.97	7.00
32	18.62	8.5	6.5	0.28	12.0	11.43	19.0	2.5	0.0	2.55	7.05
33	12.28	3.0	4.0	0.40	8.6	12.25	14.1	5.9	0.0	2.55	7.35
34	18.58	9.5	6.5	1.90	10.1	15.23	14.1	5.3	0.1	2.45	7.35
35	10.84	9.5	7.0	0.27	2.6	3.07	29.1	2.5	0.1	2.70	7.15
36	25.10	0.0	5.1	0.13	0.95	1.09	1.6	3.2	0.1	0.57	7.45
37	19.51	1.5	0.5	0.23	5.1	14.77	28.1	2.0	0.1	3.55	7.25
38	24.28	8.5	5.5	0.42	5.6	5.59	30.1	2.0	0.1	2.93	7.10
39	26.28	6.0	0.0	0.25	7.6	5.14	15.1	5.2	0.1	1.95	7.25
40	12.78	4.5	1.5	0.22	13.1	8.74	28.1	3.0	0.1	3.35	7.35

Continued overleaf/

APPENDIX IX

THE CHEMICAL COMPOSITION OF THE GROUND WATER SAMPLES (contd)

		Cations meq/l				Anions meq/l					
No.	Depth	Ca	Mg	K	Na	Cl	SO_4	HCO_3	CO_3	EC	pH
41	14.39	8.5	4.5	1.20	800.10	9.50	661.0	10.6	0.1	160.00	7.65
42	12.97	3.5	6.5	0.50	4.10	2.10	8.3	5.1	0.1	1.72	7.95
43	7.17	5.0	2.0	0.02	0.64	0.64	3.5	4.4	0.1	0.50	8.20
44	7.42	2.0	4.2	0.07	1.44	1.66	2.1	4.4	0.1	0.27	7.80
45	16.23	4.0	6.1	0.45	2.40	2.21	5.1	4.4	0.1	1.25	7.60
46	6.19	6.0	5.6	0.11	3.51	2.99	6.3	4.1	0.0	1.45	7.20
47	6.69	3.5	3.5	0.11	1.21	1.49	1.7	4.1	0.0	0.80	7.60
48	24.29	2.0	8.6	0.10	0.50	1.11	5.3	3.7	0.0	0.85	7.60
49	15.66	0.0	2.0	0.37	13.10	17.15	14.1	4.0	0.1	3.00	7.00
50	28.50	4.0	9.5	0.55	16.60	23.81	14.1	3.7	0.0	3.60	6.80
51	15.81	1.5	3.0	0.10	18.00	14.78	21.5	5.8	0.0	4.15	7.10
52	3.29	5.5	6.5	0.65	1.00	2.12	1.5	11.4	0.1	1.25	7.20
53	15.39	1.5	4.1	0.13	0.66	0.82	1.26	5.1	0.0	0.65	7.10
54	9.42	2.5	4.5	0.15	1.42	1.47	2.51	3.9	0.0	0.85	7.20
55	13.88	1.5	5.0	0.15	1.10	1.57	1.68	3.7	0.1	0.82	7.30
56	18.70	1.5	4.5	0.42	1.21	0.82	1.27	4.4	0.0	0.78	7.10
57	3.21	25.0	14.6	0.50	17.60	31.6	23.5	3.9	0.1	4.62	7.30
58	11.63	25.5	14.1	0.50	5.10	9.17	28.1	4.2	0.0	3.25	8.60
59	11.11	26.0	26.5	0.54	22.60	25.90	45.2	2.7	0.0	5.60	7.40
60	17.69	5.0	4.0	0.02	4.20	1.74	8.0	3.2	0.0	1.03	7.55

Continued overleaf/

APPENDIX IX
THE CHEMICAL COMPOSITION OF THE GROUND WATER SAMPLES (contd)

No.	Depth	Cations meq/1 Ca	Mg	K	Na	Anions meq/1 Cl	SO_4	HCO_3	CO_3	EC	pH
61	4.78	43.5	17.05	1.18	2.01	2.51	11.1	4.3	0.0	4.90	6.96
62	2.00	11.5	18.5	0.13	12.0	15.44	23.1	4.7	0.1	2.80	7.50
63	9.80	26.5	4.5	0.18	5.0	10.11	20.2	6.7	0.0	2.92	7.10
64	17.58	23.0	11.2	0.42	23.0	20.60	34.2	0.8	0.0	3.95	6.90
65	13.61	20.0	40.1	0.05	1.3	2.00	1.34	2.9	0.0	0.62	7.35
66	3.32	23.5	5.52	0.33	4.6	4.50	26.6	3.7	0.13	2.10	7.15
67	12.50	30.0	20.0	0.62	22.0	24.16	46.1	1.5	0.0	4.75	6.95
68	9.00	30.3	14.2	0.52	34.6	28.26	47.1	1.6	0.0	5.02	7.00
69	10.12	18.3	5.50	0.78	6.5	3.16	22.6	4.7	0.1	2.30	6.70
70	11.40	26.5	13.5	0.33	11.6	15.81	28.1	2.2	0.0	3.60	6.90
71	27.00	30.5	13.6	0.68	28.2	19.27	46.1	2.4	0.0	4.08	6.90
72	30.13	26.1	20.0	0.23	0.5	31.11	8.32	3.0	0.0	5.30	7.10
73	30.24	2.5	5.2	0.05	1.51	1.30	2.5	3.8	0.1	0.73	7.25
74	30.76	2.1	4.4	0.06	0.45	1.56	1.5	3.8	0.11	0.55	7.30
75	24.67	20.0	14.0	0.16	3.52	3.87	29.6	3.1	0.0	2.35	7.20
76	21.00	22.5	9.02	0.46	20.0	14.37	32.2	3.11	0.0	3.60	6.90
77	25.76	2.0	4.0	0.05	0.5	1.29	1.4	4.7	0.0	0.55	7.15
78	30.78	7.3	15.0	0.26	15.0	8.41	20.2	9.2	0.12	3.20	7.30
79	26.00	2.5	4.8	0.01	1.5	1.40	1.76	6.4	0.1	0.22	7.50
80	28.65	3.0	4.0	0.10	2.01	2.00	2.21	5.3	0.1	0.80	7.50

A P P E N D I X X

LAND CLASSIFICATION AND CAPABILITY

Applied to Fieldwork, Zouzou, R., 1961-74

APPENDIX X

LAND CLASSIFICATION AND CAPABILITY

Land classification groups adopted: The following groups were adopted for the classification of the land:

Class	Grades of land
I	represents arable lands of high productive value.
II	represents lands of intermediate value which may be considered arable under general farming.
III	represents lands of low productive value which may be considered arable under general farming.
IV	represents lands which have marked deficiencies of restricted utility but which have shown to be of limited use for agriculture as a result of special economic and engineering studies.
V	represents lands which are non-arable under existing conditions but which have a potential value sufficient to warrant segregation for further study.
VI	represents lands which are of low productivity and which are considered permanently non-arable.

Capability classes/

Capability classes: The following capability classes were recognised and applied in conjunction with the land classes that have been used throughout the study.

Class	Grades of land
I	represents lands suited for regular cultivation. Very good.
II	represents lands suited for regular cultivation. Good with moderate limitations.
III	represents lands suited for regular cultivation. Moderately good with severe limitations.
IV	represents lands suited for regular cultivation. Fairly good with very severe limitations.
V	represents lands not suited for cultivation but suited for grazing with slight limitations.
VI	not suited for cultivation but suited for grazing with moderate limitations.
VII	represents lands not suited for cultivation but suited for grazing with severe limitations.
VIII	represents lands not suited for cultivation or grazing, but best left to natural vegetation.

The classification adopted here for the study area, however, has a wider application for the whole of Syria.

A P P E N D I X XI

RECLAMATION PROGRAMMES

Applied to Fieldwork, Zouzou, R., 1961-74

APPENDIX XI

RECLAMATION PROGRAMMES

The following steps were taken in these reclamation programmes:

I. Sampling and Field Observation: Consideration of the effects of relief, geology and parent material; the effect of natural drainage; groundwater and its seasonal variation.

Site selection, representative profiles, method of sampling and number of samples.

II. Salinity

(a) Origin of salinity: whether marine, groundwater, irrigation water or resulting from the type of parent material.

(b) Types of salinity:

(i) groundwater rich in HCO_3, SO_4, Cl in strong solution; alumina, sodium, carbonate and sodium silica.

(ii) Soils with high levels of ESP, Na_2CO_3, $NaHCO_3$, KNO_3, $CaCl_2$, Cl, Ca, Mg, and SO_4. Sodic soils without or with (B) horizon containing Na_2CO_3.

(iii) Alkaline soil rich in $NaHCO_3$, weak mineralization of groundwater, poor in permeability, rich in colloidal clay (silica), high pH values and with low availability of nutrients.

(c) Classification of saline soils: they may be divided into three classes, according to chemical classification:

(i) Saline (solonchak) is a white encrustation, sodium content less than 15%; the chief anions are chloride and sulphate and rarely nitrate, with a low proportion of soluble carbonates; the conductivity of saturation water is not less than 4 mmhos at 25°C, and the pH values are less than 8.5.

(ii) Saline sodic (solonetz and mainly solonchak): white encrustation on high land and a mixture of white and black in depressions; the predominant anions are chloride, sulphate and carbonate, with a high sodium content and low amounts of calcium; pH values are about 8.5.

(iii) Alkaline (solonetz): in the absorbed condition the surface horizon is rich and saturated with sodium; the subsurface structure is prismatic in heavy soils; the exchangeable sodium levels are around 15%, with carbonate and bicarbonate levels, pH values range up to 10.

III. <u>Data Required for Reclamation</u>: soil permeability; depth and fluctuation in the level of the water table; quantity, quality and availability of irrigation water; climatic conditions; levelling, water required for leaching; geomorphological conditions; present irrigation systems; period and depth of reclamation and ploughing system; infiltration rate; hydraulic conductivity; bulk density of the soil; stratification, texture and structure.

IV. <u>Mapping the Salinity</u>: The following factors may help to establish the boundaries of a salinized area: natural halophytic vegetation;

the depth of groundwater; the depth of salinization; crops tolerant of salty soils, ESP maps and other factors indicate salinity. Maps indicating salinity were prepared by plotting EC values. Alkalinity maps based on the ESP content of soils were also prepared, in addition to pH, lime, gypsum, water soluble salts, carbonate and bicarbonate maps. Finally maps of soil organic content and fertility were drawn.

V. All the following are important for the success of reclamation:

(1) The addition of gypsum has proved effective in permeability and in preventing soil alkalinity.

(2) A salinity test should be made every six months, since this is a period over which significant changes can be observed.

(3) The following crops are recommended, if reclamation is to be successful: barley followed by harseem, cotton followed by corn or rice, wheat followed by clover, clover followed by beans or wheat.

(4) Keep leaves and plants over the soil to protect the surface from evaporation.

(5) The land should be deep ploughed (30 cm maximum) before leaching.

(6) Frequent irrigation is required to keep the moisture level above 70% of field capacity.

(7) Fertilization with N and P is necessary.

(8) Water with a total salinity of 1000 - 7000 ppm could be used for leaching; in a highly calcareous soil, water with 1000 ppm

salt concentration improved the ESP value of percolation water as a result of a solution of $CaCO_3$; water with a salinity of 1200 - 1500 ppm, used to leach saline sodic soils, lowers the ESP, but not far enough to consider the soil completely reclaimed; the sodium content of groundwater should be about 750 ppm and the salts level of groundwater about 1500 - 3000 ppm.

(9) Sodic saline water, with a value of 1-5 g/l may lead to increased alkalinity, necessitating the addition of gypsum.

(10) From 48 to 72 hours after irrigating a field, it is necessary to remove the excess irrigation water, by draining, to prevent re-salinization.

(11) Intensive agricultural systems are recommended.

(12) Sulphuric acid is added to leaching water (30 tons/0.01 km^2 and used to reclaim 100 cm soil depth with the addition of 1500 m^3/0.01 km of water).

(13) Continuous leaching was employed in the following cases: where there is good permeability, high salinity, a high evaporation rate and 4500 - 8000 m^3/acre (0.004 Km^c), and 500-800 m^3/acre of sufficient water to dissolve soluble salts.

(14) Intermittent leaching was used on the following cases: where there was poor permeability, deep groundwater, and slightly saline soils, low evaporation rates. Between 2700 - 5000 m^3/acre water necessary for this type of leaching.

(15) Leaching to be carried out every twenty days in summer and 10 days in winter.

(16) Conductivity is controlled as well as the irrigation system.

VI. Expected Results from such a Programme:

(1) Cultivation with suitable crops tolerant of salts.

(2) Reduction of salt content in the root zone.

(3) Reduction of sodium content to below 10%.

(4) Lowering of water table below the minimum level: cotton 150 - 180 cm, rice 30 - 45 cm, wheat 100 - 120 cm, and sugar beet 60 - 90 cm.

(5) Reduction of the rate of evaporation.

(6) Replacement of Na by Ca.

(7) Prevention of upward movement of groundwater rich in $NaHCO_3$ and Na_2CO_3.

(8) Improvement of tilth and other physical properties of the soil once prepared for agricultural purposes.