

Vegetation in Jordan

Introduction

Although the vegetation of Jordan has been studied previously, most of these studies are of the survey type, and were based on short visits mainly during the fifties of this century: Kasapligil (1956), Long (1957), Hunting Technical Services Limited (1956), Poore and Robertson (1964), Zohary (1962).

Until now there have been no real solid investigations into the ecology and the vegetation of Jordan based on recent aerial photographs and supported by extensive field trips for mapping and definition of the structure of plant associations, to recognize the vegetation types and the geographical regions. In this report the vegetation of Jordan will be discussed in the light of the previous work, and related to information collected from experience through teaching the subject of ecology at the University of Jordan, and from observations recorded during extensive field trips to collect and study the flora of Jordan for the past 12 years.

Floristic notes with some remarks on local parts of Jordan have been published within the last 10 years which are of great help in giving some information about the vegetation composition in these particular places, Al-Eisawi (1977, 1982), Boulos and Al-Eisawi (1977), Boulos and Jallad (1977), Boulos and Lahham (1977), Jallad (1975), Lahham (1975).

The topography, rainfall, temperature, soil classification, bioclimatic subdivisions, vegetation regions and the vegetation types in the eastern part of Jordan will be discussed.

Topography

Jordan is a small country and as a result of its special topography, considerable climatic variations are very well marked within this limited area.

Jordan can be subdivided longitudinally from north to south into three major topographical regions:

1. The Rift Valley: which extends from lake Tiberias in the north down to the Gulf of Aqaba in the south. This region is the lowest part on earth which reaches the maximum (about 396 m.) below sea level in the Dead Sea area.

2. The Mountain Ranges: extends from the north in Irbid down to the south in Ras En-Naqab. This region is interrupted several times by some depressions in the wadi areas like that of Wadi Mujeb. Some of these mountains reach about 1500 m. above sea level.

3. The Eastern Desert: comprising the majority of the country and links with Arabian Desert at the borders of three Arab Countries, Syria, Iraq and Saudi Arabia from the north, east and south respectively.

These regions have been the main critical factors of extreme climatic variations within the restricted area of Jordan.

Rainfall

Data of 31 stations for the period of 1966-80 have shown variations of precipitation with a range of 50-500 mm. annually. The lowest amount of rain was recorded in Wadi Araba 50 mm. while the highest was in Ras Muneef in Ajloun area 500 mm. (FIG. 1).

The rain usually falls during Winter and Spring starting as early as October and may extend as late as May. Usually the maximum amount will be during January. The amount and the period of rainfall are very variable and fluctuate from year to year, often there is barely any rain until December or even January and at some other times there will be no rain after the middle or even early March. Generally speaking the amount of rainfall decreases from north to south and from west to east.

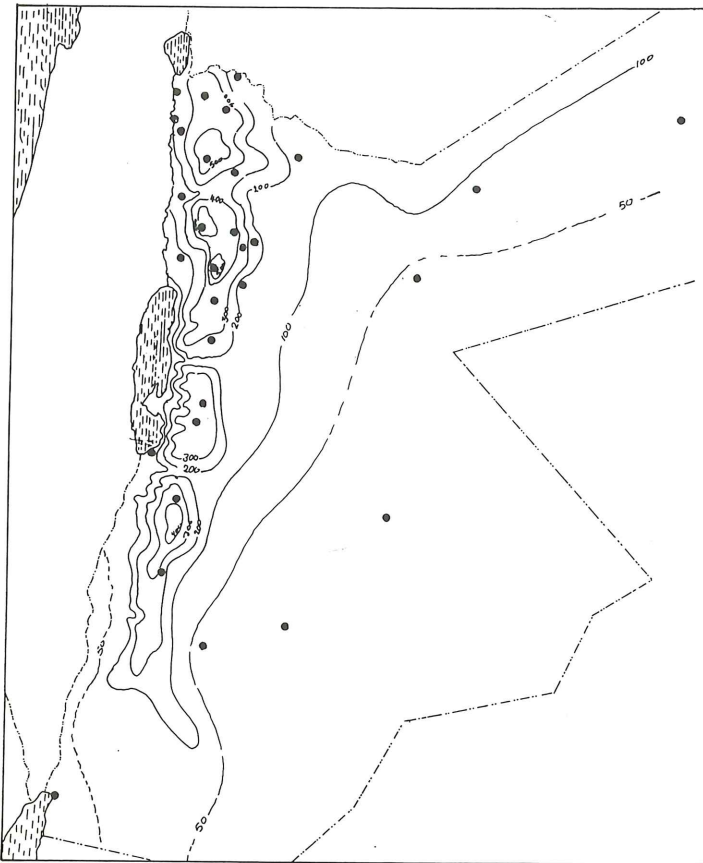
Temperature

The temperature is highly affected by the topography and the latitude of the different parts by which notable variations are recorded. The mean annual minimum temperature for the period between 1966-80 ranged between 5°C in Ash-Sharah mountains, and 20°C in Aqaba (FIG. 2).

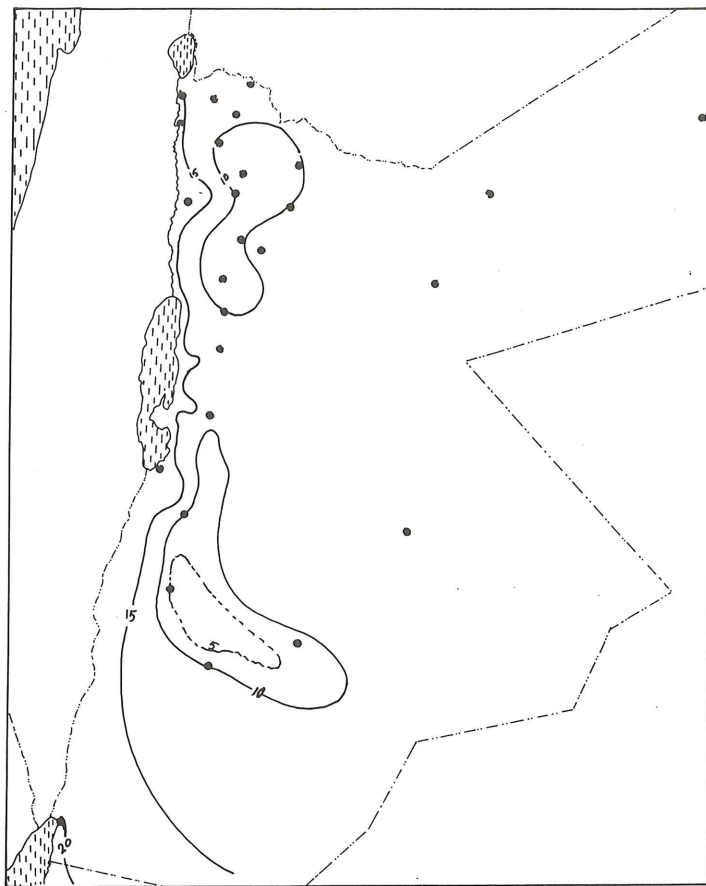
The mean annual maximum temperature ranged also between 30°C in Wadi Araba and 20°C in the mountain ranges (FIG. 3).

These values vary considerably from year to year and even from season to season especially if we consider that the temperature may drop to below zero in the coldest month

1. East Jordan. Mean annual rainfall 1966–80.



2. East Jordan. Mean yearly minimum temperature 1966–80.



with frost formation in some places. It also may rise up in the hottest month reaching 50°C in some places like the Rift Valley.

It can be said that the temperature correlates quite well in Jordan with the amounts of rainfall, when the rainfall increases the temperature decreases in the same direction and the reverse is true.

The soil

There is no doubt about the importance of the edaphic factors, especially the soil type and the soil texture in relation to the vegetation type and the association structure on the different soils.

The soils in Jordan were studied and classified by several workers. There are differences in the methods of classification of the soil according to the different schools and methods used in this field; Moormann (1959), Zohary (1962), NEDECO-Dar Al-Handasah (1969), Harris (1971), and Bender (1975).

However, the soils in Jordan do not show mature profile except in some places of the Mediterranean region and under the forest vegetation, where the best profile is found. It is made of horizons A & C, with some litter and organic matter on the floor of the forest. Other than that the soil is only represented by C horizon or even just the parental rock and

that is mainly due to poor vegetation and continuous erosion. The soils in Jordan often show enormous variations within a very limited area, which in turn affect the vegetation accordingly.

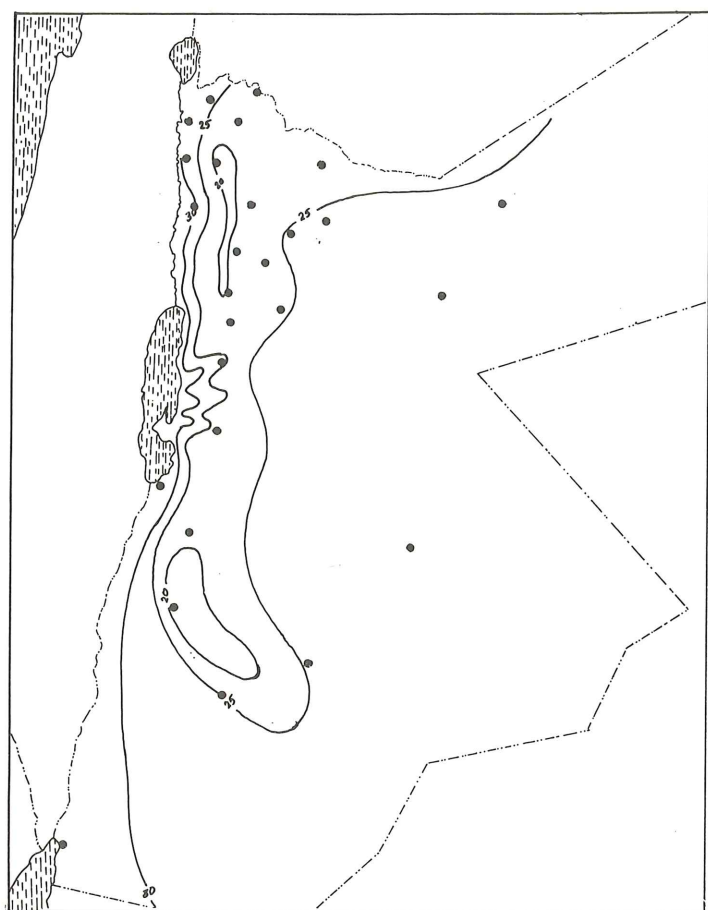
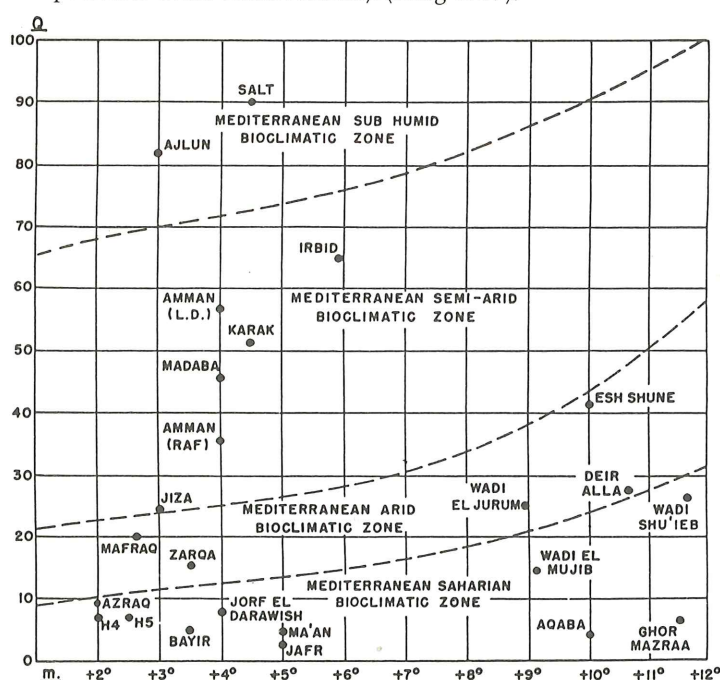
The most fertile soil types in Jordan are the Terra Rosa and the Rendzina Series or what is equal to the Red and Yellow Mediterranean soil, which are used for cultivation and support the best natural vegetation in the country. These types of soil usually occur under the maximum amount of rainfall and the least mean annual minimum and maximum temperatures.

The loess and the calcareous are dominant in the Irano-Turanian region while the sandy, the saline and the hammada soils are dominant in the desert region. These soil types are considered to be poor and well correlated with poor vegetation and with a low amount of precipitation and high temperature.

The biogeographical regions

Jordan has been subdivided into different bioclimatic or biogeographical regions according to the workers' points of view. However, most of these studies were not based on the analysis of climatic data; Kasapligil (1956), Hunting Technical Services Limited (1956), Zohary (1962), Poore and Robertson (1964), Beskök (1971), The League of Arab States

3. East Jordan. Yearly mean maximum temperature 1966–80.

4. Distribution of 24 stations of East Jordan regarding their Q (quotient pluviothermique of Emberger) and m . (mean of the minima temperatures of the coldest month). (Long 1957).

(Arab Organization for Agricultural Development (1976)), Boulos and Lahham (1975) and Madany (1978). Long (1957) classified Jordan into eight bioclimatic regions (FIG. 4), with a map of distribution for these regions (FIG. 5).

Based on the rain distribution during the seasons of the year, the whole of Jordan is considered to be of the Mediterranean type because the rainfall is mainly in the Winter and the Spring WSpSA.

In this study, analysis similar to that done by Long (1957) is presented for 31 stations during the period of 1966–80 (TABLE 1). This analysis was made with the help of Mr. I. Atawi in the Meteorological Department. The method used is based on Emberger quotient (1955):

$$Q = \frac{P}{(M + m)/2 \times (M - m)} \times 1000$$

where:

P: is the mean annual rainfall of the site.

M: is the mean maximum temperature of the hottest month.

m: is the mean minimum temperature of the coldest month.

$M + m/2$: is the mean of extreme temperature

$M - m$: represents a value proportion to evaporation.

The values of Q are plotted against m . (FIG. 6).

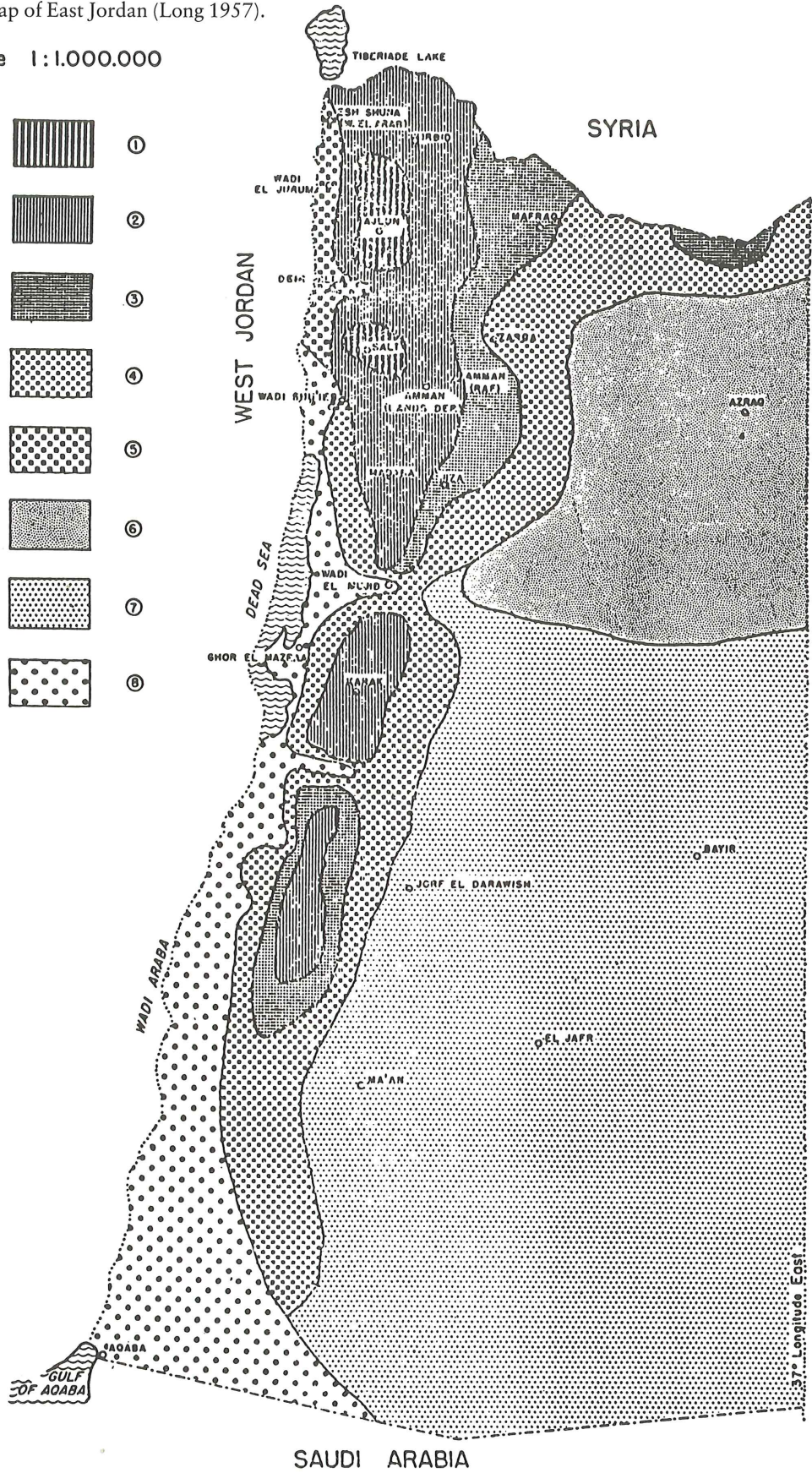
The distribution of the resulting bioclimatic zones are shown in FIG. 7.

Table 1

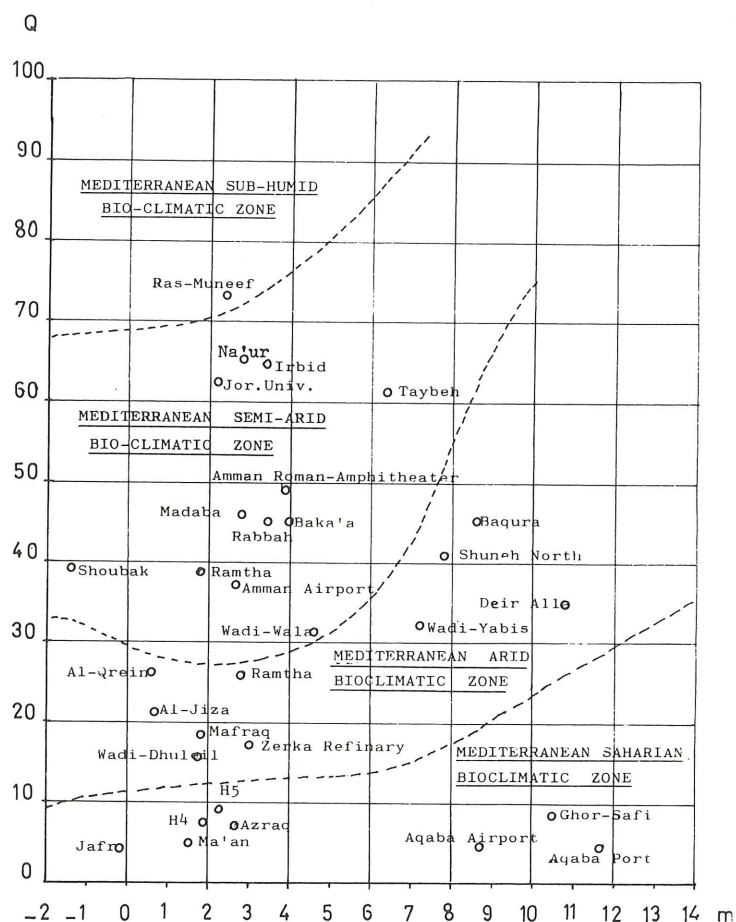
Station	P	M	m	$M + m$	$M - m$	Q
Baqura Nursery	379.8	37.0	8.6	295.8	28.4	45.21
Shuneh North	348.5	36.5	7.8	295.15	28.7	41.14
Wadi Yabis	292.0	37.9	7.2	295.55	30.7	32.18
Dair Alla	289.0	38.5	10.8	297.65	27.7	35.1
Ghor Safi	73.3	40.1	10.5	298.3	29.6	8.3
Aqaba Airport	36.9	39.2	8.7	296.95	30.5	4.48
Aqaba Port	35.3	37.2	11.6	297.4	25.6	4.64
Irbid Nursery	495.9	30.6	4.4	290.5	26.2	64.18
Ramtha	219.9	32.1	2.9	290.5	29.2	25.92
Taiyiba	488.1	33.7	6.4	293.1	27.3	61.0
Ras Muneef	519.4	26.9	2.4	287.65	24.5	73.7
Baka'a	364.3	31.6	4.0	290.8	27.6	45.4
Jordan Univ. Jubaiha	474.2	28.6	2.2	288.4	26.4	62.28
Amman Civil Airport	290.1	31.8	2.7	290.25	29.1	34.34
Amman Roman Theater	410.7	32.8	3.9	291.35	28.9	48.77
Na'ur Transmitting St.	502.5	29.7	2.9	289.3	26.8	64.81
Madaba	368.1	30.5	2.9	289.7	27.6	46.0
Wadi Wala	269.5	33.7	4.6	292.15	29.1	31.7
Er-Rabbah	344.3	29.8	3.5	289.65	26.3	45.2
Al-Hassan Agr. Sta.	298.9	29.3	1.8	288.55	27.5	37.67
Shoubak	298.3	25.6	-1.4	285.1	27.0	38.75
Al-Qurein	199.2	27.7	0.6	287.15	27.1	25.6
H4	76.4	37.1	1.9	292.5	35.2	7.42
Mafrq	164.0	32.3	1.8	290.1	30.4	18.6
H5	86.5	36.0	2.3	292.15	33.7	8.79
Wadi Dhuleil	147.6	34.4	1.7	291.05	32.7	15.51
Zarka Refinery	148.0	33.2	3.0	291.1	30.2	16.8
Azarq	69.9	36.3	2.6	292.45	33.7	7.1
Al-Jiza	189.4	31.5	0.7	289.1	30.8	21.7
Ma'an Airport	43.8	33.9	1.5	290.7	32.4	4.65
Jafr	37.9	35.4	-0.2	290.6	35.6	3.66

5. Bioclimatological map of East Jordan (Long 1957).

Scale 1:1.000.000



6. Distribution of 31 stations of East Jordan regarding their Q (quotient pluviothermique of Emberger) and m . (mean of the minima temperatures of the coldest month).



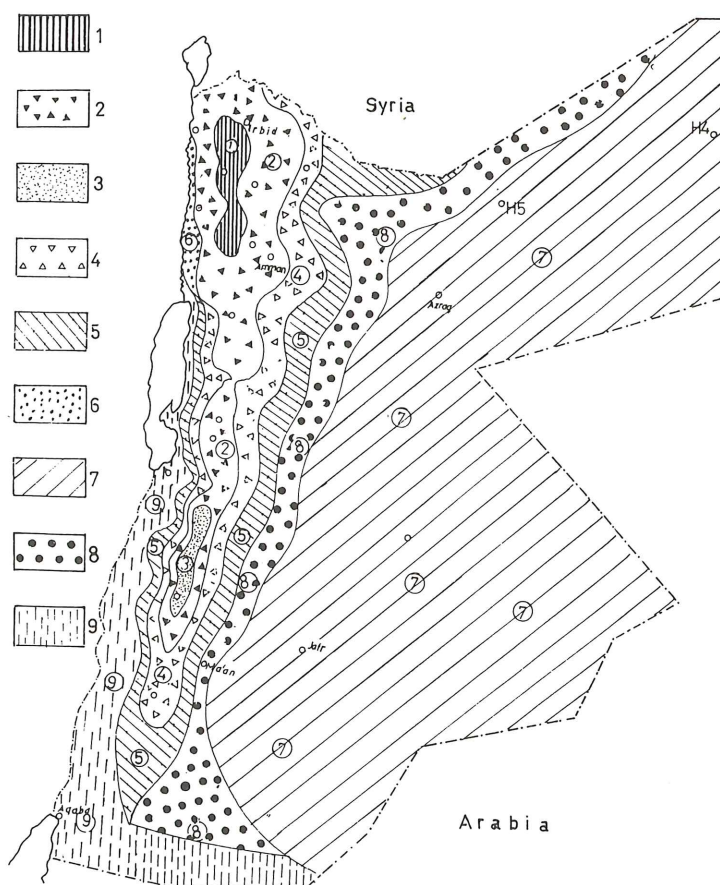
Nine bioclimatic subdivisions are considered as follows:

- 1) Sub-humid Mediterranean bioclimate, warm and cool varieties (Ras Muneef, Ajloun).
- 2) Semi-arid Mediterranean bioclimate, warm variety (Irbid, Amman, Madaba, Taybeh and Baka'a).
- 3) Semi-arid Mediterranean bioclimate, cool variety (Shoubak).
- 4) Arid Mediterranean bioclimate, cool variety (Ma'raq, Al-Jiza, Al-Qurein and Wadi-Dhuleil).
- 5) Arid Mediterranean bioclimate, warm variety (Zerka and Ramtha) falls at the border line between cool and warm.
- 6) Arid Mediterranean bioclimate, very warm variety (Deir Alla, Al-Baqura, Shuneh North, and Wadi-Yabis) falls at the border of the line between warm and very warm.
- 7) Saharan Mediterranean bioclimate, cool variety (Al-Jafr, H4, Ma'an, H5 and Al-Azraq).
- 8) Saharan Mediterranean bioclimate, warm variety (Belt of land with an average width of 20 km. along the Eastern hills to the east).
- 9) Saharan Mediterranean bioclimate, very warm variety (Ghor-Safi, Wadi-Araba and Aqaba area).

7. Bioclimatological map of East Jordan.

Scale 1:1,000,000

- 1) Sub-humid Mediterranean bioclimatic warm and cool varieties (Ras Muneef, Ajloun).
- 2) Semi-arid Mediterranean bioclimatic, warm variety (Irbid, Amman, Madaba, Taybeh and Baka'a).
- 3) Semi-arid Mediterranean bioclimate, cool variety (Shoubak).
- 4) Arid Mediterranean bioclimate, cool variety (Ma'raq, Al-Jiza, Al-Qurein and Wadi-Dhuleil).
- 5) Arid Mediterranean bioclimate, warm variety (Zerka and Ramtha, falls at the border line between cool and warm).
- 6) Arid Mediterranean bioclimate, very warm variety (Deir Alla, Al-Baqura, Shouneh North, and Wadi-Yabis, falls at the border of the line between warm and very warm).
- 7) Saharan Mediterranean bioclimate, cool variety (Al-Jafr, H-4, Ma'an, H-5 and Al-Azraq).
- 8) Saharan Mediterranean bioclimatic, warm variety (Belt of land with an average width of 20 km. along the Eastern Hills to the east).
- 9) Saharan Mediterranean bioclimate, very warm variety (Ghor-Safi, Wadi-Araba and Aqaba area).



The results of this analysis are almost similar to those of Long except:

- 1) A new sub-division of the semi-arid Mediterranean cool variety is found and exists in the region of Shoubak and Tafilah which has a Q value ranging between 30–70 and m value of less than 3°C .

2) The whole eastern desert falls under one sub-division as Saharan Mediterranean—cool variety bioclimate, while in Long's analysis it is divided into two sub-divisions:

- a) Saharan Mediterranean bioclimate-cool variety which included H4, H5 and Azraq.
- b) Saharan Mediterranean bioclimate-warm variety in the area of Ma'an, Jorf El-Darawish, Bayir and Jafr.

These nine bioclimatic sub-divisions fall under four main regions:

A. Sub-humid Mediterranean bioclimate

The quotient (Q) according to Emberger lies between 70 and 100. The mean minimum temperature (m) of the coldest month (January) varies between $+2^{\circ}\text{C}$ and $+5^{\circ}\text{C}$. The different temperatures characterising a cool variety vary between 2°C and 3°C , and a warm variety above 3°C . The mean maximum temperature (M) of the hottest month (August) is almost 27°C which is a characteristic for a moderately warm summer.

The map (FIG. 7) shows that this sub-division exists only in a relatively small part of the country, Salt and Ajloun.

B. Semi-arid Mediterranean bioclimate

The (Q) value according to Emberger lies approximately between 30 and 70. The average minimum temperature (m) during the coldest month (January) varies approximately between -1°C and $+7^{\circ}\text{C}$; it indicates a cool variety (m between -1 and 3°C) and a warm variety (m between $+3^{\circ}\text{C}$ and 7°C) of the semi-arid Mediterranean bioclimate. The average maximum temperature (M) during the hottest month (August) ranges between 26°C – 33°C . The region is slightly warmer than sub-humid zone. The places included under this region are: Amman, Irbid, Madaba, Taybeh, Baka'a, Shoubak and Tafilah (FIGS 6 & 7).

This region includes the rest of the mountain ranges.

C. Arid Mediterranean bioclimate

The value (Q) according to Emberger lies approximately between 10 and 30 in the cool and warm varieties and between 20 and 50 in the very warm variety. The mean minimum temperature (m) of the coldest month (January) varies approximately between 1°C and 11°C . This wide range of variation makes it possible to observe a large number of bioclimatic varieties such as a cool variety (m between 1°C and 3°C), a warm variety (m between 3°C and 7°C) and a very warm variety (m between 7°C and 11°C).

The mean maximum temperature (M) of the hottest month (August) varies between approximately 28°C and 39°C . The summer is definitely warmer in the arid zone than the preceding ones.

The varieties of this arid Mediterranean region are shown in FIGS 6 & 7. Al-Qurein, Al-Jiza, Wadi-Dhuleil and Al-Mafraq in the cool variety; Ramtha and Zerka in the warm variety, and Baqura, Shuneh North, Deir Alla and Wadi-Yabis in the very warm variety.

D. Saharan Mediterranean bioclimate

The (Q) value according to Emberger lies approximately between 2 and 15 for the cool and warm varieties and between 2 and 30 for the very warm variety. The mean minimum temperature ranges between -1°C and $+3^{\circ}\text{C}$ for the cool variety and between $+8^{\circ}\text{C}$ and $+12^{\circ}\text{C}$ for the very warm variety. It is presumed that the warm variety falls between 3°C and 7°C .

The maximum temperature (M) of the hottest month (August) ranges between 35°C and 40°C .

The summer in this region is very warm while the winter is mild. This region has a cool variety which includes almost all the eastern desert, H5, H4, Azraq, Jafr and Ma'an; a very warm variety which exists in the Rift Valley south of Deir Alla; and a warm variety which forms a strip of about 20 km. in width and separates the cool Saharan region from the warm arid zone from north to south.

The vegetation regions

From the previous climatic subdivisions and from the vegetation characteristics of these divisions and according to Zohary's (1973) delimitations of the vegetation regions in the Middle East, four regions of vegetation are found:

1. The Mediterranean region.
2. The Irano-Turanian region.
3. The Saharo-Arabian region.
4. The Sudanian region.

These regions are shown in the map of distribution (FIG. 8) and may represent the climatic subdivision as follows: The Mediterranean, the Semi-arid Mediterranean-warm variety and the Semi-arid Mediterranean-cool variety (zones 1, 2 and 3 in FIG. 7).

The Irano-Turanian or the steppes region which includes the Arid-Mediterranean bioclimate; cool, warm and very warm varieties (zones 4, 5 and 6 in FIG. 7).

The Saharo-Arabian which includes the Saharan-Mediterranean bioclimate: cool and warm varieties (zones 7 and 8 in FIG. 7).

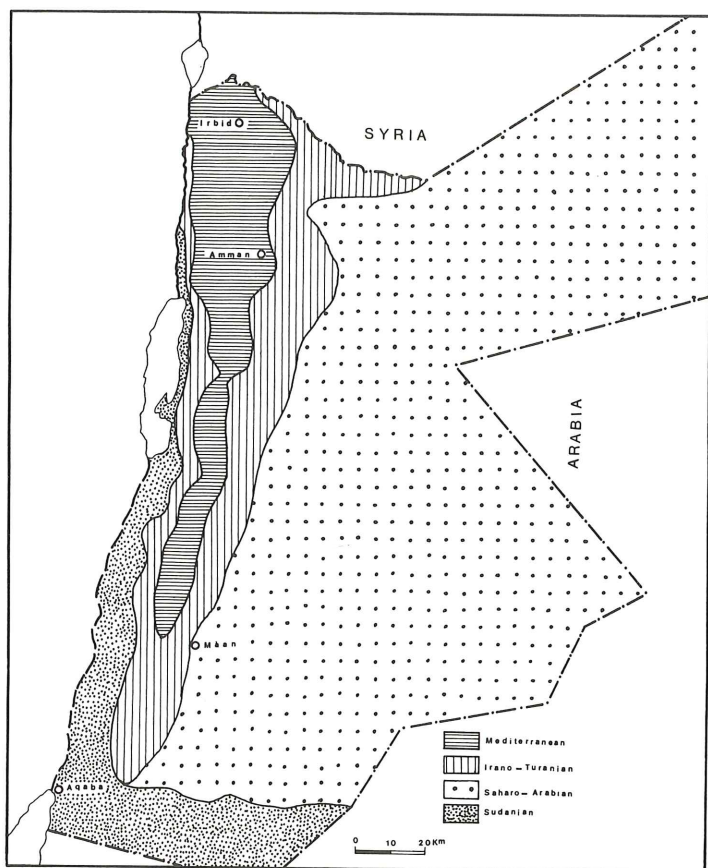
The Sudanian region which includes the Saharan-Mediterranean bioclimate-very warm variety only (zone 9 in FIG. 7).

The factors and the characteristics determining the distribution of the four vegetational regions are the following (FIG. 8).

1. The Mediterranean region

This region includes almost all the mountain ranges which extend from the north in Irbid down to the south in Ras En-Naqab with a mean annual rainfall usually over 300 mm. The soil is of the types Terra Rossa and Rendzina which are the richest in the country and support the best vegetation especially the forest climax of *Pinus halepensis*, *Quercus calliprinos*, *Q. ithaburensis*, *Ceratonia siliqua*, and *Pistacia* spp.

8. Plant geographical regions.



2. The Irano-Turanian region

It surrounds all of the Mediterranean region except the north, and forms a narrow strip in some places which may interrupt the Mediterranean region in some of the depressions such as Wadi Mujeb and Wadi Al-Hasa. The mean amount of rainfall in this region is usually over 150 mm. The soil is mostly poor, eroded and mostly of the calcareous or loess types. The vegetation is mainly of small shrubs and bushes like those of *Retama reatum*, *Ziziphus lotus*, *Artemisia herba-alba*, *Noea mucronata*, *Anabasis syriaca*.

3. The Saharo-Arabian region

It comprises the majority of Jordan and borders the Irano-Turanian on the east. The mean annual rainfall is almost over 50 mm. The soil again is very poor and mostly of the hammada type with some sandy hammadas, saline soils or mud flats. The vegetation is very poor and sometimes non-existent, especially in the mud flats. Most of the plant cover is restricted to the watershed in the wadies where enough soil moisture is available to hold some vegetation. The most common species are *Artemisia herba-alba*, *Achillea fragrantissima*, *Phlomis*, *Astragalus*, *Stipa*, *Trigonella*.

4. The Sudanian region

This region comprises the Rift Valley south of Deir Alla including the area of the Dead Sea, Wadi Araba, Aqaba and the granite mountains in the south including part of Wadi Rum. The mean annual rainfall is usually less than 50 mm. The soil is mostly sandy or sandy hammada, some granite fragments and saline soils. The vegetation here is related to tropical varieties like those of *Acacia* spp., *Balanites aegyptiaca*, *Calotropis procera*, *Maerua crassifolia*, *Salvadora persica*, *Haloxylon persicum*, *Ocradenus baccatus*, *Panicum turgidum* and others.

The vegetation types

The vegetation classification of Jordan has been treated and discussed differently by the previous workers. Long (1956) considered two main groups: 1) Forests and 2) Pasture types; with 38 different associations and about 10 or more sub-associations. The Hunting Technical Services Limited (1956) and Poore and Robertson (1964) considered five types: 1) Grass land 2) Brush 3) Bare Rock 4) Forest 5) Bare Ground, with many subdivisions under them. Kasapliligil (1956) considered five types as: 1) Secondary Degraded Forest 2) Coniferous Forest 3) Broad Leaved 4) Grass lands 5) Other Main Vegetation Types. Zohary (1962) recognized many classes and types of vegetation in relation to their territories. Al-Jundi represented the vegetation of Jordan through six sectors passing across the country from the west to the east. Abu-Howayej (1973) gave the vegetation distribution in the Agricultural Atlas of Jordan, taken from Hunting Technical Services and Poore and Robertson.

In this study the vegetation types will be discussed in relation to their vegetation regions considering only the natural vegetation without dealing with the cultivated land. The following recognized types are cited on a map of distribution (FIG. 9).

I. Pine forest

Typical Mediterranean vegetation forms the best forests in Jordan and reaches a climax in some places, with the dominant trees of *Pinus halepensis* up to 10 meters. This forest vegetation usually occurs on high altitudes, mostly over 700 m. and where rendzina and calcareous soils are present. In some places the pine trees are replaced by *Quercus calliprinus* as a result of the degradation of the primary vegetation.

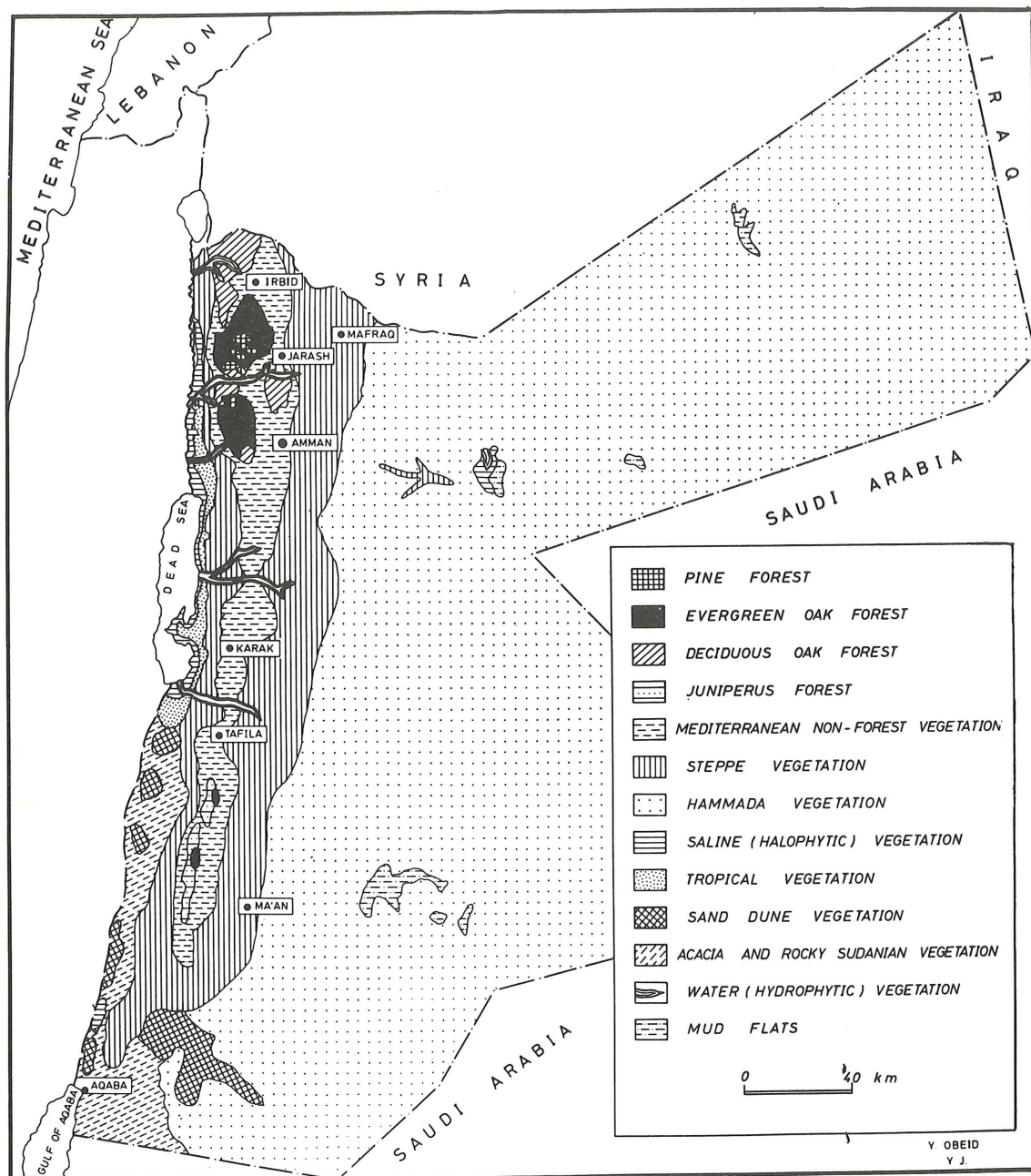
Localities: Ajloun city, in the mountains opposite Qal'at Al-Rabad, along the road between Sakib and Anjara; along the road between Jarash and Sakib, Dibbeen and Zai in As-Salt district.

Composition: four strata can be recognized in this type of vegetation:

Stratum 1. The high trees:

Pinus halepensis

9. Vegetation types in Jordan (Al-Eisawi 1983).



Stratum 2. The low trees and shrubs:

Arbutus andrachne *Pistacia palaestina*
Quercus calliprinus

Stratum 3. Low shrubs and bushes:

Calycotome villosa *Cistus salvifolius*
Cistus villosus *Smilax aspera*
 and others.

Stratum 4. Herbaceous:

Fumana arabica *Helianthemum lavandulaefolium*
Thesium bergeri
 Most of the orchids occur under such forest, for example:
Ophrys spp. *Cephalanthera longifolia*
Lemodorum abortivum *Orchis anatolica*

II. Evergreen oak forest

This vegetation is often classified as Mediterranean shrub land (Maquis). It comprises the major part of the forest vegetation in Jordan and occurs in the north and south, differing from other types which either occur in the north (pine and deciduous forests) or the south (Juniperus forests). This type of vegetation grows at high altitudes of more than 700 m., and on Terra Rosa soil of hard limestone parental rock, unless it is a secondary vegetation replacing pine plants on calcareous or rendzina soil of soft limestone parental rock.

This is the vegetation which is being affected the most by human impact through the reduction of the forest into agricultural land, and through the cutting of trees for heating and coal production. Vast areas in Jordan show the remnants of such forests in the new growth of shoots from the lower parts of the trunks and the roots.

This vegetation, if protected, will reach the climax and will be dominated by leading trees of about 6 meters in height. But if not, degradation will rapidly take place and most of the vegetation will be destroyed, being represented only by scattered shrubs and bushes.

The vegetation composition of this type of forest varies throughout the leading species including the evergreen *Quercus caliprinus* which is the most important element, and on which the forest name is based. Although this vegetation is called evergreen, many of its components are deciduous like *Pistacia palaestina*, *Pyrus syriaca* and *Crataegus azarolus*.

Localities: This forest type extends from Wadi Es-Sir near Amman almost up to Irbid in the north. It also occurs in the south in Bir-Al-Ata'ta, Tafil district and Al-Hisha between Shoubak and Petra. The vegetation in the north is interrupted by other types of forest but it is best represented in Ishtafaina near Ajloun.

Composition: Three strata can be recognized in well preserved forest:

Stratum 1. Trees or high shrubs:

<i>Quercus calliprinus</i>	<i>Pistacia palaestina</i>
<i>Pistacia atlantica</i>	<i>Arbutus andrachne</i>
<i>Crataegus azarolus</i>	<i>Styrax officinale</i>
<i>Ceratonias seliqua</i>	<i>Olea europaea</i>

Stratum 2. Low shrubs and climbers:

<i>Amygdalus communis</i>	<i>Rhamnus palaestinus</i>
<i>Asparagus aphyllus</i>	<i>Rubia olivieri</i>
<i>Lonicera obtusa</i>	<i>Calycotome villosa</i>
<i>Sarcopoterium spinosum</i>	<i>Cistus villosus</i>

Stratum 3. Herbaceous:

<i>Dactylis glomerata</i>	<i>Poa bulbosa</i>
<i>Anemone coronaria</i>	<i>Cyclamen persicum</i>
<i>Echinops</i> spp.	<i>Linum pubescens</i>
<i>Lecokia cretica</i>	<i>Adonis palaestina</i>
<i>Orchis anatolica</i>	

III. Deciduous oak forests

The name of this vegetation is derived from the deciduous oak species. Three to four species of *Quercus* are used by different workers to designate the vegetation as *Q. aegilop*, *Q. boissieri*, *Q. ithaburensis* and *Q. infectoria*. The taxonomic status of these taxa in Jordan is not clear, although some taxonomist may consider two or even one valid taxon. Whatever the taxonomic treatment is, the species *Q. ithaburensis* in this study will be used as the indicative species for the deciduous oak forests in Jordan.

The deciduous oak forests in Jordan occur at a lower altitude than all other forest and mostly grow on red or brown soil of hard limestone parental rock. Most of these types of forest are not well protected, therefore they are subject to degradation. The deciduous oak forests are found at the lower borders of the evergreen oak forests and they mix together for a limited area until they become pure stands of each type alone. If one travels within the Mediterranean region in Jordan one will find scattered old deciduous trees which can be used as standing witnesses to the fact that degraded forests used to grow in such places.

The composition of deciduous oak forest varies in relation to the amount of humidity and temperature. For example the forests in Um-Qies and Malka are associated with *Pistacia palaestina*, *Ceratonias seliqua*, *Styrax officinale* and *Amygdalus communis*; while the forest in Al-Alouk is associated with *Pistacia atlantica*, *Amygdalus korschinskii*, *Rhamnus palaestinus*, since the latter forest is at the Irano-Turanian border which receives less rainfall and higher temperature.

Localities: Um-Qies and Yarmuk River; Malka; Dair Abu Said to the borders of Ishtafaina forest in Ajloun; Al-Alouk near Jarash; As-Baihi near Salt; over the hills facing the Zerka river near King Talal Dam; west Mahes on the hills facing Wadi Shuaib and in Al-Bahhath, west Amman.

Composition: Three strata, not always clear, can be found with the following leading species:

Stratum 1: Trees:

<i>Quercus ithaburensis</i>	<i>Styrax officinale</i>
<i>Ceratonias seliqua</i>	<i>Pistacia palaestina</i>

Stratum 2: Shrubs:

<i>Crataegus azarolus</i>	<i>Olea europaea</i>
<i>Amygdalus</i> spp.	<i>Calycotome villosa</i>
<i>Rhamnus palaestinus</i>	<i>Retama raetun</i>

Stratum 3: Herbaceous bushes:

<i>Dactylis glomerata</i>	<i>Sarcopoterium spinosum</i>
<i>Urginea maritima</i>	<i>Euphorbia hierosolymitana</i>
<i>Carlina corymbosa</i>	<i>Salvia</i> sp.
<i>Poa bulbosa</i>	<i>Alcea</i> spp.
<i>Colchicum</i> sp.	<i>Tulipa</i> sp.

IV. *Juniperus* forest

This occurs only in the southern mountains of Jordan usually at high altitudes, over 1,000 m., and on sandy rocks.

The temperature in the coldest month in the region of this type of forest is usually below zero with snowfall mostly every year.

Unfortunately *Juniperus* forests are the least protected in Jordan except in a very limited area in Lahtha, near Rashediah, Tafila district where a stand of about 40 old trees of *Cupressus sempervirens* remain. Most of the forests are in fact threatened because of the heavy grazing, and human impact.

Localities: The *Juniperus* forests almost extend from Rashediah near Tafila; Dana; Shoubak; Wadi Musa; At-Taibeh 10 km. S. Wadi Musa; to Dlagha, where few trees are seen.

Composition: Only two strata can be recognized because of the heavy grazing and the degradation of the vegetation.

Stratum 1: Trees and shrubs:

<i>Juniperus phoenicea</i>	<i>Daphne linearifolia</i>
<i>Cupressus sempervirens</i>	<i>Thymelaea hirsuta</i>
<i>Pistacia atlantica</i>	<i>Colutea istryia</i>
<i>Rhamnus palaestina</i>	<i>Crataegus azarolus</i>

Stratum 2: Bushes and herbaceous:

<i>Globularia arabica</i>	<i>Noea mucronata</i>
<i>Helianthemum vesicarium</i>	<i>Achillea santolina</i>
<i>Sarcopoterium spinosum</i>	<i>Onobrychis crista-galli</i>
<i>Osyris alba</i>	<i>Artemisia herba-alba</i>
<i>Geranium tuberosum</i>	<i>Dactylis glomerata</i>
<i>Zosima absinthifolia</i>	<i>Scandix iberica</i>

The previous Mediterranean forests can be found as mixed *Juniperus* and evergreen *Quercus* in the south, deciduous and evergreen or pine forest and evergreen *Quercus* in the north.

V. Mediterranean non-forest vegetation

The Mediterranean region which is not covered by forests contains some shrubs and bushes. Such region is often referred to as Garigue and Batha Mediterranean vegetation. The leading species of this vegetation are *Rhamnus palaestinus*, *Calycotome villosa*, *Sarcopoterium spinosum* and *cistus* spp. in the north, and *Artemisia herba-alba* will be associated with others in the south.

The Mediterranean non-forest vegetation is treated as degraded forest. Therefore some scientists believe that if this vegetation is protected, steps toward forest climax will be observed until the final stage is reached.

Localities: It is found in all the Mediterranean region except the forest lands and the cultivated lands.

Composition:

<i>Rhamnus palaestinus</i>	<i>Capparis spinosa</i>
<i>Echinops</i> spp.	<i>Sarcopoterium spinosum</i>

Dactylis glomerata
Tecrium polium
Ononis natrix
Ballota undulata
Eryngium glomeratum
Noea mucronata
Calycotome villosa
 and many annuals.

Hordeum bulbosum
Varthemia iphionoidea
Artemisia herba-alba
Poa bulbosa
Tymus capitatus
Asphodelus microcarpus
Asparagus aphyllus

VI. Steppe vegetation

This vegetation is confined to the Irano-Turanian region and may intrude either into the Mediterranean or the Saharo-Arabian regions. The composition of the vegetation varies according to the soil and other climatic differences depending on its location with respect to the Mediterranean region. For example the steppe vegetation in the northern Ghor which links with the northern mountains is dominated by *Ziziphus lotus* and *Ferula communis* with almost no *Artemisia herba-alba*, while the steppe vegetation in the north, east and south Mediterranean borders show other elements like *Pistacia atlantica*, *Anabasis syriaca* and *Artemisia herba-alba* which are not found in the western steppes. This might be due to the fact that the western steppes are more affected by the tropical conditions and vegetation in the Rift Valley, while the eastern steppes are more affected by and related to the Sahara conditions and vegetation. Therefore variation in the vegetation composition is recognized, a fact that led some workers to distinguish distinct sub-divisions of this major type. However, since it is very difficult to make unambiguous distinctions between the different types it would be more advisable not to sub-divide this type of vegetation.

The common features of this type of vegetation are the presence of shrubs and bushes and the absence of tree vegetation.

Localities: This vegetation forms a strip surrounding the Mediterranean region, except the north.

Composition: The leading species are:

<i>Ziziphus lotus</i>	<i>Artemisia herba-alba</i>
<i>Pistacia atlantica</i>	<i>Noea mucronata</i>
<i>Retama raetum</i>	<i>Asphodelus microcarpus</i>
<i>Tamarix</i> spp.	<i>Urginea maritima</i>
<i>Anabasis syriaca</i>	<i>Ferula communis</i>
<i>Hammada</i> spp.	<i>Gypsophila arabica</i>
<i>Salsola</i> spp.	<i>Astragalus spinosus</i>
<i>Capparis decidua</i>	<i>Crocus moabiticus</i>

The vegetation of Wadi Al-Buttom is a special case where *Pistacia atlantica* trees are growing along the wadi side, especially in the area near Qaser Amra. Although this place is within the Sahara region, its vegetation belongs to the steppe type. Wadi Al-Buttom is an example of intermingling regions, which shows the difficulty in drawing a clear-cut line to

delineate the regions. Some of the leading species in this locality:

<i>Pistacia atlantica</i>	<i>Tamarix</i> spp.
<i>Retama raetum</i>	<i>Amygdalus arabica</i>
<i>Atriplex</i> spp.	

VII. Hammada vegetation

Most of the Saharo-Arabian region in Jordan is of hammada type which comprises about 50 per cent of the total area. Three subdivisions of hammada can be recognized.

1. Run-off hammada
2. Pebble and gravel hammada
3. Sandy hammada

1. Run-off hammada:

The vegetation here is mainly confined to the wadies and water accumulation. The leading species are:

<i>Retama raetum</i>	<i>Tamarix</i> spp.
<i>Atriplex halimus</i>	<i>Peganum harmala</i>
<i>Lycium europaeum</i>	<i>Astragalus</i> spp.
<i>Artemisia herba-alba</i>	<i>Anabasis articulata</i>
<i>Achillea fragrantissima</i>	<i>Atractylis mutica</i>
<i>Phlomis brachyodon</i>	<i>Iris sisyrinchium</i>

2. Pebble and gravel hammada:

The vegetation cover in the pebble part consists only of lichens covering the black stones with white-grey growth. The pebbles cover a vast area between Mafraq and H4 up to the borders with Syria.

The gravel hammada is mostly covered by some annuals of the following leading species:

<i>Mesembrianthemum nodiflorum</i>	<i>Spergularia diandra</i>
<i>Herniaria hirsuta</i>	<i>Filago desertorum</i>
<i>Aaronsohnia faktorovskyi</i>	<i>Gymnarrhena micrantha</i>
<i>Anthemis deserti</i>	<i>Stipa capensis</i>
<i>Asteriscus pygmaeus</i>	<i>Bromus</i> spp.
	<i>Trigonella stellata</i>

3. Sandy hammada:

Most common along the borders with Iraq and Saudi Arabia and in Ash-Shumari reserve. The leading species are:

<i>Seidlitzia rosmarinus</i>	<i>Capparis leucophylla</i>
<i>Atriplex</i> spp.	<i>Ephedra transitoria</i>
<i>Artemisia herba-alba</i>	<i>Pituranthus triradiatus</i>
<i>Anabasis articulata</i>	<i>Calligonum tetrapterum</i>
<i>Achillea fragrantissima</i>	<i>Zilla spinosa</i>
<i>Halocnemum strobilaceum</i>	

VIII. Saline (Halophytic) vegetation

This occurs in the desert (Saharo-Arabian) region around Azraq Oasis, in the Rift Valley around the Dead Sea, in Wadi Araba, and around the shoulders of the River Jordan on what

is known locally as Katarat. The leading species vary, depending on their ability to tolerate the degree of salinity.

<i>Arthrocnemum</i> spp.	<i>Frankenia pulverulenta</i>
<i>Suaeda</i> spp.	<i>Aeluropus littoralis</i>
<i>Juncus littoralis</i>	<i>Desmostachya bibinnata</i>
<i>Limonium meyeri</i>	<i>Prosopis farcta</i>
<i>Tamarix</i> spp.	<i>Alhagi murorum</i>
<i>Lycium</i> spp.	<i>Beta vulgaris</i>
<i>Nitraria retusa</i>	<i>Inula crithmoides</i>
<i>Sonchus maritimus</i>	<i>Rhus tripartita</i>

IX. Tropical vegetation

It occurs in the Sudanian region which extends from Deir Alla in the north down to Aqaba Gulf in the south but it is concentrated more in the regions close to the Dead Sea, as in the southern Ghor, Ghor Safi and Ghor Faifa. The vegetation is confined to the alluvial soils of the Rift Valley most of which have been destroyed and used for vegetable agriculture. There is no protected part, but if some places like Ghor Faifa are protected it will definitely reach the climax. The leading species are:

<i>Ziziphus spina-christi</i>	<i>Ocradenus baccata</i>
<i>Calotropis procera</i>	<i>Acacia radiana</i>
<i>Balanites aegyptiaca</i>	<i>Cocculus pendulus</i>
<i>Maerua crassifolia</i>	<i>Aerva</i> spp.
<i>Salvadora persica</i>	<i>Forsskaolea tenacissima</i>
<i>Moringa aptera</i>	

X. Sand dune vegetation

Such vegetation is only found in the Sudania region especially in Wadi Araba and Wadi Rum. The vegetation is made up of shrubs or bushes, mainly of sand dune fixatives. In some places the vegetation has reached its climax especially in the area near to Gharandal along the road to Aqaba where the plants reach a height of three meters. The leading species are:

<i>Haloxylon persicum</i>	<i>Plantago ovata</i>
<i>Retama raetum</i>	<i>P. cylindrica</i>
<i>Calligonum cummosum</i>	<i>Stipagrostis</i> spp.
<i>Panicum turgidum</i>	<i>Savignya parviflora</i>
<i>Hammada scopira</i>	<i>Arnebia</i> spp.
<i>Dipcadi erythraeum</i>	<i>Eremobium aegyptiacum</i>
<i>Pancratium sickenbergeri</i>	<i>Cakile maritima</i>
<i>Hyoscyamus pusillus</i>	<i>Schismus barbatus</i>
<i>Neuruda procumbeus</i>	<i>Silene villosa</i>

XI. Acacia and Sudania rocky vegetation

This vegetation is confined to the granite mountain bases and to the rocky part of Wadi Araba in the Sudanian region. *Acacia* trees are scattered through Wadi Araba but they get more dense toward the hard rocks of the mountain bases until they form a pure stand of *Acacia* woodland especially 20–40 km. before Aqaba. Within the same habitat and on the

hilly ground covered with hammada a special type of plant grows, with the following leading species:

<i>Acacia radiana</i>	<i>Fagonia</i> spp.
<i>Acacia tortilis</i>	<i>Reaumuria hirtella</i>
<i>Anabasis articulata</i>	<i>Gymnocarpus decandrus</i>
<i>Hammada scopira</i>	<i>Helianthemum lippii</i>
<i>Cassia italica</i>	<i>Asteriscus graveolens</i>
<i>Zygophyllum dumosum</i>	<i>Sclerocephalus arabicus</i>
<i>Caralluma</i> spp.	<i>Anastatica hierichuntica</i>
<i>Traganum nudatum</i>	

XII. Water (Hydrophytic) vegetation

This occurs around the streams and river banks and around the water pools in Azraq. The vegetation does not occur much in Jordan but still it is clear around Jordan river; Yarmuk river; Zerka river; Wadi Shuaib; Wadi Mujeb; Wadi Al-Hasa and in Azraq Oases. The leading species are:

<i>Salix</i> spp.	<i>Tamarix</i> spp.
<i>Phragmites communis</i>	<i>Typha angustata</i>
<i>Vitex angus-castus</i>	<i>Nerium oleander</i>
<i>Cyperus longus</i>	

XIII. Mud flats (Qa or Bajada)

These are places in the desert where water accumulates and soil is made of very fine particles, mainly of clay and silt. After the water evaporates the soil becomes solid and very hard, which does not help any plant to germinate and survive. Examples of this are Qa Al-Jafr and Qa Al-Desi, Qa Al-Azraq and some others distributed in the eastern desert of Jordan.

General Discussion

From the analysis of climatic data nine bioclimatic subdivisions are found, out of which four vegetative regions are proposed. These four regions were treated previously as only three divisions Mediterranean, Steppe and Desert. The desert in this case includes the Saharo-Arabian and Sudanian. Moreover, in this study the Sudanian region is well marked by its climatic and vegetation characteristics, which cannot be found in the Saharo-Arabian. Again the workers included the whole Rift Valley as one vegetation region (Kasaplilgil 1956). But the vegetation and the climatic conditions in the northern Ghor are not similar to those of the southern Ghor or Wadi Araba.

The borders of the four regions are not well defined because of the intermingling elements between any two adjacent regions. Examples of this are the occurrence of *Pistacia atlantica* in the desert, *Ziziphus lotus* at the borders of the Mediterranean region, and the vegetation of Wadi Mujeb and Wadi Al-Hasa which is of a steppe type in the Mediterranean region.

The 13 major types of vegetation considered in this study are the most clear cut ones. Variations within each type are recognized especially when soil type is changed, then the leading species within each association are different.

Generally speaking all the vegetation types suffer from destruction and heavy grazing. Therefore, the following suggestions are listed to protect the natural vegetation:

- 1) All the natural vegetation, especially the forests, should be protected and measures should be employed against those who break the law.
- 2) The cutting down of the very limited forest area for cultivation should be stopped.
- 3) Restrictions should be placed on the cutting of trees for wood and coal production.
- 4) Grazing, especially by goats, is one of the major causes of forest degradation especially in the south, so there should be a solution to this problem.
- 5) Some of the forests are privately owned and often sold for house building which results in the destruction of the vegetation.
- 6) The natural forests are used by people for pleasure as national parks. But the misuse of such natural habitats by lighting fires and parking cars beneath the trees has damaged vast areas of such forests together with the delicate plants such as orchids growing on the floor of the forest. Therefore, instruction and information must be given to people to make use of and enjoy such places without too much destruction.
- 7) Many rare species are considered to be threatened by destruction if they are not protected.
- 8) Much of the marginal land at the Irano-Turanian border has been used for cereal production. But as the rainfall is irregular such land will be deserted, and the natural plants which used to grow there will need a long time to re-establish themselves again. This is one of the most dangerous areas for possible desertification.
- 9) The desert of Jordan is not a typical desert, and some parts support reasonably good vegetation. If such places are protected they can be used for well organized grazing which may help in solving this problem.
- 10) The natural reserves should be increased so as to protect as much as possible natural habitats and in turn the wildlife, especially the animals and birds. The Shaumari reserve is one of the best examples of vegetation protection in the desert. If one compares the vegetation within the fence of the reserve with that directly outside the fence, astonishing differences will be apparent.
- 11) Protection of some habitats, especially the degraded and the bushy Mediterranean vegetation, may provide an opportunity for climax formation.
- 12) A project of reforestation should be adopted in Jordan, by selecting the exact species for each particular habitat, and not using one or two species everywhere. Not only that, but it is important to maintain the reforested areas until the plants are well established. I believe that this should have first priority on starting the planting of new areas.

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