A Thousand Years of Farming: Agricultural Practices from the Byzantine to Early Ottoman Period at Khirbet Faris, the Kerak Plateau, Jordan.

Summary:

This archaeobotanical analysis was carried out as part of the Khirbet Faris project: a multi-disciplinary archaeological study of a rural village on the Kerak plateau with a chronology dating from the Bronze Age to Ottoman period. It has contributed to the debate surrounding settlement, economic continuity and change and the influence of Islamic expansion on agricultural practices in this environmentally and politically marginal location. An ethnoarchaeological analysis, FIBS (Functional Interpretation of Botanical studies), was carried out to aid the interpretation of crop management practices from archaeobotanical remains.

Results of the analysis have indicated general continuity in agricultural activity from the Byzantine to early Ottoman periods:

- Free threshing wheats, barley, pulses, fig, olive and vine were all cultivated throughout this period. The samples were rich and of mixed origin, and typically dominated by cereal grain and chaff (mostly cleaned barely and wheat grain and chaff).
- Settled farmers seem to have adopted a mixed economy, utilising a range of crops together with animal herds. Crop residues were used to feed herds and the dung used as fuel, to varying degrees across the site, throughout the Islamic period.
- Contrary to Watson's (1983) belief that free-threshing wheats were introduced at the time of Islamic expansion, as part of a wider agricultural revolution, these crops seem to have been cultivated from at least the Byzantine period.

Signs of agricultural change appear from the 13th century A.D:

- New, 'exotic' crops: cotton, sorghum, watermelon, pistachio and citrus fruit.
- Analogy with FIBS evidence suggests irrigation may have been introduced at this time.
- These 'introductions' appear first in the mid-Islamic period, not at the advent of Islamic expansion as Watson describes, perhaps due to the marginal location of Kerak.
- It is questionable whether these 'exotic' crops were cultivated or imported as they are present at a low frequency in the samples. Irrigation evidence comes from the weeds of winter cereal crops so there is no direct evidence for the irrigation of 'exotic' summer crops. It is, therefore, uncertain to what extent these introductions affected the local landscape and economy.

The success of the FIBS analysis in aiding interpretation of the archaeobotanical assemblage, in terms of crop management practices, is encouraging for future archaeobotanical research.

Thesis submitted in fulfilment of the degree of Doctor of Philosophy: Chantelle Hoppé

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Chapter 1: Introduction

1.1. Aims of the project:

One of the most important aspects for understanding economic and social change in past societies is an appreciation of their agricultural basis. There are many major areas of debate surrounding the study of agricultural development. This project tackles the role of irrigation in the medieval Arab expansion (e.g. Glick, 1970; Watson, 1983; Rowley-Conwy, 1989), using archaeobotanical evidence recovered from the site of Khirbet Faris. The effect of Arab expansion on agricultural activity through the Islamic period is a widely debated issue that will be addressed in this study. There are two elements to the research strategy:

- The ethnoarchaeological analysis of modern weed floras from Wadi[1] Ibn Hammad, the water catchment area for Khirbet Faris, studied between 1993 and 1996.
- The archaeobotanical analysis of samples taken from the site Khirbet Faris, Kerak, southwest Jordan, from excavation periods between 1988 and 1994.

The former study was used as an aid to the interpretation of plant remains identified from the Khirbet Faris archaeobotanical study. The relationship between the different elements of the study (how the ethnoarchaeological study is related to the interpretation of the archaeobotanical data) is illustrated in figure 1.1.

This study has evolved from the archaeological excavations at Khirbet Faris, co-ordinated by Alison McQuitty (Director of the British Institute in Amman for

[1] A wadi is a seasonally flowing water course.

Archaeology and History). The Khirbet Faris archaeological project, the study of an Islamic village on the Kerak Plateau of central Jordan, involves the reconstruction of the socio-economic structure of a rural community from the 7^{th} century to the present.

The aim of the archaeological project is to increase our understanding of the archaeology of Islamic Jordan by the study of a rural community within its human and natural environment. The long term aim is an integrated study of Khirbet Faris using the combined techniques of excavation, post-excavation analysis of finds, architectural survey, palaeo-environmental studies, field survey, historical studies and ethnoarchaeology. There exists no similar study of an Islamic village in Jordan. The project is, therefore, of fundamental importance to the study of the material culture and socio-economic structure of Islamic Jordan. In addition, the multi-disciplinary nature of the project is itself new in Jordan for this period, and will be important for the development of new methods and techniques. This archaeobotanical study forms an integral part of the multi-disciplinary Khirbet Faris project. The archaeobotanical data will be used in conjunction with other evidence from the site to reconstruct the Islamic period rural community at Khirbet Faris.

A major area of interest in rural economies for this region is the effect of Islamic expansion on the agrarian economy. On the basis of literary evidence, Watson (1983) has argued that Islamic expansion in the circum-Mediterranean area exerted a radical influence on farming during the last millennium. This influence is reflected in the introduction of new crops (e.g. macaroni wheat, sorghum, citrus fruits, watermelon), new technology, particularly irrigation, and new patterns of land use, such as intensive orchard husbandry. It has been argued that this intensification of agriculture caused major changes in land-use and friction between nomadic pastoralists and settled farmers. Subsequent studies have suggested the need for significant reconsideration of current orthodoxy (e.g. Rowley-Conwy 1989). In particular, the possibility that these innovations took the form of much more gradual introductions pre-dating the Islamic period or that small rural settlements were by-passed by these innovations, needs investigation. The study of archaeobotanical remains from Khirbet Faris may help elucidate the debate surrounding the influence of Islamic expansion on agricultural practices, notably the introduction of new crops, new technology such as irrigation and the effect this may have had on the pastoral-farmer socio-economic relationship.

The reconstruction of agriculture may aid interpretation in terms of socio-economic change or continuity through this period. Many scholars believe that agriculture and settlement closely paralleled the political fluctuations of the Islamic period. Sedentary agriculture and settlement are said to have been abandoned due to nomadic incursions during periods of relaxed central control. The core-periphery type models that these arguments are based on are particularly of interest in this region due to its history of political and environmental marginality. Some scholars are beginning to question these traditional views and argue for more continuity during this period, especially in marginal regions (Johns, 1994; Lancaster and Lancaster, 1995). It is hoped the study of archaeobotanical remains from Khirbet Faris, reconstructing agricultural activities in a marginal region through the Islamic period, will further inform this debate.

In order to aid the interpretation of the archaeobotanical remains from Khirbet Faris an ethnoarchaeological study was carried out in an area adjacent to the site (Wadi Ibn Hammad). The method adopted for the interpretation of the ethnoarchaeological data is FIBS (Functional Interpretation of Botanical Surveys), an autecological method of vegetation analysis used to predict land-use changes, developed at the Unit of Comparative Plant Ecology (UCPE), University of Sheffield (Hodgson, 1989, 1990, 1991). It is used as a method of describing vegetation in functional terms to explain or predict vegetation change in response to land-use or environment (Hodgson *et al*, unpub. a). The FIBS method involves a study of the characteristics of the modern weed floras from different environments and/or under different management regimes.

For this study a botanical survey of weeds in present day irrigated and unirrigated cereal fields in and around Wadi Ibn Hammad was carried out. This region is rare in the Mediterranean in having irrigated cereal fields and, in Jordan, provides a unique comparative site to aid the investigation of irrigation in the past. Also, this area is sufficiently marginal for rain-fed cereal cultivation that irrigation is relatively likely to have been practised in the past. If weed floras characteristic of irrigation can be identified from the present day fields, it is hoped the attributes of these plant groups can be measured for the floras found in archaeobotanical samples in order to search for evidence of irrigation in the past.

The collection of field data on the distribution of weeds relative to agricultural regimes will result in the identification of species groups. FIBS can be used to determine characteristic functional plant groups using field measurements of certain attributes of the species present. This will provide valuable information on the characteristics of plants growing under different irrigation levels. These attributes can then be measured for species common in archaeological samples to provide an interpretational tool for archaeobotanists: linking functional plant groups with agricultural practices. The presence or absence of evidence for irrigation in Islamic period samples from Khirbet Faris could help to shed light on the debate surrounding 'agricultural revolution' and socio-economic change in this region and time period.

In addition to its relevance to this specific research question, region and period, the ethnoarchaeological investigation will be of great value as part of a larger research programme conducted by staff of the Department of Archaeology and Prehistory, University of Sheffield. The aim of this overall research programme is to develop an improved methodology for the application of modern ecological data to the interpretation of archaeobotanical weed floras in terms of crop management practices. This particular study will aid the understanding of irrigation in the Near East. It will also contribute, along with other ARCHFIBS projects, to ongoing research on the intensity of agriculture in historic and prehistoric periods in other parts of the Old World.

1.2. Environmental setting:

1.2.1. Topography:

Figure 1.2 shows the location of Jordan with its major topographic regions. The Hashemite Kingdom of Jordan is situated in the Near East, bordered by Syria in the north, Iraq in the east, Saudi Arabia in the south and east and Israel and the West Bank in the west. The land area covers 89,000km^2 of which only 5% is estimated to be under cultivation (Blench, 1995).

Aresvik (1976) described the country in terms of four major zones, delimited by the major east - west wadis: the Yarmouk, Zerqa, Mujib and Hasa. Between Yarmouk and Zerqa is the Ajlun district, a hilly region of upland with pine forests and oak scrub. From Zerqa to Wadi Mujib the region containing the capital, Amman, is situated. The Kerak Plateau is part of the central highlands and lies in the third zone between Wadi Mujib and Wadi el Hasa. It is the region in which the archaeological site of Khirbet Faris and the ethnoarchaeological study of Wadi Ibn Hammad are located. South of this region (south of Wadi el Hasa) is a mountainous area called the Southern Highlands of Jordan, running to Aqaba, the southern tip of Jordan. The most distinct topographic unit in Jordan is the Rift Valley on the eastern border. It runs approximately north south and within it the Dead Sea (392m below sea level) is located at the western limit of the central highlands with the Jordan valley to the north and the Wadi Araba to the south.

According to Miller (1991) the Kerak Plateau corresponds roughly to the land of ancient Moab. It extends from the Wadi Mujib in the north to Wadi el Hasa in the south and from the edge of the Dead Sea Escarpment in the west to Wadi el Lejun in the east (see figure 1.3). The Kerak plateau rises up sharply from the Ghor (the flats surrounding the Dead Sea) to a height of some 850m, with occasional summits over 1,400m (see figure 1.4). The plateau covers an area of c. 875km^2 and the basic material is limestone with an overlay of basaltic soils. This plateau top region is essentially a high altitude grassland cut across by very deep wadis. There is an escarpment on the western plateau edge where deep wadis have a strong east-west orientation, cutting down to the Ghor, creating marked variations in microclimate over very short distances. The major water catchments of the Kerak plateau are Wadi Kerak, Wadi Ibn Hammad and parts of Wadi Mujib and Wadi el Hasa. The terrain of the wadi walls is deeply dissected. The lower reaches of these wadis are very steep-sided, highly eroded and unsuitable for agriculture. In the upper reaches, towards the level of the main plateau, intermediate to gentle slopes predominate and, together with the plateau surface itself, represent the major areas of cultivation in the study area.

The area of the ethnographic and archaeological studies can be divided into three of the four major topographic zones (summarised in table 1.1): the plateau and wadi sides with rain-fed cereal cultivation; and the wadi bottom with irrigated cereal and vegetable cultivation.

Table 1.1: The major topographic zones of the Kerak region (after Blench, 1995):

Land Class	Arabic term	Description
Plateau[1,2]	*Ardh hamr*	The high-altitude grassland occurring along central Jordan
Wadi sides[2]	*Ardh baidha*	Dissected land on the sloping sides of the wadis
Wadi bottom[2]	*Ardh baidha*	The trough at the bottom of the wadi
Ghor	*Ghor*	The marshy land where the wadi leads into the Jordan Valley (Dead Sea)

[1] land class of Khirbet Faris and its immediate hinterland
[2] land classes incorporated in the Wadi Ibn Hammad study

Within this region the archaeological site of Khirbet Faris is situated on the plateau edge, 25km northwest of the central administrative town of Kerak and west of the village of el Qasr. It is located on the eastern edge of Wadi Zuqîba, a tributary of Wadi Ibn Hammad, which dissects the plateau and descends to the Dead Sea.

1.2.2. Geology:

Miller (1991) described the underlying geology of the Kerak area, consisting of: Nubian sandstone deposits (Lower Cretaceous and earlier), 'Ajlun series marine deposits (Lower Cretaceous to Jurassic) and Belqa' series marine deposits (Miocretaceous to Eocene), with volcanic overflows capping the sedimentary rock. The 'Ajlun series marine deposits are exposed along the Dead Sea Escarpment, especially where wadis, like Wadi Ibn Hammad, cut deep. Water seeps into the Belqa' series limestone and re-emerges from the 'Ajlun series limestone as springs in the wadi bottoms due to the different nature of the deposits. Embedded limestones at the top of the geological sequence act as aquifers that absorb water. The embedded marls of the 'Ajlun series act as an aquiclude which prevents water from seeping deeper. Water is, therefore, forced to the surface in the form of springs. It is these springs that are the source of irrigation for crop cultivation in the wadis. Figure 1.5 illustrates the small-scale, local geology of the Khirbet Faris and Wadi Ibn Hammad study area while the general geology of the Kerak plateau is summarised in figure 1.4.

1.2.3. Soils:

Soils of the agricultural areas of Jordan are mainly calcareous, clay loams with pH values of around 7.5 - 8 and they are generally low in nitrogen, phosphorus and organic matter (Blench, 1995). According to Zohary (1969) the limestone: chalk, chert and marls, weather to form red/yellow Mediterranean soils. These include terra rossa and rendzina series - the most fertile of the Jordanian soils used for cultivation. Terra rossa, together with rendzina, characterise the plateau, the agricultural hinterland of Khirbet Faris (see figure 1.6). Loess and calcareous soils are common in the Irano-Turanian region on the edge of the plateau, where Khirbet Faris is located. Grey-brown alluvial and colluvial soils formed of limestone and granite gravel (Aresvik, 1976) are found in wadi systems such as Wadi Ibn Hammad, providing land for cultivation, though not as fertile as the Mediterranean soils. Sandy, saline and hammada soils are dominant in desert regions such as the Ghor. There are small scale, local soil differences between the Khirbet Faris and Wadi Ibn Hammad study area (see figure 1.6).

According to Blench (1995), soils of the Kerak region are often stony or rocky, which adversely affects mechanised farming practices for seed bed preparation, field crop maintenance and harvesting. The soil surface is generally hard setting, and this, together with the shrinking and cracking characteristics of the clays, may present problems for seed emergence and crop establishment. The surface capping also leads to increased sheet flow during rainfall periods and contributes to the rill erosion and gully formation frequently observed in the area. Since the rate of soil formation in Jordan is typically low, the high rate of soil loss currently being widely experienced is considerably reducing soil resources.

1.2.4. Water resources:

Blench (1995) made a study of the Kerak region and the water resources available to agriculture. The four major wadi systems of Mujib, Ibn Hammad, Kerak and el Hasa, together with minor wadis in the southern highlands, have a total annual flow of about 165 million cubic meters (MCM), of which 117 MCM (70%) is base flow originating from springs in the lower reaches of the wadis. The remaining 48 MCM (30%) is seasonal runoff and floods due to occasional storms over the catchment areas. The baseflow of all wadis, with the exception of Wadi Mujib, is fully utilised primarily for irrigation of about 4,600 ha of agricultural land in the southern Ghors.

Groundwater is found in two major aquifers, the Upper Limestone and the Lower Sandstone. The Upper Limestone aquifer is replenishable by infiltration of rainwater through the soil and fractured rocks, with an estimated annual cache of about 87 MCM. At present about 50% of this amount appears in the form of springs along the lower reaches of the wadis. The Lower Sandstone aquifer is very deep and is not directly replenishable (see figure 1.4).

The water catchment region to the west of Khirbet Faris, Wadi Ibn Hammad, has an area of about 324km^2 and flows in a westerly direction from the highlands to the Dead Sea. The annual precipitation over the catchment area ranges from 350mm, at the top, to 100mm, at the Dead Sea. The average annual flow of the wadi is estimated at about 10 MCM, of which 8 MCM is base flow. This flow fluctuates yearly but is more reliable than the rainfall (Harlan, 1981).

1.2.5. Present climate:

The main climatic influence on Jordan is the Mediterranean Sea, modified by the effects of continental air masses and altitude. This influences the amount of precipitation and, therefore, the boundary between desert and agriculture that occurs around the 200mm isohyet (Aresvik, 1976). The major feature of a Mediterranean climate is the extremes of precipitation at different times of the year with a rainy season in the cold months and a dry season in the warm months (Tomaselli, 1977). Rain falls mainly during winter and spring starting in October and extending into May with most rainfall in January (Al-Eisawi, 1985). On average, throughout the year, evaporation exceeds precipitation; a situation referred to as a precipitation deficit (FAO-UNESCO, 1974). The coincidence of summer drought and temperature maximum is reflected in the vegetation types and agriculture practices that are adapted to aridity (Nahal, 1981).

Blench (1995) studied the impact of precipitation on the agricultural zones of Kerak. Only an estimated 8.5% of Jordan (800,000 ha) receives more than 200mm rainfall, and only 400,000 ha receives over 300mm. The distinctions between farming systems are a clear reflection of the rainfall based agro-climatic zonation in Jordan whereby the country has been divided into four categories as shown in table 1.2.

Table 1.2: Rainfall based agro-climatic zones of Jordan (after Blench, 1995):

Region	**Precipitation (mm)**
Arid desert	<200
Marginal	200-300
Semi-arid	300-500
Semi-humid	>500

The Kerak region lies almost entirely in the marginal zone with rainfall between 200-300mm. This is marginal in terms of crop cultivation that requires an average of 300mm of rainfall per annum (Blench, 1995). Only a small area around Kerak and Rabba falls into the semi-arid zone with between 300 and 500mm of rainfall annually.

Local climatic variation is influenced by topography and the marked separation of the Ghor from the highland areas. The high altitude of the plateau (850m to over 1,400m) has a marked influence on rainfall distribution. This is illustrated by the graph of rainfall for the plateau, wadi systems and Ghor shown in figure 1.7. The distribution of precipitation in the study area changes from an average of 300mm on the plateau (location of Khirbet Faris) to 180mm in the wadi (such as Ibn Hammad), towards the Dead Sea, as the altitude decreases. Thus, the amount of rainfall differs markedly over short distances which has a marked influence on the local environment and agriculture.

The large degree of variation in annual rainfall across the study area is not reflected in the average regional figures. The amount and timing of rainfall may vary from year to year: sometimes it will not arrive until December or January and often it does not rain after March (Al-Eisawi, 1985). The Kerak region shows one of the highest inter-annual coefficients of variation (Shehadeh, 1985, estimates it at over 70%). This variability has an effect on the agriculture, introducing an element of uncertainty to farmers' yields. This is reflected in wheat yield figures compared to rainfall in figure 1.8. This figure illustrates the strength of the effect of rainfall on yields as the latter mirrors the peaks and troughs in precipitation. This may influence agricultural management decisions such as the use of irrigation and risk spreading strategies such as growing a variety of crops.

Aresvik (1976) noted that temperature variation in Jordan increases from north to south, west to east and in the interior, but decreases with altitude. Mean summer temperature for the uplands is about 17°C with a maximum of 33°C in the summer. The Dead Sea region, the Ghor, has an average summer temperature of more than 40°C and an average annual temperature of 20°C. The study area encompasses both the plateau and the wadi system between the plateau and the Ghor. Temperatures will, therefore, increase westwards, from Khirbet Faris on the plateau edge, as altitude decreases in Wadi Ibn Hammad.

The relative humidity of the Ghor varies between 70% in the winter and 50% in the summer, whereas on the highlands this variation is from 75% to 35% (Aresvik, 1976). This humidity variation will be reflected in the study area as it encompasses highland plateau in the east and wadi bottom (towards the Ghor) in the west.

These climatic differences are reflected in the crops seen growing in the Kerak region. On the plateau, where there are winter frosts, hardy cereals were the most obvious form of cultivation, whereas frost sensitive banana plants were observed a few kilometres down from Wadi Ibn Hammad in the Ghor. A variety of crop types, occupying different environmental niches, may be cultivated over relatively short distances.

The Khamsin, a hot dry wind, blows from the east in the spring and autumn. It originates in the Atlas Mountains, in North Africa, and above the southern shores of the Mediterranean and is associated with low-pressure fronts and late rains (Shehadeh, 1985). It brings with it desert dust and can cause temperature increases harmful to vegetation. Blench (1995) described high wind velocities with between 50-75% of winds experienced in the uplands capable of transporting soil causing a wind erosion hazard. In addition, high wind velocities contribute to high evapotranspiration rates and the common inability of soil moisture content to meet crop requirements during the growing season.

In summary, the climate of the plateau is usually described as Mediterranean arid. The peak rainfall areas are in the highlands with over 300mm with a sharp drop to less than 50mm in the Ghors. Rainfall is the main source of the springs and seeps found in many of the wadis. Rain is concentrated in the 'winter' months (December to March) with virtually no rainfall from June to September. This rainfall is very variable in quantity and duration. Mean annual temperature varies from about 14°C for the highlands to >20°C for the Ghors. Thus the general climatic variation in the study area occurs from west to east. It is generally cooler and wetter in the east on the plateau, hotter and drier in the west in the wadi bottom, with higher humidity in the summer. This variation is due, in the main, to altitudinal differences. These differences may affect agricultural practices, with irrigation and a variety of crops used to compensate for variable and marginal environmental conditions.

1.2.6. Islamic period climate:

Shehadeh (1978, 1985) asserts, with reference to Butzer's (1955) environmental evidence such as geological sequences, that there is evidence of numerous climatic variations during the Islamic period with a recognisable impact on ecosystems and land use. He also uses archaeological evidence such as Ummayad palaces, hunting lodges and bath houses in the desert, where there is no water today, to substantiate his argument. These fluctuations are listed in table 1.3.

Table 1.3: Rainfall trends in the Christian and Islamic periods from Butzer, 1955 (In: Shehadeh, 1985):

Period	**Rainfall**	**Period**	**Rainfall**
1-180	very moist	1428-1460	very moist
180-390	dry	1460-1540	dry
390-415	moist	1540-1680	very moist
415-670	very dry	1680-1708	dry
670-925	very moist	1708-1838	moist
925-1100	very dry	1838-1875	dry
1100-1310	very moist	1875-1900	moist
1310-1428	very dry	1901-	very dry

(The terms 'dry' and 'moist' are not defined further, thus the table is of limited use and can only be used to show *general* variability in climate through the Islamic period)

The table illustrates a degree of variability in precipitation in the past that may have influenced agricultural activities, as the present day situation illustrates the close link between climate and agriculture.

1.2.7. Vegetation:

According to Mountford (1988), although the national territory of Jordan is relatively small, the diversity of habitats allows a rich flora. Over 1,800 wild species can be found in deserts, the Jordan Valley, mountains and plateaux, the Azraq oasis, the Dead Sea basin and Wadi Aqaba. The dominant families are Leguminoseae, Compositeae, Gramineae, Crucifereae and Caryophyllaceae. Species of the family Chenopodiaceae are fewer in number but some species are dominant over vast areas, especially in desert regions e.g. *Anabasia articulata, Haloxylon persicum* and *Hammada salicornica.*

Aresvik (1976) describes the vegetation in Jordan roughly corresponding to the levels of precipitation in different regions. Highlands, with high precipitation, are characterised by woodland; little rainfall results in steppe vegetation and, where there is no rainfall, there is desert. Other factors, such as temperature, geology, soil, underground water and the effects of agriculture, also contribute to the type of vegetation present. Mediterranean upland zones with a rainfall of more than 300mm have a Mediterranean type of pine forest, oak scrub and bushes, but severe grazing has resulted in deforestation of these areas. Nineteenth century documents indicate that, in the past 150 years, decreases in precipitation and increases in population have led to the large-scale overgrazing and landscape denudation apparent today. In the Wadi el Hasa region, where today there is low level scrub, 19th century travellers noted the luxuriant grassland of the uplands and wooded wadi bottoms with oleander, tamarix, willow, acacia and palm, (Smith, 1975). Forests have been destroyed by agriculture, overgrazed or cut for fuel.

Zohary (1969) described the vegetation of Jordan in terms of three plant geographic zones. These three zones are apparent in the study area with the Mediterranean territory in the high Kerak Plateau, Irano-Turanian (steppe) territory on the plateau edge and Saharo-Arabian (desert) territory in the lower reaches of the wadi system leading to the Dead Sea. Zohary attempted to reconstruct the original vegetation of these zones using endemic species. These would have been the major vegetation types before the onset of major agriculture and overgrazing. The dominant plant types for the different zones are listed in table 1.4 and the zones of vegetation are illustrated in figure 1.9.

Table 1.4: Leading species of the vegetation zones of the Kerak region (after Al-Eisawi, 1985):

Mediterranean non-forest (Plateau top)	**Steppe (Plateau edge)**	**Hammada (Wadi bottom)**
Rhamnus palaestinus	*Pistacia atlantica*	**Upper Reaches:**
Echinops spp.	*Retama raetum*	*Ziziphus lotus*
Capparis spinosa	*Tamarix* spp.	*Ferula communis*
Sarcopoterium spinosum	*Anabasis syriaca*	**Lower Reaches:**
Dactylis glomerata	*Hammada* spp.	*Atriplex halimus*
Tecrium polium	*Salsola* spp.	*Lycium europaeum*
Ononis natrix	*Capparis decidua*	*Artemisia herb-alba*
Ballota glomeratum	*Noea muronata*	*Achillea fragrantissima*
Noea mucronata	*Artemisia herb-alba*	*Calotropis procera*
Calycotome villosa	*Asphodelus microcarpus*	*Phlomis brachyodon*
Hordeum bulbosum	*Urginea maritima*	*Tamarix* spp.
Varthemia iphionoidea	*Gypsophila arabica*	*Peganum harmala*
Artemisia herb-alba	*Astragalus spinosus*	*Astragalus* spp.
Poa bulbosa	*Crocus moabiticus*	*Anabasis articulata*
Tymus capitatus	*Helianthemum* spp	*Salvadora persica*
Asphodelus microcarpus		*Ziziphus spina-christi*
Asparagus aphyllus		*Balanites aegyptiaca*
Thymus spp.		*Iris sisyrinchium*
		Prosopis farcta

The Mediterranean zone is characterised by batha (dwarf shrub community) and garigue (open vegetation in dry localities, on forest soil, composed of xerophytic perennial shrubs). These occur where climatic and soil conditions did not allow the development of maquis (evergreen transition between steppe and forest composed of tall shrubs) and forests or where forests have been degraded (Zohary, 1969). This is referred to as Mediterranean non-forest vegetation and dominates the Kerak Plateau.

The Irano-Turanian territory on the plateau edge has vegetation made up of herbaceous and dwarf shrub communities (Zohary, 1969). These communities mainly consist of *Artemisia herb-alba*, *Noëa mucronata* and *Helianthemum* spp. Places exhibiting deep loess soils may have been dominated by grass steppe in the past characterised by *Stipa* and *Aristida* spp., among others.

The upper reaches of the wadis are dominated by *Zizphus lotus*, and *Ferula communis* with almost no *Artemisia herb-alba* (Al-Eisawi, 1985). Further down towards the Dead Sea the Saharo-Arabian zone occurs. Most of this region is of hammada vegetation; run-off vegetation is confined to wadis (Al-Eisawi, 1985). Zohary named the typical species as: *Ziziphus spina-christi*, *Calotropis procera*, *Balanites aegyptiaca* and *Salvadora persica*. The natural vegetation in the tropical areas in the bottom of these wadis has been almost completely eliminated by intensive cultivation. There is reason to believe tree growth in the wadis has been substantially reduced by agricultural land clearance. Lancaster and Lancaster (1995) mention the disappearance of many trees such as terebinth around Wadi Ibn Hammad. In the wadi bottoms, the common plants are oleander, mint, clover and occasional willow. *Tamarix* spp., *Atriplex* spp. and *Prosopis farcta* have also been recorded. These are the major vegetation types represented in the study area.

1.3. Socio-economic setting and farming practices in the study area:

An appreciation of the current socio-economic relationship between the settled farmers and nomadic Bedu may help to reconstruct the setting of agricultural activities in the past. This relationship is a major focus of the archaeological project of Khirbet Faris. It is hoped that the archaeobotanical analysis of samples from Khirbet Faris will shed light on the debate surrounding continuity or change in this relationship through the Islamic period, particularly the influence of the Islamic advance on agricultural practices and how this affected the socio-economic dynamic of nomadic pastoralists and settled farmers. The ethnographic information described below may help the interpretation of archaeobotanical data to reconstruct past agricultural practices, as many traditional farming methods are still carried out today in the region. Appreciation of the agricultural practices in the region will also provide the setting and agricultural variables of the Wadi Ibn Hammad ethnoarchaeological study of irrigation.

The information presented in this section is from various sources. An economic aid report was provided by R. Blench of the International Fund for Agricultural Development (IFAD) Agricultural Resource Management Project, 1995. The IFAD project was carried out in the Kerak region, with special attention to the region including Khirbet Faris and Wadi Ibn Hammad. A detailed ethnographic survey of farmers and pastoralists in the area was carried out during the course of the IFAD project, gathering information from interviews with 366 respondents. Information has also been provided by Lancaster and Lancaster (1995) from their extensive ethnographic study of the nomadic pastoralists in the Khirbet Faris and Wadi Ibn Hammad region. This has been supplemented by data on the nature of agricultural variables gathered from interviews, conducted by the author and a local translator, with local farmers during the 1993 and 1995 study seasons of this project.

1.3.1. Cultivation practices:

Land-use in the study area can be categorised into different areas of use, cereals being the major crop, as is shown in table 1.5.

Table 1.5: Land use in the Kerak region (source: Feasibility study: Kerak-Tafila Development Region. JICA, 1990, In: Blench, 1995):

Land use	**Percent of Land Area**
Field crops	59.9
Olives	12.8
Grapes	7.6
Other Fruits	1.7
Vegetables	17.6
Other	0.8

The farming systems in the Kerak region essentially follow the agro-climatic zones and more specifically the altitude. There are four major types: plateau, wadi sides, wadi bottom and the Ghor. This represents a fall in altitude of some 900m from the plateau to the Ghor. The agriculture on the Plateau relies almost entirely on rainfall, but the other farming systems benefit from accumulated water through irrigation strategies. The crops cultivated in the Kerak region are extremely varied, although the majority are cultivated in very small areas and certain crops predominate. There is a small set of 'traditional' crops, such as durum wheat and six-row barley, olive and certain pulse crops (lentils, chickpeas, beans) and a large number of recent introductions, such as vegetable crops, notably tomatoes. Today most of the plateau region is given over to rain-fed cereal production, with olives and almonds as perennial crops. Pulses, especially lentils and chickpeas are often part of the cropping cycle. Descending into the wadi, increased groundwater makes possible the cultivation of a wide variety of fruit trees and vegetables.

Where rainfall allows, macaroni wheat (*Triticum durum*) tends to replace barley (*Hordeum sativum* - 2 and 6 row) as the preferred cereal for domestic consumption. Both crops may be sown on a single farm, although the greater drought tolerance of barley provides a better insurance for farmers given the uncertainties of rainfall. The relationship of crop cultivation to agro-climatic zone is illustrated in table 1.6, for selected crops. This shows how crops grown today are influenced by the micro-environments of the Kerak region, with mostly cereals on the cooler, wetter plateau and more market gardening in the hotter, drier, irrigated wadis. This may be comparable with the situation in the past if new tropical crops were indeed introduced in the Islamic period, with exotic crops utilising the hotter, more humid land of the wadi bottoms and Ghor under irrigation.

Table 1.6: Area of selected crops cultivated in relation to agro-climatic zone (after Blench, 1995):

Mean area (dunums*) of crop cultivation in 1995				
Crop	**Plateau**	**Wadi sides**	**Wadi bottom**	**Ghors**
Field crops				
Barley	41.4	36.9	11.2	5.9
Wheat	42.3	26.6	8.9	3.8
Pulses				
Lentils	3.0	2.8	0.5	0.0
Vegetables				
Tomatoes	1.6	0.9	5.6	13.6
Fruits				
Watermelon	-	-	-	0.1
Grape	1.0	2.8	6.2	-
Tree crops				
Olive	6.0	5.1	n/a	-
Fruit trees				
Citrus	0.4	-	-	-

* 1 dunum = 0.1 hectares

In interviews, the reason given for growing irrigated cereals in the wadi bottoms, when the flat expanse of rain-fed plateau above was devoted to large-scale cereal production, was the fairly stable price of wheat grain. It was said that the use of irrigation water on the crop caused it to be taller and more dense and, therefore, more productive. Mean yields from the cropped area, indicated by farmers during the IFAD project, showed that wheat and barley yields are about twice as high under irrigation in the wadis than under dry-farmed conditions on the plateau. With vegetable cultivation, some years could be quite profitable but the market price is variable, therefore, choosing a 'vegetable only' strategy was considered to be risky. Some farmers also said they were too poor to grow vegetables and could not afford the initial outlay of black plastic pipes and sheeting required for irrigating and minimising water loss (see section 1.3.4). The choice of crop was very much dependent on economic considerations, choosing a mixed strategy to spread the risks in an environment marginal for cultivation. Such risk spreading strategies will be looked for in past agricultural activities.

Several variations of arable crop rotation are practised in rain-fed farm systems on the plateau. Fallow land is left uncultivated under traditional farming practice and represents about a third of the cultivated land at any one time. The different rotation systems used on the plateau are summarised in table 1.7.

Table 1.7: Rotation practices on the Kerak Plateau (after Blench, 1995):

Rotation Type	**% of Farmers**
Wheat/lentils	26
Wheat/fallow/lentils	7
Wheat/fallow	30
Wheat/fallow/barley	20
Barley/fallow	9
Wheat/lentils/barley	8

Interviews with farmers from Wadi Ibn Hammad revealed that cereals were winter sown. Many fields were continuously sown with cereals though interviews also revealed the practice of crop rotation. This involved winter cereal cultivation alternating with summer vegetable cultivation in some fields (see table 1.8).

Table 1.8: Rotation practices in Wadi Ibn Hammad:

	Crop	**Sowing time**	**Harvest time**
Year 1	Winter Fallow		
Year 1	Vegetables (viewed as rest period)	Spring (March/April)	Summer
Year 2	Durum wheat, occasionally 2 or 6 row barley	Winter (December/January)	Summer (May/June)

Traditional agriculture is still practised in the area with relatively few inputs providing continuity with past agricultural practices. The use of herbicide remains relatively rare and most weeding is still done by hand. The use of pesticides is more common. Manure is principally gained from the grazing of pastoral herds on stubble. There is a strong correlation between region and expenditure on inputs (irrigation, herbicide, pesticide and chemical fertiliser). Essentially, farmers in the Ghor spend the most and those on the plateau the least. According to Blench (1995) the reason for this relates to the certainty of water availability and the types of crops grown because of this. Farmers in the Ghor can depend on water, since it derives from springs not rain, and, therefore, grow vegetable crops requiring many inputs. On the wadi sides, water can almost certainly be depended on from aquifers. In this region vegetable crops and cereals are rotated under irrigation. On the plateau, however, farmers are uncertain about the quantity and duration of rainfall. It is, therefore, increasingly less attractive to invest in expensive inputs when there is a decreasing certainty of harvesting a crop. Cereals and pulses are mostly grown on the plateau as these require fewer inputs than vegetable crops.

The most widespread practice is to leave crops unattended after sowing until harvest, or at most carry out a single weeding of grain legumes. The labour intensive approach of harvesting by hand is carried out by the majority of farmers in the hilly upland regions of the Kerak plateau and the wadis. The steepness of slopes and stony nature of the soils on the majority of farms restricts the use of combine harvesters. For this reason animal-drawn ploughs are still used in the region to prepare the soil. On the flatter plateau fields, tractors and combine harvesters are sometimes used. The modern weed flora should be fairly comparable to weed assemblages found in archaeological samples due to the lack of mechanisation or chemical inputs that may alter field weed floras over time.

Reliance on the highly variable rainfall in the Kerak region leads to extremely high risk farming in which a good year may occur only once in a four or five year period, and a drought which results in partial or total crop failure may have a similar probability. Yields fluctuate widely and closely reflect the seasonal variations in rainfall. The cropping patterns and systems established by farmers have evolved in response to these marginal production conditions, and represent various forms of risk management depending on the locality and land resources available rather than being conditioned by government impositions such as subsidies etc. The techniques employed in the region include:

- ⇒ The use of bare fallow (where no crop is grown but the ground is tilled) in rotation as a means of conserving moisture for the subsequent cereal crop.
- ⇒ The use of low input technology to minimise investment losses during poor years.
- ⇒ Wide spacing of fruit trees usually accompanied by under-sown cultivation (e.g. chickpeas) between trees, as a means of conserving moisture (as evaporation will be reduced for the pulse crop due to the shade provided by the trees).
- ⇒ The cultivation of a variety of crops which can produce yields under different conditions (for instance barley can withstand lower rainfall than wheat) spreads the risk of crop failure in a low rainfall year.
- ⇒ Common reliance on small ruminants provides income from meat, wool/hide and dairy products during poor rainfall years when crop production is low.

One of the major areas of interest is whether this sort of mixed economy is a continuation of earlier economic activities or a more recent practice.

1.3.2. Pastoralism:

Although crop farming is the principal activity of householders in this region, livestock production is an important secondary activity (Blench, 1995). Where arable farmers also have small ruminants, the cereals are viewed as an integral part of a crop/livestock farm production providing an important source of animal feed. In good rainfall years, the cereals will be harvested for grain and the stubble made available for grazing *in situ* by livestock. In poor rainfall years, where the farmers anticipate yields of 500 kg/ha or less, the 'failed' crop will be directly grazed or may be cut for hay and stored for feeding to stock at the farm. Similarly, the 'straw' of grain legumes also represents an additional source of fodder for small ruminants.

In the Kerak region, ruminants owned by settled farmers are kept penned for most of the time with feed brought to them in the form of barley or other cereal and vegetable residues. For short periods during the summer they are taken to graze the wadi slopes. After the harvest they are occasionally taken to graze the stubble left in fields on the plateau and wadi sides. The majority of animals in the region, however, are kept by the pastoralists, Bedu (nomads), who range east and west along the wadis. There are a series of migration patterns from the Ghor, where pastoralists spend the winter with their flocks, up the wadis exploiting the natural vegetation and onto the stubble fields on the plateau after the cereal harvest (June/July). The exchange of manure for fodder is extremely important in the rain-fed areas because of the low fertility of much of the soil and the need to use dung as fuel in an area lacking in trees. In autumn and winter the pastoralists rely on grain, bran and purchased straw as fodder for their flocks.

1.3.3. Interactions between farmers and pastoralists:

Lancaster and Lancaster (1995) carried out detailed ethnographic research in the area around Khirbet Faris, describing the traditional socio-economic practices of the region to provide an analogy for the past. Their research describes a multi-resource economy with arable cultivation, herding, irrigated orchard and vegetable cultivation being carried out in the same year. They suggest that this socio-economic structure is common in a marginal environment and emphasise the symbiotic relationship between settled mixed farmers and nomadic pastoralists.

According to their research, varied environmental niches in the Kerak region - the Ghor, wadis and plateau - provide different types of economic resources. Mobility between these resources is essential for nomadic pastoralists. These pastoralists tend sheep, goats, camels, horses, mules and donkeys, and are an important aspect of the economy. The feed for these animals comes partly from wild pasture but must be supplemented by cultivated fodder, thus the interaction between pastoralism and settled cultivation is necessary. The local diet is based on grain and dairy products and the combination of the two provides a stable form of production. Flexibility of mixed farming production (such as the cultivation of barley rather than wheat as it is more hardy, the use of dried fruits as a trading item, and animal herding) and the mobile, nomadic lifestyle of pastoralists provides economic security. Habitual use of land builds up claims to control, and the enhancing of resources with wells, cisterns, irrigation systems etc, confers ownership. Share partnerships operate whereby the owner of the land (settled farmers) and providers of resources (nomadic pastoralists) have an equal share in the produce. In this way pastoralists interact with agriculturalists by providing inputs such as plough animals, manure from their herds and labour. An interesting question is whether or not such interaction existed in the past.

1.3.4. Irrigation practices:

The introduction of irrigation is of interest to the debate surrounding the influence of Islamic expansion on agriculture, especially in marginal environments. The modern ethnoarchaeological study at Wadi Ibn Hammad will be used to help look for the use of irrigation from the archaeobotanical record at Khirbet Faris in the Islamic period. Irrigation is not currently practised on the plateau edge around Khirbet Faris, as there is no water source. However, there are underground cisterns, currently in disrepair, that could have been used for small-scale irrigation of the terraced fields surrounding the site as is seen in nearby wadis. Rainfall on the plateau is generally sufficient for dry-farmed winter cereal and pulse crops, though not for summer crops.

In Wadi Ibn Hammad, interviews with farmers showed that there were two types of irrigation being practised today, depending on whether the fields were continually cultivated with cereals or whether the cereals were rotated with vegetable crops. The first was the traditional annual gravity-fed flood method, the second where vegetable crops were irrigated using a modern pipe-feed system (*tif-taf*) followed by unirrigated cereal cultivation.

Most of the irrigation water derived from the main spring in Wadi Zuqaiba (the wadi directly below the site of Khirbet Faris, which feeds into Wadi Ibn Hammad). Water was allocated to farmers by means of time slots except where small springs occurred on a farmer's land, as that water would be theirs to use freely.

Gravity-fed flood irrigation was achieved by channelling spring water from the wadi using aqueducts. Typically there were two irrigations during the growing season of continuously cultivated winter cereal crops. Water was allowed to flood the field along channels from several entry points along the watercourse. Local informants described the timing of the two irrigations as generally occurring when the crop was 20/30cm tall, and later on when the crop was 70/80cm tall. This practice is referred to as full irrigation in this study as these fields were continually used for cereal cultivation and, therefore, irrigated every year with the water being directly applied to the winter cereal crops. Figure 1.10 illustrates the technique of gravity fed irrigation. The concrete irrigation channels were built in 1968 by an American agricultural aid group under the direction of the Jordan Valley Water Authority and were finished in 1984. According to local farmers the channels already existed but were made of stone and earth and the older farmers always remember the irrigation system being in use.

Vegetable crops were watered using modern pipe feed irrigation with water pumped from storage tanks. The pumped water passed through a main pipe from which led sets of small rubber hoses set to drip on individual plants partially covered by black plastic sheeting to retain moisture. After the vegetable harvest these fields were ploughed and winter cereals sown in December/January with no further irrigation. Irrigation, therefore, only took place every other year in these vegetable rotated fields and this irrigation was not directly applied to the winter cereals. This second watering regime is referred to in this study as biennial irrigation. Figure 1.11 illustrates the technique of pipe-feed irrigation.

This socio-economic review, using ethnographic sources, demonstrates the marginality of the region for agriculture. In this marginal zone the interaction between nomadic pastoralists and settled farmers is a vital aspect of a mixed agricultural economy designed to spread the risks of production in uncertain environmental circumstances. It appears that the influence of government, through subsidies, is of secondary importance to this socio-economic structure. This ethnographic information will be of use when interpreting the Khirbet Faris archaeobotanical data, especially as many of the practices observed today – the use of irrigation, cultivation of a variety of crops, use of different land resources and the mixed nature of the economy – are pertinent to the reconstruction of agriculture in the Islamic period and the debate surrounding continuity or change.

Figure 1.1: The research design:

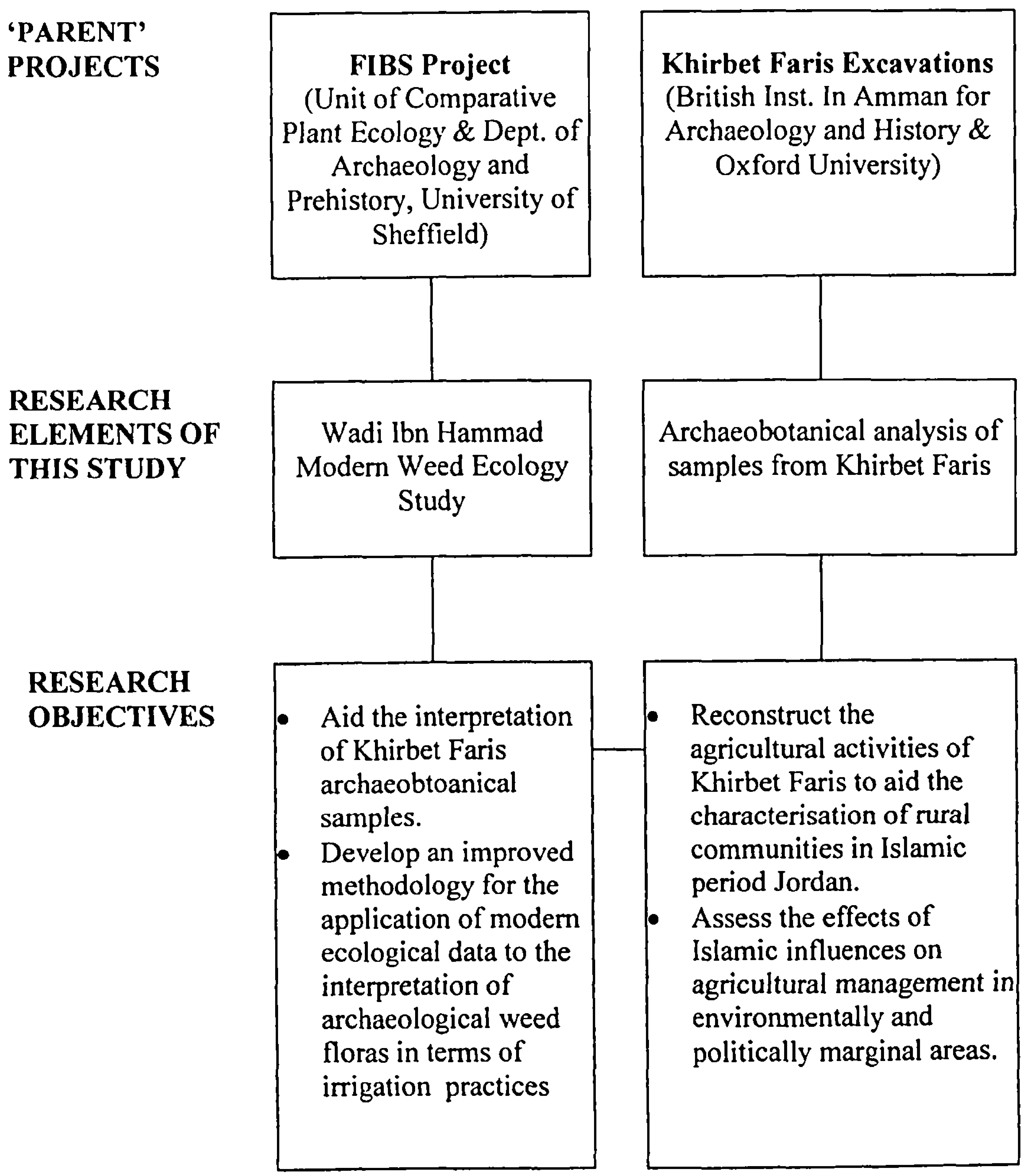


Figure 1.2 Jordan and the major topographic zones

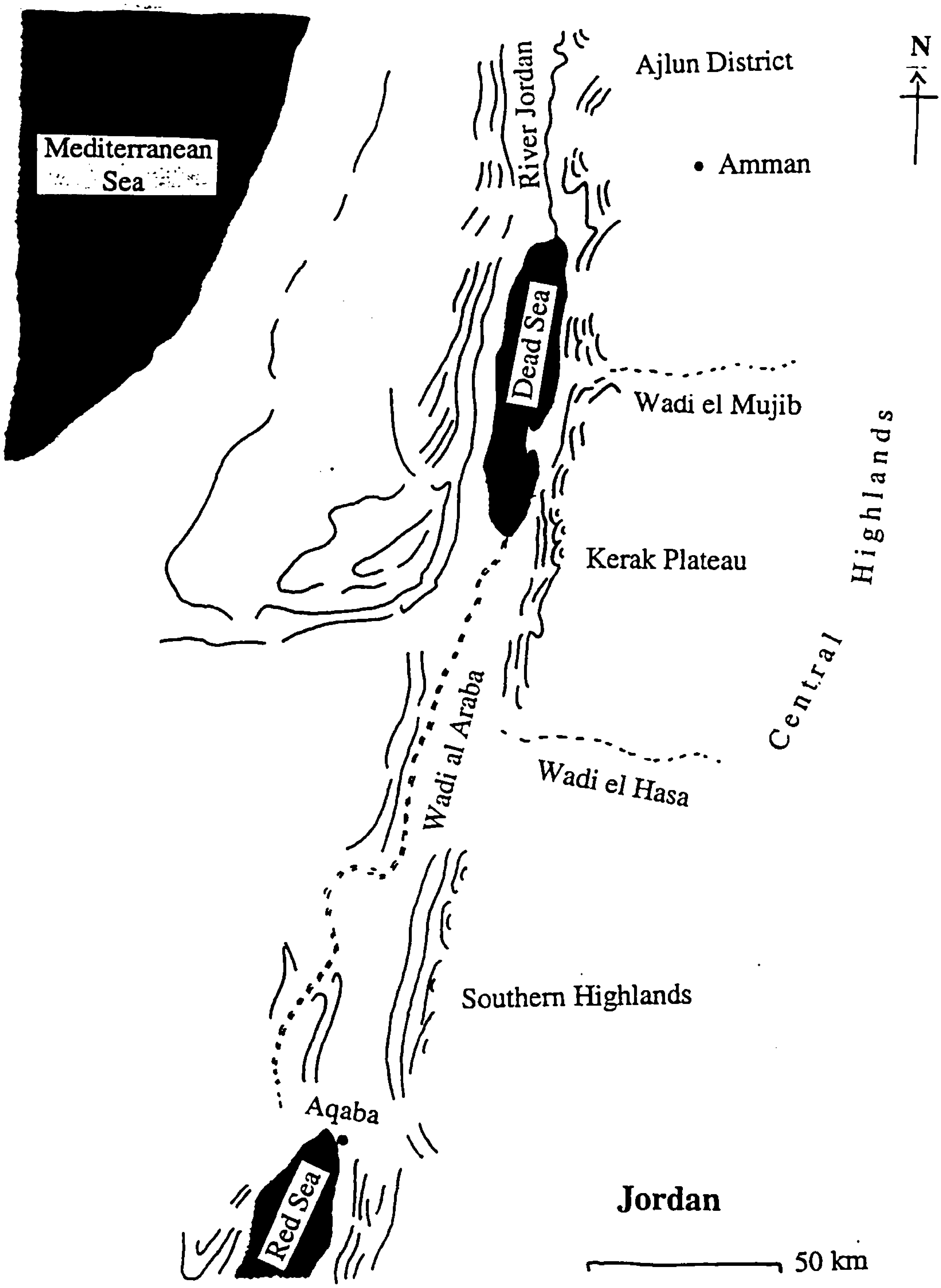


Figure 1.3 Map of the Kerak region with the locations of Khirbet Faris and Wadi Ibn Hammad

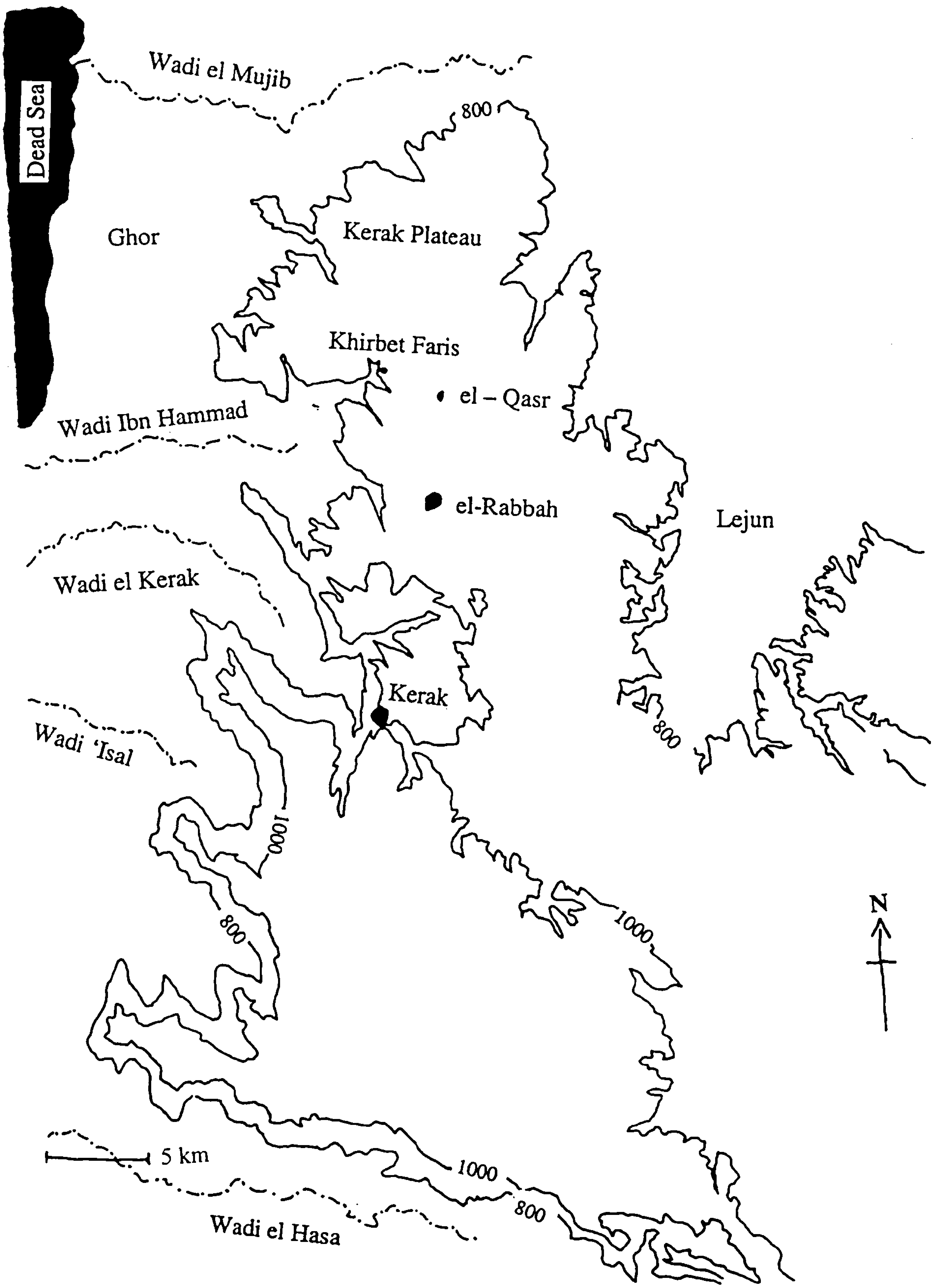


Figure 1.4 Summary of the environment of the Khirbet Faris and Wadi Ibn Hammad study area

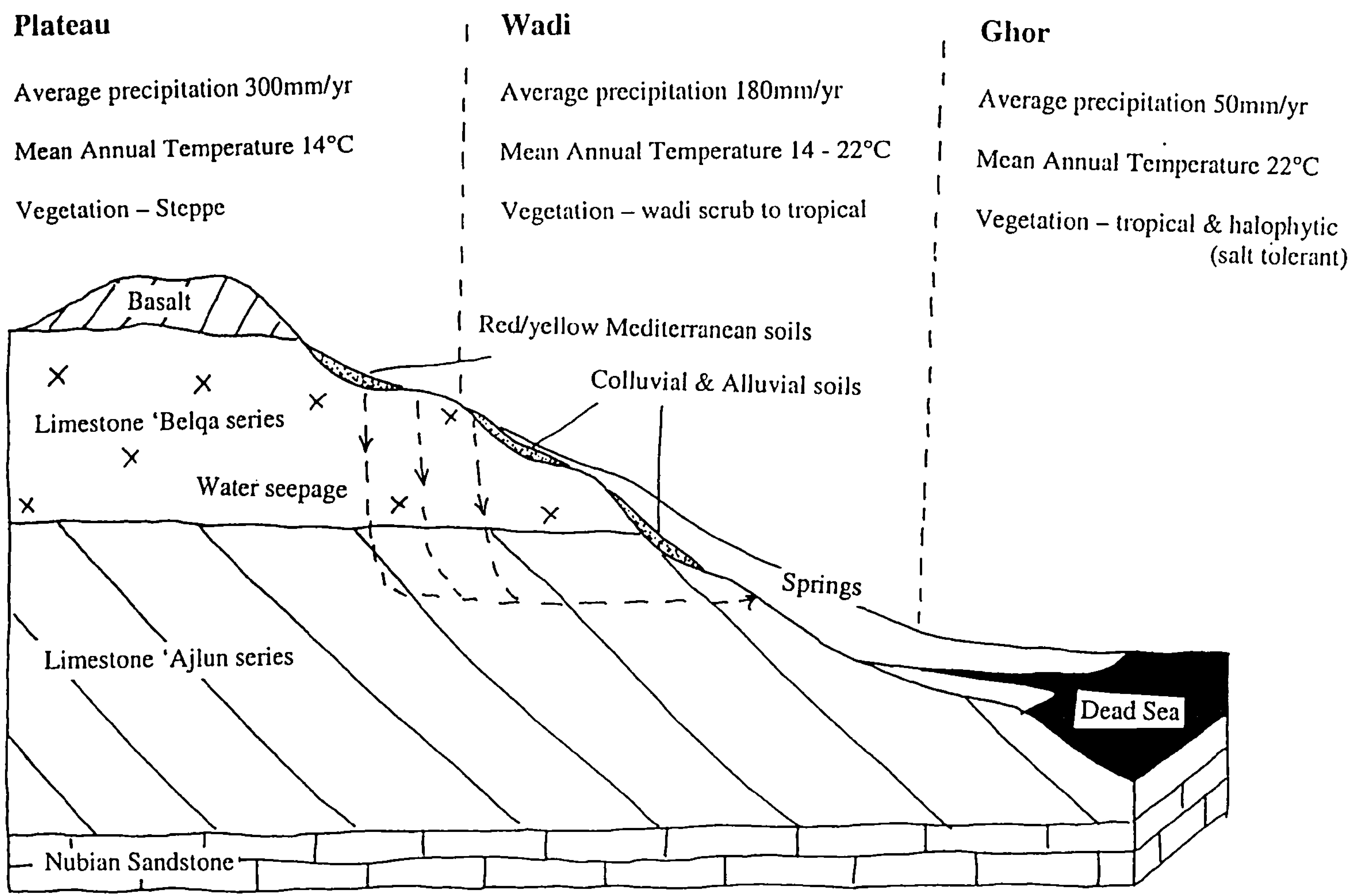


Figure 1.5 Geology of the Khirbet Faris and Wadi Ibn Hammad study area

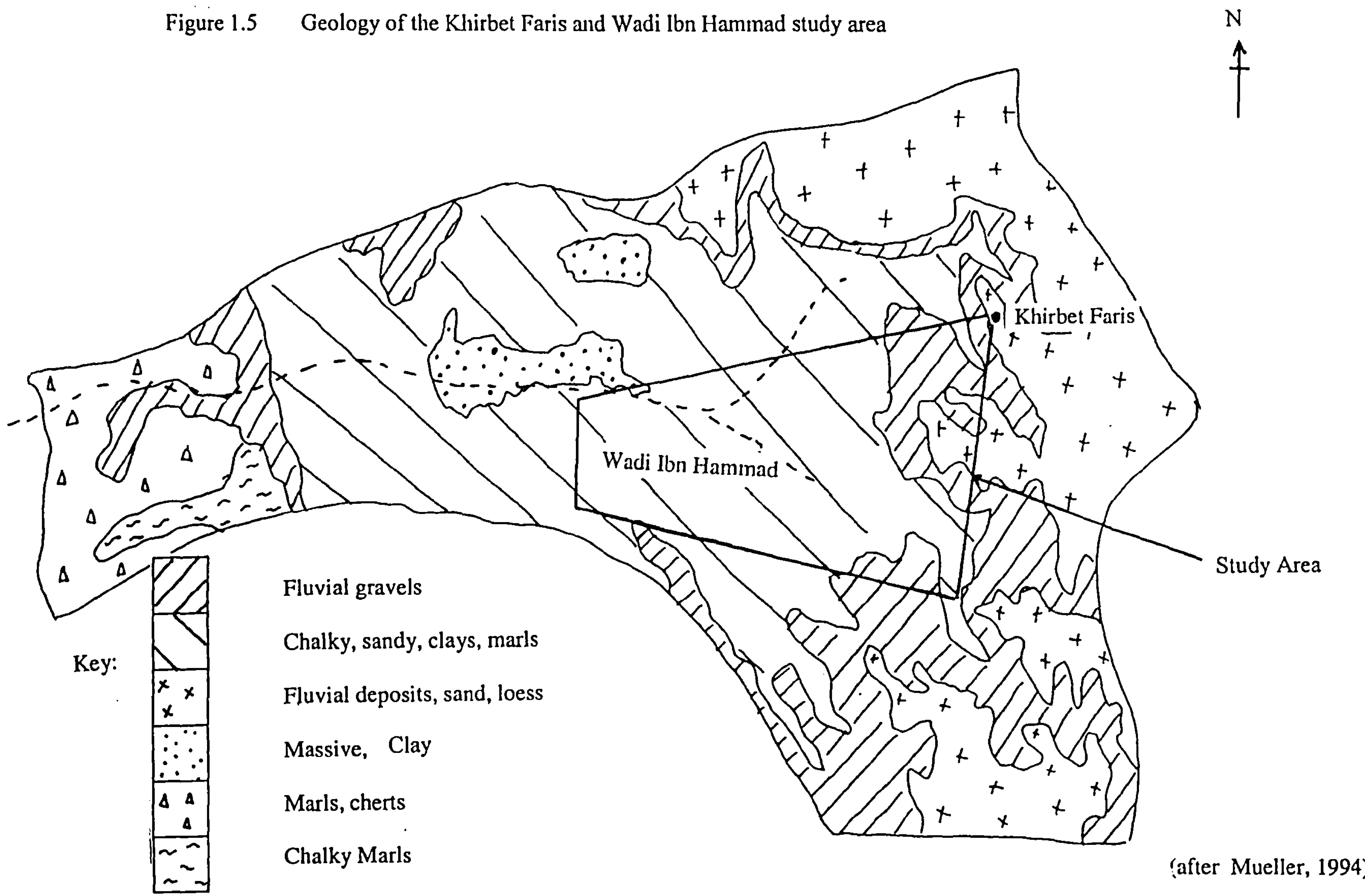
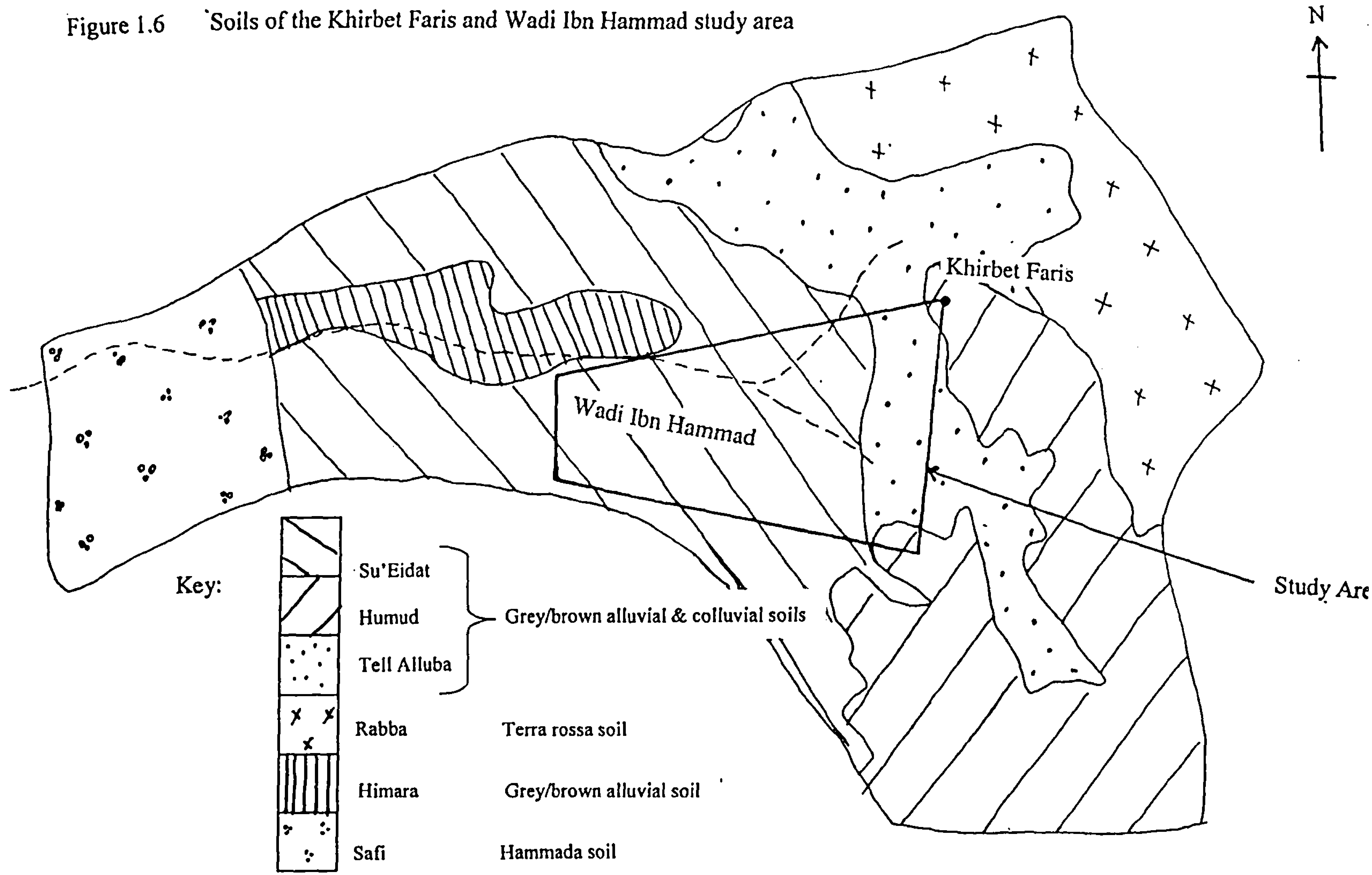
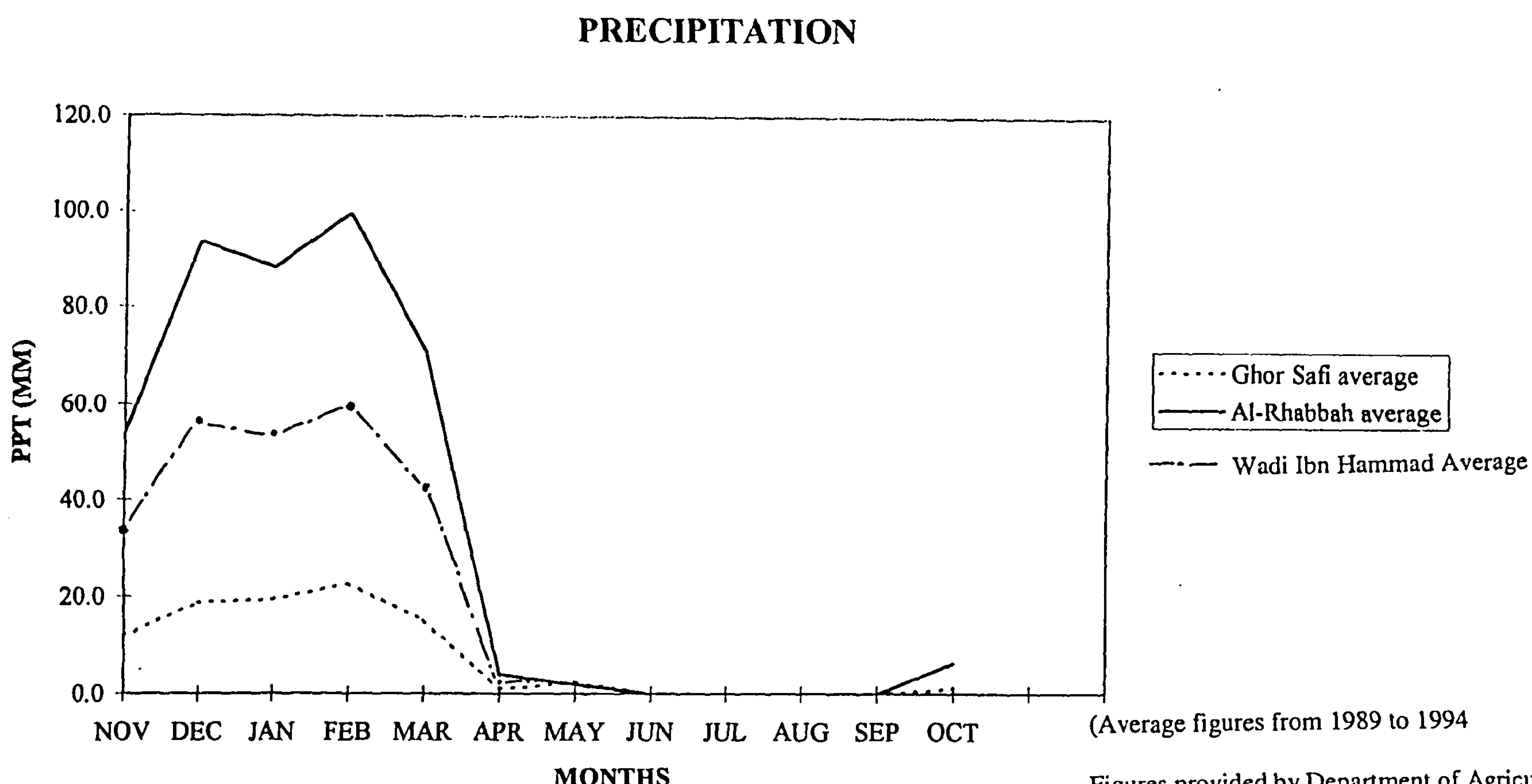


Figure 1.6 Soils of the Khirbet Faris and Wadi Ibn Hammad study area



(after Mueller, 1994)

Figure 1.7 Rainfall figures for Kerak and the Khirbet Faris and Wadi Ibn Hammad study area



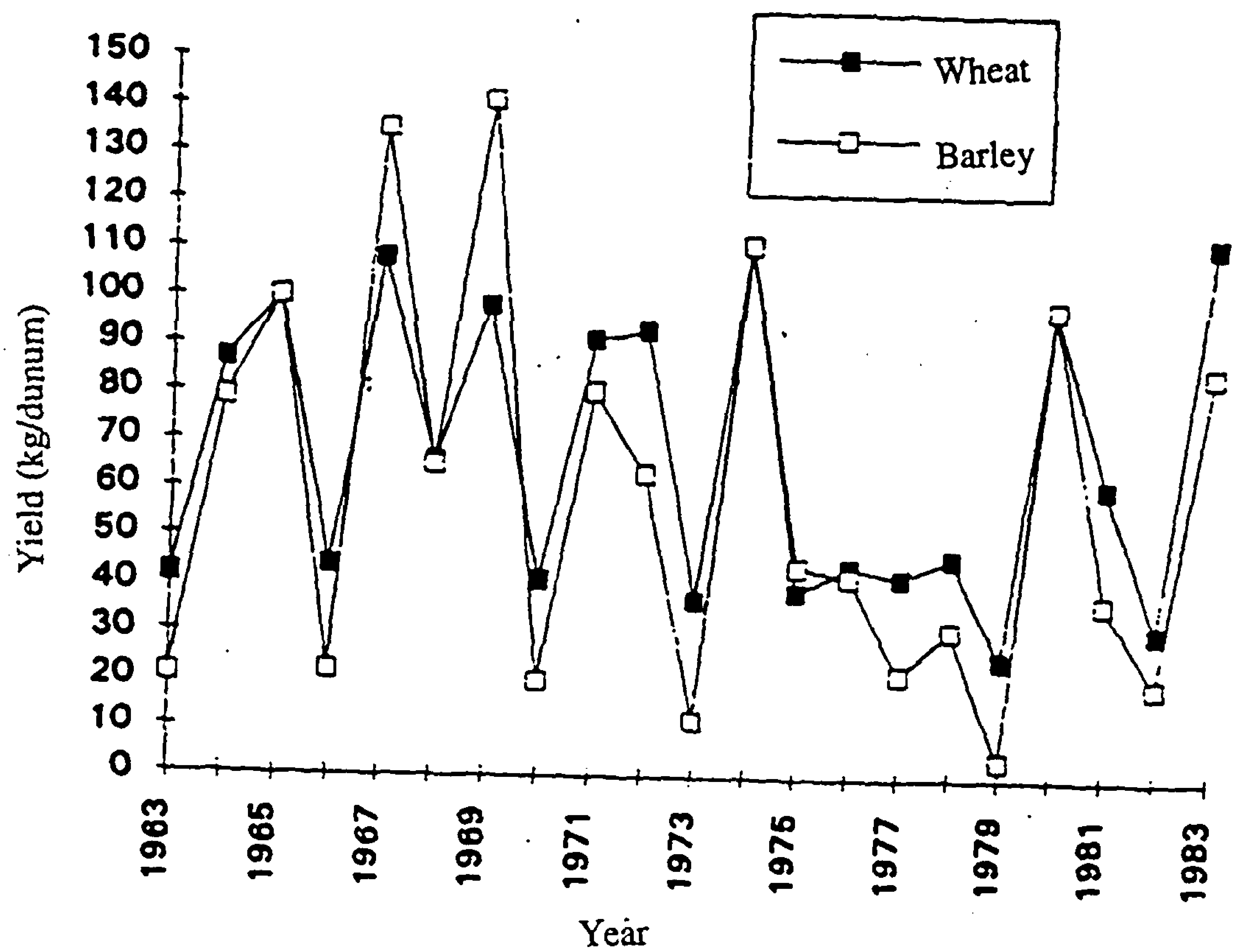
(Average figures from 1989 to 1994

Figures provided by Department of Agricul

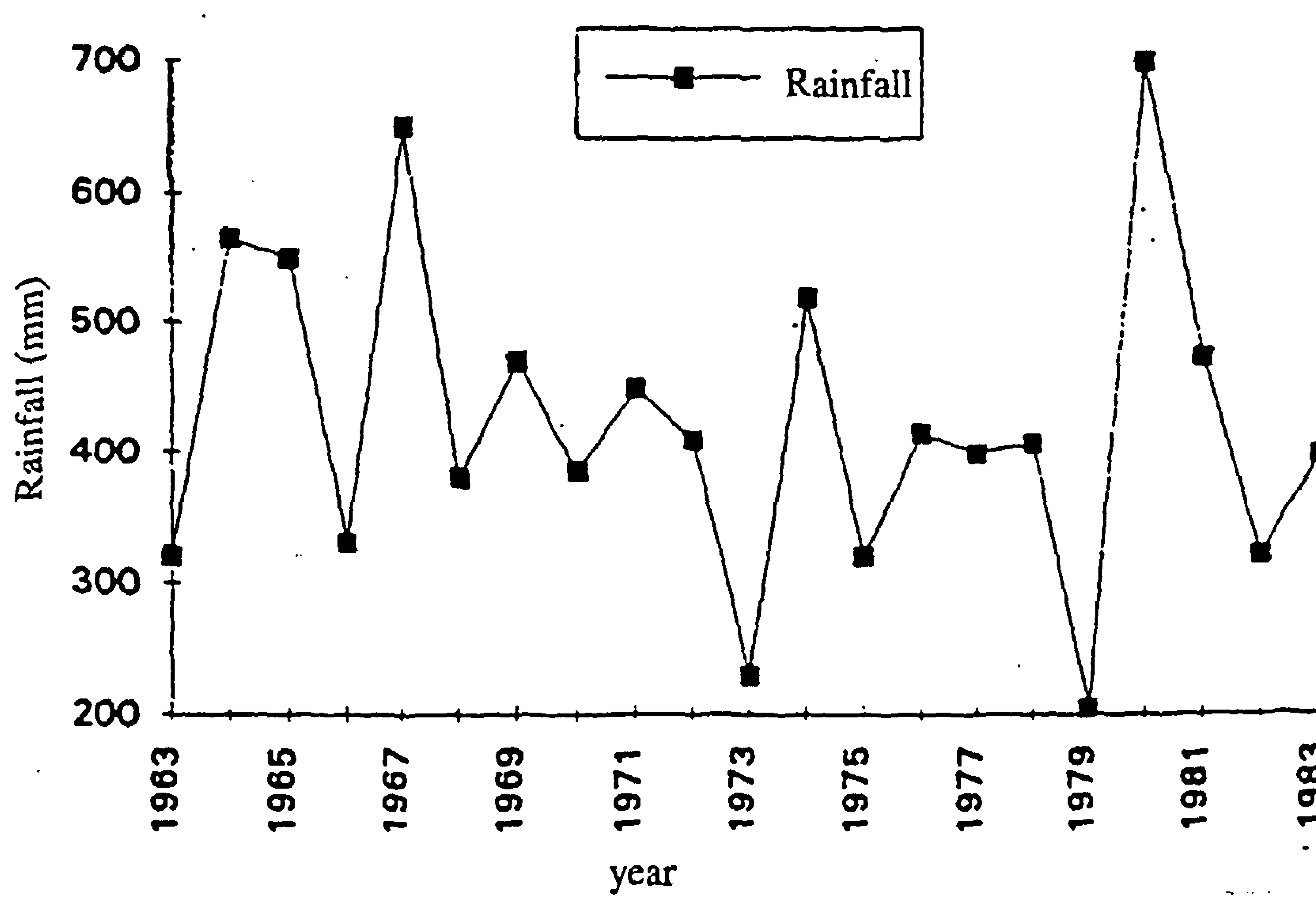
Hashemite Kingdom of Jordan, 1995)

Figure 1.8 Rainfall figures compared to crop yields

Wheat and Barley Yields in Irbid, North Jordan (1963-1983)

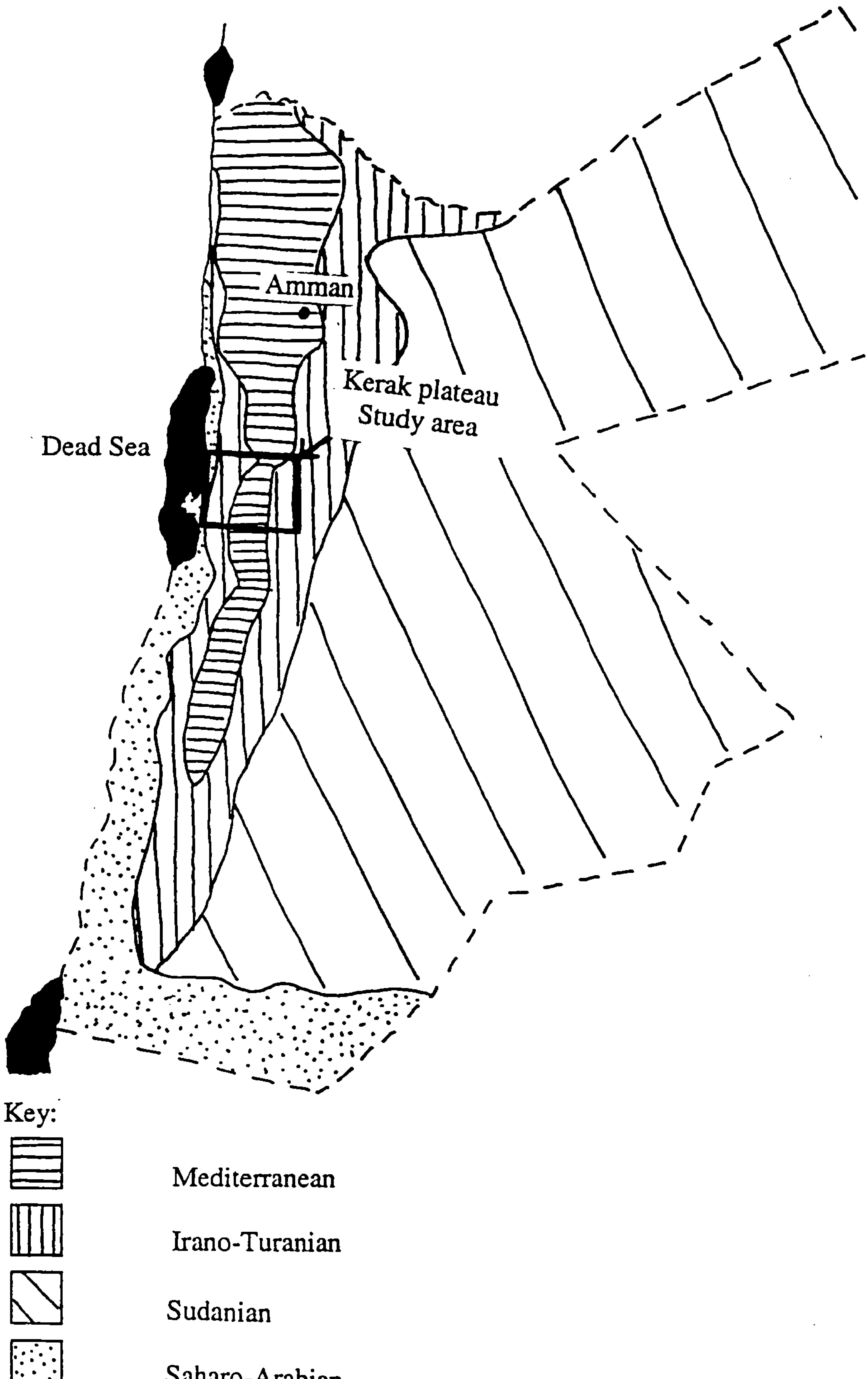


Annual Rainfall in Ribid, North Jordan (1963-1983)



(after Blench, 1995)

Figure 1.9 Vegetation zones of the Khirbet Faris and Wadi Ibn Hammad study area



(after Al-Eisawi, 1985)

Figure 1.10: Gravity-fed irrigation in Wadi Ibn Hammad:

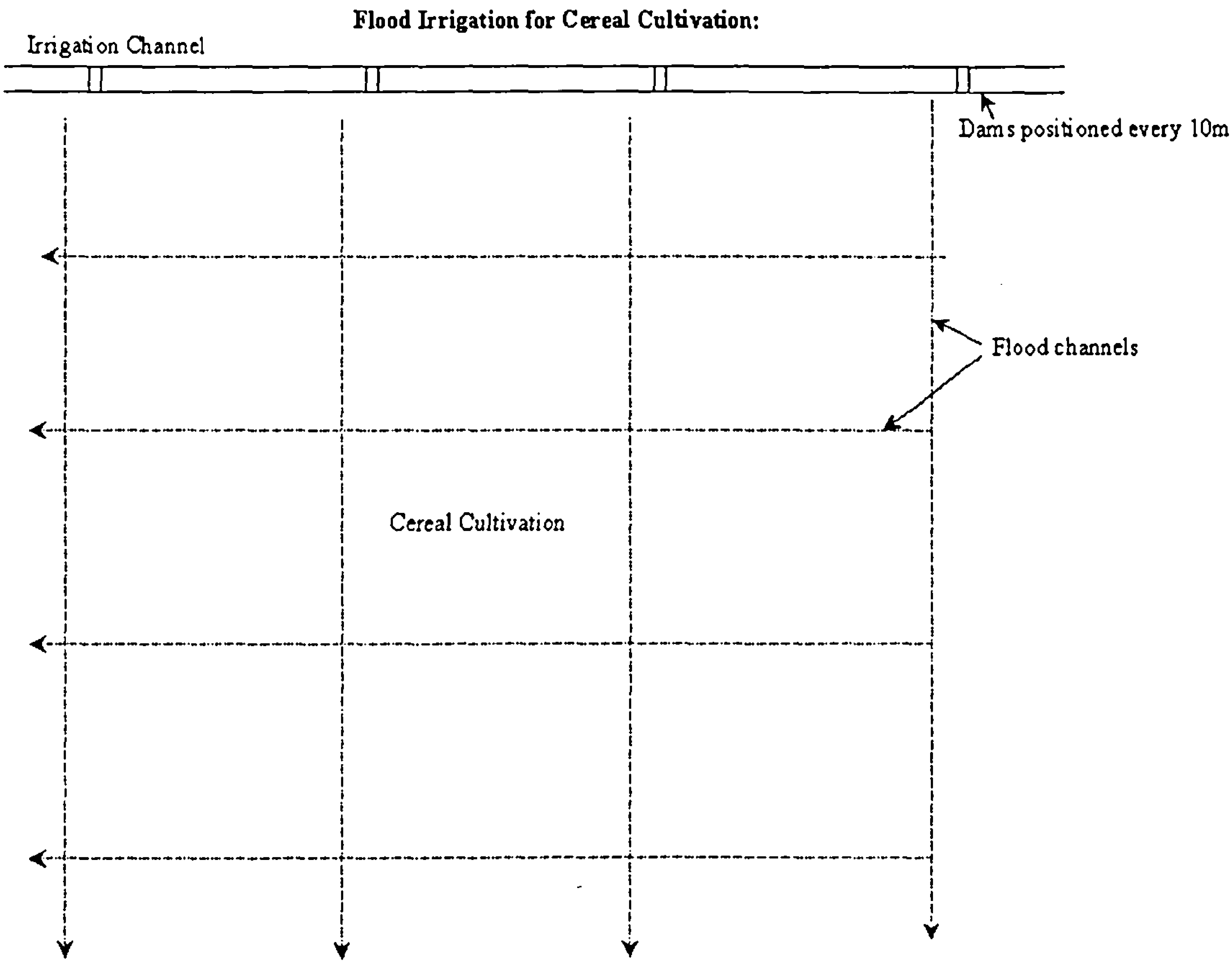
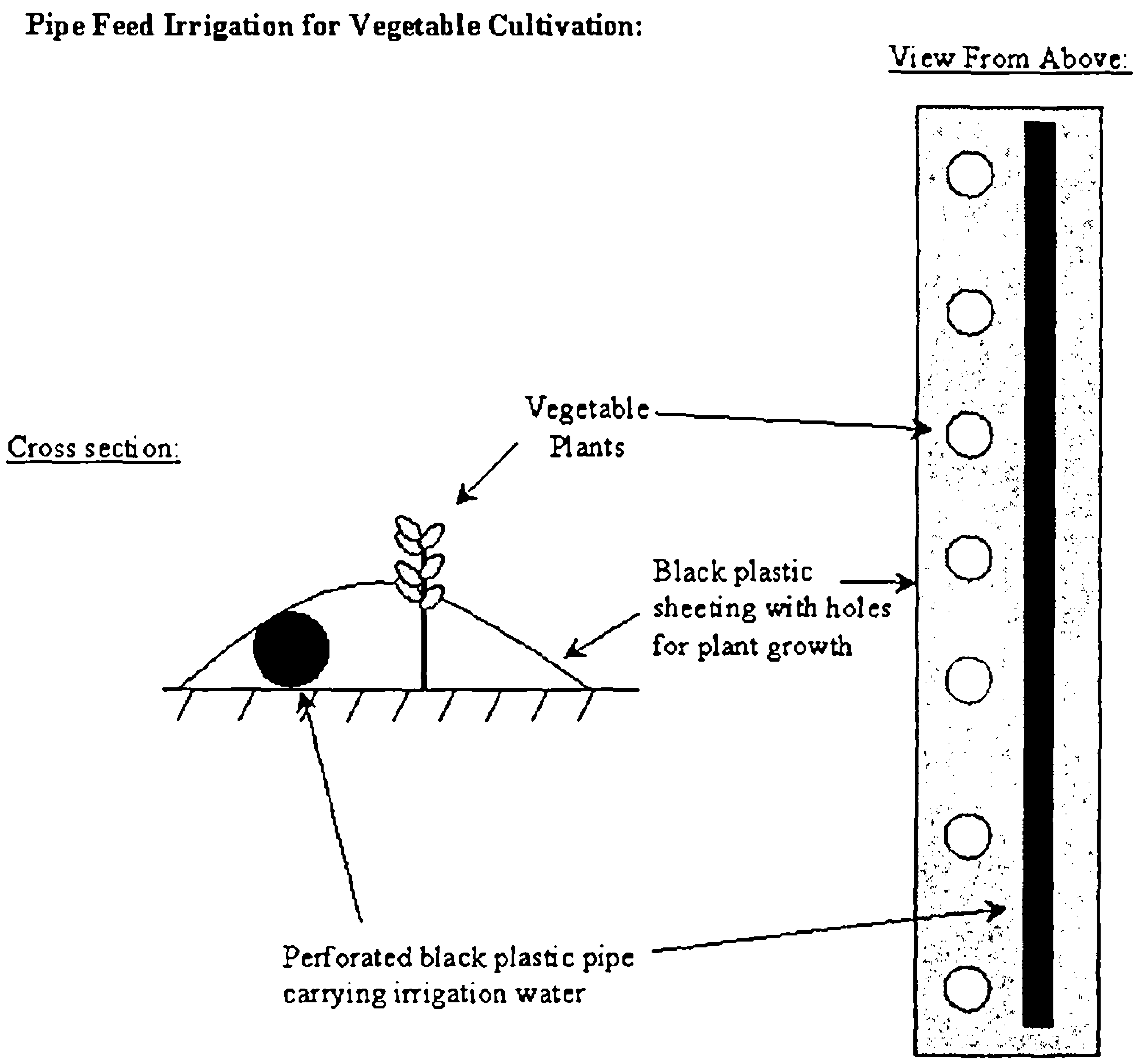


Figure 1.11: Pipe-feed irrigation system in Wadi Ibn Hammad:



Chapter 2: Archaeology of the Kerak Plateau from the Byzantine to early Ottoman period

The Islamic period of the Kerak plateau relates to a time in history dating from the 7th to 16th centuries. It is a complex period characterised by conflict between many different ruling factions at different times. A brief outline of the different phases of the social history, AD 324 - 1918, is given in table 2.1. The samples from Khirbet Faris were phased according to pottery found in the contexts from which they derived. Pottery from different periods was usually mixed but five major categorisations could be made: 5th to 9th century (Byzantine to Abbasid period); 5th to 13th century (Byzantine to Mamluk period); 13th century (Ayyubid to Mamluk period); 14th to 17th century (Mamluk to early Ottoman period). The settlement pattern and agricultural practices on the Kerak plateau during these phases will be discussed in detail below.

Table 2.1: Social history of the Kerak Plateau from AD 324 to 1918 (after Miller, 1991; Homes-Fredericq and Hennessy, 1986):

Time period:	Major events:
Byzantine (AD 324 - 636)	Clash between Byzantine and Islamic armies near Mota, Kerak Plateau; Arab conquest AD629, by AD 640 all of Palestine was under Muslim control
Umayyad (AD 636 - 750)	Kerak had a strategic position between the political capital of Damascus and the religious capital of Mecca, Arabic replaced Greek as the dominant language, Islam replaced Christianity as the dominant religion
Abbasid (AD 750 - 969)	The capital of the Arab world changed to Baghdad
Fatimid (AD 969 - 1099)	Abbasid rule fragmented, Palestine was ruled by Egyptian Fatimids. Earliest references to Maāb (Kerak) as a region, with the capital el Rabba (<10km S.E. of Khirbet Faris)
Crusader (AD 1099 - 1187)	Kerak and Shaubak Crusader castles were built. Kerak had a prominent location in Frankish - Arab affairs. AD 1187 Kerak fell to Ayyubid leader Saladin at the battle of Hattin
Ayyubid (AD 1187 - 1263)	Kerak was an Ayyubid (Syrian) stronghold against Mamluks (Egyptians) until conquered by Baybars in AD 1263
Mamluk (AD 1263 - 1515)	Kerak was the administrative centre for Mamlukah (parts of Transjordan and Hejaz). By AD 1300 Mamluk strength began to decline.
Ottoman (AD 1515 - 1918)	Inconsistent Turkish power in the Kerak region.

2.1. Settlement and economy on the Kerak plateau from the Byzantine to early Ottoman period:

The reconstruction of agricultural practices attempted in this thesis must be set in the wider context of socio-economic patterns and settlement fluctuations on the Kerak plateau during the Islamic period. It is within this context that the archaeobotanical remains from Khirbet Faris will be interpreted.

Islamic expansion over this area took place from the 7th century AD. Travellers to the region, in the 19th century, believed the ruined settlements they saw were the result of the Arab invasion of nomads destroying settlements in their wake (Tristram, 1874). Archaeological surveys, however, have shown that settlements which existed before Islamic expansion were occupied during the Islamic period. Archaeologists have used this survey data, however, to say that settlement occupation fluctuated in this period. It has been argued that periods of intense settlement during the Byzantine, Ayyubid-Mamluk and modern times alternated with times of sparse settlement in the Umayyad-Abbassid, Fatimid/Crusader and Ottoman times (Miller, 1991; Worschech, 1985, 1986). Evidence for settlement fluctuation has been obtained from field surveys, using pottery scatters as evidence for sites. This evidence is summarised in table 2.2.

Table 2.2: Numbers of sites on the Kerak Plateau from the Byzantine to early Ottoman period (evidence from Field Survey, Miller, 1991):

Period	Dates (AD)	Number of sites	With 5 or more sherds
Late Byzantine	491	132	54
Ummayad	640	37	3
Abbasid	750	6	1
Fatimid / Crusader	969	34	9
Ayyubid/Mamluk	1174	152	74
Ottoman	1516 - 1918	27	4

The peaks and troughs in settlement frequency have been attributed to the rise and fall of central political power. When the state control was strong, it could stem the tide of nomads from the steppe region and, when control was weak, nomads were able to drive out settled populations (Ibach, 1987; Macdonald, 1988, 1992; Miller, 1991; Brown, 1992). Regional authority "probably more than anything else has determined when the villages expand in number along the desert frontier and approach maximum utilisation of the cultivable land and when they would be abandoned" (Miller, 1991:5,6). Miller's basic criterion for stable cultivation is the maintenance of security provided by the infrastructure of regional authority.

Johns (1994) sees this interpretation of the archaeological evidence as adhering to the Orientalist myths of nomadic peoples: the state being located far away in the Mediterranean regions with the steppe being over-run by nomads, ready to invade farmed land at any opportunity. He sees this notion as ethnocentric in that it assumes agricultural stability can only be achieved through conventional western ideas of centralised government, as opposed to tribal control. The underlying sentiment is reminiscent of early ideas about 'civilised' and 'primitive' societies with a distinctly hierarchical tone. This generalisation of the relationship between the nomad and settler denies the complexities of the diverse social and economic strategies employed by those living in an environmentally marginal zone (Lewis, 1987; Lancaster, 1981; Lancaster & Lancaster, 1991, 1993, 1995).

The relationship between nomadic pastoralists and settled farmers has often been viewed as competitive and the contraction and expansion of settlement on the plateau edges has been used as evidence of this. However, according to Miller (1991) there exists an 'age old dynamic' between sedentary farmers and nomadic pastoralists. In environmental terms there is a convergence zone for farmers and pastoralists where precipitation becomes insufficient for agriculture but can support pasture. In this area subsistence strategies may be integrated. An element of symbiosis exists in most ethnographic cases of agricultural/pastoral relationships in the form of trade and other socio-economic practices (Lancaster and Lancaster, 1995). Farmland after harvest provides good grazing for herds in the form of stubble. In return the field is manured and dung provided for fuel. This has led to established cycles of transhumance for nomadic tribes (see section 1.3.3). There are also tribes that include both nomadic and sedentary elements contemporaneously (Lancaster and Lancaster, 1995). Indeed, this is the situation observed in the study area currently.

Given these descriptions of the interdependency of beduoin peoples involved in both sedentary agriculture and nomadic pastoralism, it may be simplistic to assume such a well-established relationship would break down due to short term political fluctuations as is implied for the Islamic period. According to Lancaster and Lancaster (1995) this political determinism produces a one-dimensional interpretation of past events and the initiatives behind them. Political, economic, social and environmental factors should be integrated to appreciate the full range of interpretational possibilities. Archaeological sites should be located within their natural and cultural context to attain insight into issues of social and economic change or stasis. This archaeobotanical analysis, as part of a multi-disciplinary study, will provide insight into one element of the socio-economic context of Khirbet Faris in the form of a reconstruction of the agricultural system in the wider natural and cultural context of the Islamic period and Kerak location.

Until the excavations of Khirbet Faris, the only evidence for Islamic settlement in the Kerak region was from archaeological surveys. These field surveys are difficult to interpret as they are based on scant artefactual remains such as pottery scatters used to locate sites. There are many problems with the identification and classification of early Islamic pottery and there is little consistency between survey methods used by different field workers. This makes comparison between survey data problematic, and interpretation dubious.

Many of these surveys have been used as indicators of population and settlement density. Ibach (1987) and Miller (1991) both reported findings of over 100 sites in the Byzantine period, between 30 and 40 in the Umayyad and less than 10 in the Abbassid (see table 2.2). Ibach correlated this with evidence of a catastrophe, estimating a huge population fall from 70,000 to less than 5,000. However, Miller warns against drawing such precise conclusions from such sparse evidence.

Weaknesses with survey methods have encouraged more reliance on written sources (Johns, 1992). These surveys, however, should, wherever possible, be backed up by archaeological excavation, as written sources raise other problems such as bias towards the urban political sphere (Keller & Rupp, 1983; Macready & Thompson, 1985). To put Khirbet Faris in the setting of occupation in this region during the Islamic period (from Byzantine to early Ottoman times) a summary of archaeological and historical evidence for settlement in Kerak is presented below.

During the Byzantine period rich villages and farms are recorded in the surveys of the Kerak plateau (Ibach, 1987; Miller, 1991). The evidence suggests intense agricultural activity with long-term investment in the land such as the planting of olive groves. During this period agriculture expanded into marginal regions (Rosen & Avni, 1993). According to Johns (1994) it is clear that this boom during the Byzantine period was not due to increased state power, controlling the nomadic tribes. This was a period of relaxed administration in which the state withdrew authority and entrusted the region to Arab allies from the Steppe (Parker, 1986; Isaac, 1990).

It is claimed that many early Islamic sites have been missed in previous field surveys due to the difficulty of identifying the ceramic wares from this period (Johns, 1994). Therefore, many sites thought to have been abandoned after the Byzantine period were in fact occupied through the Umayyad-Abbasid periods, giving continuity of occupation through to the Ayyubid-Mamluk period (Brown, 1992). This contradicts the popular belief of an early Islamic (7^{th} to 12^{th} centuries) decline in population and settlement. When early Islamic sites have been excavated in Jordan they have shown continuity of settlement through the Abbasid period: Pella (Walmsley, 1982), Jarash (Gawlikowski, 1986), Amman citadel (Bennet and Northedge, 1977-78), Hesban

(Sauer, 1973), Dhiban (Tushingham, 1972), Khirbet al-Mafjar (Whitcomb, 1988), Mushatta (Grabar, 1987), al-Muwaqqar (Najjar, 1989). Also, the hand-made pottery that has been used to diagnose the Ayyubid-Mamluk period is now thought to have continued until the 17th century (Brown, 1992). Thus the supposed sharp increase in sites in the mid-Islamic period may, therefore, be an artefact of misinterpretation of ceramic material from survey data. Johns (1994) argues instead for more continuity of rural settlement throughout this period. The written sources seem to concur with these findings. Arab geographers of the time report that the region had many villages with almond and vine cultivation that would suggest long-term, reliable agriculture, with Zhugar, on the Dead Sea coast, an important market town (Donner, 1981).

Johns (1994) suggests the material evidence from previous surveys implies the early Islamic period on the Kerak plateau was one of steady economic activity, though not of the boom proportions of the Byzantine era, but perhaps much more in tune with the environmental marginality of the area. He describes the literary evidence, indicative of a mixed economy, with cereal cultivation on the plateau, olives and fruit trees in the western wadi systems, dates and sugar cane in the Ghor around the Dead Sea. Pastoralism was apparently transhumant but co-existed well with the mixed agricultural economy. Winter grazing was located in the Ghor or in the Eastern Desert (*Badiya*), with summer grazing on the plateau.

From the 12th century, Latin chroniclers from the Crusades also describe the rich harvests of wheat, barley, olives and vines and an annual fair that was held at Kerak town (Deschamps, 1939). The Kerak region was reported to be densely populated with some 400 villages in the 12th century (Imad al-Din *et al*, 1982; William of Tyre, 1986). Trade on the Dead Sea, from Zhugar to Jericho and the West Bank, included wheat, barley, oil, wine, dates, refined sugar, bitumen and salt (William of Tyre, 1986). This, it has been suggested, attests to the continuity of economic activity and settlement under Frankish rule (Johns, 1992). Literary evidence from the 12th century indicates a long-term continuum of settlement with a short disruption at the end of the Crusader period. The level of state control changed over this period, with relatively low levels of control before AD 1142, increasing when the Crusaders took control after this period. There seems, however, to have been little impact on settlement in this region, until the short period of devastation after Saladin's invasion in the late 12th century when, during a period of unrest and invasions, a great deal of damage was inflicted on the Kerak region. Crops were laid waste and villages destroyed (Al-Qadi al-Fadil, 1982).

In the mid Islamic Ayyubid period (13th century), after Saladin's recapture of the region, the town of Kerak became an important regional centre, reporting first to Damascus, then to Egypt, though still remaining fairly autonomous. This period was relatively quiet, with little disruption from feuding factions (Humphries, 1977). With the unification of Syria and Egypt, Kerak became an important town en route between the two (Al-Qadi al-Fadil, 1982).

The Mamluk leader Baybars put an end to Ayyubid rule and began the Mamluk era in the province in AD 1263 (Humphries, 1977). Kerak remained a fairly independent region and the town of Kerak was a prosperous centre until at least the 15th century under Ayyubid and then Mamluk control (Irwin, 1986). Using old theories linking state control and socio-economic prosperity, it would be expected that this period of peace and strong control would lead to increased agricultural prosperity. While the written sources do indicate that the region was fertile and productive (Brown, 1992) some of the archaeological evidence does, however, present a more complex picture of rural life.

Detailed ceramic studies show that pottery of the early Islamic period was characterised by mass-produced, wheel thrown pots, traded over long distances, found in villages and large towns (Johns, 1994). From the 13th century, however, a separation is evident between the centre of Kerak town and the surrounding villages, as the wares of the town were dominated by wheel thrown pots and imported ceramics while the villages had locally produced coarse, hand-made, geometrically decorated wares. Brown (1992) saw this as an indication of the difference between the prosperous Mamluk centre of Kerak and the increasingly isolated, self-sufficient, subsistence based economy of surrounding villages. This conflicts with past interpretations of the period which have assumed sharp population increase and agricultural prosperity in the mid Islamic period across the region, based on the written sources and from archaeological surveys which indicate an increased number of settlement sites.

Brown (1984, 1992) carried out a detailed study of unpublished data for late Islamic settlement. She identified a shift from agricultural villages located on the central plateau in good fertile land in the 13th and 15th centuries to the hilly country in the south west of the region, where the land is unsuitable for arable farming but springs allow the cultivation of irrigated orchards and gardens. The later sites are characterised by fewer pottery sherds and more ephemeral structural remains than the earlier sites. Brown has used this evidence to suggest a late Islamic (AD 1400-1600) shift in agriculture towards more pastoralism. One possible explanation for this is conflict between nomadic pastoral tribes and the settled farmers, the latter being driven to more unsuitable lands. However, there is no evidence for a violent relationship between these two social groups (Johns, 1994). In fact, on the contrary, there is evidence of a very cordial and mutually beneficial relationship between the tribes and Mamluk Kerak institutions (Irwin, 1986; Humphries, 1977). It has been suggested, supported by evidence from the Ottoman tax registers *defter-i mufassal,* that this shift in settlement pattern did not occur until later in the Ottoman period, 17th century onwards (Johns, 1994).

It is widely believed that the beginning of the Ottoman era (16th century) brought with it organisation and control after rebellions in the late Mamluk period. The 16th century was thought to be a time of growth and trade (Lewis, 1987; Hütteroth *et al*, 1977). Tax registers, *defter-i mufassal*, for this region survive from the year 1596, giving an important insight into the settlement and economy of the region described by Hütteroth *et al* (1977). Johns (1994) interprets the evidence from the *defter-i mufassal* to suggest there was a local population of several thousand, located in small villages on the plateau. A mixed economy was practised using the many different aspects of the environment. Long term investment in the landscape and economy is demonstrated by the widespread cultivation of olives and vines, on the western wadi systems, utilising spring fed irrigation systems. Cultivation of wheat, barley and summer crops was carried out on the fertile plateau. It might be said that this period of thriving economy was due to Ottoman state control but it is evident that the Ottoman governor, who took control of Kerak, soon became independent from

Ottoman rule and Ottoman invasions in 1678/9 and 1710/11 failed in the attempt to regain control (Johns, 1992). It is also significant that this situation is very similar to the state of the economy from the 7th to 12th centuries, with the same sort of mixed economy and the same cereal and orchard crops cultivated, indicating an element of continuity in rural production strategies.

Continuity of settlement can, therefore, be argued for the Islamic period up until at least the 16th century. Between the 16th and 18th centuries Johns (1994) believes settlements were abandoned and pastoralism with shifting cultivation became dominant in the landscape, as Brown described earlier. From the tax register a total of 909 tax-paying households were noted and the following settlements listed in the register: the town of Kerak, 27 villages and 48 *Mazari* (seasonally occupied settlements inhabited during ploughing, sowing and harvest times). This may suggest a dramatic decrease in settlement since Mamluk times when 400 sites were mentioned (William of Tyre, 1986; Hütteroth *et al*, 1977). Johns (1994) proposes that competition for land may have been the catalyst for these settlement changes rather than state control (i.e. high taxation) as Kerak remained fairly autonomous from Ottoman control until the 19th century.

Lancaster and Lancaster (1995) use ethnographic studies in the area around Khirbet Faris to argue for social continuity in the Ottoman era where, using archaeological surveys and written sources, it is argued there is discontinuity (Hütteroth *et al*, 1977; Brown, 1984, 1992; Miller, 1991). Flexible socio-economic structure is common in marginal environments, because of the need to respond quickly to changes (Fabietti, 1990; Lancaster,1981; Lancaster and Lancaster, 1991; Goitein, 1978). The main thrust of Lancaster and Lancaster's argument is that to see the change from agricultural surplus to pastoralism as a decline shows a mis-understanding of the pastoral system of production, which relies heavily on the exchange of surplus animals, storable dairy products and services with farmers for crop produce and the use of stubble as fodder.

Lancaster and Lancaster (1995) suggest that ideas of what constitutes a village may be too limited. It is perhaps not surprising that, in an environment where mobility is an asset, villages may not have involved permanent settlement in houses. Many of the sites listed in the 1596 register are *Mazari*. This change in the use of villages may have occurred for many reasons: e.g. disease or natural disasters, which may have gone unrecorded for this period, heavy taxation is another possibility resulting in farmers turning to a nomadic way of life to escape heavy financial penalties. Lancaster and Lancaster discount competition with nomadic tribes and maintain that, given the mobility of labour, the de-settlement of villages does not necessarily mean land abandonment and agricultural decline. Villages as centres of trade need not be permanently settled due to the seasonal nature of the production of goods such as grain, dried fruits, tobacco, wool, clarified butter and lambs. The village could have been used merely as a store and for hospitality. "Village living might be seen as a managed, flexible system, part of which was the management of surpluses in exchange for goods and services." (Lancaster & Lancaster, 1995:120).

Lancaster and Lancaster (1995), therefore, contend that the assumption of centrally controlled surplus producing sedentary farming, declining into subsistence nomadic pastoralism due to a lack of state influence during the Ottoman period, is questionable. Continuities in social and economic processes may have been much more enduring than central administrative powers. The use of villages may have changed through time but the agricultural practices going on in the surrounding countryside may well have remained constant. "A lack of effective administration from Damascus does not necessarily mean that all was disorder and confusion, nor that there was an absence of surplus agriculture or pastoral production." (Lancaster & Lancaster, 1995:108).

According to Johns (1994) it is only by comparison with the earlier Byzantine and later modern periods of relative boom that the early Islamic era seems to be one of decline. This 'decline' has been attributed to the destructive influences of the intrusive nomadic tribes of the region, challenging state control. However, Johns suggests much more continuity and indeed it was at periods of tight state control such as the Mamluk era that a flourishing market economy turned to a subsistence economy. The Lancasters also question the concept of agrarian decline during the 17^{th} century, arguing for continuing agricultural and pastoral surplus production. The Kerak region has always been characterised by peripheral state control (Johns, 1992). Even at the height of state power in the 12^{th} and 15^{th} centuries this control seemed to stop at the gates of Kerak town, with villages continuing to adhere to mixed agricultural strategies suited to a marginal environment.

2.2. Agriculture on the Kerak plateau from the Byzantine to early Ottoman period:

On the basis of literary evidence, Watson (1983) has argued that Islamic expansion in the circum-Mediterranean area exerted a radical influence on farming during the last millennium. This influence is reflected in the introduction of new crops (e.g. macaroni wheat, sorghum, rice, citrus fruits, watermelon, banana), new technology, particularly irrigation, and new patterns of land use, such as intensive orchard cultivation.

Many of these new crops may have been introduced as medicines from India, which then came to be demanded as foodstuffs. Watson sees this as a fashion set by the rich that rural communities picked up on and started experimenting with agriculturally. In this way these innovations would have changed patterns of consumption and land use. If these changes in agricultural practices did occur, however, the question is raised of how far they would have reached more remote and marginal regions of the Islamic world like the Kerak plateau. Watson treats the Arab world as a large unified region open to new introductions, easily diffused. He ignores the environmental and social complexities of such a large area, encompassing varied environments and social groups.

New crops and more intensive methods of farming, it is argued, made for more productive agriculture resulting in economic boom, increases in agricultural income, population increase and increased urbanisation. Watson asserts that cultivating many different crops created a more stable economy - spreading risks so that if one crop should fail the other crops could be used as insurance. In this way "more stable incomes were important in alleviating the periodic misery which punctuated the lives of rural dwellers in earlier agricultural systems" (Watson, 1983:128). However, by referring to this era as one of 'agricultural revolution' he implies that strategies to spread risk in marginal environments before this time did not exist. The possibility of earlier risk spreading agricultural strategies such as the use of a diversity of crops and irrigation needs to be investigated.

If new crops (e.g. mangos, bananas, watermelon, cotton) were introduced in the Islamic period many of them would have required irrigation as they originated in the tropics. Investigating the uptake of irrigation in the Islamic period is a major focus of this research project. If the use of irrigation is detectable in the archaeobotanical record using new interpretative methods, the assessment of one aspect of agricultural change or continuity in this period may be possible.

Watson describes the summer months, in the period prior to the Islamic expansion, as a dead season whereas, with the Arab expansion and widespread use of irrigation, came summer crops like rice, cotton, sugar cane, colocassia, eggplants, watermelons and sorghum. According to Watson, these summer crops were often combined with winter crops to provide year-round cultivation, or to produce two to three crops of cereals throughout the year. With the eradication of fallow periods to retain soil moisture, irrigation became necessary, often throughout the year. It is assumed that pre-Islamic irrigation systems mostly concentrated on collecting and distributing flood water in the wet months of the year whereas these new crops required a new form of summer irrigation: capturing rainwater supplies, tapping rivers and springs and channelling into canals made of mud or brick. Watson surmises that, with increased Islamic state control and new mechanisms for irrigation, larger areas of land could be cultivated for longer periods: "by the 9th or 10th century virtually every part of the Islamic world had countless areas...heavily irrigated into which the new crops could easily move." (Watson, 1983:111).

Watson ascribes this 'agricultural revolution' to the Arab conquerors and migrants from the Arabian peninsular with a history of intensive, irrigated agriculture, who in turn influenced the local populations. He sees the radical changes in agricultural patterns as bound up with a demographic explosion from the 8th to 12th centuries as attested by an increase in settlements in rural areas to places previously unoccupied. As has been seen in section 2.1, the archaeological survey data for this period is complex and can be interpreted in different, often contradictory, ways.

On the basis of assumptions of agricultural intensification, Watson sees the relationship between settled farmers and the nomadic pastoralists of the region as one of conflict, the latter posing a threat to agriculture. According to Watson this 'agricultural revolution', with new production systems, especially the introduction of irrigation, summer cultivation, and new hardier crops, made for a much more intensive form of agriculture, creating more intensive rotation systems and pushing forward "the frontiers of sedentary agriculture" (Watson, 1983:127) onto previous 'badlands'. Watson saw this as a source of conflict with nomadic incursions which "overan one part or another of the Islamic world, destroying much that lay in their path and bringing institutions and attitudes that were harmful to farming." (Watson, 1983:6). This view has been challenged by many scholars working in this area (see above; Lancaster & Lancaster, 1995).

Due to the scarcity of Islamic period archaeological excavations and archaeobotanical reports, Watson's work is based almost entirely on documentation (farming manuals, geographical reports, travel accounts, botanical compendia) as he states "there are few published reports of early Islamic plant remains or representations of plants" (Watson, 1983:4). In his work Watson contends than many crops, such as *Triticum durum,* were not cultivated before the Islamic period as there are no records of them. Thus it is questionable whether this is a real absence from the archaeological record or merely a dearth of knowledge due to a lack of pre-Islamic written sources or integrated studies of sites occupied before and during Islamic times. The problem with relying so heavily on written sources from so long ago is that the dating and reliability of the information are often questionable. Also, many plant names may have changed through time adding difficulties of interpretation. The texts used were also fairly late in date, the earliest being 9th century but most dating to the 10th, 11th and 12th centuries, well after this diffusion is purported to have taken place. Many of these sources come from the literate elite of jurists, agronomists and geographers. These would have been considered *hadhari* (civilised and educated) urban dwellers (Lancaster and Lancaster, 1995), perhaps far removed from the realities of rural life in more marginal regions of the Arab world. Some archaeological studies have also suggested the need for significant reconsideration of this current orthodoxy.

Rowley-Conwy (1989) described the archaeobotanical remains from the site of Qasr Ibrim in Egyptian Nubia. The site was occupied from 700 BC to AD 1800, before and during the Islamic period. Evidence from the well-preserved plant remains show that the major period of change for this site was before the Islamic period: "As a time of innovation the years AD 0 – 550 are not equalled during any other period at Ibrim" (Rowley-Conwy, 1989:136). These changes involved the introduction of many of the new crops Watson had assigned to the early Islamic agricultural revolution - sorghum (*Sorghum bicolor*), cotton (*Gossypium herbaceum*), durum wheat (*Triticum* cf. *durum*) - as well as other tropical introductions - bulrush millet (*Pennisetum*), termis bean (*Lupinus albus*) and sesame (*Sesamum indicum*). These new crops, as well as irrigation methods, were introduced well before the Arab expansion at Qasr Ibrim. Rowley-Conwy notes that Arab writers were more interested in geography and agriculture than any others since classical times. Thus any agricultural practices and changes before this period would have gone unrecorded. Evidence from Qasr Ibrim demonstrates that Watson's Islamic agricultural revolution theory can be questioned. The remaining question posed by Rowley-Conwy is whether or not this is the same at other sites occupied before and during Islamic times. Khirbet Faris provides the opportunity for comparison with this site as it was occupied before and after the Arab expansion and also has rich archaeobotanical remains.

During the Islamic period, Arab geographers, Crusader reports and the Ottoman tax registers all agree that the most common produce of the Kerak plateau were cereals, summer crops, vines, olive oil and fruits. Travellers from the 19^{th} century also report these crops, adding that cereal cultivation was located on the plateau whilst orchards and summer crops were grown in the wadis and the Ghor. Pastoralism was important for local subsistence and the regional economy. According to Irwin (1986) the Mamluks were particularly interested in Kerak for the supply of horses, camels and sheep. 19^{th} century travellers mention the trade of sheep, mules, dairy products and dried fruit to Palestine (Tristram, 1874). The picture of a mixed farming economy integrated with nomadic pastoralism with wide trade networks has been established for the Kerak region from the Byzantine to early Ottoman period.

2.3. Archaeological evidence from Khirbet Faris:

Evidence from the recent past can be gathered from archaeological surveys, written sources and ethnographic studies that provide analogies with which to interpret archaeological findings. However, social and economic diversity in the past will only be discovered with the excavation of settlement sites on the Kerak plateau (Johns, 1994). Apart from Kerak castle, Khirbet Faris is the only site of this period to have been excavated in the Kerak region (Johns and McQuitty, 1989; McQuitty and Falkner, 1993).

The tell site of Khirbet Faris is located on the plateau edge, just north of Kerak town (see figure 1.3). Its marginal location on the edge of rain-fed cultivation land on the plateau, grazing on the slopes and irrigated farming in the wadi bottom has made this a prime site for investigating the effects of central administrative powers, settlement continuity, agricultural innovations and the relationship between sedentary and nomadic peoples.

The first surveys of the Khirbet Faris area (also referred to as Khirbet Tadun) describe a site consisting of a platform about 110m east to west and 250m north to south (see the plan of the site, figure 2.1). It consists of remains of structures, the most prominent being the ruins of two large Ottoman farm buildings and a Muslim grave. It was tentatively interpreted as an agricultural settlement dating from at least as early as the 7^{th} century AD to Ottoman and early modern times (early 20^{th} century). Areas to the south of the main tell have produced remains from Chalcolithic, early Bronze Age, Iron Age, late Roman, Byzantine and Mamluk periods. About 150m to the north east of Khirbet Faris dense scatters of late Roman, Byzantine and Umayyad pottery have been recorded (Hommes-Frederiq and Hennessy, 1986; Worschech, 1985, 1986).

Archaeological excavations at Khirbet Faris, co-ordinated by Alison McQuitty (Director of the British Institute in Amman for Archaeology and History) began in 1988 and were completed in 1994. The Khirbet Faris archaeological project involves the study of a rural community through the reconstruction of its material culture and socio-economic structure. The combined techniques of excavation, post-excavation analysis of finds, architectural survey, palaeo-environmental studies, field survey, historical studies and ethnoarchaeology have been implemented.

Six main areas of the site have been excavated: FAR I, FAR II, FAR IV, FARV, House 1 and House 2. Most of these areas are multi-period, with many re-use phases except Houses 1 and 2 which are of Ottoman construction and sit on top of the tell (and are the two standing Ottoman farm buildings described in the survey of the site).

FAR I is an area 15m x 18m opened up on the western edge of the site. Five middle Islamic period barrel vaulted buildings with associated alleyways and courtyards dug into earlier (Byzantine) structures were exposed. The floors were of beaten earth or re-used Byzantine paving. Occupation material was not found *in situ* as the houses appear to have been abandoned (or cleaned out) and then used for dumping and/or re-use. Overlying these vaulted structures were purpose built and more ephemeral *ad hoc* oven houses (*Tawabeens* – clay and mudbrick ovens used for baking bread). An earlier Byzantine cistern was re-used and sealed in the late Islamic period. This area provides an excellent sequence for middle Islamic domestic occupation and archaeological evidence for the range of types of occupation, from temporary seasonal, to permanent.

McQuitty (1997) contends that the structures excavated from the middle Islamic period may not have been used purely for storage as are many of the later Ottoman farm buildings found in the area. They are clustered around a courtyard like the family units found in modern villages, and the alleyways are narrow making access for animals and agricultural produce poor. The houses are not large and have no purpose built storage areas such as the niches found in the 19th century Ottoman farm buildings. The *tawabeen* ovens excavated are fuelled by dung, which requires stabled animals. Settled villagers have traditionally used these types of ovens in the area. The interpretation is, therefore, that the middle Islamic buildings so far examined represent village houses. McQuitty suggests that these buildings were constructed in the Mamluk era but continued into the Ottoman period, due to the extensive evidence for re-building phases.

FAR V is an area 10m x 10m opened on the highest point of the site, revealing a very well-preserved arched building constructed within an earlier middle Islamic building which itself used the arches of an earlier Islamic building inserted into an original 5th century AD (Byzantine) structure. This long sequence of construction offers an insight into Islamic period activity and will provide a comparison to material and environmental evidence from area FAR I.

The FAR II/FAR IV/House 2 complex is an excavation area laid out around one of the standing buildings on the site (House 2). FAR IV is a well-preserved vaulted structure onto which House 2 was butted. The excavation revealed that it was Nabatean (1st century BC/AD) in origin although used continuously since then. FAR II, to the south, was excavated in order to clarify the constructional history of FAR IV. Excavation revealed an arched early Islamic house that was constructed using earlier Nabatean structures. House 2 was abutted to FAR IV in the 19th century and conforms to the traditional building style of the Kerak Plateau, with storage niches. Excavation of the interior provided useful evidence of Ottoman material culture. This complex therefore provides an occupational sequence that can be traced from the 1st century BC/AD to the 19th century.

House 1 is an Ottoman vaulted farm building standing at the northern edge of the site. Two trenches on the south-west external corner and southern interior wall were excavated to examine the constructional history of this farm building. The trench on the exterior showed that the house corner was older, possibly Nabatean, since the masonry style paralleled that of FAR IV. A middle Islamic period structure had been abutted to this and the 19th century farm building was the latest addition. Inside, the excavation exposed the cobbled floor of the building and provided useful evidence for Ottoman material culture.

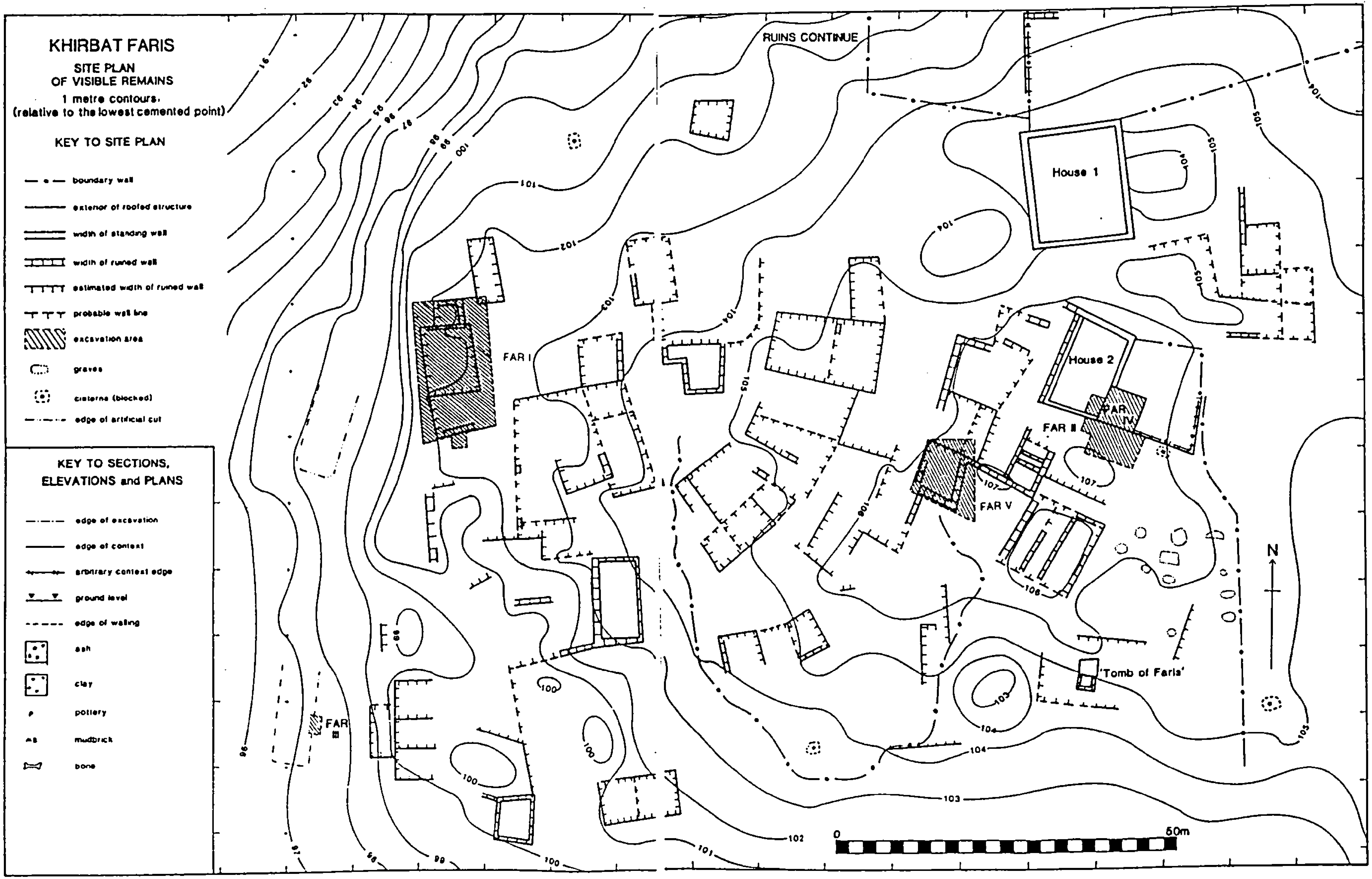
A similar set of barrel vaulted buildings clustered around a courtyard was excavated at another site called Hesban, on the northern edge of the Central Highlands south west of Amman, with similar patterns of use, abandonment and dumping (LaBianca *et al*, 1986). At the nearby modern village of Hmoud a very similar vaulted structure was used for storage of crops until recently. Using such ethnographic comparisons McQuitty asserts that the two Ottoman, 19th century, vaulted farm buildings (House 1 and 2) at Khirbet Faris were used for storage with agriculture and pastoralism perhaps being carried out from tents.

The archaeological evidence is being compiled into a multidisciplinary study of Khirbet Faris. A preliminary report (table 2.3) has been made on the animal bone finds across the site. These results show the importance of small ruminants in the rural economy of the site. The archaeobotanical data will add to this wider multidisciplinary study.

Table 2.3: Animal bones recovered from Khirbet Faris, 1988 (after Rielly in: Johns and McQuitty, 1989: Table 3):

	Area Far I	**Area Far IV**	**Total (all contexts)**
Sheep / Goat	49%	63%	55%
Cattle	35%	9%	23%
Others	16%	28%	22%

Figure 2.1 Plan of the Khirbet Faris excavation site



Chapter 3: Methodology

3.1. Background:

3.1.1. Identifying the source of archaeobotanical material:

Knörzer (1971) made three observations relating to archaeobotanical material: carbonised assemblages nearly always include cereal grain; those assemblages with large amounts of weed seed also include chaff; most wild species found in the samples occur today as weeds of cereal fields. The conclusion drawn from this is that most carbonised plant remains are derived from cereal fields, and an important factor in the variation between samples is the different crop processing stages from which they result. There are, however, many reasons for the appearance of botanical material on site besides the arable harvest, such as the use of hay for animal feed, the occurrence of animal dung and the utilisation of plants for bedding and thatching (M. Jones, 1988). Plant material could then become carbonised, and appear in the archaeobotanical record, for a number of reasons: parching of grain prior to storage, burning of crop processing by-products as waste or for fuel, accidental burning during food preparation in ovens, accidental fires in general or the use of animal dung as fuel.

M. Charles (1998) proposed a method for identifying dung fuel in the archaeobotanical record based on evidence from Abu Salibikh, a Bronze Age site in Iraq. He concluded that the most reliable evidence for dung fuel was the presence of dung pellets in the samples, especially where plant seeds could be found embedded in the dung material itself. Other evidence used to indicate fodder as the source of archaeobotanical material was the character of wild species found in the samples. In particular those species flowering and fruiting outside of the harvest period must have become incorporated in the archaeobotanical record by some means other than by harvest along with crops, for example in dung fuel. For instance, at Abu Salibikh, Charles found that *Prosopis farcta*, a species that does not fruit until several months after the harvest in this area, was common in archaeological samples. Today the plants, including fruits, are widely grazed by sheep and goat herds in the area during the autumn. However, fodder can be provided by crop processing residues, as well as wild pasture, resulting in weeds of crops being found in dung samples. The presence of dung, together with large amounts of straw (culm nodes) and chaff material in samples may point to the use of crop processing material as fodder and of dung for fuel. In this case, though used for fodder, the plant material will still have agricultural origins.

3.1.2. Identifying crop processing stages:

Weed species are often found accompanying crops in archaeological samples as they are harvested accidentally with the crop. However, archaeobotanical samples do not contain complete weed floras as found growing in the crop fields. Some plants will have been weeded out, others will not have been in seed at harvest time and some will not have been harvested along with the crop (M. Jones, 1984). Also, when the crop is processed, weeds are removed selectively at different stages in the process. Therefore, the weed composition of archaeobotanical samples will depend partially on the crop processing stage from which it is derived (Hillman, 1981, 1991).

Using archaeobotanical evidence, crop processing stages can be reconstructed. The major stages of crop processing are: reaping (to harvest the crop); threshing (to break up the ears); winnowing (to remove straw and coarse chaff); coarse sieving (where the grain passes through the sieve, separating it from the coarse chaff, large weed heads and unthreshed ears left in the sieve); fine sieving (where small weeds pass through leaving the grain in the sieve); and hand-picking (to remove weeds which mimic grain in size). Proportions of weed and crop components are, therefore, altered as they are removed at different stages in the process. These processes are fairly uniform through time and across continents and produce crop processing products and by-products of fairly similar composition (G. Jones, 1983a, 1984). These remains, found archaeobotanically, can be used to reconstruct crop processing activities.

One of the most successful aspects of this type of reconstruction is the identification of crop processing stages using weed species properties (Hillman, 1981, 1984; G. Jones, 1984, 1987). As ethnographic studies cannot possibly encompass all the weed species likely to be found in archaeological samples it is important to use the physical characteristics of weed seeds (size, aerodynamic properties etc.) when using ethnographic models to identify crop processing. Different products and by-products of crop processing can also be inferred using the proportions of grain, chaff and weed seeds found in archaeobotanical samples (Hillman, 1981, 1984; G. Jones, 1984, 1987, 1990).

3.1.3. Identifying crop management practices:

It is important to separate the effects of crop processing stage from habitat differences, when accounting for differences between samples in their weed composition. As botanical samples pass through a series of crop processing stages which alter their composition, it is necessary to classify samples according to their origin in terms of crop-processing before going on to compare the weed composition of different samples to identify activities such as crop management practices (Hillman, 1984, 1991; G. Jones, 1983a and b, 1984, 1987, 1992).

3.1.3.1. The use of phytosociology and indicator values:

The ecology of weeds, found growing with crops and processed with them, allows us to identify the crop growing environment as plant species have particular environmental preferences. Weed floras are also influenced by crop management practices: time of ploughing and sowing, crop type, rotation and fallowing practices, alteration of soil conditions (manuring, irrigation, drainage etc.). It is, therefore, possible to identify past management practices by using the ecological characteristics of weed floras found in archaeobotanical samples (Knörzer, 1979, 1984; Willerding, 1980, 1983; Wasylikowa, 1981; M. Jones, 1981, 1988; Grieg, 1988; Behre & Jacomet, 1991; Küster, 1991; G. Jones, 1992; van der Veen, 1992).

The study of crop management practices in the past necessitates an understanding of the ecology of modern weeds to which plant species identified from archaeobotanical samples can be compared. Phytosociology and autecological indicator values have been applied to archaeobotanical weed assemblages to identify crop management practices on the basis of modern weed ecology. There are, however, fundamental problems associated with applying present-day ecology to archaeobotanical material. As ecological factors change through time so will species change and adapt. Arable weeds were once wild species that have adapted over time to live in a cultivated environment alongside crops (G. Jones, 1992). Agricultural innovations will have caused further changes in the composition of weed floras and plant adaptations. Herbicides have affected competition amongst weed species, aiding the colonisation of cultivated fields by more hardy resistant species (Holzner, 1978). The use of herbicides has decreased the diversity of weed species present today. Agricultural practices have affected weed ecology, particularly in relation to seed dispersal (Hodgson & Grime, 1990; Marshal & Hopkins, 1990; Thompson unpub.). Improved seed cleaning has caused a decrease in specialised cereal weeds like *Agrostemma githago*, which rely on incorporation into seed corn for dispersal (Hill, 1977). Combine harvesting causes the dissemination of small light weed seeds at harvest which would have been collected with the crop if hand harvested (Bunting, 1996).

There is possibly no present day analogue to ancient arable habitats, as different environmental factors will have influenced them (Hillman, 1991; G. Jones, 1992; Wasylikowa, 1981). Differences in weed composition may include combinations of weed species found together in the past not currently associated in the present, or species not currently considered to be arable weeds. One way to minimise the effects of these problems has been to use as many species as possible to indicate a habitat type (Holzner, 1978, G. Jones, 1992).

Phytosociology was developed by Josias Braun-Blanquet and modified by Rheinhold Tüxen, Erich Oberdorfer and others, as a tool for describing vegetation types and their habitats (Ellenberg, 1978; Wilmanns, 1984; Buttler, 1983). Using the phytosociological approach, plant communities are recognised by character species (and companion species) that are used to express the association of species (Westhoff & van der Maarel, 1973). Weed species can be classified into phytosociological groups (syntaxa) by their co-occurrence in the field (e.g. Braun-Blanquet, 1936; Tüxen, 1950). The character species is identified as being more rigidly associated with a particular syntaxon than the companion species that may belong to several synatxa (Westhoff & van der Maarel, 1973). Phytosociological groups are defined by their floristic composition with only slight consideration to the ecological conditions that gave rise to their formation.

Phytosociology is useful for modern vegetation studies but there are problems in its adaptation to archaeobotanical interpretation. By nature archaeobotanical samples are incomplete floras (they have gone through cultural processes: harvesting, crop-processing, carbonisation, deposition, sampling, sample processing and analysis) and, therefore, character species of syntaxa may be absent. Also, phytosociological groups are based on individual vegetation stands such as the cultivated field. However, the harvest from several different fields may be combined together during crop processing, thus mixing the weed groups (Knörzer, 1970, 1984; Wasylikowa, 1978a, b; Willerding, 1979; M. Jones, 1984). Assumptions of uniformitarian stability of phytosociological groups through time is also problematic. As mentioned, weeds react quickly to environmental change and, therefore, phytosociological weed groups may also have changed through time (Holzner, 1978; M. Jones, 1984; Behre and Jacomet, 1991; Hillman, 1991). The most cohesive syntaxa through time seem to be those most removed from human contact (Whittaker, 1978). However, it is the landscapes most affected by human management that are of interest to the archaeobotanist (M. Jones, 1988; Holzner, 1978).

Küster (1991) suggests archaeobotanists should use only the most general phytosociological affiliations such as 'forest plants', 'crop weeds' and 'grassland species' due to the problems of uniformitarian assumptions described above. Character species of the higher syntaxa relate to broader ecological conditions but have a stronger allegiance to that syntaxon over a wide area. However, if only higher syntaxa can be inferred from archaeobotanical samples it is of limited use in interpreting past cultivation practices (Behre & Jacomet, 1991; Küster, 1991; Hillman, 1991; van der Veen, 1992; Palmer, 1994). Past interpretations of the same phytosociological classes represented in archaeobotanical data have varied widely. For example, the abundance of character species of the class Chenopodietea in archaeobotanical samples has been interpreted as evidence of sparse cultivation by Willerding (1980), as evidence of spring sowing by Wasylikowa (1981) or as evidence of garden type agriculture by G. Jones (1992). This is because a number of agricultural variables, such as sowing time, soil nutrient status, water availability etc., influence the weed flora (Charles *et al*, 1997) and determine the phytosociological syntaxa represented.

An alternative to phytosociology is the use of autecological 'indicator values'. With this method individual species are used to indicate particular habitat conditions. The advantage of the autecological approach over phytosociology is that autecology directly links a species to its environment and does not depend on the association of different species. The most widely used type of indicator values are Ellenberg numbers. They are a quantitative estimate of the relationship between species and major edaphic (e.g. soil moisture, pH, nitrogen) and climatic (e.g. light, temperature, continentality) variables. For each environmental variable the species is scored on a scale according to 'ecological behaviour', gauged from observation of field distribution in central Europe (Ellenberg, 1950, 1978; Ellenberg *et al*, 1992). However, the fundamental flaw with this type of approach is the circularity of argument:

"Any approach based primarily on field observations addresses the issue of where a species is found and not why it is there (thus assuming, for example, that weeds which grow in shady places are shade-loving) and so cannot provide a means of disentangling the many environmental variables to which individual species are responding."

(Charles *et al*, 1997:3).

3.1.3.2. Using the Functional Interpretation of Botanical Surveys (FIBS):

Despite the problems outlined above archaeobotanists must rely on the knowledge and approaches of modern botany in the interpretation of archaeobotanical assemblages (Küster, 1991). As modern weed species are our only comparandum for those found in the past, it is critical to find a method of successfully interpreting archaeobotanical assemblages using this data. To use modern weed studies to interpret archaeological practices from archaeobotanical assemblages, where different species and different crop management practices may be represented, it is important to identify ecological principles underlying species distribution (Charles *et al*, 1997).

The Functional Interpretation of Botanical Surveys (FIBS) is an autecological approach that can be used, on present-day vegetation, to identify suites of ecological characteristics (functional types) of species associated with different habitats (Hodgson, 1989, 1990, 1991; Hodgson *et al*, unpub. b). FIBS was developed at the Unit of Comparative Plant Ecology (UCPE) at the University of Sheffield. This method describes vegetation in functional terms to explain or predict vegetational change in response to environment (including land management practices). Plant functional attributes are quantitative measures that can be used as a surrogate measure of ecological characteristics. Examples of this are shown in table 3.1.

Table 3.1: Examples of functional attributes used to measure ecological characteristics:

Functional Attribute Measured	**Ecological Characteristics Predicted**
Specific Leaf Area	Growth rate and productivity
Canopy dimensions	Growth rate and productivity
Leaf area	Growth rate and productivity
Seed size and shape	Persistence in the soil and environmental unpredictability
Root diameter	Drought tolerance

As functional attributes are a measure of a plant's ability to respond to different environmental conditions, the ecological significance of the attribute can help in understanding the relationship between particular species and a particular agricultural regime. Canopy dimensions, for example, are a measure of a species' growth rate. Therefore, under irrigated conditions, it is likely that a large canopy is due to the favourable watering conditions which encourage fast growth (Hodgson & Grime, 1990; Grime *et al*, in press; Hodgson *et al* unpub. a).

FIBS is an offshoot from Grime's (1979) theory that there are limited physiological, morphological and strategic permutations available to complete the plant's life-cycle. According to Grime (1979), species have different strategies depending upon the habitat in which they (usually) grow. The governing factors involved in determining these strategies are stress (a limit to photosynthetic capability and therefore growth rate) and disturbance (causing destruction of biomass). Different habitats will combine these two factors in different ways: high stress and low disturbance; low stress and high disturbance; low stress and low disturbance; high stress and high disturbance (though, according to Grime, no plant species could survive under the latter extreme conditions). Arable fields provide an environment of increased disturbance and decreased stress. Species that are fast growing, short lived and flower and seed at an early growth stage, prevail in these circumstances (Bogaard *et al*, 1998).

The advantage of FIBS over both indicator values and phytosociology is that it provides an understanding of the ecological principals linking species with habitat and because these functional attributes relate to habitat, the ecological information is transferable from one species to another (Charles *et al*, 1997). It should be possible, therefore, to identify suites of functional attributes that characterise different agricultural regimes and to use these to identify similar practices in the past (Charles *et al*, 1997). FIBS, therefore, provides a reliable alternative to indicator values that are circular in argument and phytosociological syntaxa that depend on modern groupings which may not have occurred in the past. FIBS is also a very practical method as accurate, standardised, reproducible and objective measurements may be rapidly compiled (Bogaard *et al*, 1988) and can be used on any species found archaeologically.

It has been the goal of a 3 year NERC funded 'ARCHFIBS' project at the department of Archaeology and Prehistory at the University of Sheffield to provide an alternative to current, unsatisfactory, methods of archaeobotanical interpretation, by identifying suites of attributes that characterise different crop management practices. Several aspects have been identified as important for the analysis of weed floras from arable environments: degree of soil disturbance, soil nutrient status and water availability. The impact of various cultivation practices on modern weed floras in several recent (and earlier) surveys have been studied for the ARCHFIBS project: different levels of cereal irrigation in northern Spain; different levels of agricultural intensity in Evvia, Greece; different rotation and fallow regimes in northern Jordan; crop sowing time in Germany and the current project: different levels of cereal irrigation in southern Jordan. The ultimate aim of the ARCHFIBS project is to produce suites of functional attributes to distinguish these different agricultural practices. These attributes can be measured on species found in archaeobotanical samples and 'strategies' defined for each species. In this way, using the attributes and strategies that these species possess, it is hoped that agricultural practices carried out in the past can be identified.

The study on the effects of irrigation on cereal weeds in northern Spain (Charles, *et al* 1997) is of particular relevance to this project. The results indicate that dry-farmed and irrigated fields can be distinguished on the basis of functional attributes of the weed species. Specific leaf area and maximum canopy height show an increasing trend from dry-farmed to biennially and fully irrigated fields. In many dry-farmed fields, species without a persistent seed bank are rare. Root diameter and stomatal density are useful attributes for distinguishing between the two types of irrigation - biennial and full.

The Spanish study emphasised the need to identify a suite of common adaptive attributes to characterise each level of irrigation, i.e. a functional type, rather than relying on individual attributes. This alleviates the problem of ecological ambiguity. For example, a species with a large canopy may occur in a productive, well-watered habitat but also in a dry, unproductive habitat if it has other characteristics allowing it to tap into subsoil water. By the same principle, two different strategies may equip a species to survive in the same habitat - e.g. drought avoidance and drought tolerance are two very different strategies for coping in an arid environment, and result in different functional types co-existing in the same environment.

The FIBS method was used for the ethnoarchaeological analysis of weeds from different irrigation levels at Wadi Ibn Hammad. It is an aim of this project to investigate further those attributes thought to indicate irrigation practices but in an area where rainfall is lower than in the Spanish study. In this study it is expected that the irrigated fields will represent an environment of relatively low stress, relative to the dry-farmed fields at Wadi Ibn Hammad, allowing the development of faster growing, competitive plant communities with a larger biomass. In comparison, dry-farmed fields are predicted to exhibit signs of higher stress due to drought resulting in slower growing, small plants with drought tolerant attributes. The functional attributes measured for each weed species should illustrate these habitat differences. These attributes will then be used to interpret the archaeobotanical weed species from the site of Khirbet Faris. This is a site where rainfall is marginal for cereal cultivation and irrigation is practiced today (in some of the fields used for the Wadi Ibn Hammad study) and so may have been practiced in the past.

3.2. Ethnoarchaeological research strategy:

3.2.1. A survey of the weed species in irrigated and unirrigated fields:

During the 1993 excavation season at Khirbet Faris Dr. M.P. Charles, of Sheffield University, located the irrigated cereal fields in Wadi Ibn Hammad. Field collections of weeds from both irrigated and unirrigated cereal fields were also made in 1993 in order to ascertain whether or not there was a discernible difference in weed floras between the different crop management regimes.

In May 1995, just before the harvest, a detailed survey was carried out of the weeds in irrigated and unirrigated cereal fields. Pulses, which were cultivated under rain-fed conditions only, were not sampled. The cereal crops cultivated in the area and, therefore, included in the study were *Triticum durum* (macaroni wheat: a free-threshing variety), *Hordeum sativum* L. var. *distichum* and var. *hexastichum* (2 and 6 row hulled barley, respectively). The recording of modern weed floras from local arable fields was carried out in three different regions in order to assess geographical variation, along with irrigation differences (see table 3.2):

Table 3.2: Locations of field samples recorded:

GEOGRAPHICAL LOCATION	SOIL TYPE	MANAGEMENT REGIME
Plateau	Terra rossa soil	Dry-farmed (rain-fed) cereals
Wadi sides	Thin colluvial soil	Dry-farmed (rain-fed) cereals
Wadi bottom	Thick alluvial deposits	Fully-irrigated cereals Biennially-irrigated cereals

Both fully- and biennially-irrigated fields of the wadi bottom were sampled. For comparison, fields were also sampled on the wadi sides and on the plateau where irrigation was not practised. The prediction was that productivity would decrease from fully-irrigated to biennially-irrigated to dry-farmed plateau (where rainfall was higher) to dry-farmed wadi fields. The locations of the sampled fields in the wadi bottom, wadi sides and plateau, are shown in figures 3.1, 3.2 and 3.3.

The weed flora of each field was sampled along a transect starting just inside the field edge and extending to the opposite side of the field. The weed species present in ten $1m^2$ quadrats along the transect were recorded. The quadrats were placed at arbitrary intervals along the transect. The stage of development of each species was also recorded as follows: vegetative, flowering, fruiting or fruiting and flowering. A total of 52 transects were made across 41 fields (see table 3.3) and this included all the cereal fields in the wadi (both irrigated and dry-farmed). Nine duplicate transects were made in the irrigated fields for control purposes, as there appeared to be some variation within the fields.

Table 3.3: Fields sampled in Wadi Ibn Hammad according to crop type and watering regime:

Location	Irrigation status	Crop	Number of fields	Number of replicates
Wadi bottom	Full Irrigation	wheat	23	5
		6 row barley	1	
	Biennial irrigation	wheat	7	4
	uncertain	wheat	2	
		6 row barley	1	
Wadi side	dry (rain fed)	wheat	5	
		2 row barley	3	
Plateau	dry (rain fed)	wheat	6	
		2 row barley	2	
		6 row barley	2	
Total			52	

Plant specimens were collected so that field identifications could be verified and refined later in the Jordan University Herbarium (with the aid of Dr. Al Aisawi), Sheffield University and Edinburgh Botanical Gardens herbarium and also using Flora Palestina (Zohary and Feinbrun-Dothan, 1964-1986), Flora of Iraq (Townsend and Guest, 1966-85) and Flora of Turkey (Davies *et al*, 1965-88). Some species were not correctly distinguished from each other in the field. When field specimens were not collected from all the transects for these species it was not possible to subsequently correct the mistake and they had to be treated as grouped types. A type collection of the plants recorded and collected for this survey was compiled.

Information regarding environmental variables and agricultural methods applied to each field were recorded as they were sampled. Further information was obtained by questioning the farmers who were cultivating the fields. Crop variables were recorded: crop height (cm) and crop cover (%) - both values were averaged for the field as a whole. These variables were recorded in an attempt to estimate the effect of different management regimes (i.e. dry or irrigated) on the resultant crop. Soil samples taken from each field were exported to Britain and analysed for pH and organic matter content at the University of Sheffield in order to see if soil characteristics, other than moisture, affect the weed composition. Soil types were taken from Mueller (1994) and are presented in figure 1.6 and stoniness of the soil was recorded (where 1 = few and 5 = very dense). Other variables recorded for each field were: aspect (north, north-east etc.); slope (ranging from 1 to 5; where 1 = flat and 5 = steep); rotational cropping history (continuous cereal cultivation or rotation with vegetable crops) and agricultural inputs (manure, pesticides etc.). These variables were recorded in order to look at other possible factors affecting the weed floras of each field as well as irrigation. For an example of the field quadrat recording sheet see Appendix 1. The field variables, coded numerically for analysis, are shown in Appendix 2.

Amy Bogaard (Research Assistant at the Deptartment of Archaeology and Prehistory) carried out the analysis of soil samples at the Analytical Services Unit, Department of Animal and Plant Sciences, Sheffield University. Initially, 4 soil samples from each irrigation level (full, biennial and dry) were analysed to determine typical organic carbon content. The organic carbon content of the samples was typically around 1% and, therefore, too low to be reliably detected by loss-on-ignition (Andy Fairburn, pers. comm.). All of the soil samples were, therefore, analysed by titration with potassium dichromate according to the procedure described by Allan (1989: 94-95), to assess the percent organic carbon content. The soil was air-dried and passed through a 2mm mesh sieve. Ca. 1-2g was weighed out which was estimated to contain between 5mg and 15mg of organic carbon. Exactly 20ml of potassium dichromate solution and approximately 30ml of acid mixture (H_2SO_4/H_3PO_4) were added. The sample was then refluxed for 20 minutes at 180°C and allowed to cool for 15-20 minutes. Approximately 5 drops of indicator reagent were then added, causing the sample to turn bright purple. Titration with ferrous ammonium sulphate was then carried out until the bright purple colour changed to a dark green. A blank (dichromate and acid only) was included in every batch of 8 samples and refluxed together. If 1ml 0.5N dichromate = 1.5mg organic carbon, percent organic carbon content is calculated according to the following formula:

$$\%\ \text{organic carbon content} = \frac{\text{blank - sample titre (ml) x 0.15}}{\text{sample weight (g)}}$$

(Allan, 1989)

The accuracy and precision of the method was assessed by including a control soil of known organic carbon content at the beginning of each workday (a total of 4 iterations) and by duplicating every tenth sample.

The method is both reasonably accurate (all the values fell within 2 standard deviations of the mean) and precise (nine samples were duplicates as they derive from the same fields as other samples analysed. No set of duplicates differed by >5%).

3.2.2. The measurement of functional attributes for weeds found in the survey:

Attributes were measured on weed species recorded from the 1995 field survey. Only those species present in 10% or more of fields (i.e. 5 fields or more in total) were measured because, in previous such studies, it was decided that species occurring in less than 10% of fields could not be used satisfactorily as indicators of specific habitats due to their low frequency (G. Jones *et al*, 1995). A total of 63 species were measured and this included some of the species occurring archaeologically at Khirbet Faris. There was insufficient time to locate other Khirbet Faris species not measured as part of the ethnographic study, and so these were not measured.

The study area of Wadi Ibn Hammad was revisited in the early spring (April) and the selected species sought out. Some of the measurements had to be taken in the field and others while the plants were fresh: these were all carried out in the study area, the latter in a make-shift 'field laboratory' in Kerak. The final measurements were carried out at Sheffield University as more complex equipment was necessary and the plants did not have to be fresh in order to do them. In all there were, therefore, three major stages to the measurement procedure:

- Plant measurements and field collection (Wadi Ibn Hammad, Jordan)
- Fresh plant measurements (Kerak, Jordan)
- Final laboratory measurements (Sheffield University, England)

3.2.2.1. Field methods:

When the species were located in the field, the following measurements and records were immediately taken from the largest specimen:

- location of the plant
- plant type: basal, semi-basal or leafy - according to the distribution of leaves (leafy = plants with leaves of approximately equal size all the way up the stem; semi-basal = stems are leafy but the largest leaves occur towards the base; basal = leaves occur mostly at the bottom of the stem.)
- maximum canopy height (for basal and leafy species)
- true canopy height (only applicable if the plant is semi-basal)
- plant height
- canopy diameter (taken as an individual plant if an annual or as an individual and a discrete patch of plants if perennial)
- rooted patch diameter (if perennial)
- type of root system (tap root or other)
- plant growth stage: vegetative, flowering, fruiting, flowering and fruiting or dehisced

Robust, well-developed individuals were measured even if located outside the cereal fields to ensure that functional measurements reflected the maximum potential of each species rather than performance of an individual plant under a particular arable regime (Charles *et al*, 1997). Where possible, measurements were replicated using specimens collected at three different locations (Bogaard *et al*, 1998). For an example of the recording sheet see Appendix 3. For each species a bag of plants to be used for the various laboratory measurements was collected and, where possible, seeds. Seeds of some species had also been collected in the 1995 field season, which was later in the year, and seeds ordered from botanical gardens supplemented the collections.

One plant of each species was taken as a herbarium specimen (placed in a separate, labelled bag to prevent damage) so that identifications could be checked to ensure that the species measured in 1996 were the same as those recorded in 1995. Final identification of the species was carried out at the Royal Botanic Gardens Herbarium in Edinburgh, with the aid of Dr. M.P. Charles and Amy Bogaard from Sheffield University.

3.2.2.2. Laboratory methods in Kerak:

From the collected plants, the following measurements were taken in the field laboratory at Kerak:

- root diameter at 10cm (from the largest specimen seen in the field)
- the fresh weight of c.1gm of leaves
- leaf thickness

In addition, the following collections were prepared for transport to Sheffield:

- the measured root
- the weighed leaves (allowed to dry out naturally)
- c. 5 of the largest leaves, pressed
- acetate impressions of the leaf surfaces (see below)

3.2.2.3. Laboratory methods in Sheffield:

The following measurements were completed in Sheffield:

- dry leaf weight (using the same leaves as for fresh leaf weight)
- leaf area (using the c. 5 pressed leaves)
- length of stomatal guard cell (from the acetate impressions)
- stomatal density (from the acetate impressions)
- epidermal cell area (from the acetate impressions)
- seed weight
- seed length, breadth and width

3.2.3. Functional attributes used:

Functional attributes were used that combine ease of measurement with value for functional ecological analysis. Attributes relating to drought tolerance and avoidance were used as potential indicators of irrigation or dry-farming regimes. Attributes relating to the duration and quality of the growth period indicate site productivity and are, therefore, relevant to the use of irrigation. Attributes related to environmental unpredictability were also investigated because, in the dry-farmed fields, water supply is more unpredictable than in irrigated fields and this may have an effect on plant strategies in these contrasting environments. The attributes used to explore the species - habitat relationship are listed in table 3.4.

Table 3.4: List of functional attributes used to describe ecological characteristics:

Functional plant attributes	Ecological characteristics predicted
Canopy dimensions (height and diameter)	Growth rate, competitive ability (relates to site productivity)
Leaf area per node	Growth rate, competitive ability (relates to site productivity)
Leaf width	Growth rate (relates to site productivity)
Specific leaf area	Growth rate (relates to site productivity)
Leaf dry matter content	Growth rate (relates to site productivity)
Leaf thickness	Growth rate (relates to site productivity)
Leaf width	Growth rate (relates to site productivity)
Seed size and morphology	Persistence in soil (relates to environmental unpredictability)
Root diameter (surrogate for length)	Drought avoidance
Epidermal cell size & shape	Drought tolerance
Stomatal density and size	Drought tolerance
Flowering start and duration	Drought avoidance

3.2.3.1. Attributes relating to the duration and quality of the period for plant growth:

3.2.3.1.1. Canopy dimensions:

Ecological Significance: Maximum size provides an estimate of whether or not a species is capable of achieving high biomass. The maximum size that a species can attain is a function of its growth rate. Weeds capable of achieving high values for canopy height and diameter are largely restricted to productive conditions. By contrast, some weeds are inherently smaller because they exploit less productive conditions where factors such as nutrients, water, light and even temperature limit the quality or length of the growing period (Bogaard *et al*, 1998). Environment will also affect season and duration of growth, which will in turn affect canopy dimensions. In unproductive environments species will tend to grow in the early part of the year during more favourable conditions, with higher rainfall, but have a short window for growth resulting in small biomass. In more productive environments species are able to grow for longer, into the later, more unfavourable time of the year and thus have a longer growth period allowing greater biomass.

Predicted Result: In dry-farmed fields smaller species are expected due to the unproductive environment and restricted growth period. On irrigated land larger species should be more frequent as the environment is more productive and the period available for growth is longer.

Procedure: Diameter (cm) and height (cm) of the canopy were measured at a number of locations, and the maximum used for each species. For semi-basal plants only (where stems are leafy but the largest leaves occur towards the base) the height of the densest part of the canopy was taken as an alternative because the smaller leaves at the top provide little competitive shading. This 'true' canopy height included only leaves that were 50% of the area (c.67% of the length) of the largest basal ones (Martí *et al*, 1996). For all species maximum canopy height was estimated using the following formula:

$$\frac{\text{measured canopy height}}{\text{measured plant height}} \times \text{maximum plant height (taken from Flora Palestina)}$$

Since canopy height and diameter are, to some extent, alternative methods of attaining high biomass, the sum of maximum canopy height and maximum canopy diameter (sum canopy dimension) was also calculated.

3.2.3.1.2. Leaf area per node:

Ecological Significance: Leaf area is positively correlated with potential productivity and plant growth rate (Hodgson *et al.*, in press). The plant shoot can be viewed as an essential modular structure made up of a series of nodes each with its associated leaf or leaves. Nodal units with many and/or large leaves necessitate a major investment of resources (both of carbon and nutrients) and each new unit may, because of its size, be comparatively slow to reach maturity. Thus large nodal units would not be expected if resources are scarce and so species with a large quantity of leaf per node should be associated with productive conditions. In such situations, large-leaved species have a competitive advantage in that they out-shade smaller plants and they have more photosynthetic capacity allowing faster growth, giving a temporal advantage over competitors (Grime, 1979).

"Large undivided leaves are more likely to 'overheat' and lose excessive amounts of water. However larger leaves shade a larger area of ground. Under conditions where water is non-limiting they may be viewed as a 'competitive' attribute."

(Martí *et al*, 1996:5)

Similarly, species with small quantities of leaf per node would be expected in unproductive habitats (Bogaard *et al*, 1998). Smaller photosynthetic capacity results in a slower growth rate: an ecological advantage where growth is limited by nutrient stress (Givnish, 1987). Grime and Hunt (1975) noted that slow growing species produce small leaves whereas fast growing species produce large leaves.

Predicted Result: Large leaved species should be found growing in the more productive irrigated field systems while small leaved species should be favoured in the more arid dry-farmed fields.

Procedure: Robust specimens of each species were collected at two to three locations and carefully pressed flat. The area (mm^2) of 5 whole leaves from each collection was measured using the Aequitas Image Analysis program (Dynamic Data Links, 1993-1996). The average individual leaf area for each species was multiplied by the typical number of leaves per node for that species.

3.2.3.1.3. Leaf width:

Ecological Significance: As with leaf area, maximum leaf width tends to be high in species of productive habitats as leaf size increases with nutrients, light and moisture levels (Givnish, 1987).

Predicted Result: It is expected that species with wide leaves would tend to be found in irrigated fields and narrow-leaved species in dry-farmed ones.

Procedure: Leaf width (mm) was defined as the width of a more or less continuous leaf expanse perpendicular to the midrib. In the case of compound leaves (e.g. *Vicia* spp.) and deeply dissected leaves (e.g. *Ridolfia segetum*), the width of a more or less entire segment or leaflet was measured (see figure 3.4). The maximum leaf width was measured on each of 5 replicate plants and the largest of these values for each species was used in analysis.

3.2.3.1.4. Specific leaf area:

Ecological Significance: Specific leaf area (leaf area divided by leaf dry weight) is a surrogate measurement for a number of important structural and functional characteristics including net photosynthetic capacity, growth rate, leaf life span, and toughness, all of which are strongly correlated with habitat productivity and the capacity for rapid growth (Reich *et al*,1992; Reich, 1993; van Arendonk and Poorter, 1994). These relationships exist because leaf fall is associated with nutrient loss. It is argued that in productive systems, plants can maximise their photosynthetic potential by rapidly producing thin but short-lived leaves with high nitrogen concentration and high specific leaf area, while in unproductive habitats leaves will tend to be tough and long-lived with a low specific leaf area (Coley *et al*, 1985; Field & Mooney, 1986; Koike, 1988; Kikuzawa, 1991; Reich *et al*, 1991, 1992).

"If nutrients are scarce, long-lived leaves will be produced to minimise nutrient losses on senescence. Long-lived leaves will necessarily include much lignin and other carbon compounds involved in structure and defense against herbivory."

(Martí *et al*, 1996:5).

Specific leaf area does show some variation within species in response to habitat conditions but, despite this plasticity, it can be effectively used to distinguish between productive and unproductive habitats (Reich *et al*, 1992). The presence of many species with a high value for specific leaf area may be regarded as evidence that nutrient status and water availability are not major limiting factors during the growth period. If specific leaf area values are mainly low, constraints to rapid growth may be in operation.

Predicted Result: Species with high specific leaf area should predominantly occur in the more productive irrigated environment rather than the comparatively unproductive dry-farmed fields.

Procedure: The leaves used for measuring leaf area (see above) were left for two days in an oven at 80°C and then weighed (mg). Specific leaf area was then calculated by dividing leaf area (mm^2) by leaf dry weight (mg).

3.2.3.1.5. Leaf dry matter content:

Ecological significance: Although specific leaf area can be used effectively to distinguish between highly productive and highly unproductive habitats (Reich *et al*, 1992), the measurement has two major weaknesses. First, leaf thickness is an important determinant of specific leaf area (Shipley, 1995) and is very plastic particularly in relation to light intensity (Dale, 1982; Witkowski & Lamont, 1991). This may explain a tendency for replicate values to differ greatly. Secondly, the validity of specific leaf area as an estimate of site productivity requires that light is the limiting factor for photosynthesis (and ultimately growth), however, light may not be limiting in open field environments. If, however, carbon dioxide is limiting, which is quite possible if fields are very open, factors relating to stomata, through which carbon dioxide diffuses, may be more critical than specific leaf area. Therefore, dry matter content (leaf dry weight divided by leaf fresh weight) was also measured. This describes the amount of dry matter investment in leaves and, like specific leaf area, low dry matter content is associated with the rapid production of short-lived, thin, watery leaves and hence with fast growth in productive environments (Garnier & Laurent, 1994; Ryser, 1996). Unlike specific leaf area, dry matter content is more mechanistically neutral as far as constraints to photosynthesis are concerned. Fast growing species of productive habitats have a low dry matter content irrespective of whether they are shaded by taller plants or whether they occur in well-lit situations (Bogaard *et al*, 1999).

Predicted result: Species with low dry matter content should occur predominantly in the irrigated fields, whereas those with high dry matter content should be favoured in dry-farmed fields.

Procedure: About 1g fresh weight of leaves from each collection of specimens was enclosed in a moistened paper towel and kept refrigerated overnight in a sealed polythene bag. The fully turgid leaves were quickly dabbed dry with tissues and weighed (mg). The leaves were then put in an oven at 80°C for two days and weighed again (mg). Dry matter content was then calculated by dividing fresh leaf weight by dry leaf weight.

3.2.3.1.6. Leaf thickness:

Ecological Significance: As with specific leaf area and leaf dry matter content, leaf thickness may be an indicator of productivity and site fertility. In fertile areas fast growing species produce thin, ephemeral leaves. In less fertile areas, where nutrient loss is more of a problem, plants retain more long-lived, robust, thicker leaves (Coley *et al*, 1985; Field & Mooney, 1986; Koike, 1988; Kikuzawa, 1991; Reich *et al*, 1991, 1992).

Predicted Result: Thinner-leaved species should be found in the more productive environment of irrigated fields. Species with thicker leaves should be favoured in dry-farmed fields.

Procedure: Leaf thickness was measured on leaves that had been left in the fridge for a few hours to reach turgor. Three leaf thickness measurements were taken from each species collection: from the top, middle and lower canopy of the plant. The inter-veinal thickness was measured (to the nearest 0.01 mm) using a dial thickness gauge (which applies very little force to the leaf surface). One reading was taken for each of the three leaves selected per collection and an average calculated for each species.

3.2.3.2. Attributes relating to environmental unpredictability:

3.2.3.2.1. Regeneration by means of persistent buried seeds:

Ecological Significance: Seed size and shape are adaptations facilitating the formation of a persistent seed bank in the soil (Thompson *et al*, 1993). It is an important attribute as most arable weed species will need a persistent seed bank in order to tolerate the highly disturbed environment produced by cultivation. It is a mechanism for surviving if weeding, harvesting or ploughing occur before seed set (Bogaard *et al*, 1998). It also provides the ability to survive periodically fluctuating environmental conditions such as drought. This is an adaptation particularly advantageous in unproductive environments. Small, round seeds become buried more rapidly in the soil than large, elongate or flattened ones and are, therefore, less easy for potential predators to find. To form a seed bank, they must also remain dormant until favourable growing conditions occur, e.g. the right soil moisture level. Another group of species is afforded some protection on the soil surface through hard-coat dormancy (Thompson *et al*, 1996). These species are not necessarily small seeded.

Predicted Result: As most arable weeds would be expected to have a persistent seed bank, only minor differences between irrigated and dry-farmed fields are expected. It is anticipated that species with a persistent seed bank will be at a particular advantage in dry-farmed fields, because of their ability to survive years of drought.

Procedure: Seed shape and seed weight were used to predict the ease of seed burial in the soil. A binocular microscope (x10 magnification) with a graticule was used to measure the seed length, breadth and thickness (mm). Measurements were taken of the dispersal unit: either seed or fruit depending on the species (e.g. for *Medicago* the fruits are the dispersal unit as they do not readily dehisce). Five replicates were measured for each species and averaged to produce the final values. The values were transformed so that length (the longest dimension) was unity: seed variance: = var (Length x Breadth x Thickness)mm, where: Length = 1. For the resultant values: 0 = spherical (easily buried and, therefore, persistent in the soil); larger values = slim needle, disc shapes (less easily buried and less persistent). For the measurement of seed weight, twenty seeds of each species were weighed (mg) and individual seed weight calculated. The lower the weight the more easily the seed should be buried in the soil. Combined seed weight and shape was calculated using the formula:

$$\text{seed weight (mg)} \times \sqrt{\text{variance of seed dimensions}}$$

These results were then compared with figures already calculated for species showing seed persistence (i.e. the formation of a seed bank of 2 years duration): for fruits, seed persistence is indicated by, weight <3mg and variance <0.17, and for seeds, weight <3mg and variance <0.14.

3.2.3.3. Attributes relating to drought avoidance or tolerance:

3.2.3.3.1. Root diameter:

Ecological Significance: Plant species can utilise a more constant water source than precipitation in the form of subsoil water (Dobrowolski *et al*, 1990). In arid regions plants may avoid drought by developing deep root systems to tap the subsoil water, i.e. a drought avoidance strategy (Parker, 1968). Species with shallow roots may be better able to exploit the more nutrient rich upper soil levels where water is not a limiting factor. Different plant species do seem to vary in their root distribution (Hellmers *et al*, 1955) and the extent of subsoil water exploitation (Davis and Mooney, 1986; Donovan and Ehleringer, 1994).

Predicted Result: A deep root system can function as a drought avoidance mechanism and, therefore, the species of dry-farmed fields may on average possess deeper root systems.

Procedure: Past attempts to excavate entire root systems to the full extent of their depth has proved both time consuming and unsuccessful. A prediction was attempted using partial root systems (using the observation that roots are thick at the top and thin at the bottom). Root diameter was chosen as an alternative measurement under the assumption that deep roots will be thick. The reliability of this measurement has not yet been tested sufficiently, though a similar study in Borja, Spain, found that there was a significant correlation between root diameter at 10cm depth and root length, where: $r = 0.36$, $P = <0.001$, $n = 83$ (Charles *et al*, 1997). For each species, one root collection was made from a robust plant and the diameter (mm) of the main root at 10cm depth was measured using calipers.

3.2.3.3.2. Epidermal cell size:

Ecological Significance: The size of cells in the leaf epidermis can be linked to drought tolerance. The smaller the cell the less susceptible it is to damage due to water loss (Cutler *et al*, 1977).

Predicted Result: Theoretically it would be expected that species from irrigated fields would tend to have larger cells than those from dry-farmed ones.

Procedure: The method of Beerling and Chaloner (1992) was used to take acetate impressions from the upper and lower surfaces of each of 3 replicate leaves (from the top, middle and bottom foliage of the plant) per species collection (see figure 3.5). Leaf segments were placed with the desired surface facing up, painted with acetone solution and a piece of acetate sheet placed on top. They were pressed under a heavy weight for a few minutes to let the impression of the leaf surface form on the acetate. When removed from the press the leaf segments were peeled from the acetate. The acetate (with impressions) was then stuck to a microscope slide using clear sticky tape and labelled with the species and location. The impressions were checked for clarity using a portable microscope and the cells measured later using the Aequitas Image Analysis program (Dynamic Data Links, 1993-1996). Cell area (μm^2) was measured at 5 locations on each upper and lower leaf surface impression. An average was calculated for each species.

3.2.3.3.3. Epidermal cell wall undulation:

Ecological significance: In some species thick bands are produced in the cell wall producing controlled growth in these areas. During cell expansion, differential extension of the thinner parts of the cell wall between these bands results in cell wall undulation (Panteris *et al*, 1994; Watson, 1942). If positive turgor pressure is maintained undulating cell walls can provide tensile strength to leaves which possess little specialised support tissue (Linsbauer, 1930). Stace (1965) states that "straight walled epidermal cells are commoner in xeromorphic plants than in mesomorphic ones which typically have undulating cell walls."

Predicted Result: Theoretically it would be expected that undulating cell walls would be more characteristic of species from irrigated fields.

Procedure: Epidermal cell wall perimeter was measured at 5 locations on each upper and lower leaf impression (taken as above) using the Aequitas Image Analysis program (Dynamic Data Links, 1993-1996). Cell wall undulation was calculated by dividing cell perimeter by cell area. The presence or absence of cell wall undulation was also recorded visually by observation under the microscope. This was carried out in order to compare the accuracy of the two methods.

3.2.3.3.4. Stomatal size and density:

Ecological Significance: Stomata are pores in the leaf epidermis used for gaseous diffusion. The diffusion of carbon dioxide in through the stomata is balanced against the loss of water through the pore (Jarvis & McNaughton, 1986). The combination of stomatal size and density determines maximum carbon dioxide uptake without excessive water loss (Parkhurst, 1978). Interspecific differences in stomatal density and distribution have been identified in comparative studies (Salisbury, 1927; Parkhurst, 1978; Mott *et al*, 1982). These differences have been attributed to differences in water conservation and photosynthesis (Peat & Fitter, 1994). Differences in stomatal size also have a greater effect on the diffusion of water vapour than of carbon dioxide (Bidwell, 1974). In theory, therefore, leaves with smaller stomatal pores should have a greater water use efficiency than leaves with larger stomata (Abrams *et al*, 1994). There is a negative relationship between stomatal size and density (Carpenter & Smith, 1975; Hodgson *et al*, in press). It is postulated that plants from dry habitats may have smaller, more numerous stomata (Salisbury, 1927, Carpenter & Smith, 1975; Donselman & Flint, 1982). By contrast larger and fewer stomata are characteristic of moist, fertile habitats (Hodgson *et al*, in press).

Predicted Result: It is anticipated that species characteristic of the dry-farmed fields will have small, numerous stomata whereas those from irrigated fields will have fewer, larger stomata.

Procedure: Stomatal pore size is difficult to assess accurately since stomata may be at various stages of closure, and so the surrounding guard cell size was used as a measure of pore size. Stomatal guard cell area (μm^2) was measured at 5 locations on the upper and lower leaf impressions (taken as above) using the Aequitas Image Analysis program (Dynamic Data Links, 1993-1996). An average was calculated for the species as a whole. Stomatal density (number per mm^2) was measured at 5 points on each upper and lower leaf surface impression. Mean stomatal density was calculated for each species as the average for both surfaces.

3.2.4.3.5. Flowering start and duration:

Ecological Significance: The growth season of plant species will tend to occur in one or other halves of the year (as for winter and summer annuals). The life cycle of a plant is largely preconditioned by its typical environment because many species respond to environmental cues for flowering and vegetative reproduction (Evans, 1969). The period of growth for many winter annuals is foreshortened by flowering in response to the short days of spring (Evans, 1969). This allows the production of seed before an anticipated summer drought (a drought avoidance strategy). More favourable habitats will be exploited by summer annuals as the cues for flowering do not occur until later in the year allowing a longer growth period (Evans, 1969). This situation will be expected in environments where there is little stress due to nutrient or water shortages.

Predicted Result: In dry-farmed fields, early, short flowering winter annuals are expected, while on irrigated land longer, later flowering summer annuals should be more frequent.

Procedure: All information on flowering start and duration (months) was gathered from Flora Palestina (Zohary and Feinbrun-Dothan, 1964-1986), Flora of Iraq (Townsend and Guest, 1966-85) and Flora of Turkey (Davies *et al*, 1965-88).

3.3. Archaeobotanical methods:

A pilot study of the archaeobotanical remains from Khirbet Faris was carried out in 1993 (Hoppé, 1993). The samples were found to contain well preserved and varied plant remains in sufficient quantity for further analysis. Table 3.5 is a summary of the stages of analysis used for the selection of samples for detailed analysis.

Table 3.5: Summary of the sample selection procedure:

Stage of analysis	**Level of analysis**	**Criterion for selection**	**Number of samples**	**Proportion of the total number of samples (%)**
1	Samples excavated and floated	All archaeological contexts	344	100
2	D.A.F.O.R. scanned	All samples	344	100
3	Sorted, roughly identified to groups and quantified	Samples with D.A.F.O.R. score of >2	164	48
4	Complete identification, recording and statistical analysis	Samples with >50 cultivar items	100	30

3.3.1. On-site methods of sampling and extraction:

Stage 1: During the 1988 and 1989 excavation seasons, an archaeobotanical pilot study was carried out. Samples with an average volume of 2 litres were taken from every deposit. In order to increase the quantity of archaeobotanical remains obtained from 1990 to 1994, a minimum of 50 litres per deposit was aimed for. However, when the context was smaller than this, the entire deposit was taken as a sample. Samples were obtained from a range of different context types from different periods.

In total, 344 samples were processed from the site (see table 3.5). The extraction process was carried out using machine flotation (as described by French, 1971). This method is commonly used to separate carbonised plant remains from the soil matrix. The flot was collected using 1mm and 250μ geological sieves. The heavy residue was collected in a 2mm soft mesh inside the tank, to retain archaeobotanical remains that did not float. The process took place at the nearest water source; a spring at the bottom of Wadi Zubaiqa, adjacent to the site.

3.3.2. Off-site methods of sample selection and identification:

Stage 2: A preliminary scan of all 344 samples was carried out. Using the DAFOR method the following groups were recorded according to whether they were: Dominant, Abundant, Frequent, Occasional or Rare in the sample:

- charred remains (cereal grains, chaff fragments, pulse seeds, fruits, seeds of wild species, dung and charcoal fragments)

- other biological remains (beetles and molluscs)
- contaminants (modern weeds and roots)
- mineral material (silt and stones)

This information was stored on a data sheet, along with the volume of each sample and a score relating to the 'richness' of charred plant remains. The score for richness was given on a scale of 0 to 5 (0 equating to absence of charred plant remains and 5 signifying a very rich sample). For an example of the DAFOR recording sheet see Appendix 5. From this process 164 samples, with a 'richness score' of more than 2, were selected for further study (see table 3.5).

Stage3: The identifiable plant remains were sorted from the mineral fraction of each of the 164 samples, categorised into groups and a rough count made of the following categories: cereal grains, cereal chaff, cultivated pulses, fruits and nuts, and wild taxa. From this rough count, 100 samples, containing more than 50 cultivar items in each (including cereal grain and chaff, pulses, fruits and nuts), were selected for further study.

The context information and phasing for these 100 samples are given in Appendix 4. Most of the samples (71) come from the extensively excavated area of FAR I. Twenty-one samples were from the second largest excavation area on the site, FAR V. The rest of the samples were scattered over the site: three from FAR II, two from FAR IV, two from House 2 and one from House 1.

Sixteen of the 100 samples were not assigned to a context type. Many of the samples

(33) come from midden contexts; ashy waste layers full of artifactual and environmental debris such as pot sherds, animal and fish bones and charcoal, as well as archaeobotanical remains. The remaining samples come from ovens, hearths, pits, floor layers, cistern fill, feature packing/infill and rubble matrix. The phasing for these samples is based on the analysis of ceramics from the contexts, many of which contain pottery from different phases. This is perhaps unsurprising from contexts such as middens, rubble and packing, where site detritus is likely to be mixed. Many contexts also show re-use in different periods (A. McQuitty pers. comm.). Table 3.6 gives a breakdown of the sample context types represented in different periods.

Table 3.6: *Context types divided by period:*

Context type	**5th to 9th century**	**5th to 13th century**	**13th century**	**14th to 17th century**	**No pottery dating available**	**Total**
Oven		1 (8%)	3 (11%)	1 (20%)	6 (18%)	11 (13%)
Hearth			3 (11%)		2 (6%)	5 (6%)
Pit Fill	2 (40%)	1 (8%)	2 (7%)		4 (13%)	9 (11%)
Surface	1 (20%)	1 (8%)	2 (7%)		5 (15%)	9 (11%)
Packing		2 (15%)	1 (4%)		1 (3%)	4 (5%)
Midden	2 (40%)	6 (46%)	14 (52%)		11 (32%)	33 (39%)
Rubble Matrix		2 (15%)	1 (4%)	1 (20%)	5 (15%)	9 (11%)
Cistern Fill			1 (4%)	3 (60%)		4 (5%)
Total	5	13	27	5	34	84

There is a reasonable representation of context types within the early and late phases with no one type forming more than 40% of total samples; the most common type in both the early and late periods is the midden samples. There is, however, a disparity in the occurrence of oven, hearth and cistern samples as there are hardly any in the earliest phases. As all contexts were sampled, it is also known that there were very few ovens and hearths and no cistern samples from the rest of early Khirbet Faris samples (those with <50 cultivar items). So there is a real bias against these contexts in the earlier periods.

Stage 4: Preliminary identification of plant material in the 100 samples was carried out at the British Institute in Amman for Archaeology and History in Jordan. Final identification and recording was carried out at Sheffield University with the aid of the comparative seed reference collection at the department of Archaeology and Prehistory. Further clarification of identifications was carried out at the Institute of Archaeology in London, using the extensive Near Eastern seed reference collection. Use was also made of various reference resources (Anderber, 1994; Beijerinck, 1947; Berggren, 1969, 1981; Jacomet, 1987). All identification work was carried out using a binocular microscope (x10 – x40 magnification). With fragmented seeds, it is possible that the same individual specimen could be counted more than once, and so a unique part of each specimen was counted to give a record of the minimum number of plant remains (see table 3.7). These 100 samples are rich enough to provide a reasonably reliable and accurate estimate of the relative proportions of different plant components (van der Veen and Fieller, 1982) and are, therefore, suitable for statistical analysis.

Table 3.7: Summary of the recording regime for charred plant remains:

Plant Remain	Scoring Element	Score
Cereal Grain	embryo end	1 grain
Cereal Rachis	node	1 internode
Wheat Glume	base of glume	1 glume base
Wheat Spikelet fork	base of glume	2 glume bases
Legume seed	2 cotyledons	1 seed
Olive seed	apex	1 seed
Wild grass seed	embryo end	1 seed
Other Wild/Weed seed	Whole or fragmented	1 seed

The results were recorded onto a spread sheet in order to create the final tables and manipulate data in the form of summary tables. Ecological data about the wild plants identified was obtained from Flora Palestina (Zohary and Feinbrun-Dothan, 1964-1986); the Flora of Iraq (Townsend and Guest, 1966-85) and the Flora of Turkey (Davies *et al*, 1965-88).

3.4. Data analysis:

3.4.1. Analysis of Wadi Ibn Hammad ethnoarchaeological data:

The relationship of environmental and crop variables to irrigation level was explored through cross tabulation. In order to assess the likely impact of the variables on weed floras the average value for each variable was calculated per field type. In this way it could be deduced whether irrigation or other field variables were more likely to contribute to differences in weed floras between fields with different watering regimes.

Correspondence analysis was carried out on the archaeobotanical data from Wadi Ibn Hammad to explore variation in weed species composition between fields. This is an ordination technique which arranges samples (in this case fields) along axes on the basis of species (in this case weed species) composition (Hill, 1977; Jongman *et al.*, 1987; Lange 1990; G. Jones, 1991). Fields are positioned along the axes according to their composition and species according to the fields in which they occur. This highlights which fields are of similar composition, which species co-occur in the same fields and which species occur in which fields. The species and fields can then be placed in multi-dimensional space based on coordinates from the axes that are created by the analysis to account for the maximum amount of variation. The first ordination axis accounts for most of the variation in species composition the second for most of the remaining variation and so on. The programs of CANOCO (ter Braak, 1988) and CANODRAW (Smilauer, 1992) were used to carry out the analysis and plot the results respectively. The weed species data used were in the form of number of quadrats (out of 10) per field in which each species occurred. Only species present in 5 or more fields (ca. 10% of fields) were included in the analysis, as rare species tend to be over-emphasised 'masking' more fundamental patterning in the data.

Correspondence analysis allows simultaneous representation of both fields and species so that their inter-relationship can be clearly seen (Baxter, 1994). In this study, this is achieved by plotting fields and species separately (for clarity) but side by side (for comparison). In all figures the first axis is plotted horizontally and the second axis vertically (third and later axes are not plotted). In the plots of fields, the symbols indicate the field type (plateau dry-farmed, wadi dry-farmed, fully-irrigated and biennially-irrigated) and, in the plots of species, symbols indicate the attribute values for each species.

A canonical correspondence analysis, using the environmental and crop variables to constrain the ordination based on species composition, was also applied to the data. The environmental variables included soil organic content, stoniness, pH, field slope, aspect and irrigation level. The crop variables were height, cover and type (see Appendix 2 for a key to the variables used). These external variables are represented by lines radiating from the origin of the plot. The influence of a particular external variable on weed composition can be assessed by its direction and distance from the origin. The length of the line is a measure of how much influence that variable has on the ordination, with more important variables represented by longer lines than less important ones (ter Braak, 1986).

Discriminant analysis was used to distinguish different field types on the basis of weed species composition. This is a method of multivariate analysis which finds the best linear combination of variables (in this case attribute scores) for discriminating between pre-defined groups of cases (in this case irrigation level). The 'direct' method from the SPSS package was used in this analysis (Norušis, 1990). For each field, an average score was determined for each attribute. This was calculated using the following formula:

$(a_1k_1 + a_2k_2.......... + a_nk_n)(k_1 + k_2....... + k_n)$

Where,

k = number of quadrats within the field in which the species was recorded (maximum value 10)

a = value for the species of the attribute under study

n = number of species recorded from the field

This may be expressed more consisely as: $\sum_l^n ca_i k_i / \sum_l^n k_l$

Where,

k_i = number of quadrats in which the ith species is recorded

a_i = value of the attribute for the ith species

In the following worked example for a field with two species of specific leaf area 5 and 20 $mm^2\ mg^{-1}$ respectively, and present in 2 and 8 quadrats respectively, the attribute score is as follows:

$(2 \times 5 + 8 \times 20) / 2+8 = (10 + 160) / 10 = 17\ mm^2\ mg^{-1}$ (Charles *et al*, 1997)

The discriminant functions extracted are used to re-classify the fields as one or other of the field types. The percentage of fields which are correctly reclassified into their original groups may be used as a measure of the success of the attributes in discriminating between different field types.

Cross tabulation was also used to compare average attribute values for each field type. For each field type (fully-irrigated, biennially-irrigated, wadi dry-farmed and plateau dry-farmed), the total number of quadrats in which each species occurred was calculated. Species of which 70% occurrence is in a given regime were considered to be 'indicator' species for this field type. For each field type average attribute scores were calculated and compared.

3.4.2. Analysis of Khirbet Faris archaeobotanical data:

3.4.2.1. Crop processing analysis:

Crop processing has a large impact on the composition of archaeobotanical samples. The variation due to crop processing has to be understood in order to use samples to interpret archaeobotanical remains in terms of crop management practices (G. Jones, 1987). Ethnographic comparisons with present-day traditional agricultural methods have been used to interpret archaeobotanical samples in terms of crop processing (Hillman, 1973, 1981, 1984).

"The analysis of ethnographically collected samples shows that the products and by-products of different processing stages are sufficiently distinct to be discriminated on the basis of their composition (G. Jones, 1983a, 1984)."

(G. Jones, 1987: 311).

G. Jones (1983b, 1984, 1987, 1990) devised a method by which archaeobotanical samples could be compared with ethnographic data recorded from traditional cereal processing in Amorgos, Greece, in order to determine which stages of crop processing could be found in the archaeological samples. This study was of free-threshing cereals and pulses, and so is comparable with the free-threshing crop remains found at Khirbet Faris. These methods were, therefore, applied to the Khirbet Faris samples.

Samples from the products and by-products of processing at Amorgos were collected and the crop and weed components quantified. The ethnographic products and by-products sampled were selected according to whether they were likely to be charred and, therefore, preserved archaeologically. "By-products of winnowing, coarse and fine sieving are frequently burnt on site as fuel (Hillman, 1981, 1984)" (G. Jones, 1987: 314). Products of later crop processing stages are stored and could be burnt accidentally (G. Jones, 1984, 1987).

The first part of G. Jones's study involved using the relative proportions of cereal grain, chaff and weed seeds to characterise the different crop processing stages (G. Jones, 1990), and give some indication of the composition of different crop processing products and by-products that might be expected for free-threshing crops. These results are summarised in table 3.8.

Table 3.8: Character of sample groups associated with crop processing stages (summary of G. Jones, 1990):

Crop processing stage	**Rachis internodes**	**Weed seeds**	**Grains**
Winnowing by-product	50% or more	usually more than grain	usually fewer than weeds
Coarse sieving by-product	30-50%	variable	variable
Fine sieving by-product	< 10%	50% or more	variable
Fine sieving product	< 5%	variable	80-95%

The archaeobotanical data from Khirbet Faris was grouped into grain, chaff and weed components, by sample, and sorted according to the dominance of the various components. The resultant sample groups were then compared to the crop processing stages defined using the Amorgos data (table 3.7), although it is recognized that sample composition from another settlement may not match the Amorgos data exactly because of variations in the weeds growing with crops and the thoroughness of processing etc.

The second part of the Amorgos study used information on weed seed properties. G. Jones's (1984) analysis showed that crop processing stages could be differentiated on the basis of weed seed characteristics. Weed seed characteristics were used as opposed to indicator species, so that this method could be applied archaeologically - it is unlikely that the same weed species would occur at different time periods and in different places across the world (G. Jones, 1987). The way in which these characteristics relate to the Amorgos crop processing stages is shown in table 3.9.

Table 3.9: The stages at which different weed seed types are likely to be removed (*key overleaf*):

Processing stage	**Weed types**
Winnowing	small, free, light (SFL)
Coarse sieving	small, headed, light (SHL) small, headed, heavy (SHH) big, headed, heavy (BHH)
Fine sieving	small, free, heavy (SFH)
Hand sorting	big, free, heavy (BFH)

Key:

small:	tend to be removed by 2mm mesh sieve	**big:**	tend to be retained by 2mm mesh sieve
headed:	seeds remaining in pods, spikes or 'heads' during threshing (or with large appendages)	**free:**	seeds released from pods, spikes or 'heads' during threshing (and with no large appendages)
light:	seeds with wings, hairs etc (or very small)	**heavy:**	seeds without wings, hairs etc (and not particularly small)

Each species from Khirbet Faris was assigned to one of the 6 categories in table 3.9 according to the morphological properties of its seeds. A discriminant analysis (described in section 3.4) was carried out on a data set comprising the counts of seeds in each of these categories for the Khirbet Faris samples and the Amorgos samples from the different crop processing stages (as described in G. Jones, 1983b, 1987). In this analysis, the predefined groups to be discriminated were the four crop processing groups from Amorgos (winnowing by-product, coarse sieving by-product, fine sieving by-product and fine sieving product). The Khirbet Faris samples were entered into the classification stage of the discriminant analysis as samples of unknown processing group, and each sample assigned to one of the four groups with a probability level indicating the likelihood of the sample belonging to that group.

The results from these two aspects of the analysis could then be compared to determine the crop processing 'status' of each sample based on both the ratios of grain:chaff:weed elements and the character of the weed seeds present.

3.4.2.2. Compositional analysis:

The source of the archaeobotanical material was investigated to explore the possibility that some samples were derived from fodder, the resultant dung then being used as fuel, and if so, whether the source of the fodder was from crop processing residue or wild pasture. The latter would affect the validity of using the archaeobotanical data to interpret crop management practices. To assess the source of plant material various elements of the samples were examined: the crop processing stage of the material (from grain, chaff and weed ratios, weed characteristics and the amount of straw - culm nodes), the presence of dung fragments and of wild species that flower and fruit late, after the time of harvest (i.e. species that could not have been transported, in seed, to the site along with the harvested crop and, therefore, may have come to the site through animals grazing wild pasture later on in the year, the seeds from these plant species being deposited in dung at the site).

Once the source of the archaeobotanical material had been determined an internal analysis of samples was conducted using correspondence analysis (described in section 3.4.1) to examine compositional variations between samples and relate this to archaeological context, date and excavation area. Only species present in 10% or more of samples were included for this analysis, as rare species may create 'noise' and mask patterns in the data. Samples were categorised according to archaeological context, date and excavation area and plotted in relation to correspondence axes 1 and 2: symbols were used to denote context, date and excavation area.

In order to determine whether irrigation was practiced at Khirbet Faris in the past, those species found in the archaeological samples, that had been measured during the Wadi Ibn Hammad FIBS study, were classified according to those attributes that were successful in differentiating different levels of irrigation at Wadi Ibn Hammad. These species were grouped according to their attribute values in the same way as they had been for the Wadi Ibn Hammad study and symbols were used in the plots of species to denote these values.

Figure 3.1 Wadi Ibn Hammad field location map 1: the wadi bottom and sides

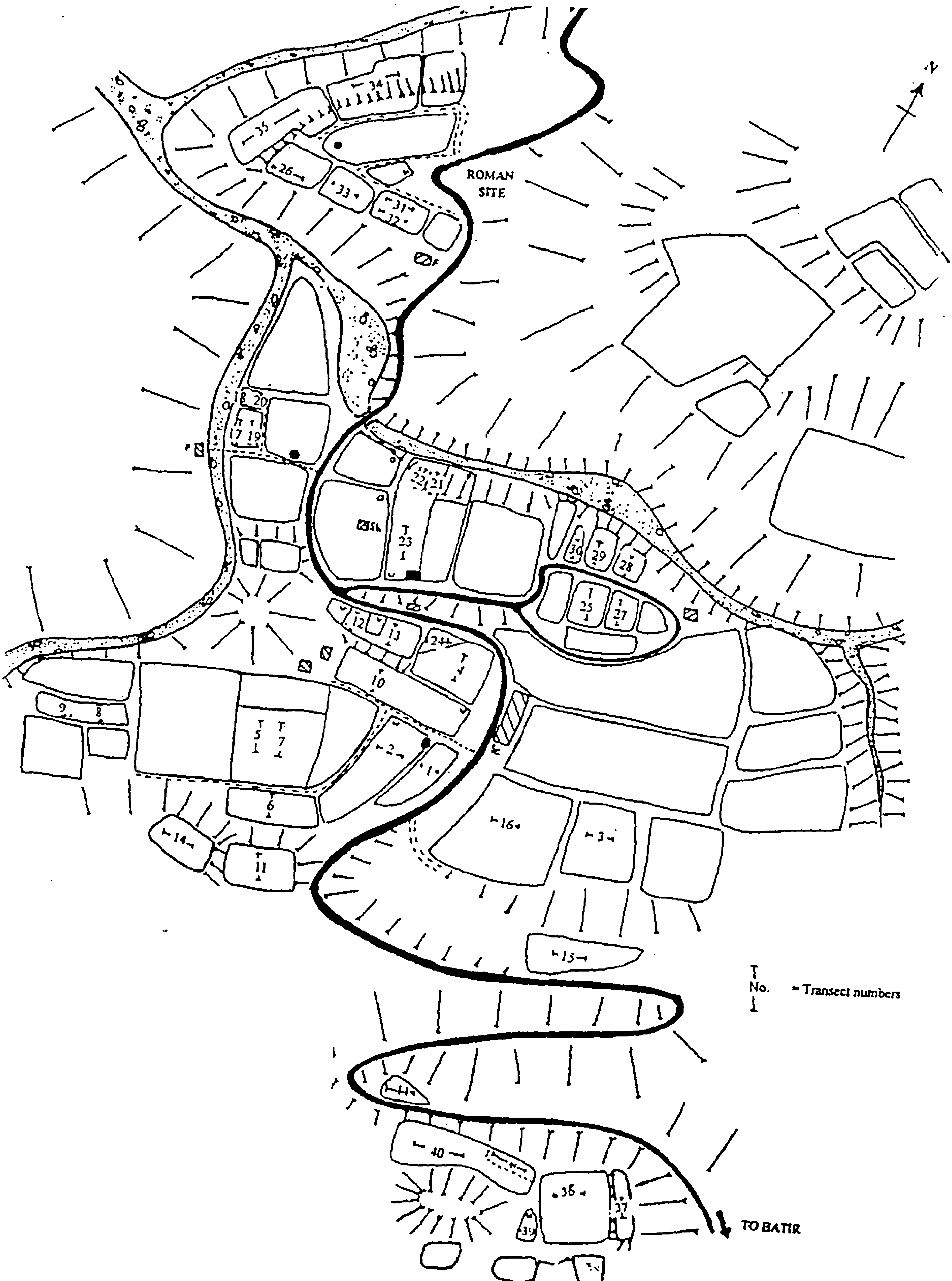


Figure 3.2 Wadi Ibn Hammad field location map 2: the plateau top

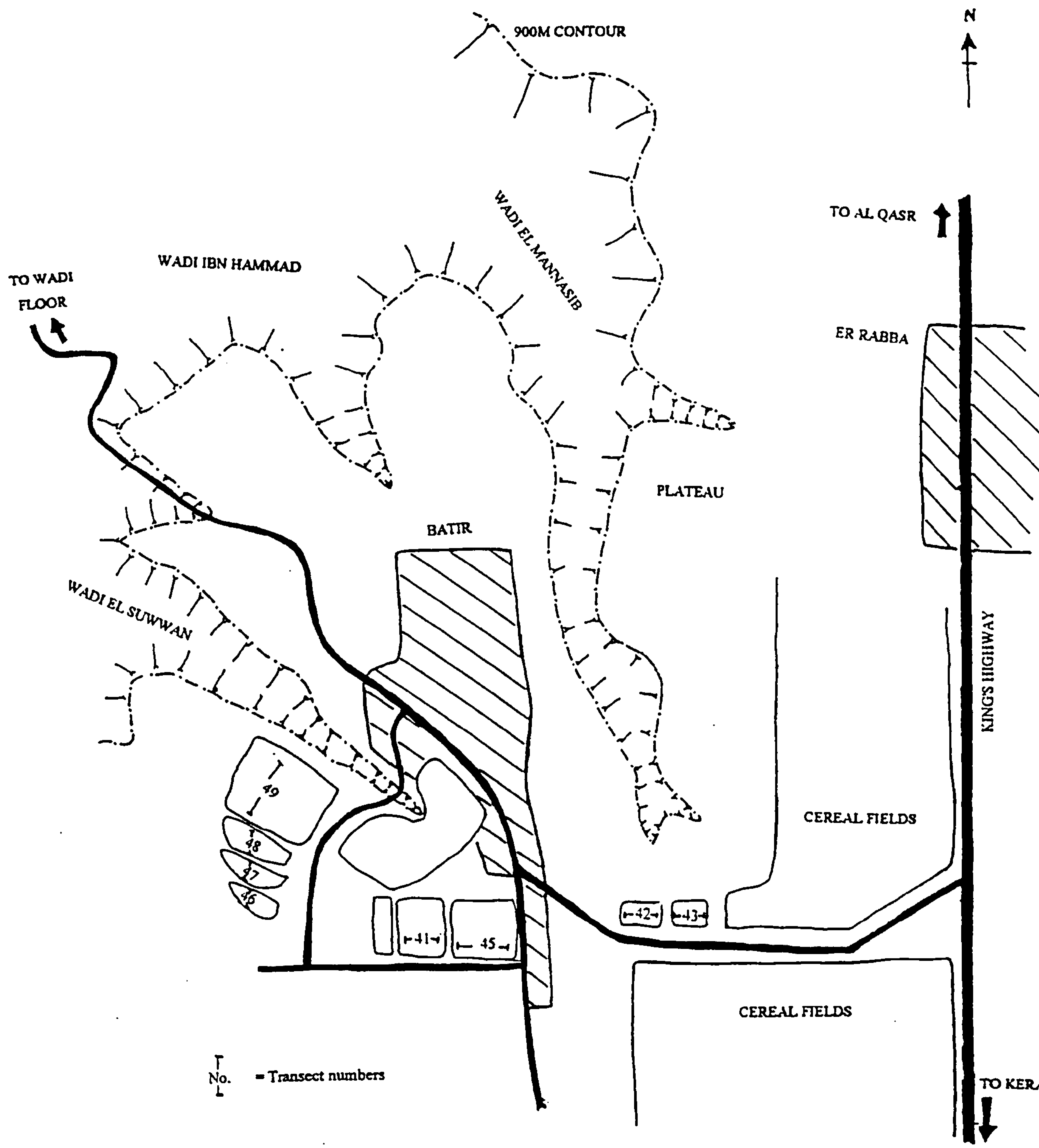


Figure 3.3 Wadi Ibn Hammad field location map 3: the plateau top

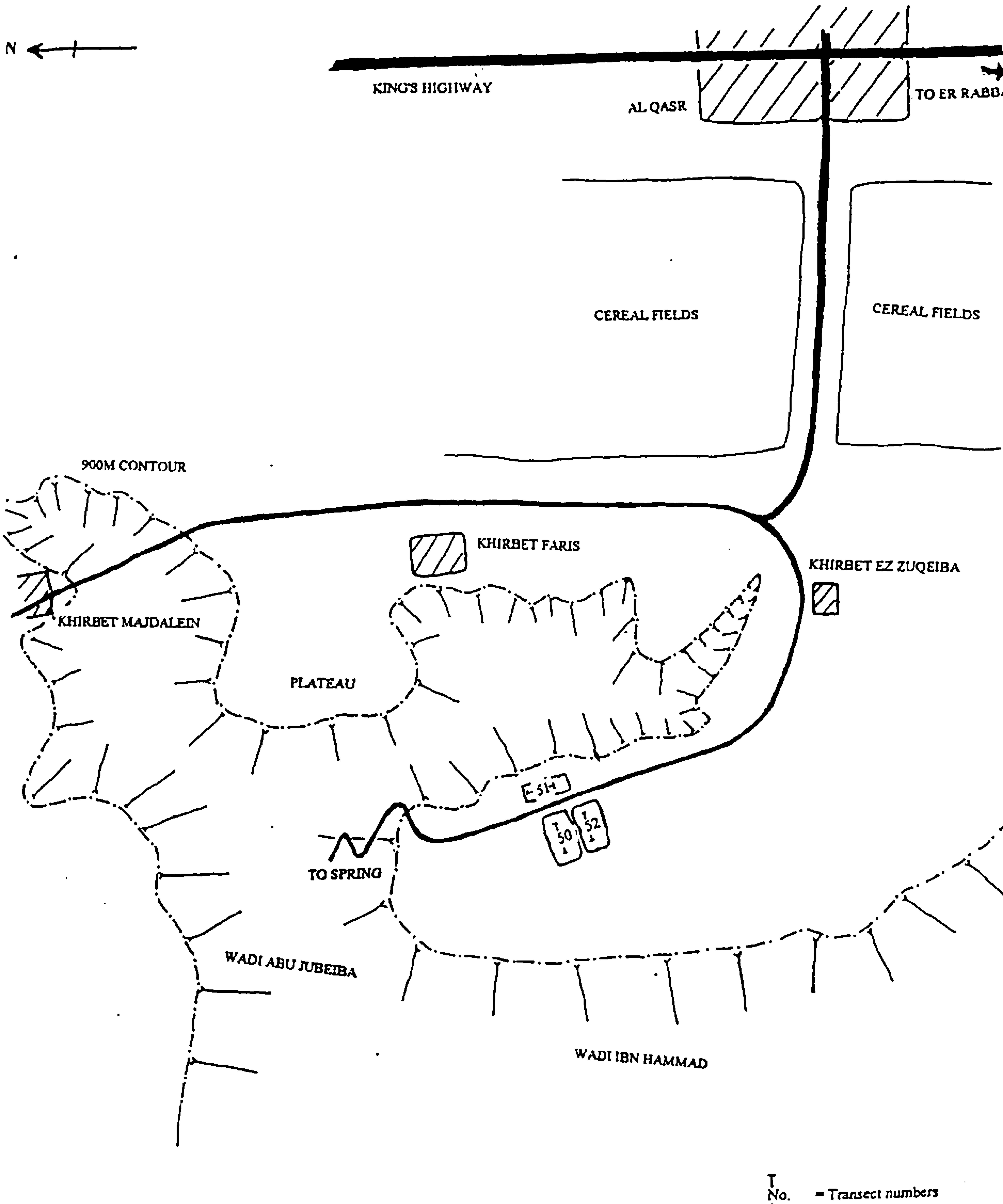


Figure 3.4: Leaf width measurement:

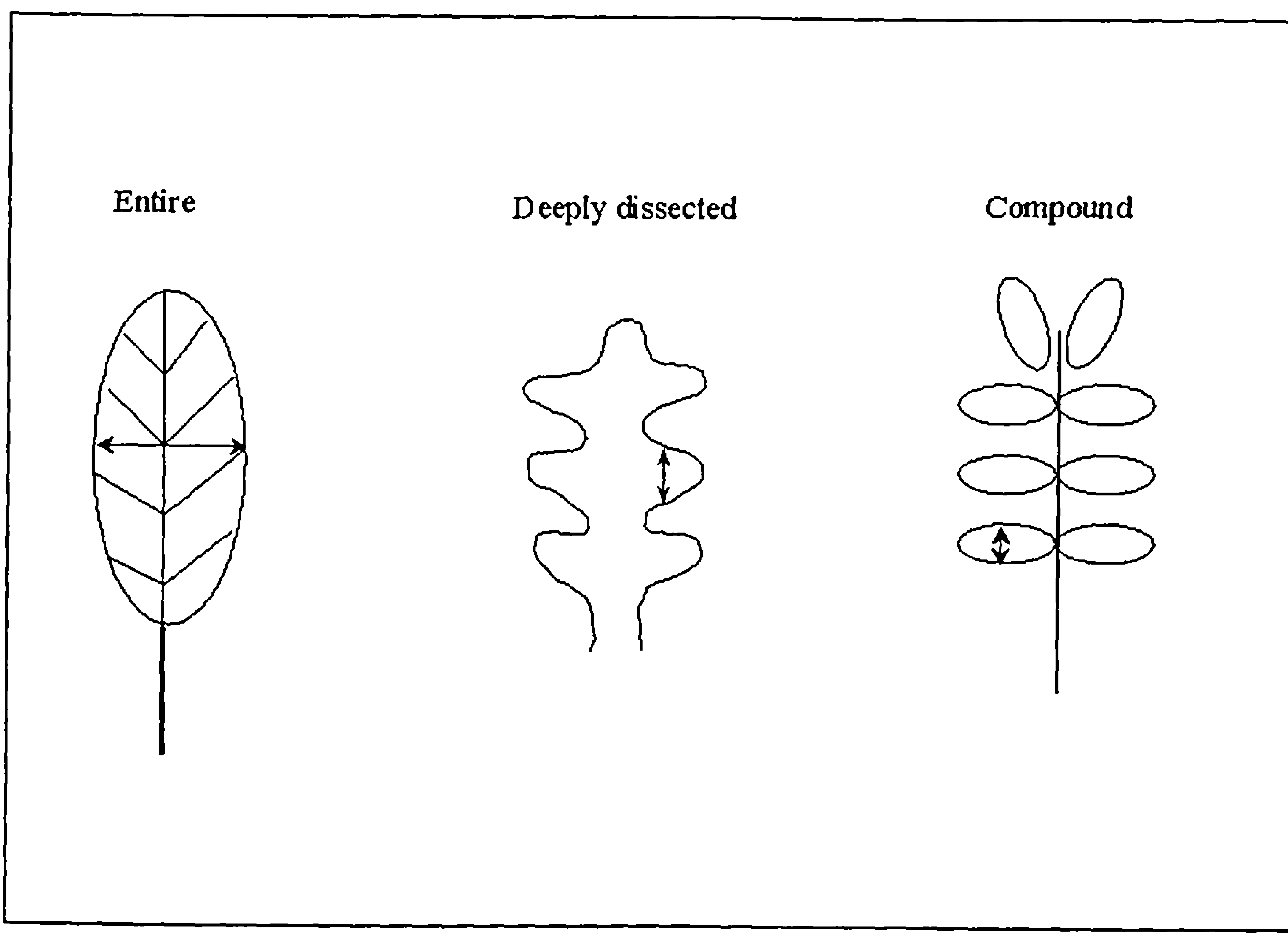
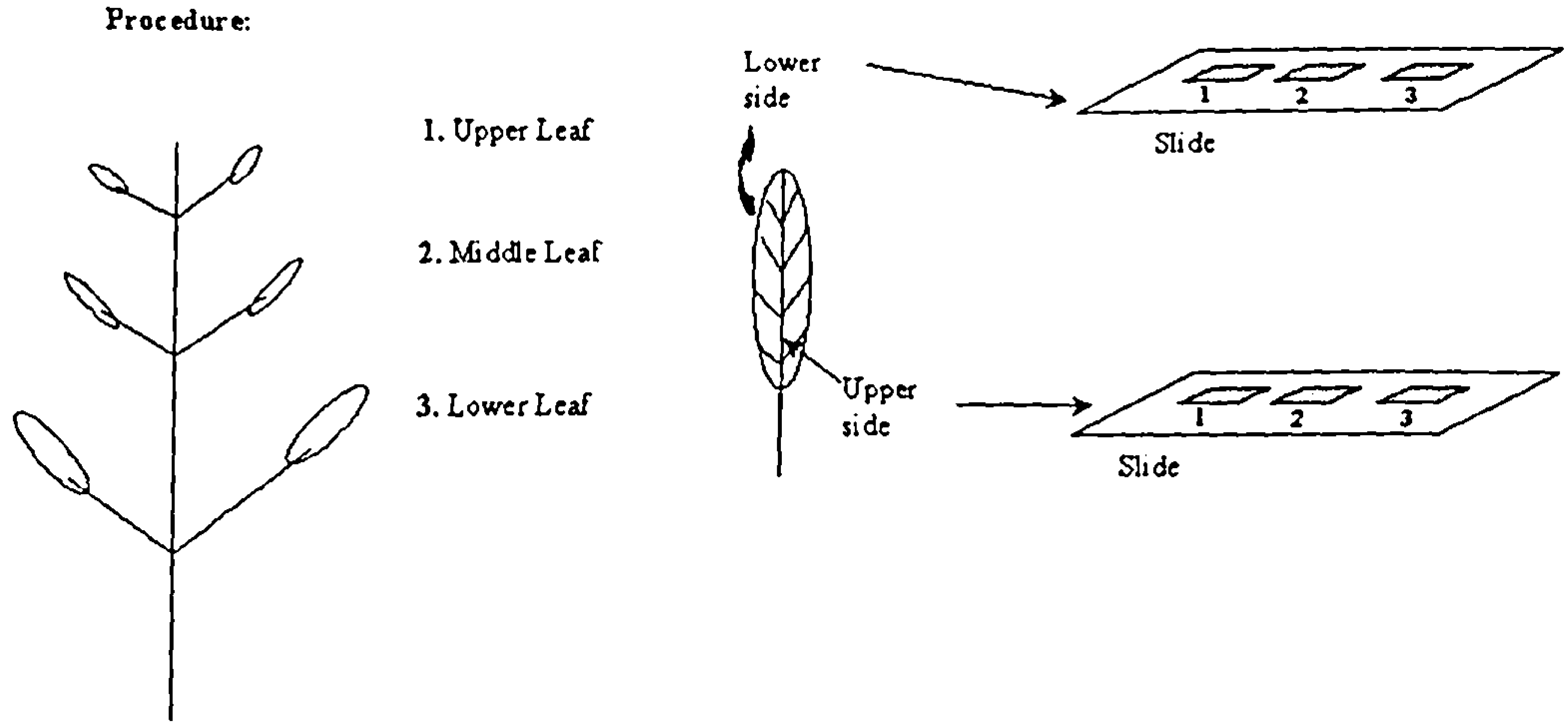
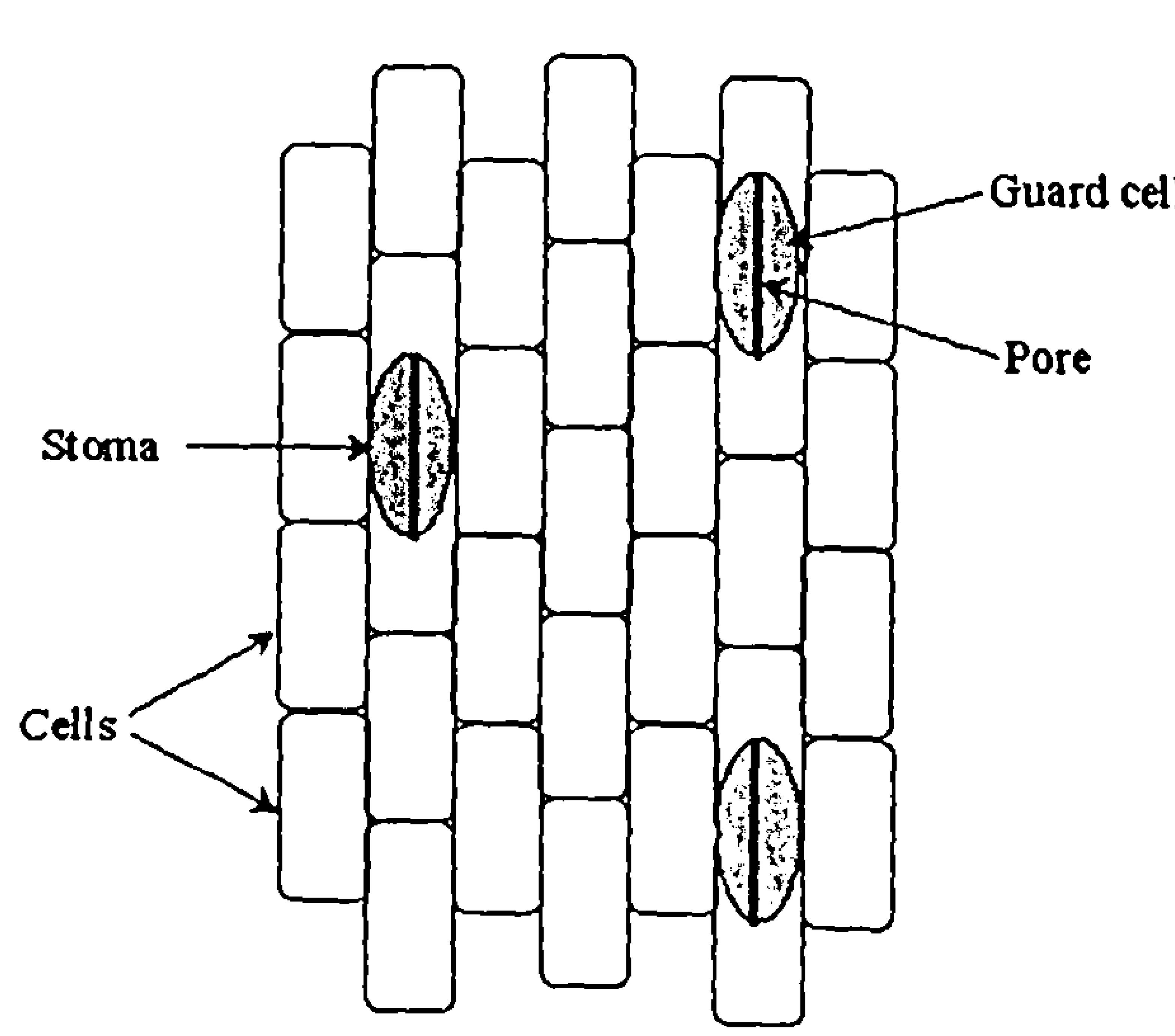


Figure 3.5: Procedure for making leaf epidermal impressions:

Procedure:



Epidermal impression:



Chapter 4: Results and Interpretation of the Ethnoarchaeological Analysis carried out in Wadi Ibn Hammad

4.1. Relationship of 'field variables' to watering regime:

4.1.1. Environmental variables:

This analysis was carried out in order to assess whether any environmental variables are associated with irrigation levels and whether they may have had an effect on weed floras found in the fields. Some conclusions about the relationship between the environmental variables and irrigation level can be drawn from the average values for each field type (see table 4.1). Appendix 6 gives all the variables for all the fields sampled.

Table 4.1: Major environmental variables for each of the Wadi Ibn Hammad field types:

Field type		Organic carbon content	Ph	Stone content*	Slope**
Full Irrigation Wadi bottom	Average	1.24	8.18	2.10	2.80
	Standard deviation	0.37	0.20	0.25	2.50
Biennial Irrigation Wadi bottom	Average	1.09	8.20	2.30	3.40
	Standard deviation	0.20	0.26	0.68	1.10
Dry Wadi sides	Average	1.49	8.21	2.50	2.50
	Standard deviation	0.33	0.24	0.67	0.90
Dry Plateau	Average	0.78	8.18	1.90	2.80
	Standard deviation	0.25	0.11	0.66	0.60

* Stone content: 1 = few, 2 = occasional, 3 = moderate, 4 = abundant, 5 = dense
** Slope: 1 = flat, 2 = uneven, 3 = gentle, 4 = moderate, 5 = steep

From the soils map of Wadi Ibn Hammad (see figure 1.6), it appears that the wadi bottom is dominated by Su'Eidat, the wadi sides grade into Tell Alluba with Humud on the plateau. The fields from these different locations, therefore, tend to have different soil types. However, both the dry-farmed and irrigated fields from the wadi bottom and side are on Su'Eidat soil so the weed floras in the wadi bottom should not be influenced by differences in soil type.

The average soil organic content for all the field types ranged from 0.78 to 1.49%. It is low in all field types but particularly so in plateau fields, however, it is uncertain whether the differences in soil organic content are great enough to affect the weed flora.

The average soil pH values for all the field types ranged from 8.18 to 8.21. This is indicative of neutral to slightly alkaline soil, reflecting the high calcium carbonate content of soils in this area. None of the values for individual fields fluctuated by more than 0.2 from the mean and the values for fully-irrigated and dry-farmed wadi fields were exactly the same (8.18). This suggests that there is no significant difference in soil pH between irrigated and dry-farmed fields. Soil pH would, therefore, not be expected to have a significant effect on weed floras from different field types.

Field stoniness varies very little between the field types, ranging from 1.9 (occasional) on the plateau to 2.5 (moderate) in dry-farmed fields in the wadi. Stoniness figures for wadi dry-farmed, fully- and biennially-irrigated fields are very similar indicating that this factor is unlikely to account for any variation in weed floras between different field types.

The slope of the various field types ranged from 2.5 to 3.4 indicating that all of the fields were located in fairly gently sloping regions. It might be expected that fully-irrigated fields would be fairly flat to allow successful gravity-fed irrigation so it is perhaps surprising that they slope as much as they do. Biennially-irrigated crops use a pipe-feed watering system to irrigate the vegetable crops as these fields are situated on slopes, up from the water-course. It is, therefore, not surprising that they are more steeply sloping fields. Dry-farmed fields in the wadi are the most flat and this bears no obvious relation to level of irrigation. As the range of slope is very small for all field types, this factor is unlikely to have had a major effect on weed floras from fields of different irrigation level.

The aspect of the field types differed markedly, biennially-irrigated fields typically face north-west while plateau fields face north-east. However, the most common field aspect for fully-irrigated and dry-farmed fields in the wadi was the same, east to south-east, indicating no clear relationship between aspect of field and irrigation level. Aspect is, therefore, unlikely to contribute to weed flora differences between dry-farmed and irrigated fields.

The information on soil type, pH, stone content, slope and aspect, suggests that none of the field types differ substantially on any environmental characteristic other than irrigation/watering regime. Organic carbon may be an exception as there is a noticeable difference between the plateau and the wadi fields. It is suggested, however, that any differences found in the weed floras from the different field types would be expected to be due mostly to irrigation level, rather than other environmental variables.

4.1.2. Crop variables:

Crop height and cover may be influenced by irrigation practices and can in turn affect weed floras through competition for elements such as light, nutrients and water. The percent crop cover and the height of the crop seem to be positively related to the level of irrigation, as indicated by table 4.2.

Table 4.2: Major crop variables for each of the Wadi Ibn Hammad field types:

Field type		Crop cover (%)	Crop height (cm)
Full irrigation wadi bottom	Average	71	101
	Standard deviation	13	14
Biennial irrigation wadi bottom	Average	60	83
	Standard deviation	9	9
Dry-farmed plateau	Average	50	60
	Standard deviation	11	16
Dry-farmed wadi sides	Average	48	53
	Standard deviation	13	22

*N.B. Crop type is mostly durum wheat

The average values grade from high/dense to low/sparse in order of: fully-irrigated, biennially-irrigated, plateau dry-farmed, wadi dry-farmed. This suggests that crop productivity is positively related to the amount of water input, fully-irrigated fields having the most water and consequently the tallest, densest crop, closely followed by biennially-irrigated fields. Plateau fields and wadi dry-farmed fields are both rain-fed, but the rainfall figures are higher for the plateau which is reflected in the slightly taller and more dense crop. There is, however, a lot of variation in crop height especially in wadi dry-farmed fields (table 4.2).

The type of crop does not seem to be related to irrigation level in the fields from the wadi bottom but, although durum wheat occurs in all field types, there is more 2-row barley in the dry-farmed wadi and plateau fields. This may affect the crop height values as the variety of 2-row barley grown is very short strawed. The number of 2-row barley fields, however, is only 5 out of the total of 52 (see table 3.3) so the inclusion of these fields may not have a large impact on the overall pattern of weed floras from the different field types.

4.2. Relationship of weed species composition to watering regime:

A list of the species found in 10% or more of the fields in the Wadi Ibn Hammad study is given in Appendix 7. The first step in the analysis of the weed species data was to ascertain whether there were clear differences in weed flora between the fields of each irrigation regime. A simple correspondence analysis was carried out using all of the 52 fields in the study and all 63 weed species in Appendix 7. A plot of the fields in relation to the first two correspondence axes (see figure 4.1) shows that the first axis, which accounts for most of the variation in species composition, clearly separates the fully-irrigated fields (towards the positive end of the axis) from the dry-farmed fields in the wadi (towards the negative end), with biennially-irrigated fields in between. Thus the greatest variation in weed flora corresponds well with irrigation level in the wadi. Dry-farmed fields on the plateau are more variable than those in the wadi, and overlap with both wadi dry and fully-irrigated fields on axis 1.

This is perhaps expected as they are not irrigated but are naturally more well-watered than those in the wadi. The second axis distinguishes the plateau fields, towards the positive end, from most of the wadi fields, towards the negative end. The irrigated fields are also separated into two groups along the second axis: the group towards the positive end of the axis are located in the west of the wadi, closest to the water-course, whereas the group towards the negative end are in the east of the wadi, further away from the water-course (see location map, figure 3.1). It is possible, therefore, that this axis is related to location in terms of distance from the water-course – whether this relates to availability of water or some difference in soil chemistry is not known.

The analysis was repeated with the plateau fields, and the 3 fields of ambiguous irrigation status in the wadi, left out (leaving 39 wadi fields in the analysis) and with all 63 species, to investigate the effects of irrigation with level of rainfall held constant. In this analysis, the separation of fully-irrigated, at the negative end of the first axis, from dry-farmed wadi fields, at the positive end of the axis, is very apparent (see figure 4.2). Biennially irrigated fields, as before, are located between fully-irrigated and dry-farmed fields. The first correspondence axis, therefore, seems to be very strongly correlated with irrigation level.

A canonical correspondence analysis was carried out (using all fields and species) to explore external variables in relation to species and fields, in particular to explore the suggestion (above) that most of the variation in the weed flora was due to irrigation rather than other environmental factors. The fields and external variables are plotted in relation to the first two correspondence axes in figure 4.3 where arrows indicate the external variables. The external variables, irrigation, crop cover and crop height, point towards the negative end of the first axis, where the irrigated fields are located, suggesting that irrigation (which also affects crop cover and height) plays a major part in determining weed species composition. Soil type points in the opposite direction towards dry-farmed fields on the plateau and biennially-irrigated fields on the wadi sides. This suggests that soil type is a factor in determining differences in the weed flora between field types. Crop type, aspect, slope, soil organic content, pH and stoniness all point along the second axis towards the negative end and are, therefore, not related to irrigation level.

4.3. Relationship of functional attributes to watering regime:

To investigate the relationship between species characteristics (functional attributes) and fields of different watering regime, species were plotted in relation to the first two correspondence axes, and symbols used to indicate the values of different attributes. For these species plots, both the analysis using wadi fields only (plots labelled with the suffix a) and the one of all field types (plots labelled with the suffix b) were included. The analysis of wadi fields alone allows the effects of irrigation on weed species composition to be investigated directly (with rainfall held constant) whereas the analysis of all fields allows differences between the wadi and plateau (in either rainfall or other environmental variables) to be considered in relation to weed species characteristics. The species plots are interpreted by comparing them to their respective field plots in figure 4.2 (for the analysis of wadi fields alone) and figure 4.1 (for the analysis including all field types).

4.3.1. Attributes relating to the duration and quality of the period for plant growth (indicative of site productivity):

4.3.1.1. Canopy height and diameter:

In the plot of species from the wadi fields, coded according to canopy height, species with short to medium canopies (<74 cm) are ubiquitous but species with the tallest canopies (>74 cm) are associated with fully- and biennially-irrigated fields (see figure 4.4a). This pattern is also apparent in the plot including plateau fields (see figure 4.4b), where species on the plateau generally have short canopies (mostly <60cm). In the plots of canopy diameter, the species with the widest canopy spread (>85 cm) are largely restricted to the fully- and biennially-irrigated fields in the wadi while the species with small to medium canopy width are more generally distributed in both the wadi and on the plateau (see figure 4.5a and b). When canopy height and diameter are combined the resultant plots showed that weed species with the largest canopy dimension (>115cm) are again largely restricted to irrigated fields in the wadi (see figure 4.6a and b). These results agree with the prediction that species with a large biomass will characterise irrigated fields that provide a productive habitat and a long period for growth. A relatively unproductive habitat is indicated for the plateau, which could be related to the dry-farming in this area or soil type, perhaps in relation to the lower organic content of the soil.

4.3.1.2. Leaf area per node:

In the plots showing leaf area per node, species with the largest leaf area (>5700 mm^2) appear to be mainly restricted to fully- and biennially-irrigated fields. Small-leaved species are ubiquitous amongst dry-farmed and irrigated fields (see figure

4.7a and b). This result also indicates that the irrigated fields represent a productive environment in comparison to the relatively unproductive dry-farmed fields. Species with large leaves (>1700mm^2) are also largely excluded from the plateau fields (see figure 4.7b), again indicating an environment of low productivity.

4.3.1.3. Leaf width:

There is no apparent relationship between leaf width and irrigation level in the wadi fields (see figure 4.8a) but species with the widest leaves (>40mm) tend not to occur on the plateau (see figure 4.8b). Wider leaves would be expected in productive environments so this may reflect lower productivity of the plateau environment.

4.3.1.4. Specific leaf area:

In the plots showing specific leaf area, no clear pattern relating to irrigation level is apparent (see figure 4.9a). Species with large specific leaf area (>16mm^2/mg) are, however, excluded from fields on the plateau (see figure 4.9b). Again, this may reflect the low productivity of the plateau fields.

4.3.1.5. Leaf dry matter content:

The species plots showing leaf dry matter content exhibit no discernible pattern relating to irrigation status of fields (see figure 4.10a) or to location in the wadi or plateau (see figure 4.10b).

4.3.1.6. Leaf thickness:

There seems to be no clear pattern linking species' leaf thickness with level of irrigation (see figure 4.11a). The thicker leaved species do tend, however, to be absent from the irrigated fields in the west of the wadi (in the top left of the diagram, towards the positive end of axis 2), closest to the water-course. This may be related to field productivity, as thicker leaved species are expected in less productive environments, suggesting that the irrigated fields closer to the water-course may provide a more productive environment than those further away. There is no discernible pattern between leaf thickness and location in the wadi or plateau (see figure 4.11b).

4.3.2. Attributes relating to environmental unpredictability:

4.3.2.1. Regeneration by means of persistent buried seeds:

The measures of seed size and shape showed no pattern in relation to the irrigation status of fields. Figure 4.12a shows that species with both high and low values of combined seed weight and shape are ubiquitous in irrigated and dry-farmed fields. Species with very high combined seed weight and shape values (>1.20) tend not to occur on the plateau however (see figure 4.12b). As low values signify seed persistence in the soil, this may be indicative of unpredictable rainfall on the plateau.

4.3.3. Factors relating to drought avoidance and drought tolerance:

4.3.3.1. Root diameter:

There is no clear relationship between irrigation level and root diameter (see figure 4.13a). The thicker rooted species (>1.7mm) are, however, absent from the irrigated fields in the west of the wadi (top left of the diagram, towards the positive end of axis 2), closest to the water source. This may be related to water availability for irrigation, as thicker (therefore deeper) rooted species are expected in drier environments. There is no discernible association between root diameter and location in the wadi or plateau (see figure 4.13b).

4.3.3.2. Epidermal cell size:

Species with the largest cell size (>25μm^2) are largely restricted to fully- and biennially-irrigated fields in the wadi (see figure 4.14a), suggesting that there is little water stress in irrigated fields, as would be expected. This pattern is not so strong in the plot including the plateau fields as one species with large cells occurs in the middle of the plot, towards the plateau fields (see figure 4.14b) suggesting that the higher rainfall on the plateau has an effect similar to irrigation. Species with smaller cell sizes are widely distributed in both plots.

4.3.3.3. Epidermal cell wall undulation:

This attribute shows no relationship with the level of irrigation (see figure 4.15a) whether recorded subjectively or as a function of cell area and perimeter. There is also no pattern between epidermal cell wall undulation and location in the wadi or plateau (see figure 4.15b).

4.3.3.4. Stomatal size and density:

The plots of stomatal guard cell length show that, contrary to expectations, both large and small stomata are spread more or less evenly amongst plateau and wadi dry-farmed fields and irrigated fields (see figure 4.16a and b). The same is true for the plots of stomatal density (figure 4.17a and b).

4.3.3.5. Flowering start and duration:

The plot showing flowering start shows, as predicted, that in the wadi most late flowering species (flowering from May onwards) are restricted to irrigated fields (see figure 4.18a). One late flowering perennial species, *Lactuca orientalis*, is associated with dry-farmed fields but this species may grow there because, as a perennial, it can survive the driest years below ground without sending up shoots. For annuals, the relationship between flowering start and irrigation level is quite strong. However, once plateau fields are included in the analysis, the pattern is not so clear as some species are pulled towards the plateau fields (see figure 4.18b) indicating that the wetter conditions on the plateau may allow some later flowering species to survive. Species that flower early (before May) are ubiquitous in irrigated and wadi dry-farmed fields and on the plateau.

In the plot showing flowering duration, the species with a long flowering period (5 months or more) occur in irrigated fields in the wadi (see figure 4.19a). These species flower well into the period of drought in the summer. Once the plateau fields are included, the pattern is maintained for species flowering for more than 5 months, but some species with flowering period of 5 months are again pulled towards the plateau fields, again indicating the wetter conditions there (see figure 4.19b). Species that flower for a shorter period (1-4 months) occur in both irrigated and in dry-farmed fields both in the wadi and on the plateau.

As there does appear to be a dichotomy between species from dry-farmed and irrigated fields in the wadi in terms of flowering start and duration, a correspondence analysis was carried out with combined flowering start and duration data for species in wadi fields (see figure 4.20). The combined effects of flowering start and duration (i.e. flowering period: early flowering species flower between January and April and late flowering species either start to flower after May, or start to flower earlier but for a long period, beyond May) are clear in that late flowering species are associated with irrigated fields in the wadi.

There is, therefore, a relationship between start and duration of the flowering period and the irrigation status of fields. From the correspondence analysis, several statements can be made about the plant strategies found under different watering regimes. In the irrigated fields two plant groups co-exist: species with a short, early flowering period thrive, as they obtain maximum benefits from rainfall as well as irrigation; species that start to flower later in the season (after May) or flower for a long period (more than 5 months) are nevertheless able to survive the summer drought period because of irrigation earlier in the year. Most of the species common in dry-farmed fields grow in the early part of the year, before May, and are therefore drought avoiding. The species that flower later tend to be excluded from dry-farmed fields because of the prohibitive effects of water stress on growth during the summer drought. As a drought avoidance strategy is likely to affect the distribution of other species attributes, the effect of flowering strategy on the relationship between species attributes and watering regime was investigated.

4.4. The effect of flowering strategy on the relationship between species attributes and field watering regime:

The irrigation level of the fields seems to have had an effect on weed flora in respect of season of flowering. Each species was, therefore, assigned to a field type (fully-irrigated, biennially-irrigated, wadi dry-farmed, plateau dry-farmed) according to the percentage occurrence in a given regime (as described in section 3.4.1, see Appendix 8). There were no species that occurred in 70% or more of biennially-irrigated fields only but there was a group of species that occurred in 70% or more of combined fully- and biennially-irrigated fields, so this was also defined as a group (see Appendix 8). The remaining species (which did not occur in 70% or more of any field type) were classified as mixed. These groups were further refined by classifying each species according to month of flowering onset (early = January to April, late = May onwards) and flowering duration (short = 1 to 4 months, long = 5 or more months). Species, therefore, fell into one of five field types (see Appendix 8) and one of two flowering period categories: (1) early (wet) period (flowering start between January and April, duration 1 to 4 months within this period); (2) late (dry) period (flowering either starting in May or after, or with a duration of 5 months or more, extending beyond May). This classification is summarised in table 4.3:

Table 4.3: Plant groups based on watering regime and flowering season:

Watering regime	Season of flowering
Fully irrigated fields	Late season (includes dry period of the year)
Fully irrigated fields	Early season (wet period of the year only)
Combined fully and biennially irrigated fields	Early season (wet period of the year only)
Dry-farmed wadi fields	Early season (wet period of the year only)
Dry-farmed plateau fields	Early season (wet period of the year only)
Mixed (ubiquitous in all watering regimes)	Early and late season

There are a high proportion of ubiquitous species ('mixed' species in table 4.3 and Appendix 8) but these occur in much lower frequency than species assigned to a specific watering regime. Two of these species (*Carthamus glaucus* and *Linaria chalapensis*) have a late flowering period but these too occur mostly in irrigated fields (44.7% and 46.4% respectively). Some of the late flowering species also occur in dry-farmed fields (see Appendices 8 and 9), but in much lower frequency.

The combination of preferred watering regime and season of flowering should affect the other attributes of the species in these groups as the combination of these factors will affect the growing environment of the plant. For example, as there appear to be two different flowering strategies (early and late) amongst the species growing in irrigated fields, species adopting these two strategies may possess two different sets of other attribute characteristics while still occurring under the same watering regime. Table 4.4 summarises the different habitat conditions of the species groups, the predicted effect this may have on functional attributes and so the functional groups represented.

Table 4.4: Species groups according to watering regime and flowering season:

Regime species common in	Flowering Start & duration	Habitat conditions	Predicted effect on other attributes	Predicted functional group
Fully-irrigated	Early and short	Wet (growing in early well-watered period only)	Few adaptations to drought	No drought adaptation needed
Fully-irrigated	Late and short, Early and long	Drier (growing into drought period due to irrigation)	Some adaptations to drought	Drought tolerating
Fully- or biennially-irrigated	Early and short	Wet (growing in early well-watered period only)	Few adaptations to drought	No drought adaptation needed
Wadi dry-farmed	Early and short	Dry (growing early but in dry conditions)	Some adaptations to drought	Drought avoiding and drought tolerating
Plateau dry-farmed	Early and short	Wetter (growing early in slightly moist conditions)	Few adaptations to drought	Drought avoiding

To investigate whether these predictions are accurate, a few attributes were selected, on the grounds that they patterned in relation to irrigation in the correspondence analysis or because of their ecological significance in relation to irrigation. The values of these attributes were averaged for the different species groups. The values for species with an early flowering season from fully- and biennially- irrigated fields were combined due to the similarity in their habitat conditions and flowering strategy (see table 4.4). Table 4.5 gives a summary of the average attribute values for the different species groups (see Appendix 9 for the attribute scores for each species).

Table 4.5: Attribute values for the different species groups according to watering regime and flowering season:

		Groups according to season			
Attribute	**Groups according to regime**	Early	n	Late	n
Canopy dimension	Fully & biennially irrigated	48.5	20	54.4	10
	Wadi dry-farmed	41.4	5		
	Plateau dry-farmed	27.5	2		
Leaf area per node	Fully & biennially irrigated	3433	20	1847	10
	Wadi dry-farmed	1510	5		
	Plateau dry-farmed	240	2		
Stomatal area	Fully & biennially irrigated	3.5	20	3.0	10
	Wadi dry-farmed	3.4	5		
	Plateau dry-farmed	3.7	2		
Stomatal density	Fully & biennially irrigated	19.8	20	24.0	10
	Wadi dry-farmed	16.7	5		
	Plateau dry-farmed	13.9	2		

Canopy dimension patterned in relation to irrigation in the correspondence analysis, with, as would be expected, species with the largest canopies occurring in irrigated fields, the more productive environment (see figure 4.6). The addition of flowering season information refines this pattern further. The canopy dimension of late flowering species from irrigated fields are on average the largest (see table 4.5) which may be due to that fact that they have a longer growth season and, therefore, more time to develop a large biomass. The group of species with the second largest canopy size is the early flowering species from irrigated fields as expected due to the high productivity of this growing environment. The species with the smallest canopies occur in dry-farmed fields on the plateau with species from wadi dry-farmed fields being somewhat larger. Though the plateau is wetter it may be less productive overall, perhaps due to soil conditions such as the low organic content (see table 4.1).

Leaf area per node also patterned in relation to irrigation level in the correspondence analysis, with the largest leaved species occurring in irrigated fields (see figure 4.7). This pattern is enhanced by incorporating flowering season (see table 4.5). The species with by far the largest leaves, on average, are the early flowering species in irrigated fields. The species with the next largest leaves are late flowering species from the irrigated fields closely followed by species from dry-farmed wadi fields. Species from the plateau have the smallest leaves. Again, this fits with expectations: species with the largest leaves are found in the most productive habitat conditions (early and in irrigated fields); those in the less productive late and dry wadi habitats are smaller leaved but not as small as those growing on the plateau where soil conditions may be less fertile

Attributes related to drought tolerance also seem to be affected by season of flowering (see table 4.5). The extreme group appears to be late flowering species from irrigated fields with many small stomata, an adaptation for drought tolerance. For early flowering species from irrigated fields, and species from dry-farmed fields, stomata are large and fewer in number, indicating less need for a water conservation strategy. As species from irrigated fields can have stomata of different sizes and density (depending on whether they are early or late flowering), it is not surprising that this attribute did not pattern in relation to irrigation in correspondence analysis. Stomatal attributes appear to be very much affected by the drought avoiding strategy of early flowering, which renders the drought tolerating attributes of stomatal size and density unnecessary.

From these average attribute values, it is possible to characterise the weed species associated with different watering regimes and flowering strategies. Early flowering species from fully- and biennially-irrigated fields inhabit a productive environment where there is little water stress, hence canopy and leaf size is large and stomata are large. Species that flower late in irrigated fields have a large canopy size, probably due to the input of irrigation water and the length of growing period that irrigation allows. However, as they grow in the droughted part of the year they suffer water stress and, therefore, have adaptations to tolerate drought such as many small stomata and smaller leaves. Species from dry-farmed fields mostly flower early to avoid the summer drought, have a short growth period and inhabit a relatively unproductive environment and, therefore, have smaller canopies and leaves. However, as they avoid the summer drought they do not have the extreme drought tolerance attributes of late flowering irrigated species, and so stomatal size and density are medium. Species growing on the plateau seem to characterise an unproductive environment in that they have the smallest canopy and leaf sizes but seem to be less water stressed than late flowering species in that they have large, few stomata. The low productivity of this environment may be related to soil conditions as soil organic carbon content is lowest on the plateau. The relationships between irrigation level, season of flowering and attribute character are summarised in table 4.6.

Table 4.6: Habitat conditions and functional attributes of weed species grouped according to watering regime and flowering season:

Species groups	Habitat conditions	Attributes
Fully and biennially irrigated fields Early flowering species	Productive environment, low water stress	Large canopies; largest leaves; few, large stomata
Fully irrigated fields Late flowering species	Long growth period due to irrigation but more water stress as late flowering	Largest canopies; medium-sized leaves; many, small stomata
Wadi dry-farmed fields Early flowering species	Less productive (dry) environment, but avoids severe water stress	Smaller canopies; medium-sized leaves; few, large stomata
Plateau dry-farmed fields Early flowering species	Low productivity environment but less water stress	Smallest canopies; smallest leaves; few, large stomata

Thus plant species recorded in Wadi Ibn Hammad can be divided into groups based on their location under different watering regimes, which affects their season of flowering, and these factors in combination affect other attributes. Species with drought tolerating strategies flower late, mostly in irrigated fields; drought avoiding species occur in irrigated and dry-farmed fields. Thus, when flowering season is taken into account, the functional attributes pattern in a much more predictable way in relation to watering regime. In the earlier correspondence analysis the effect of flowering season was masking some of the differences between dry-farmed and irrigated fields, mainly due to the co-existence of two types of species (with different flowering times) in irrigated fields. Late flowering species in irrigated fields were found to have the drought tolerant strategies originally expected for species from dry-farmed fields. As dry-farmed fields are characterised mostly by early flowering drought avoiding species, they do not have the extreme drought tolerant adaptations that were originally expected.

4.5. Using functional attributes to distinguish different levels of watering:

The relationship between attribute values and watering regime was investigated further using discriminant analysis. Two discriminant analyses were performed on the Wadi Ibn Hammad data. The first analysis used four watering regimes (fully-irrigated, biennially-irrigated, wadi dry-farmed and plateau dry-farmed) as the groups to be discriminated and all the attributes measured (canopy height, canopy diameter, leaf area per node, leaf width, specific leaf area, leaf thickness, seed persistence, epidermal cell size, epidermal cell wall undulation, root diameter , stomatal size, stomatal density and flowering season) as the discriminating variables. The groups were clearly separated (see figure 4.21a) and the percentage of fields correctly reclassified into their original groups was very high (92%), with only four fields out of the 52 being incorrectly reclassified. The first discriminant function appears to be a productivity axis as the groups are arranged along this axis in the order (left to right): fully-irrigated, biennially-irrigated, wadi dry-farmed, plateau dry-farmed. On function 2, the wadi dry-farmed fields are at the bottom with the 'wetter' categories towards the top.

The contribution of the attribute values to the first discriminant function can be explained in terms of productivity and irrigation. Many of the productivity attributes (canopy height and diameter, specific leaf area, leaf area per node and leaf width), as well as others relating to drought tolerance and avoidance (season of flowering and epidermal cell size) are associated with the irrigated fields (see figure 4.21b). Some of the attributes related to water conservation (stomatal size and density, cell wall undulation and root diameter) behave contrary to expectations, however. This could be explained by the differences in seasonality of the species if it is accepted that some species of irrigated fields flower late in the year and, therefore, exhibit some drought tolerating properties. Drought tolerance is not as extreme as expected in dry-farmed fields as the species growing there complete their reproductive cycle early before drought ensues. One attribute that could not be explained with reference to either irrigation or flowering season is dry matter content, which should be low in conditions of high productivity but, in fact, high dry matter content was associated with irrigated fields.

A second discriminant analysis was run excluding plateau fields from the analysis to avoid any ambiguity in the wet/dry axis. 97% of fields were correctly reclassified (1 field incorrectly reclassified), indicating successful discrimination. The plot of fields (see figure 4.22a) is very similar to the first discriminant analysis, showing a clear separation of fully irrigated and dry-farmed fields with biennially irrigated fields intermediate along the first discriminant function. In figure 4.22b, the attributes used in the discriminant analysis are plotted in relation to the first function with results very similar to those in the first discriminant analysis.

4.6. Summary of FIBS results and interpretation:

The aim of this study was to identify functional differences between the weed species associated with irrigated and dry-farmed fields to enable the identification of irrigation practices in the archaeobotanical record. It was apparent, however, that though there were clear differences between irrigated and dry-farmed fields in terms of floristic composition and productivity (shown by the plots relating to canopy dimensions and leaf area per node), the plant mechanisms relating to water were more ambiguous and difficult to interpret. As season of flowering is a strategy for drought avoidance, it also has an impact on other plant attributes especially those relating to water conservation. Species from dry-farmed fields were mostly early flowering strategists (drought avoiding species), completing their life cycle before the droughted part of the year (from May onwards). It is unnecessary for such plants to have extreme adaptations to drought and so they do not have attributes that reflect drought tolerance. In addition, late flowering species, which occur mostly in irrigated fields, require some drought tolerating mechanisms to enable them to complete their life cycle in the drier part of the year even in the relatively favourable conditions provided by irrigation. This means that paradoxically it is plants from irrigated fields, growing in the later part of the year, which exhibit many of the drought tolerant attributes. It was, therefore, possible to differentiate species from irrigated and dry-farmed fields on the basis of functional attributes once this had been taken into account. These attributes can, therefore, be used to identify irrigation from the archaeobotanical species identified in the Khirbet Faris samples.

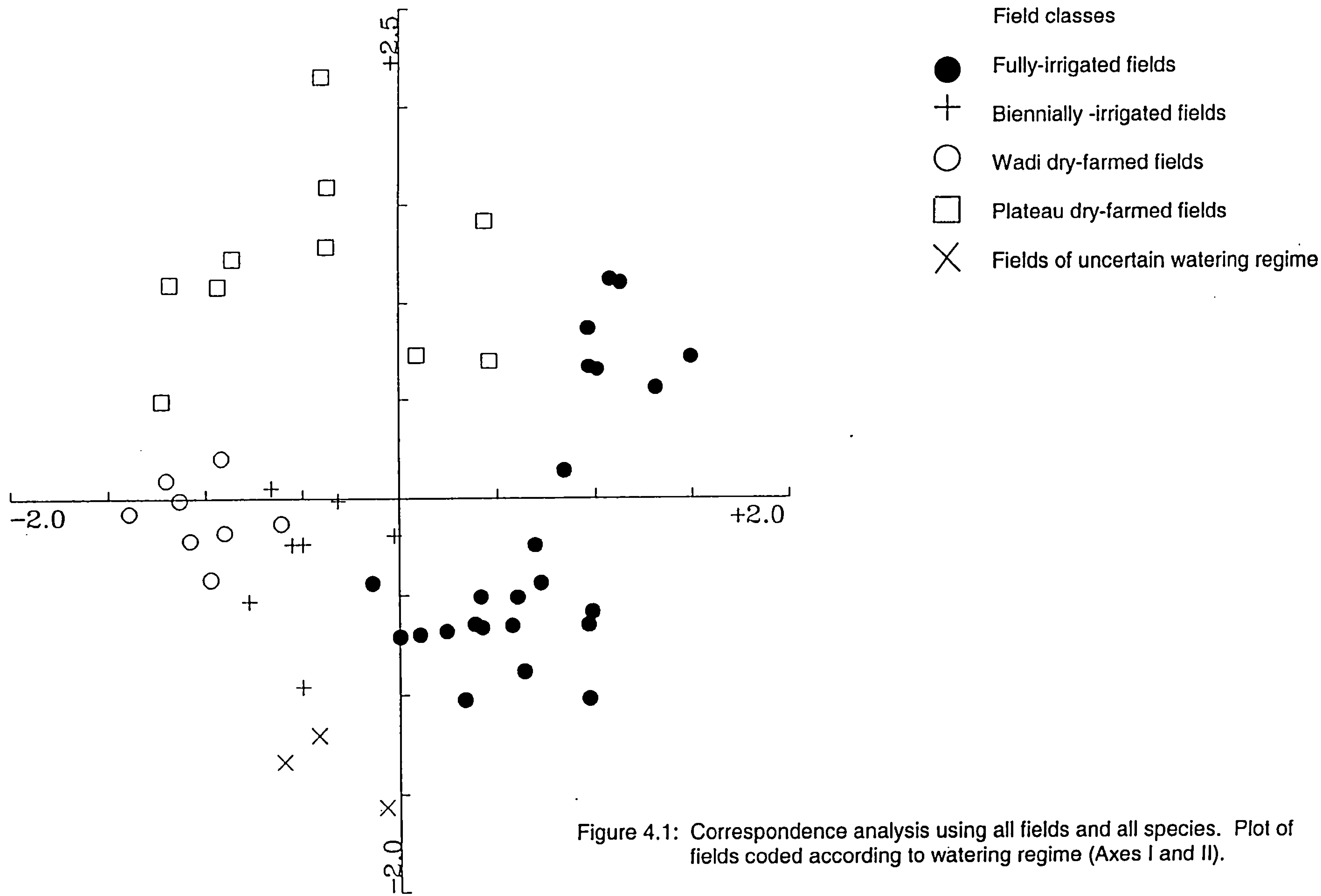


Figure 4.1: Correspondence analysis using all fields and all species. Plot of fields coded according to watering regime (Axes I and II).

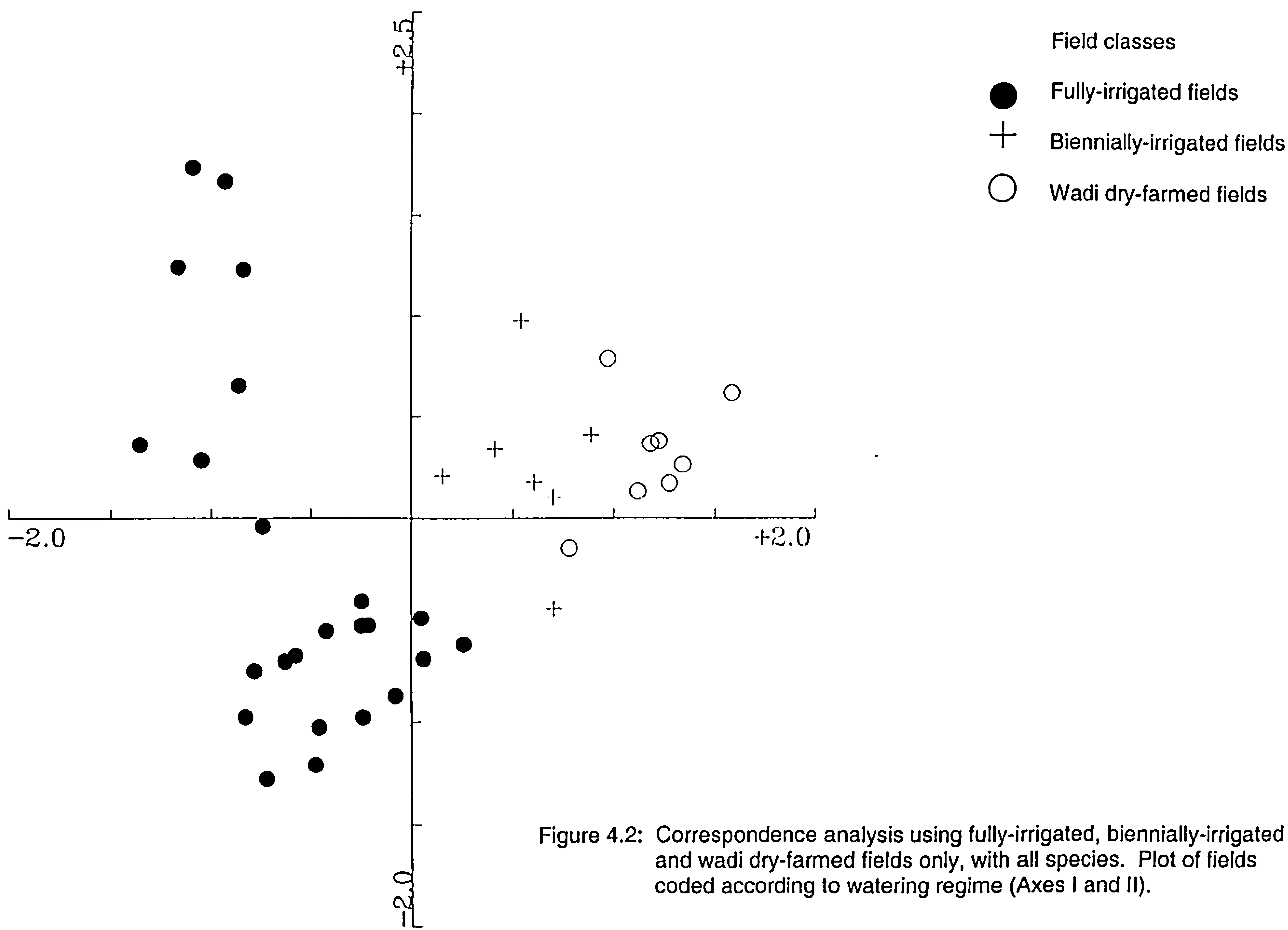


Figure 4.2: Correspondence analysis using fully-irrigated, biennially-irrigated and wadi dry-farmed fields only, with all species. Plot of fields coded according to watering regime (Axes I and II).

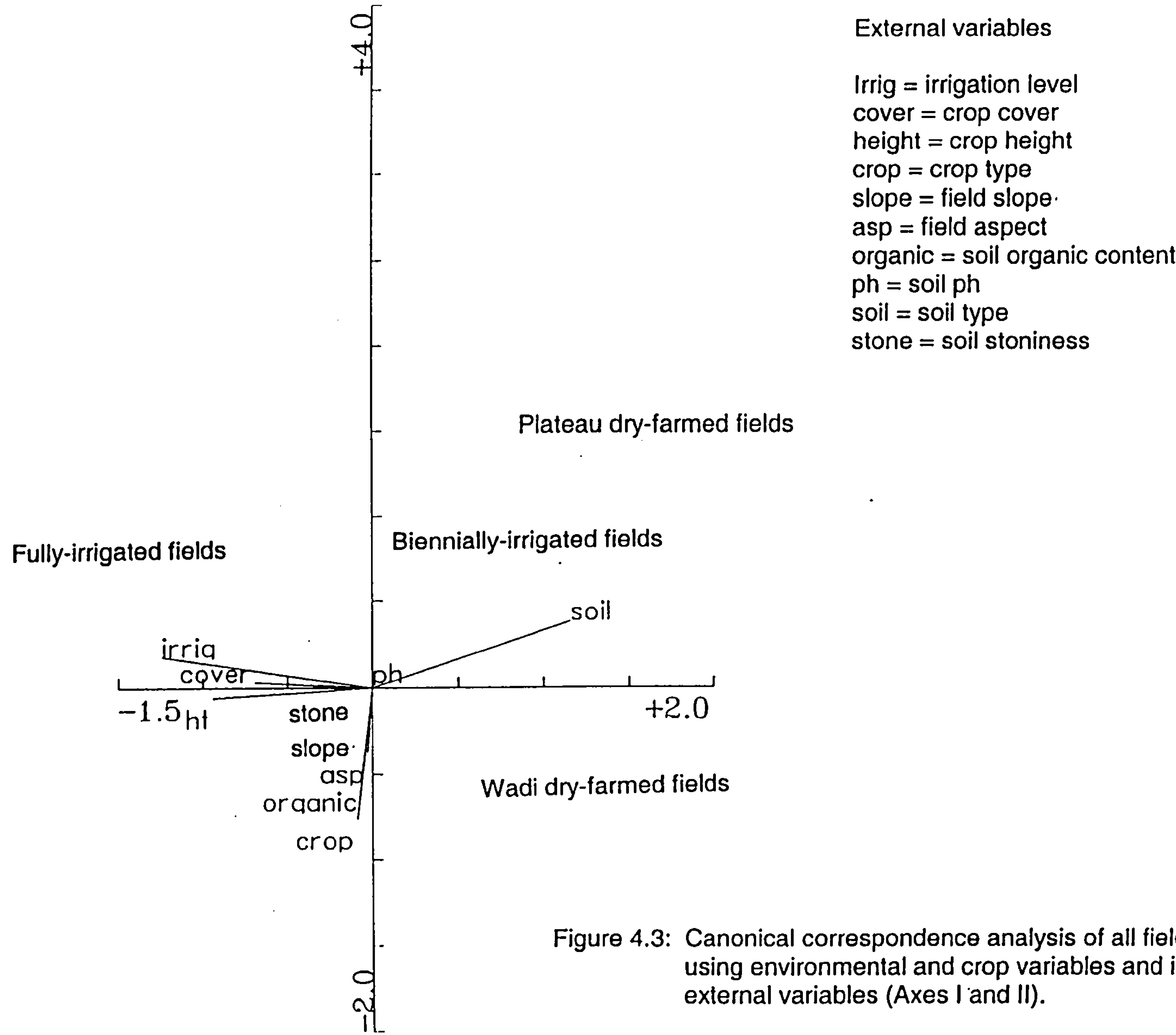


Figure 4.3: Canonical correspondence analysis of all fields and all species using environmental and crop variables and irrigation level as the external variables (Axes I and II).

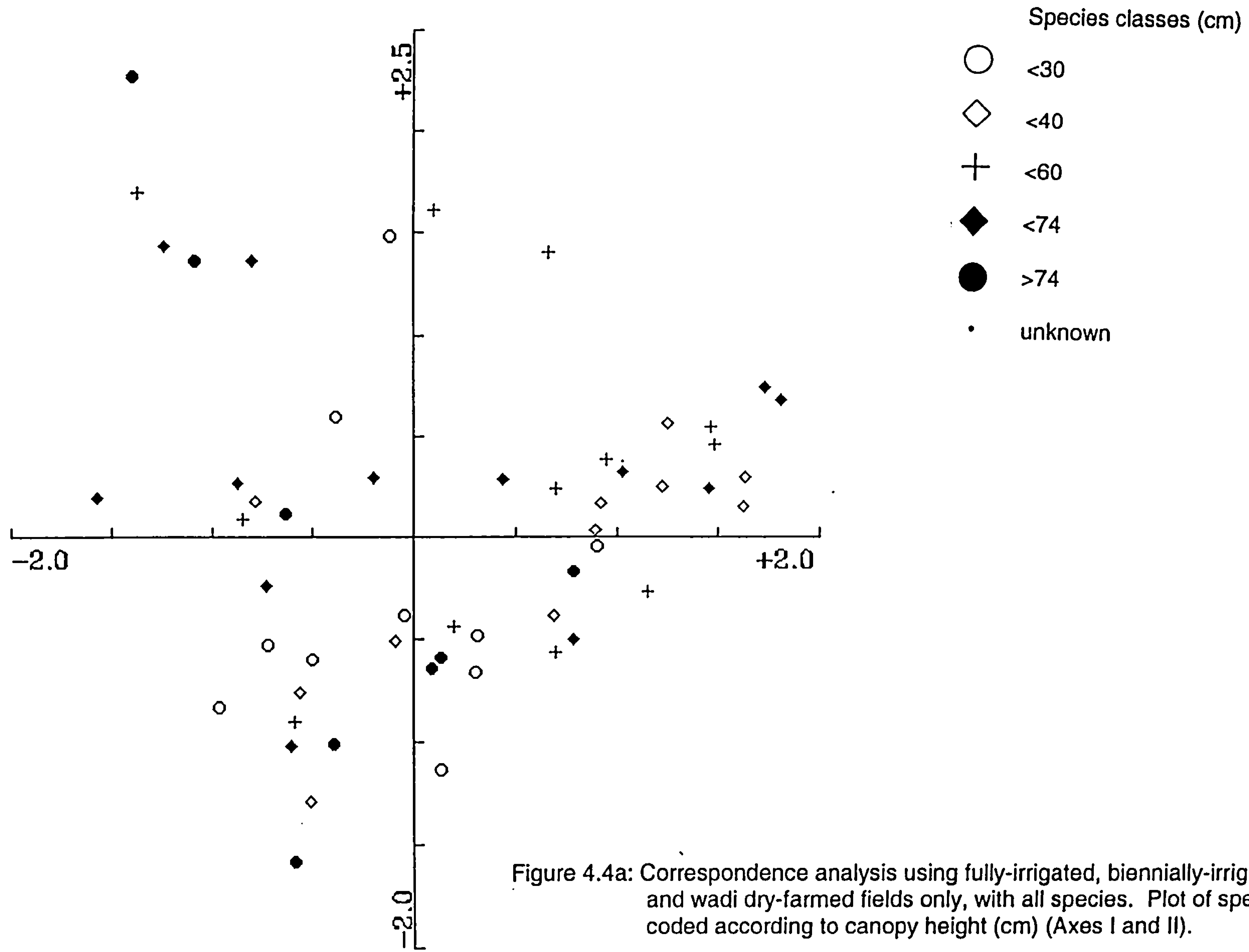


Figure 4.4a: Correspondence analysis using fully-irrigated, biennially-irrigated and wadi dry-farmed fields only, with all species. Plot of species coded according to canopy height (cm) (Axes I and II).

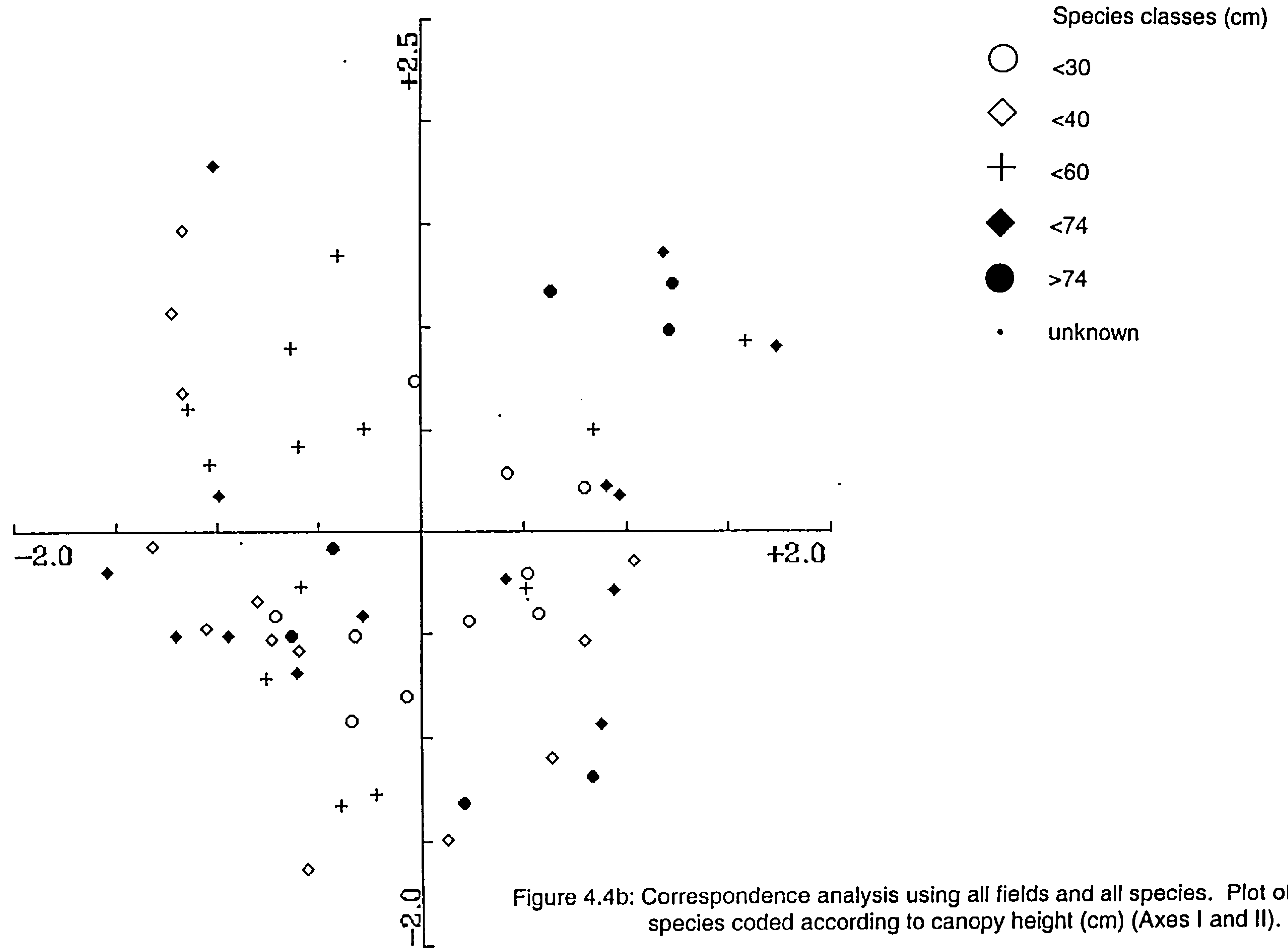


Figure 4.4b: Correspondence analysis using all fields and all species. Plot of species coded according to canopy height (cm) (Axes I and II).

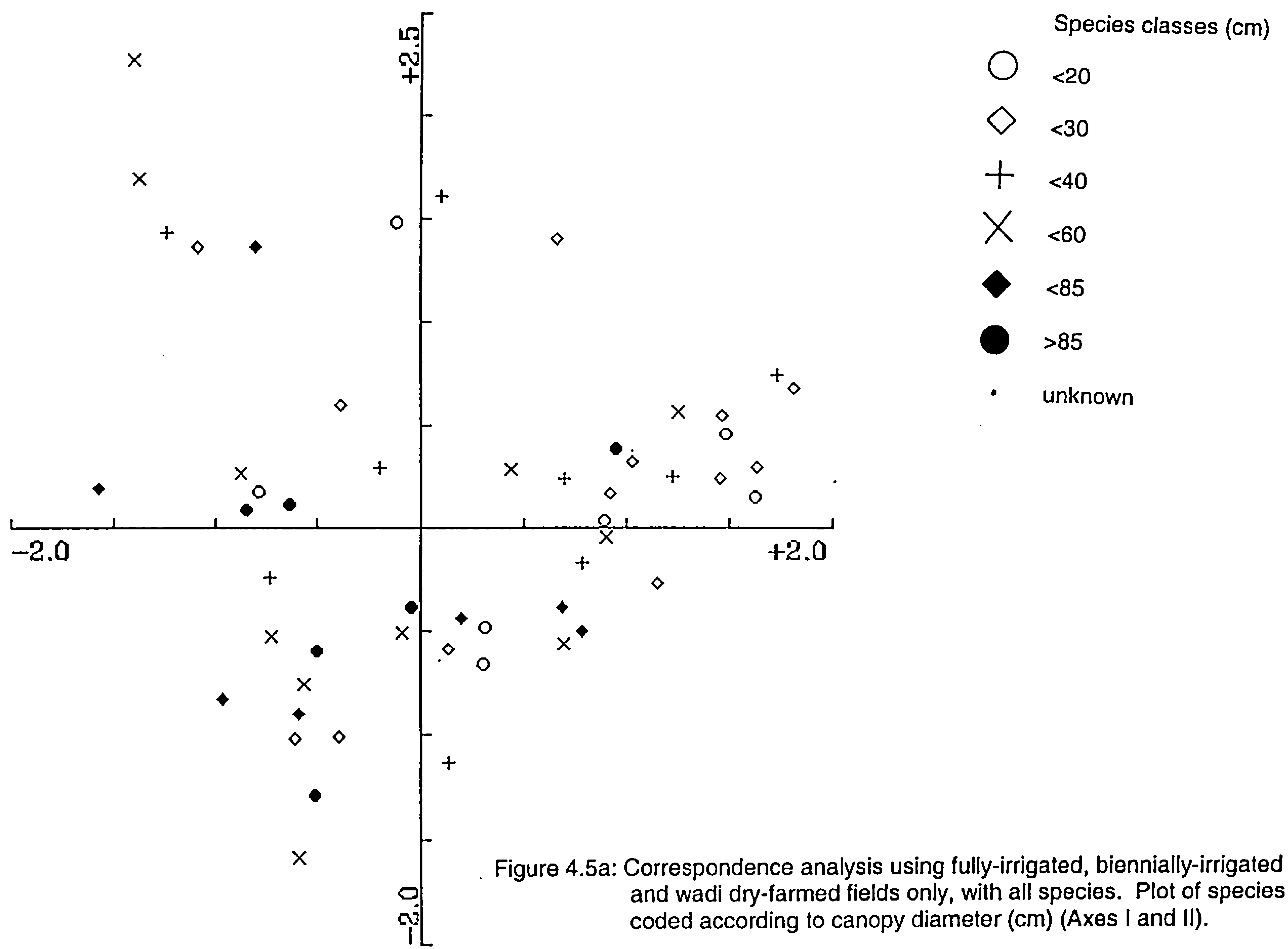


Figure 4.5a: Correspondence analysis using fully-irrigated, biennially-irrigated and wadi dry-farmed fields only, with all species. Plot of species coded according to canopy diameter (cm) (Axes I and II).

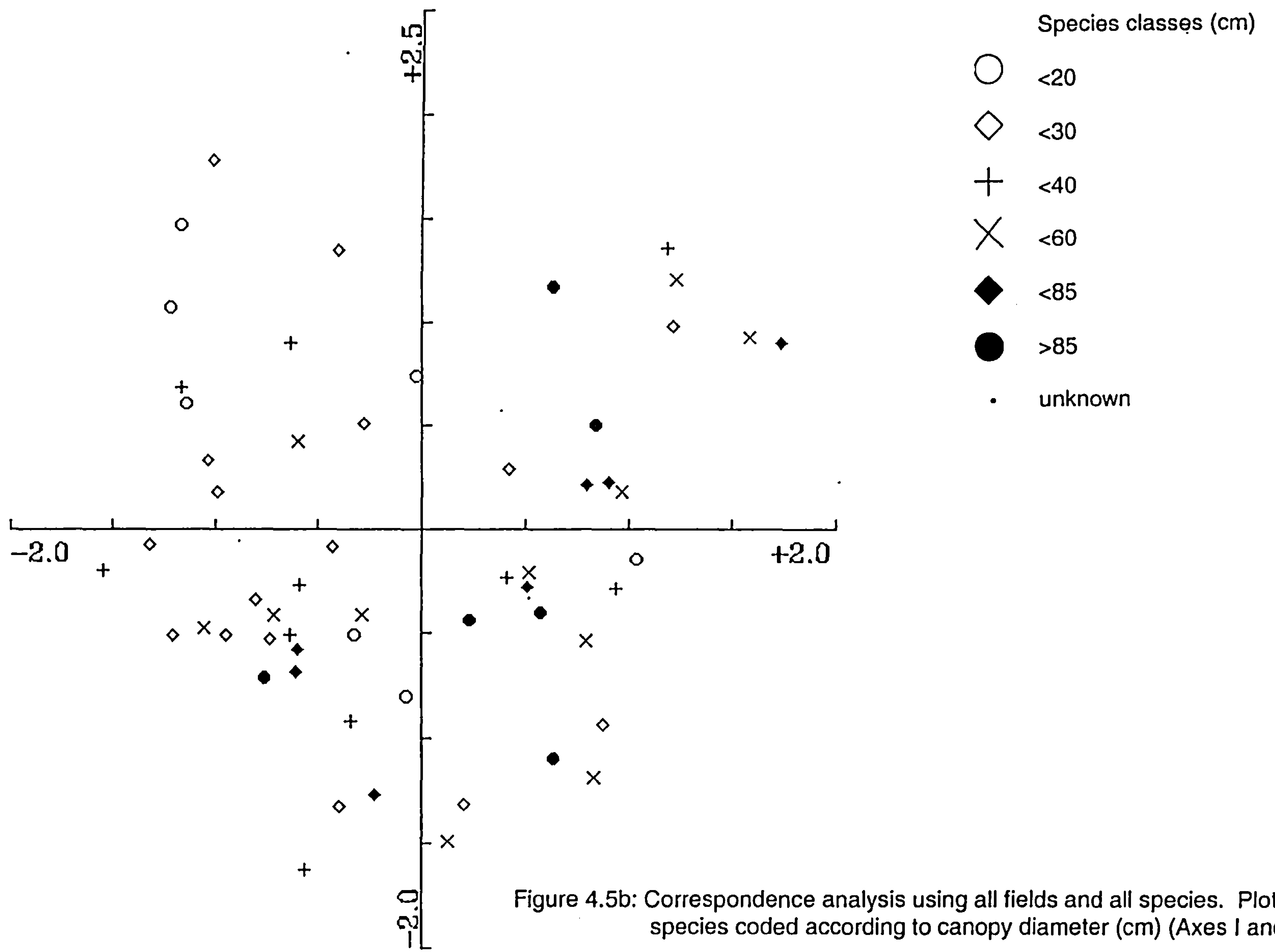


Figure 4.5b: Correspondence analysis using all fields and all species. Plot of species coded according to canopy diameter (cm) (Axes I and II).

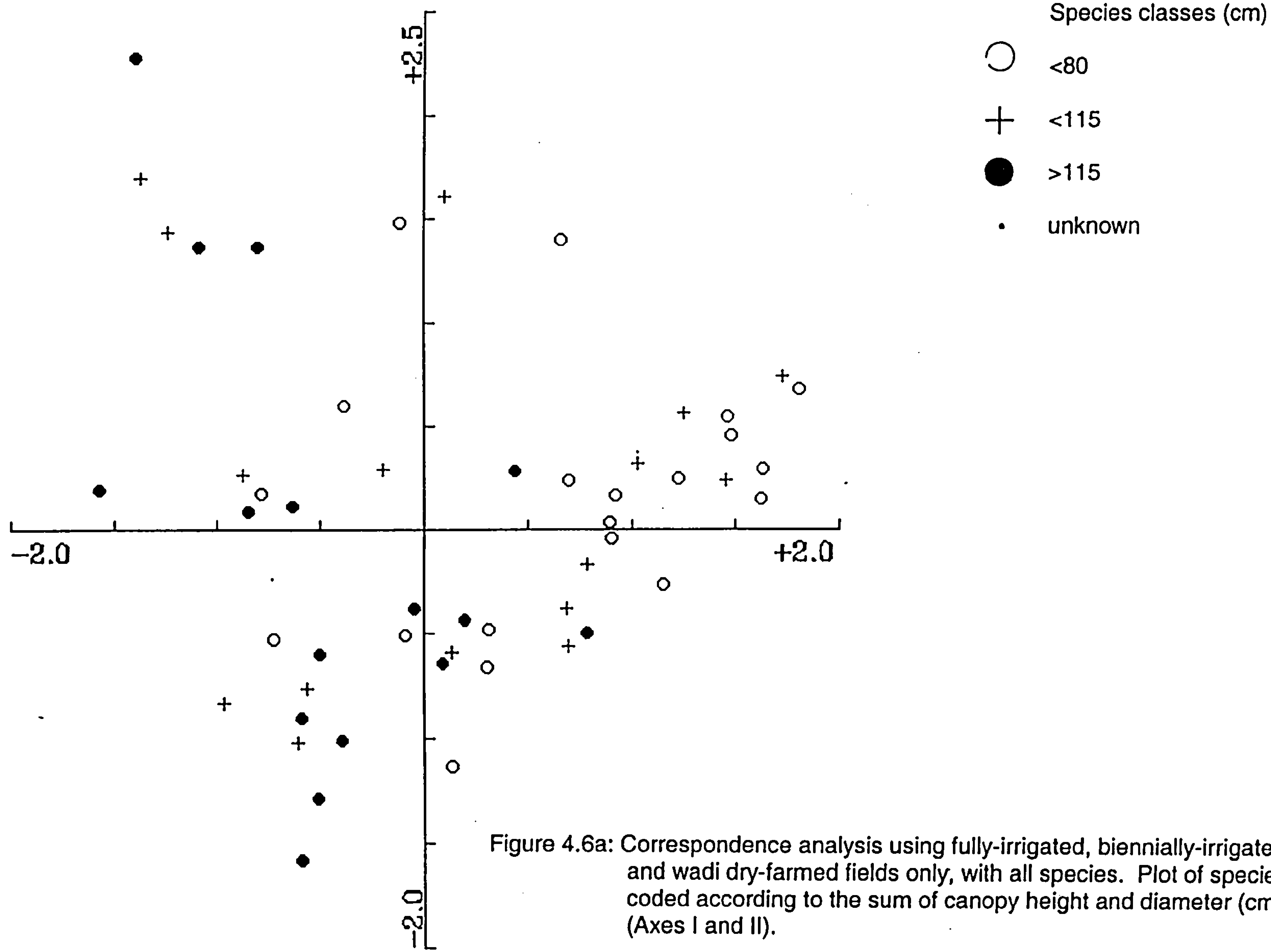


Figure 4.6a: Correspondence analysis using fully-irrigated, biennially-irrigated and wadi dry-farmed fields only, with all species. Plot of species coded according to the sum of canopy height and diameter (cm) (Axes I and II).

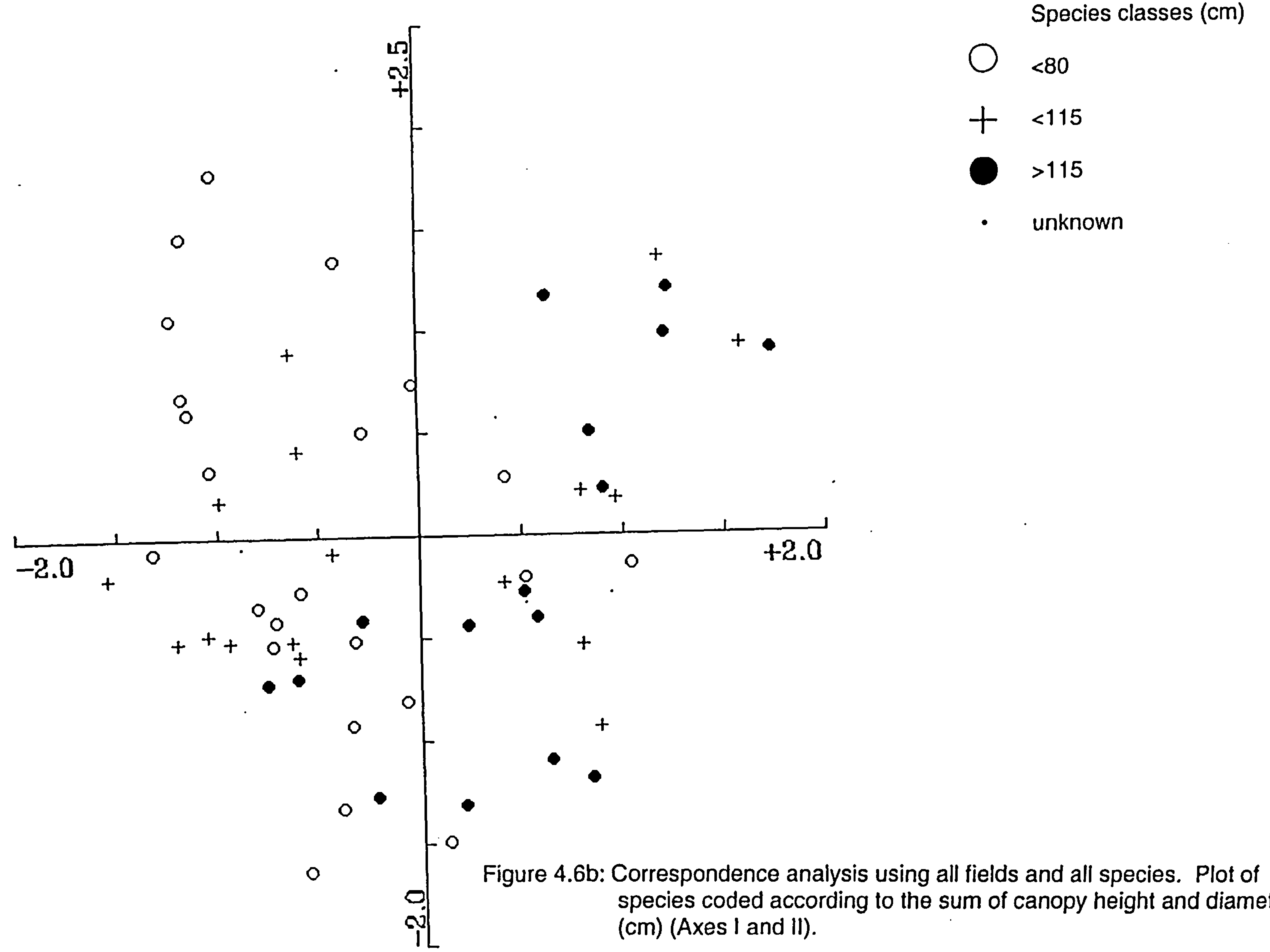


Figure 4.6b: Correspondence analysis using all fields and all species. Plot of species coded according to the sum of canopy height and diameter (cm) (Axes I and II).

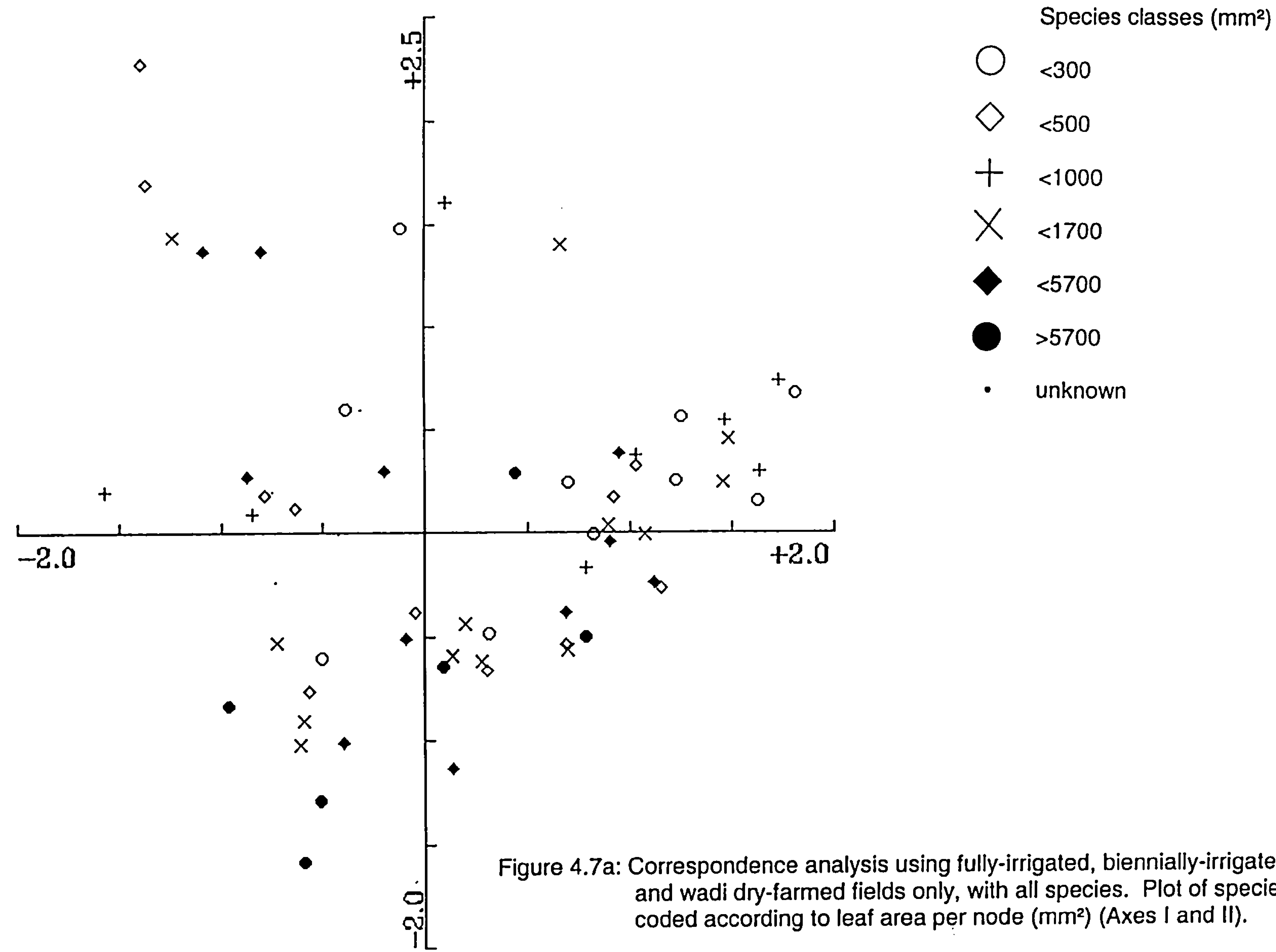


Figure 4.7a: Correspondence analysis using fully-irrigated, biennially-irrigated and wadi dry-farmed fields only, with all species. Plot of species coded according to leaf area per node (mm^2) (Axes I and II).

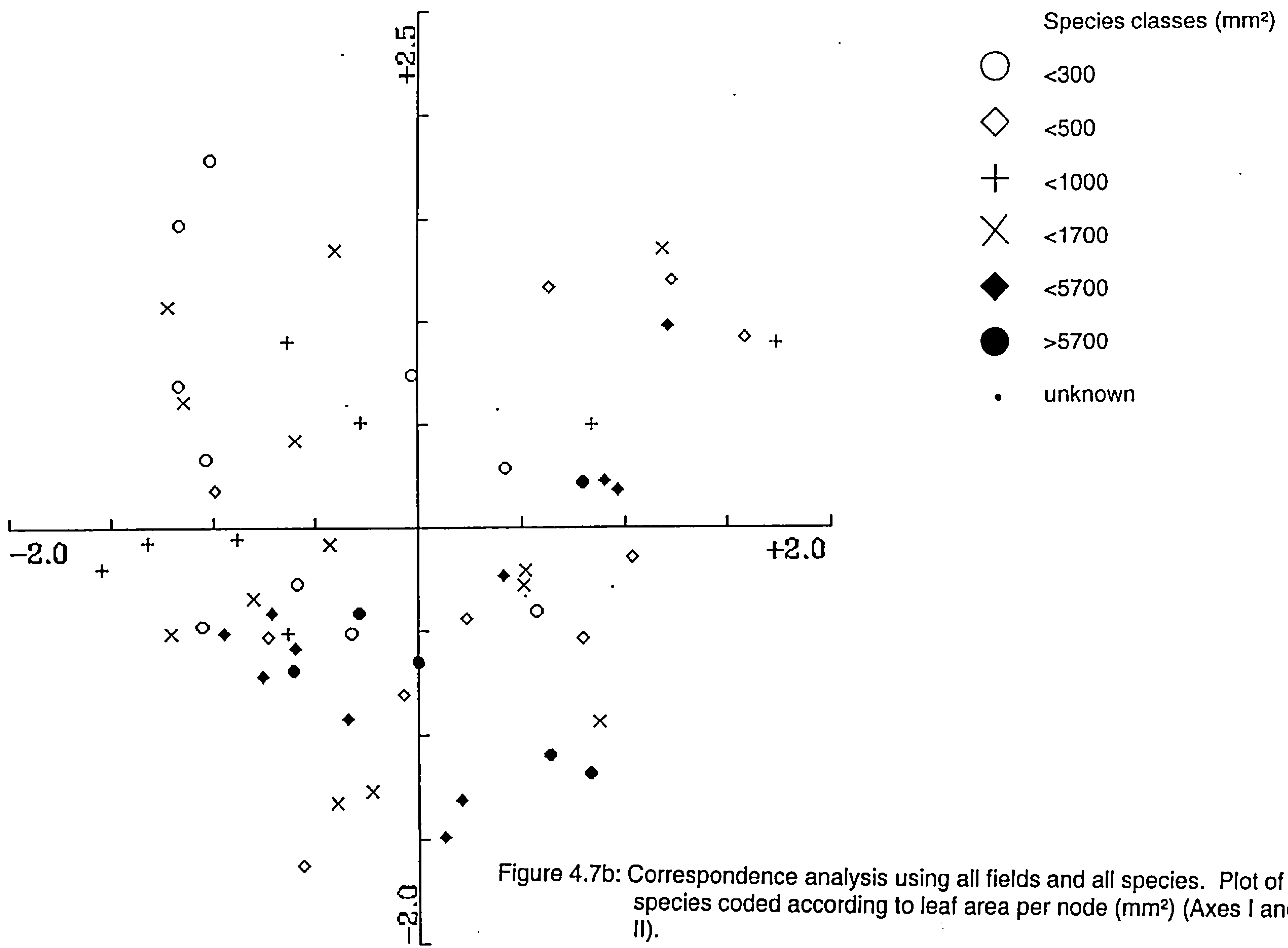


Figure 4.7b: Correspondence analysis using all fields and all species. Plot of species coded according to leaf area per node (mm²) (Axes I and II).

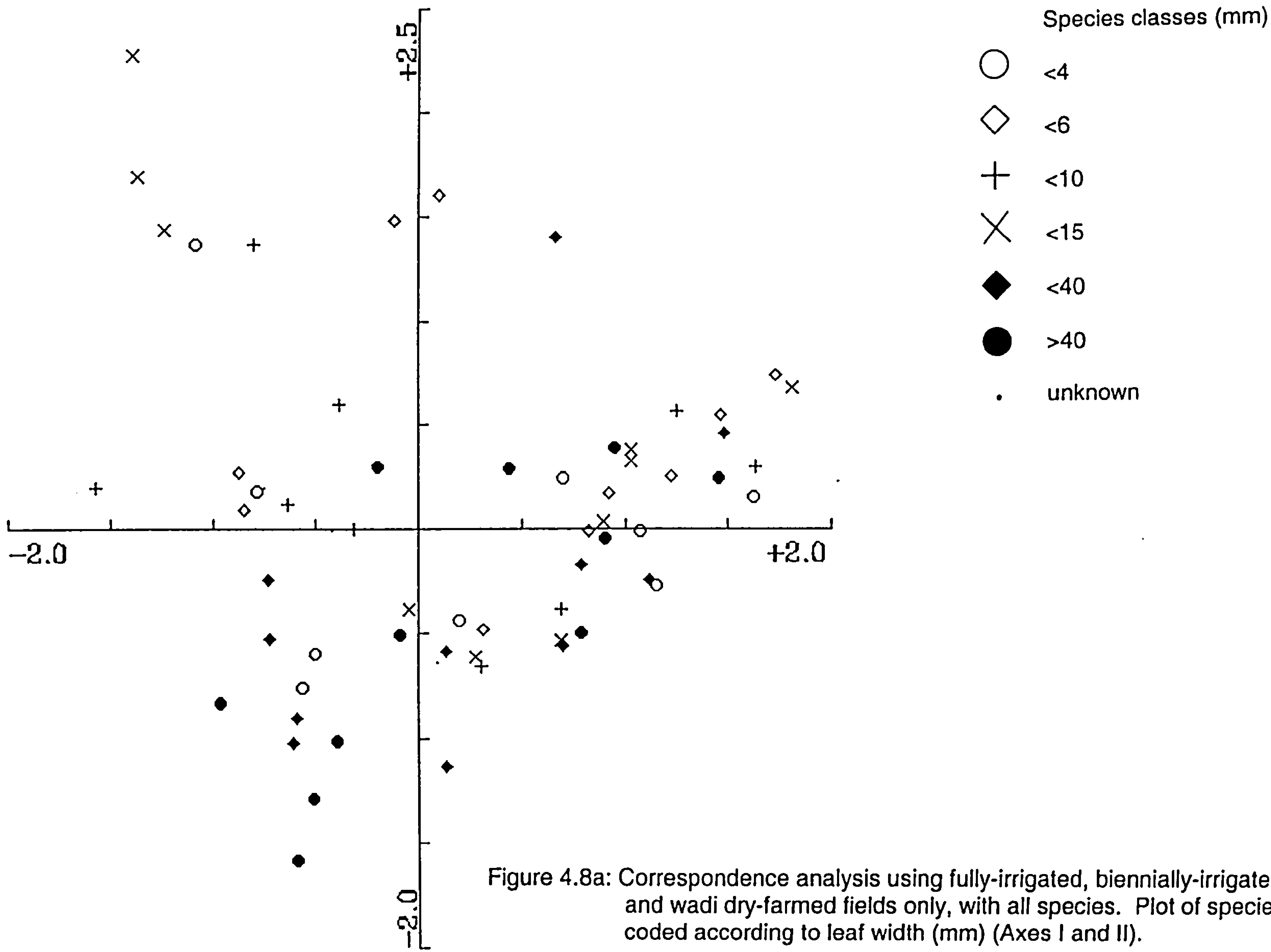


Figure 4.8a: Correspondence analysis using fully-irrigated, biennially-irrigated and wadi dry-farmed fields only, with all species. Plot of species coded according to leaf width (mm) (Axes I and II).

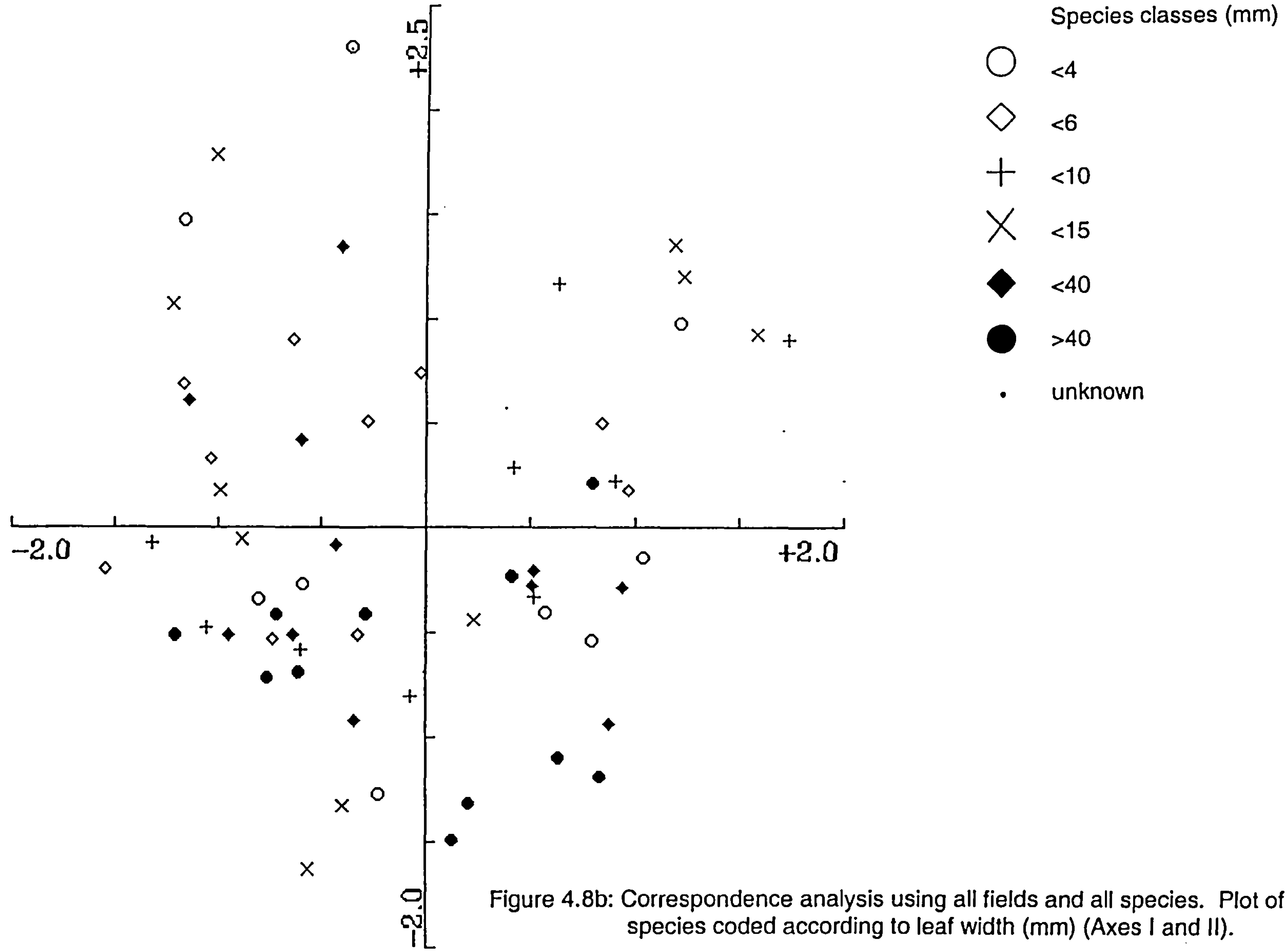


Figure 4.8b: Correspondence analysis using all fields and all species. Plot of species coded according to leaf width (mm) (Axes I and II).

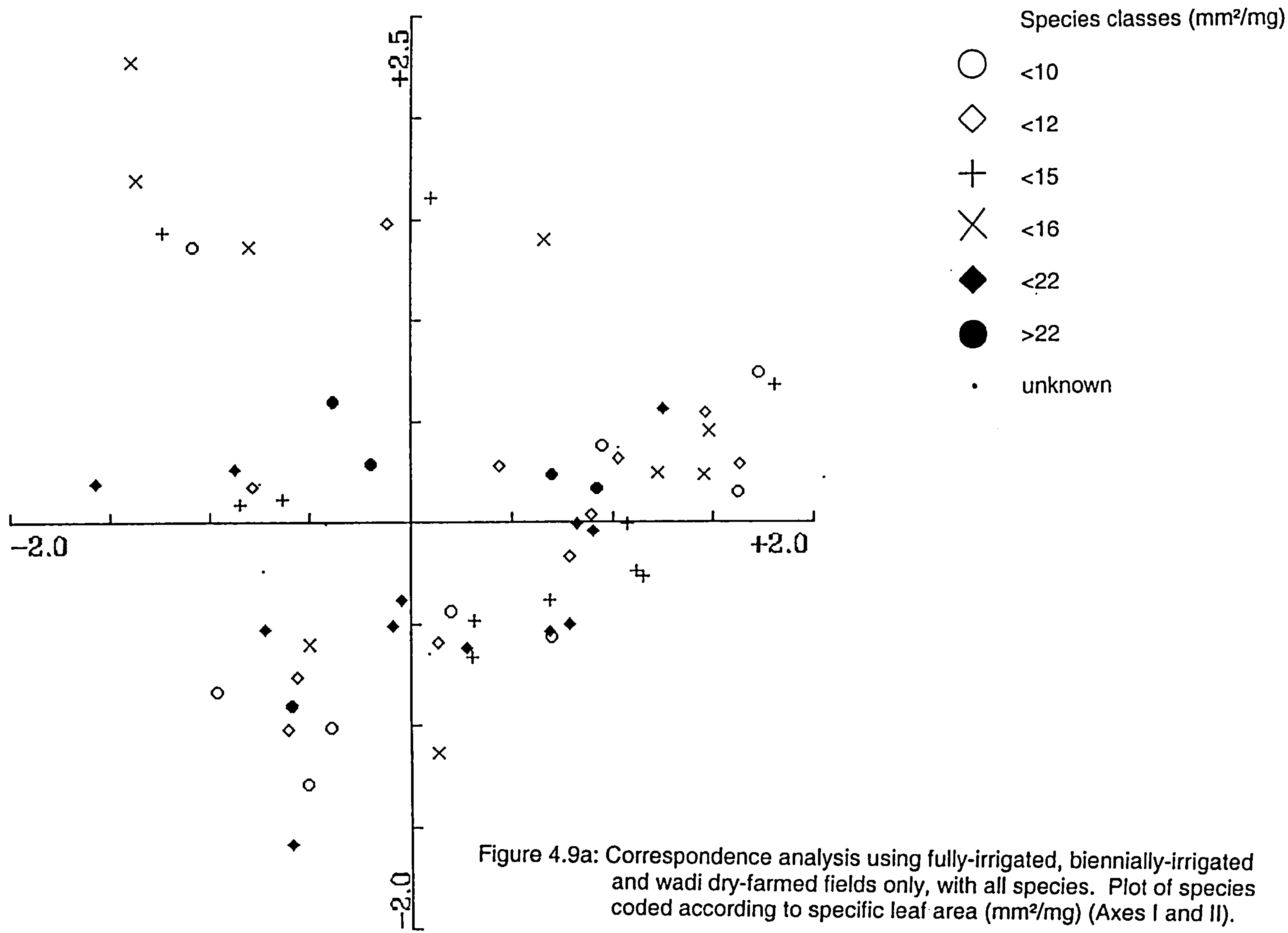


Figure 4.9a: Correspondence analysis using fully-irrigated, biennially-irrigated and wadi dry-farmed fields only, with all species. Plot of species coded according to specific leaf area (mm^2/mg) (Axes I and II).

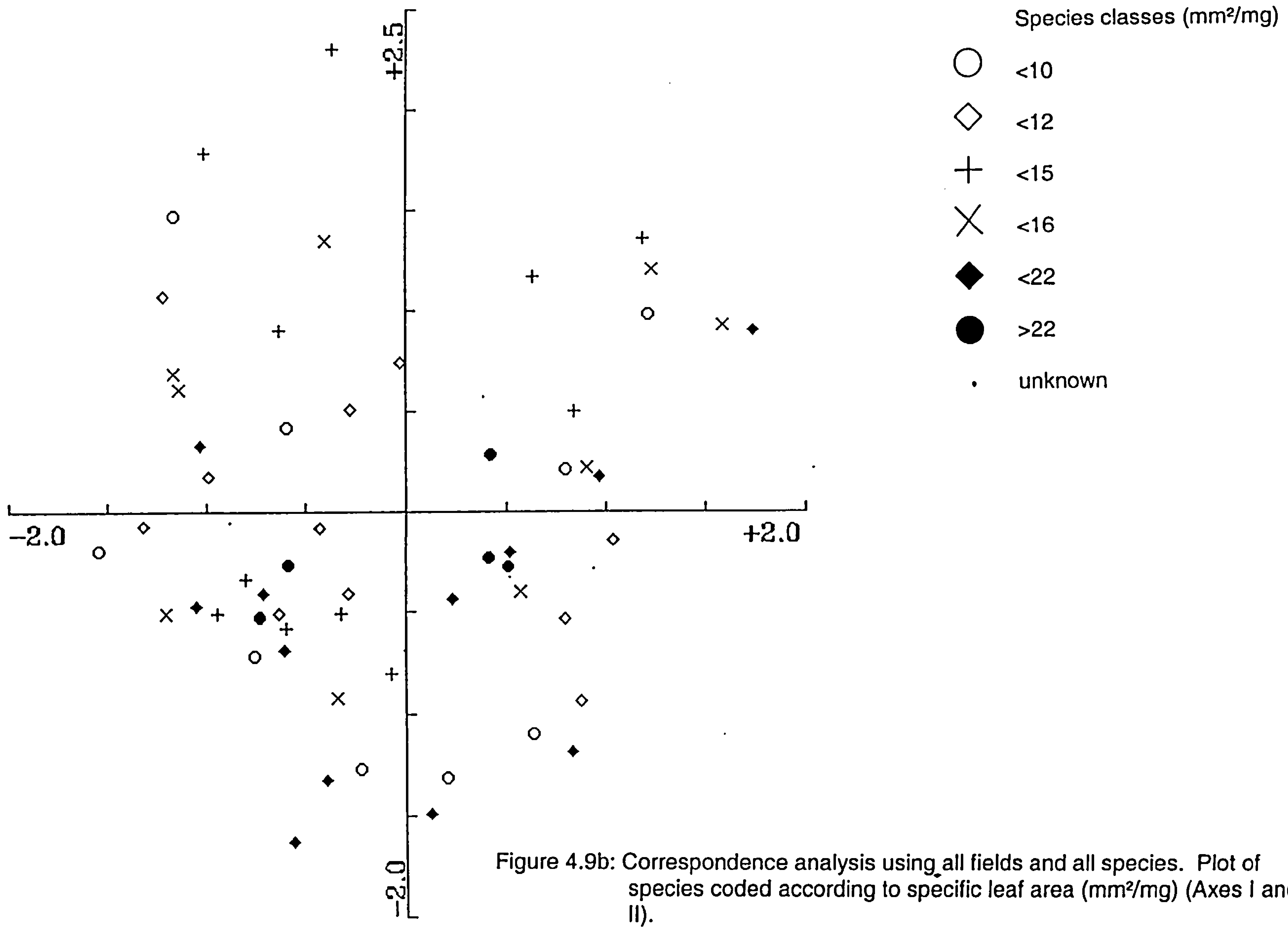


Figure 4.9b: Correspondence analysis using all fields and all species. Plot of species coded according to specific leaf area (mm²/mg) (Axes I and II).

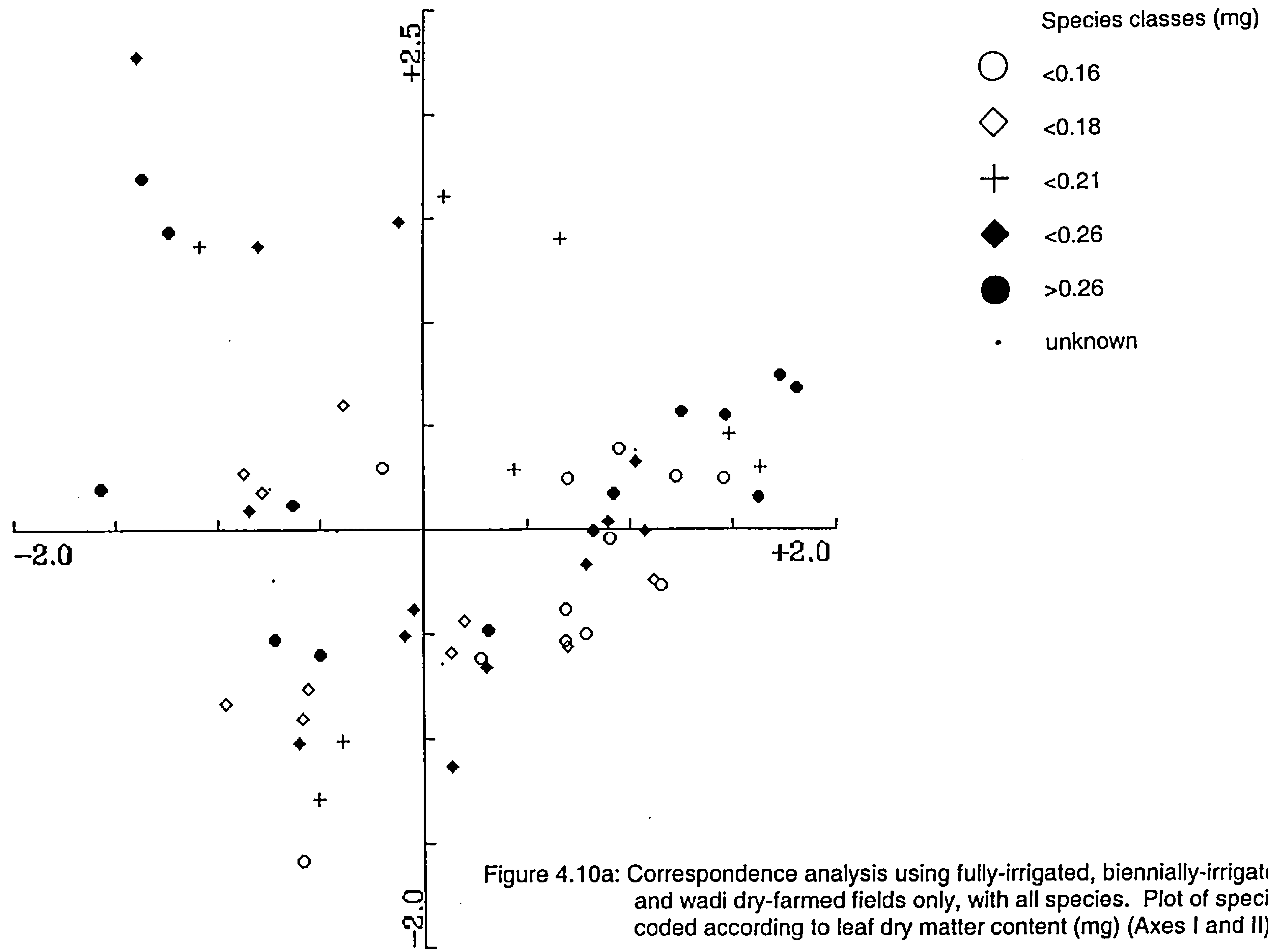


Figure 4.10a: Correspondence analysis using fully-irrigated, biennially-irrigated and wadi dry-farmed fields only, with all species. Plot of species coded according to leaf dry matter content (mg) (Axes I and II).

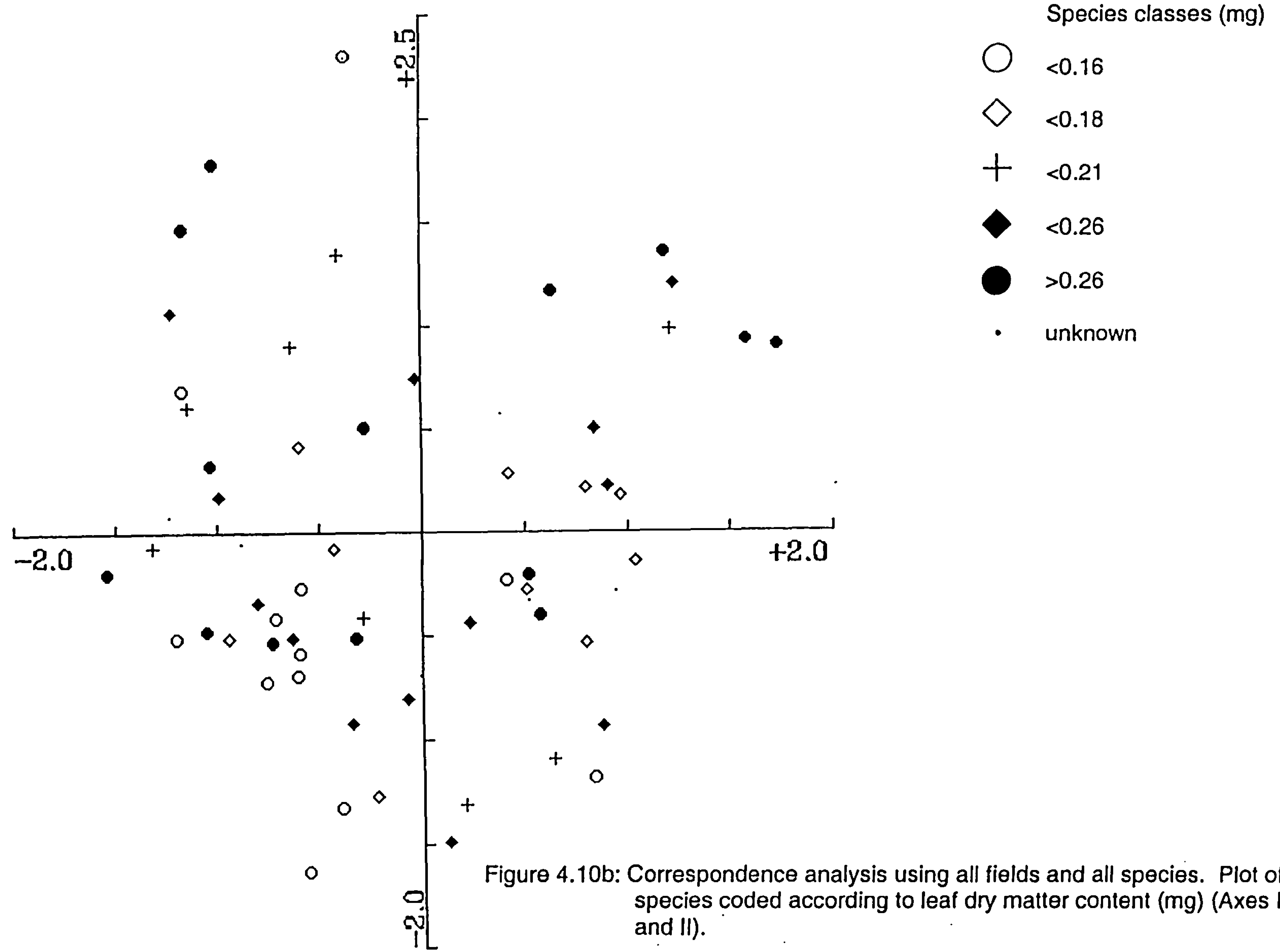


Figure 4.10b: Correspondence analysis using all fields and all species. Plot of species coded according to leaf dry matter content (mg) (Axes I and II).

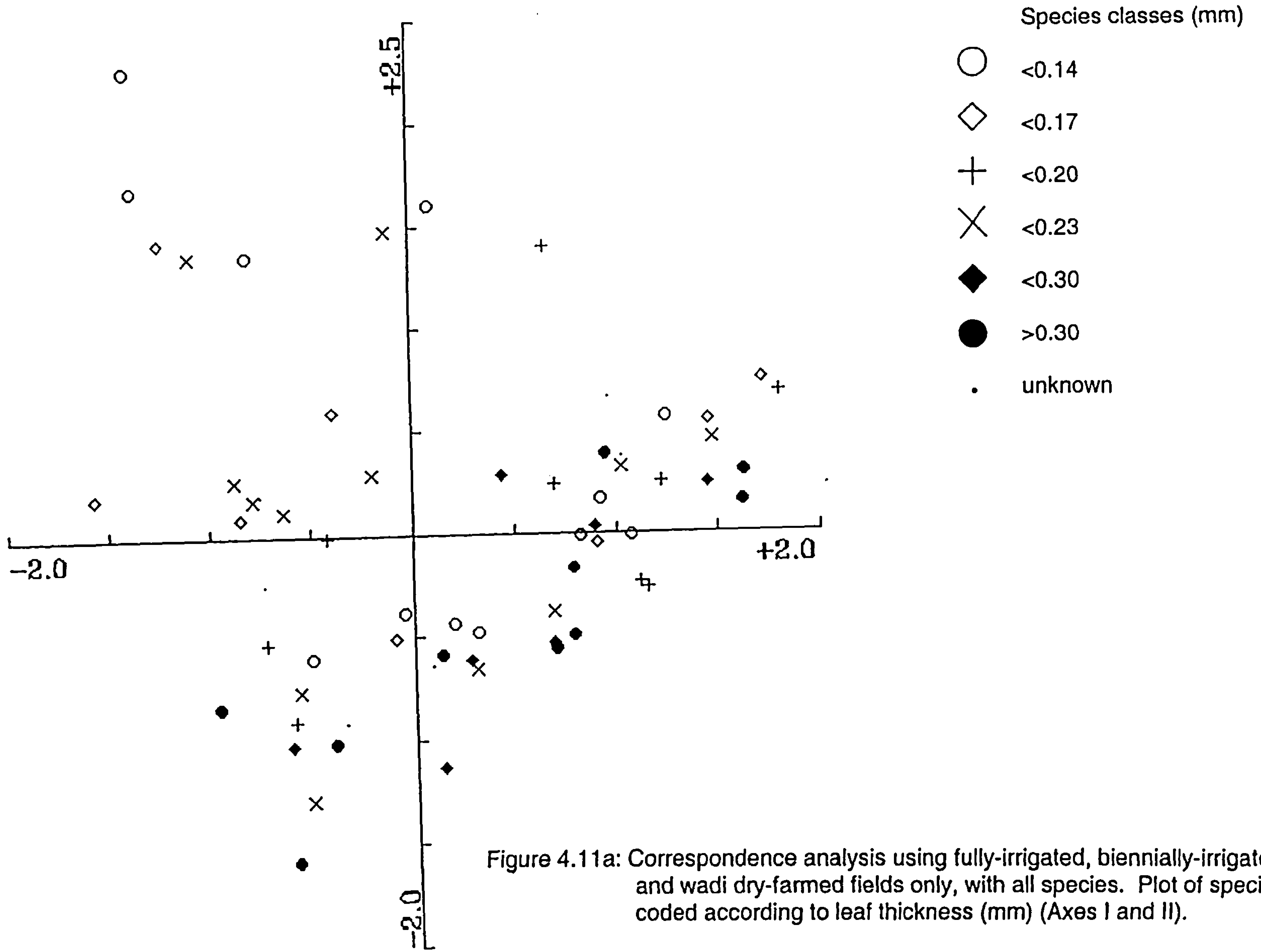


Figure 4.11a: Correspondence analysis using fully-irrigated, biennially-irrigated and wadi dry-farmed fields only, with all species. Plot of species coded according to leaf thickness (mm) (Axes I and II).

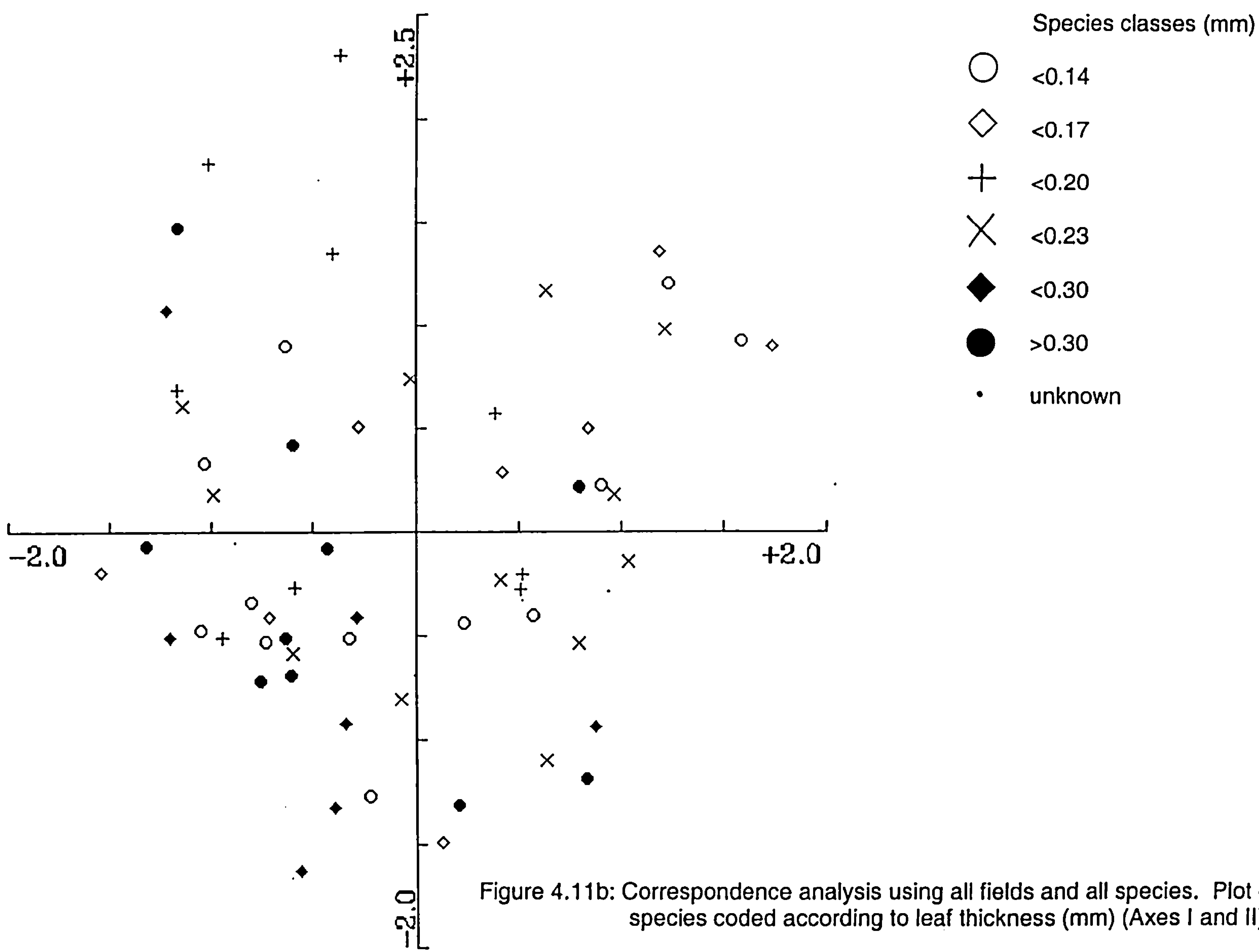


Figure 4.11b: Correspondence analysis using all fields and all species. Plot of species coded according to leaf thickness (mm) (Axes I and II).

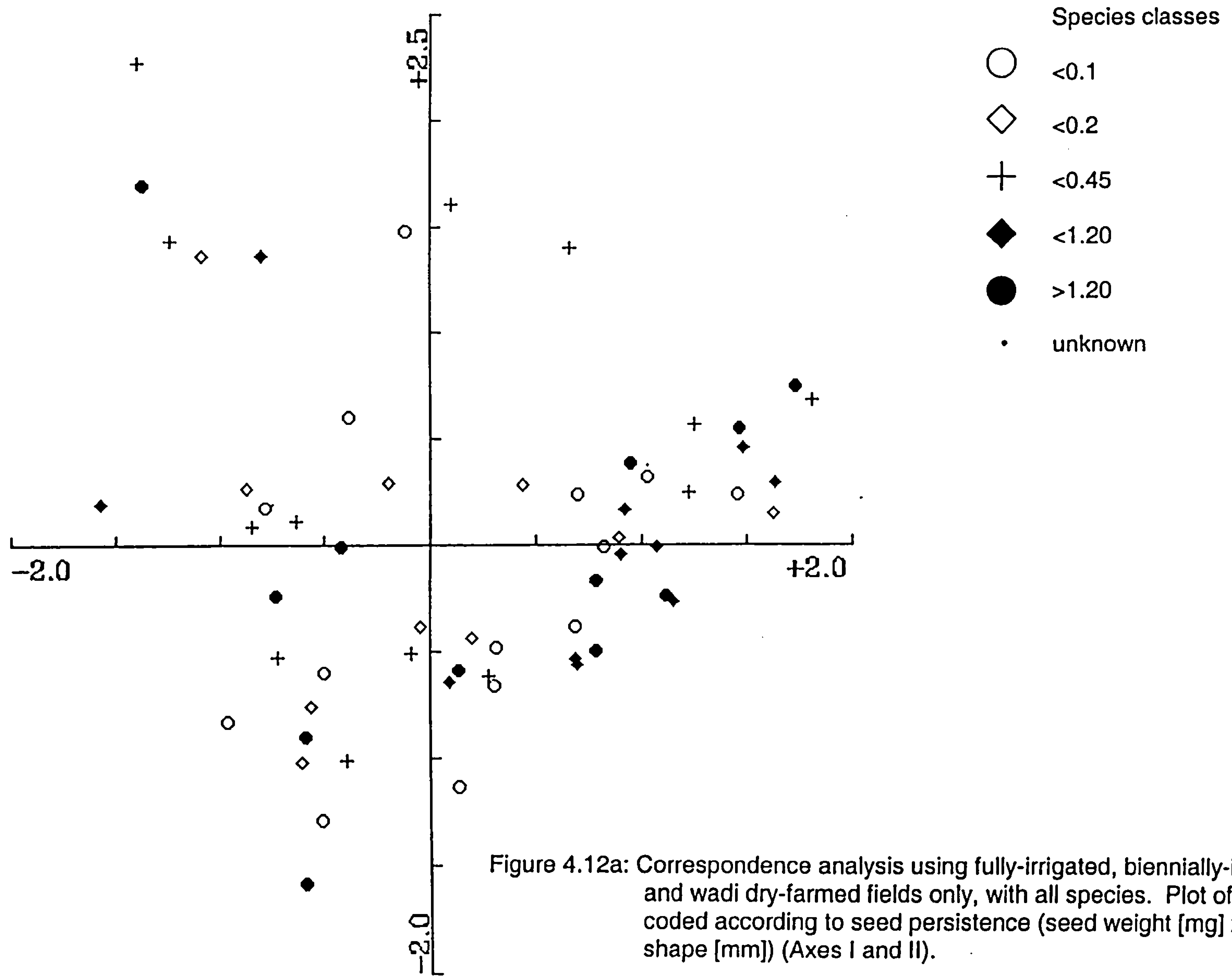


Figure 4.12a: Correspondence analysis using fully-irrigated, biennially-irrigated and wadi dry-farmed fields only, with all species. Plot of species coded according to seed persistence (seed weight [mg] x seed shape [mm]) (Axes I and II).

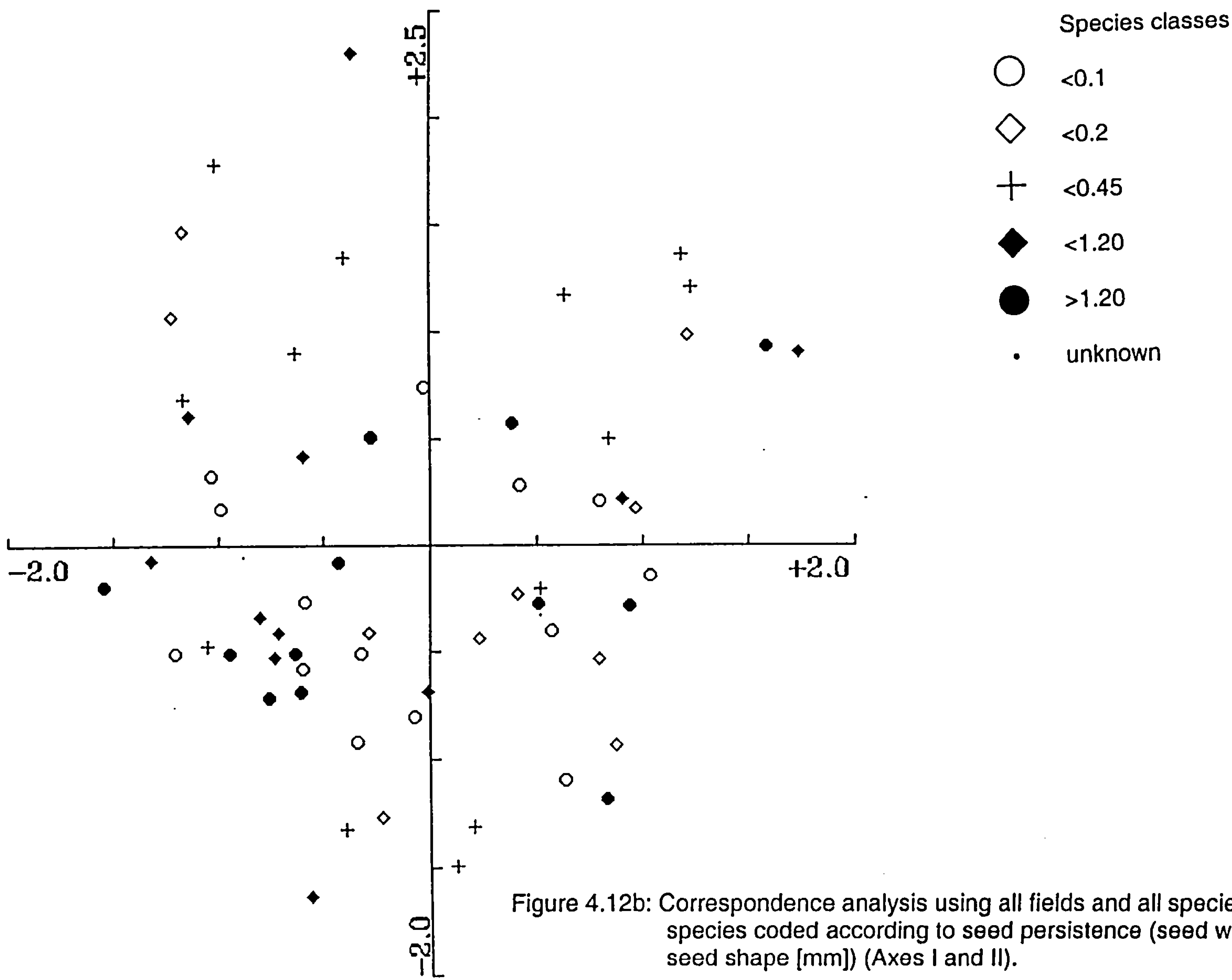


Figure 4.12b: Correspondence analysis using all fields and all species: Plot of species coded according to seed persistence (seed weight [mg] x seed shape [mm]) (Axes I and II).

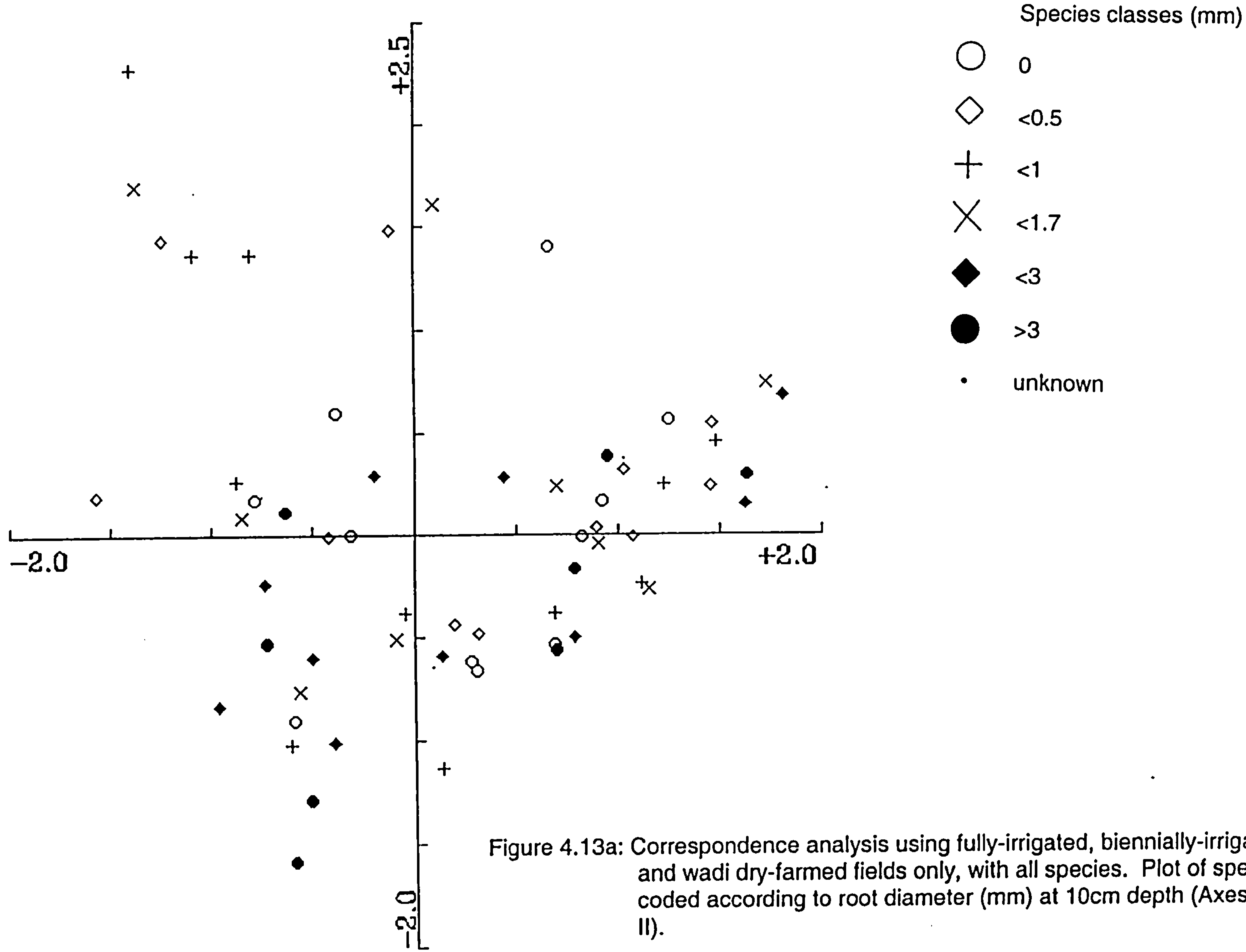


Figure 4.13a: Correspondence analysis using fully-irrigated, biennially-irrigated and wadi dry-farmed fields only, with all species. Plot of species coded according to root diameter (mm) at 10cm depth (Axes I and II).

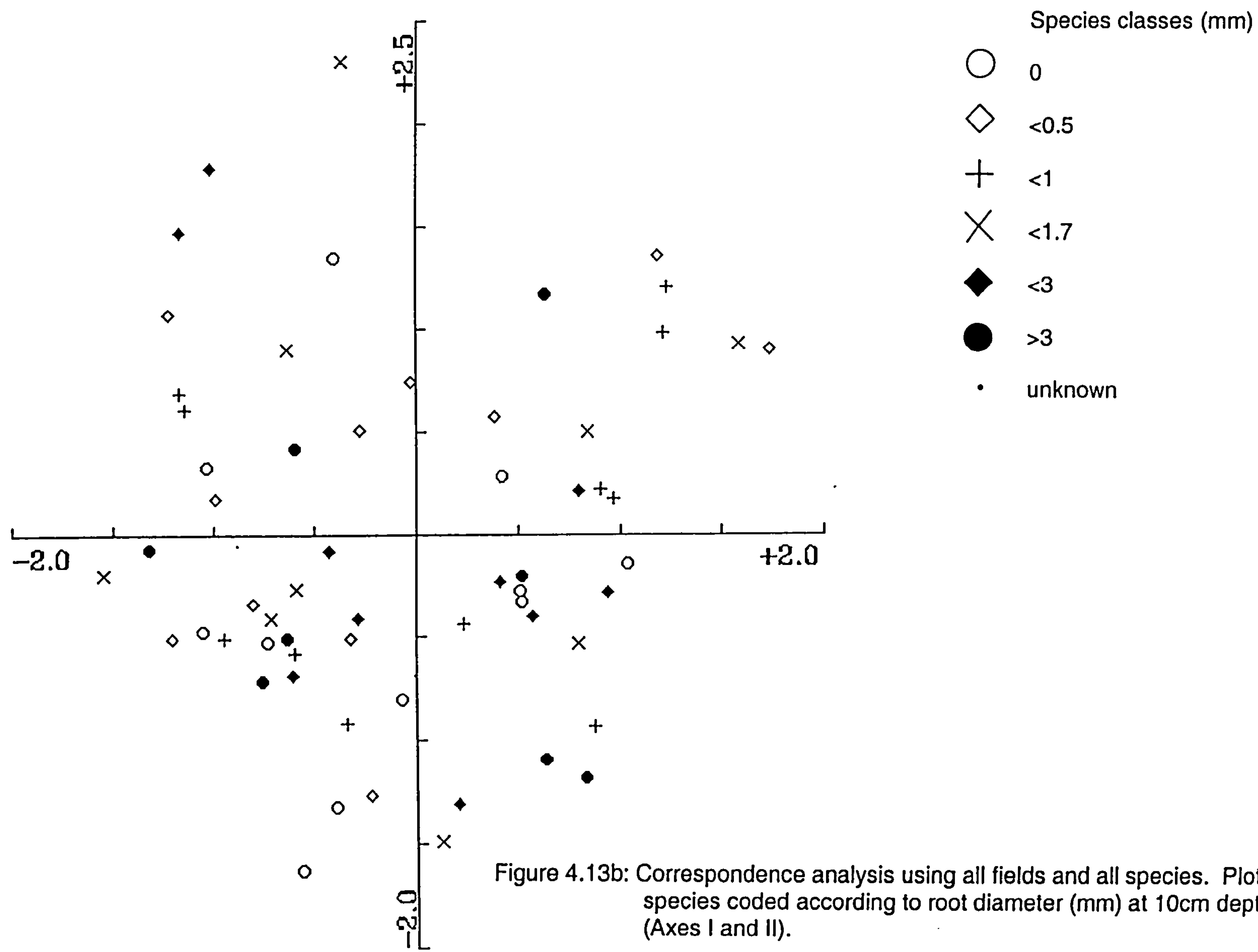


Figure 4.13b: Correspondence analysis using all fields and all species. Plot of species coded according to root diameter (mm) at 10cm depth (Axes I and II).

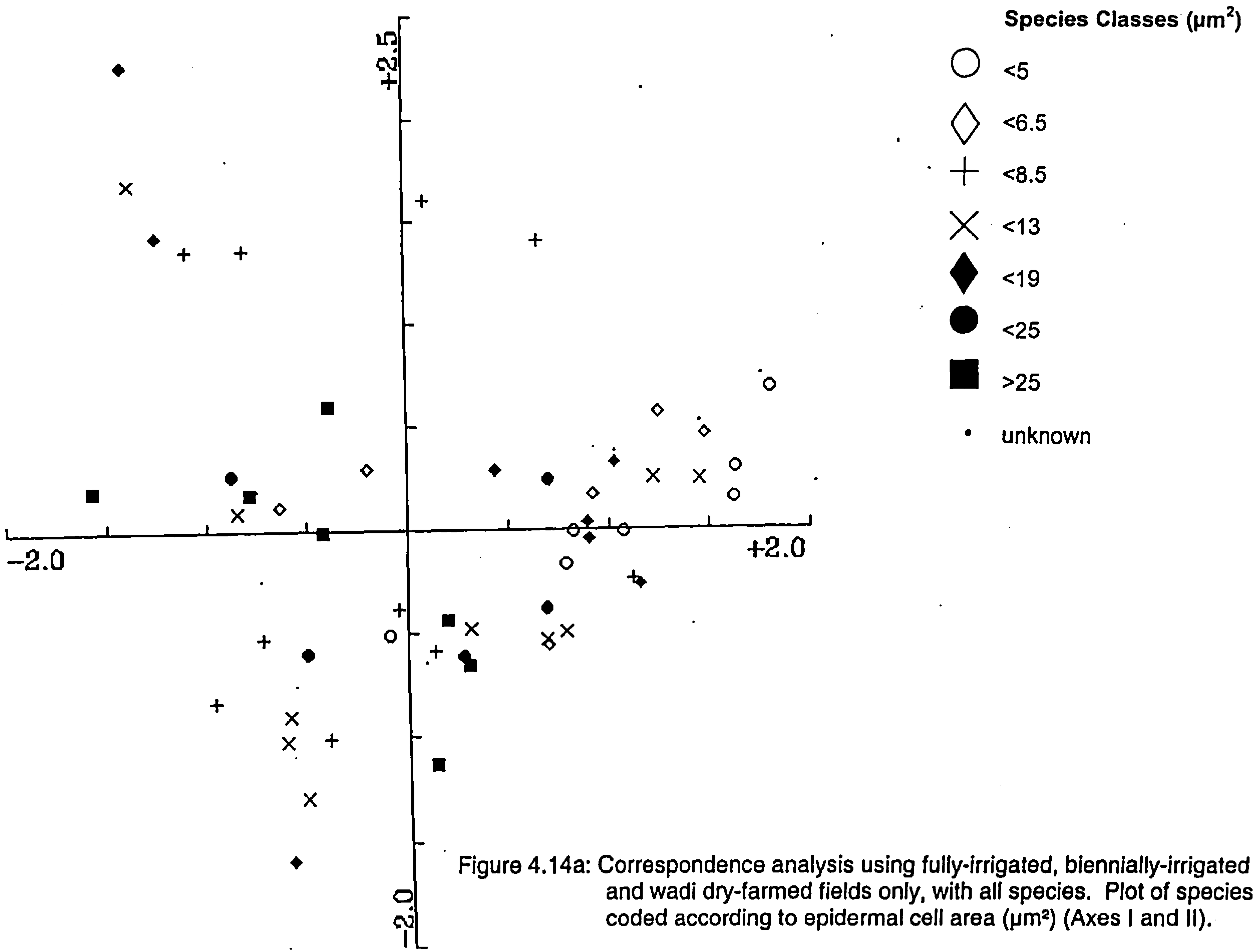


Figure 4.14a: Correspondence analysis using fully-irrigated, biennially-irrigated and wadi dry-farmed fields only, with all species. Plot of species coded according to epidermal cell area (μm²) (Axes I and II).

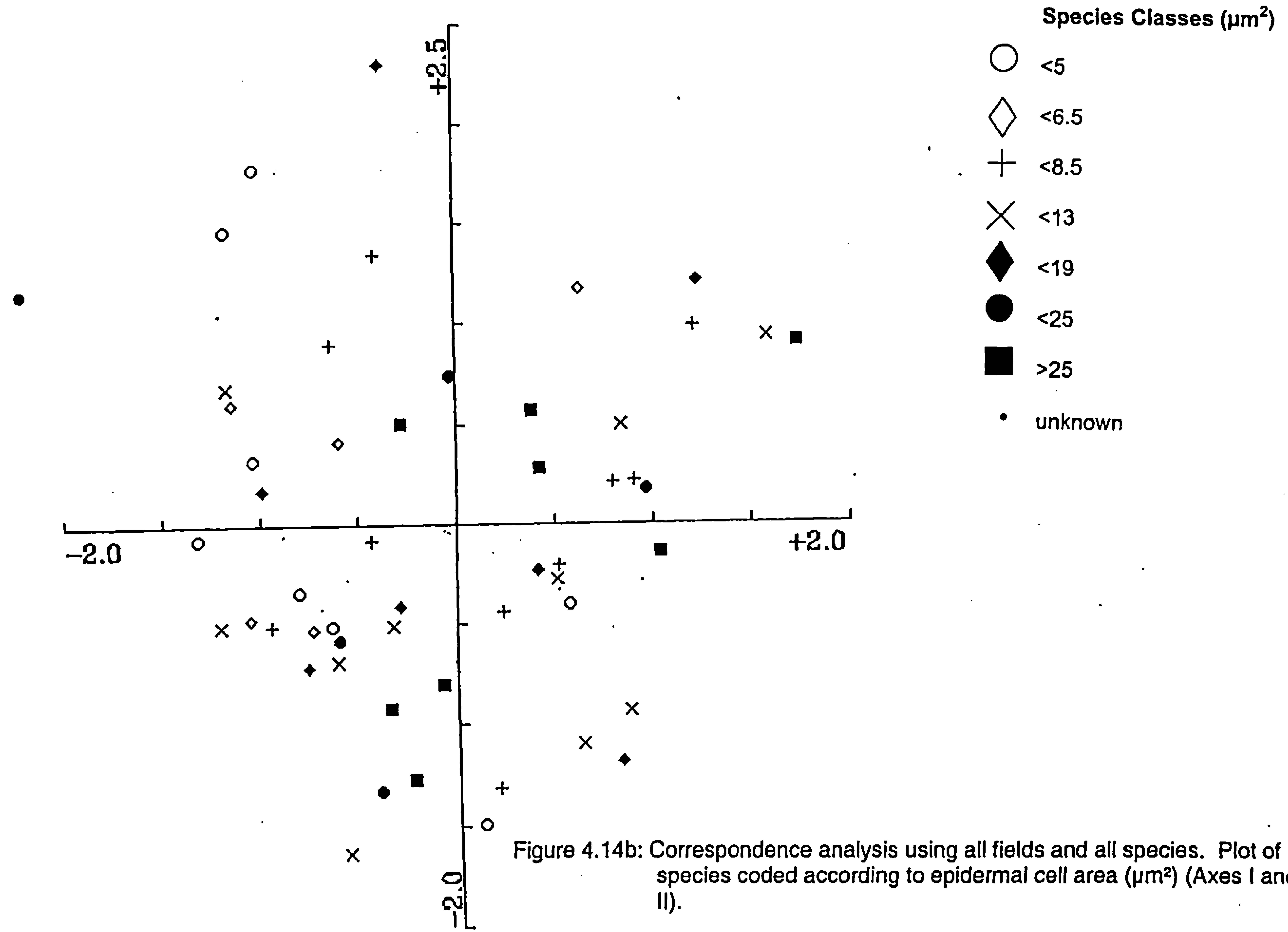


Figure 4.14b: Correspondence analysis using all fields and all species. Plot of species coded according to epidermal cell area (µm²) (Axes I and II).

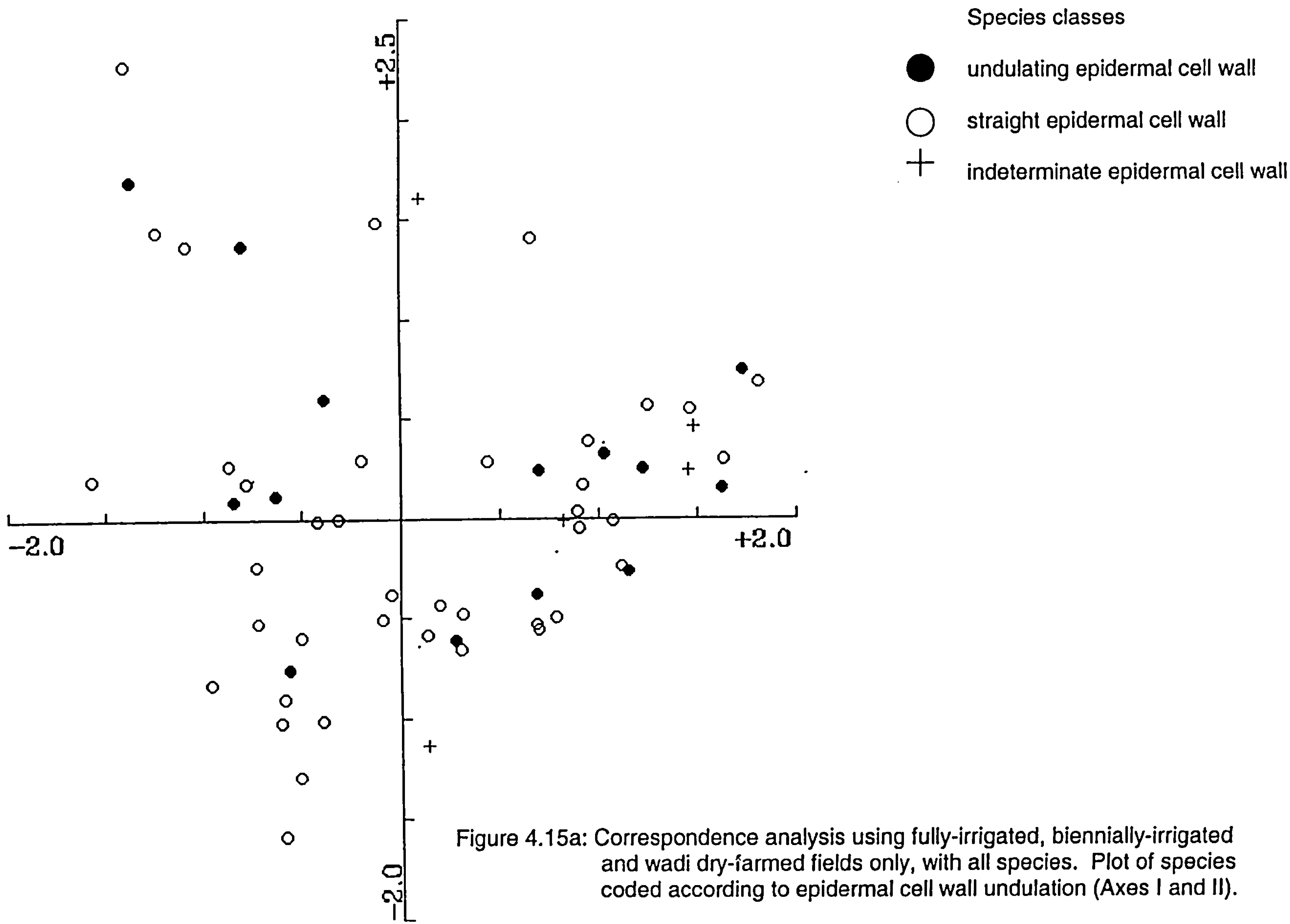


Figure 4.15a: Correspondence analysis using fully-irrigated, biennially-irrigated and wadi dry-farmed fields only, with all species. Plot of species coded according to epidermal cell wall undulation (Axes I and II).

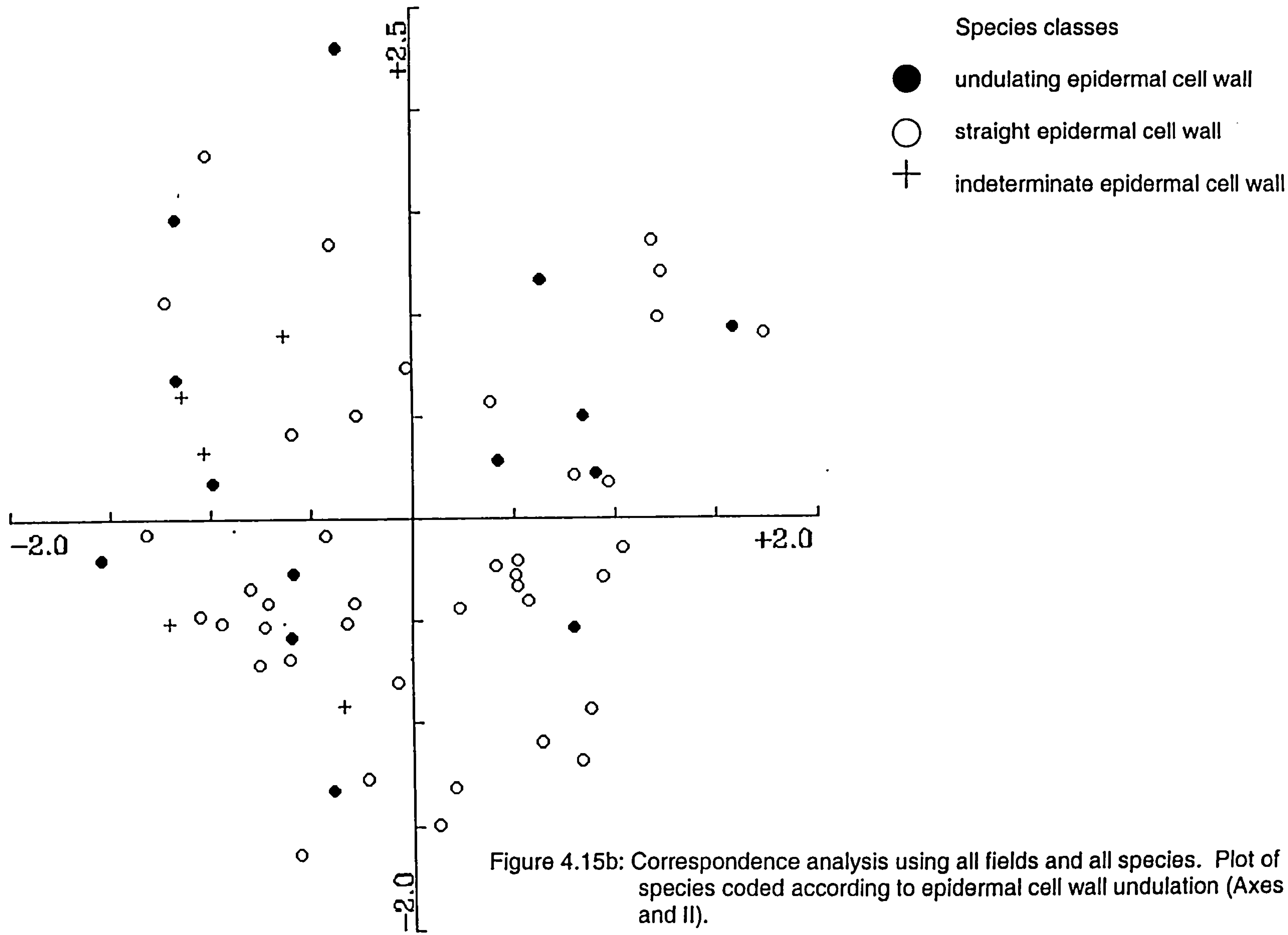


Figure 4.15b: Correspondence analysis using all fields and all species. Plot of species coded according to epidermal cell wall undulation (Axes I and II).

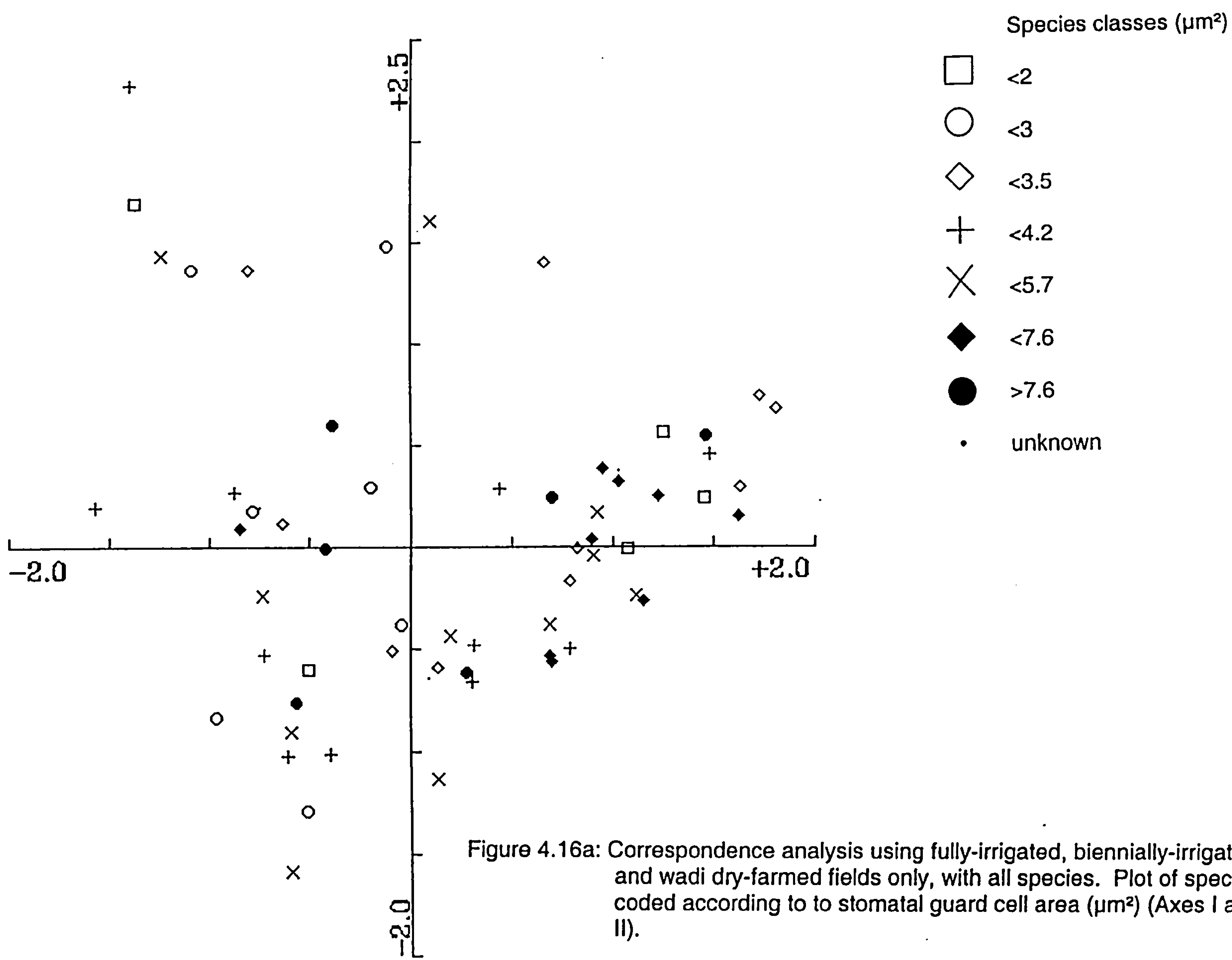


Figure 4.16a: Correspondence analysis using fully-irrigated, biennially-irrigated and wadi dry-farmed fields only, with all species. Plot of species coded according to to stomatal guard cell area (μm²) (Axes I and II).

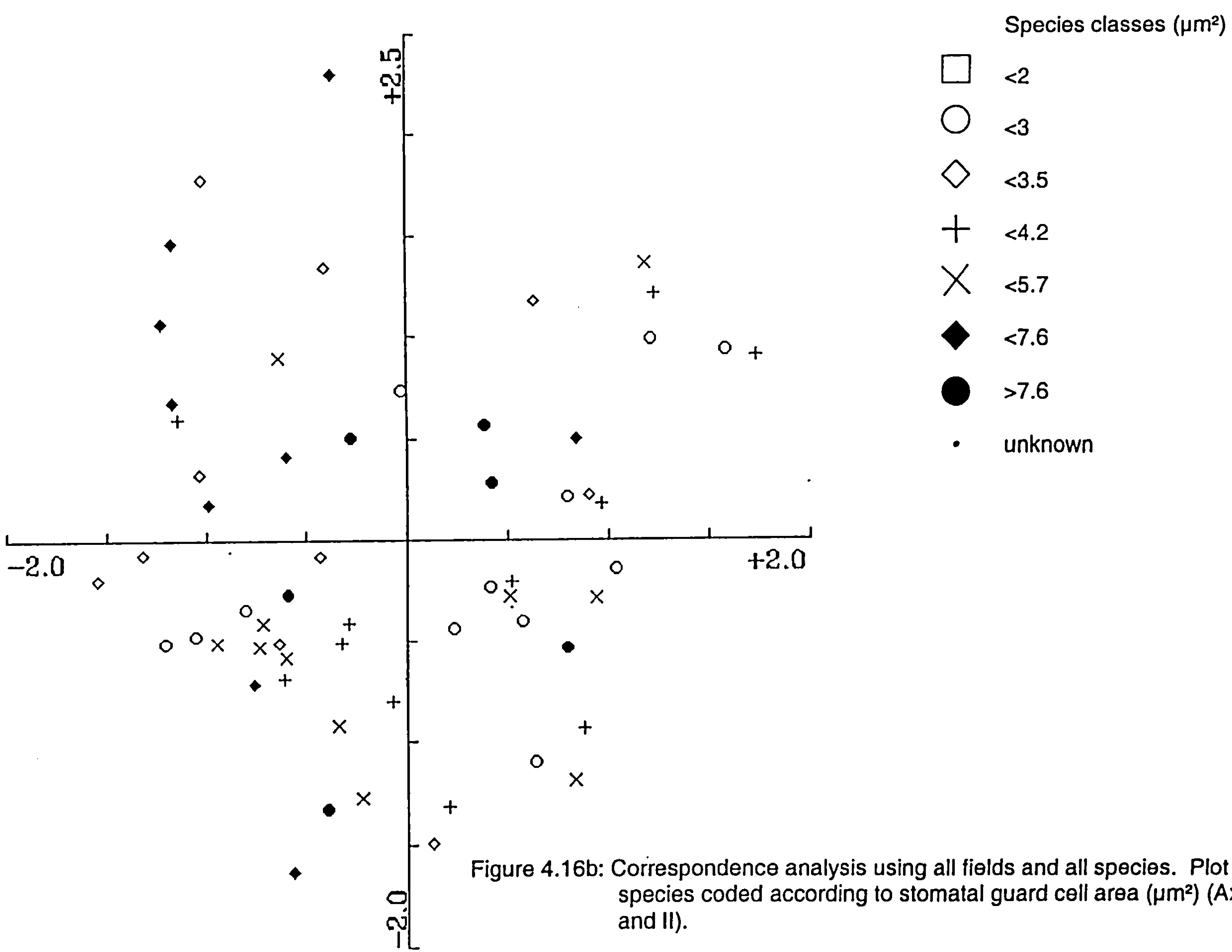


Figure 4.16b: Correspondence analysis using all fields and all species. Plot of species coded according to stomatal guard cell area (μm²) (Axes I and II).

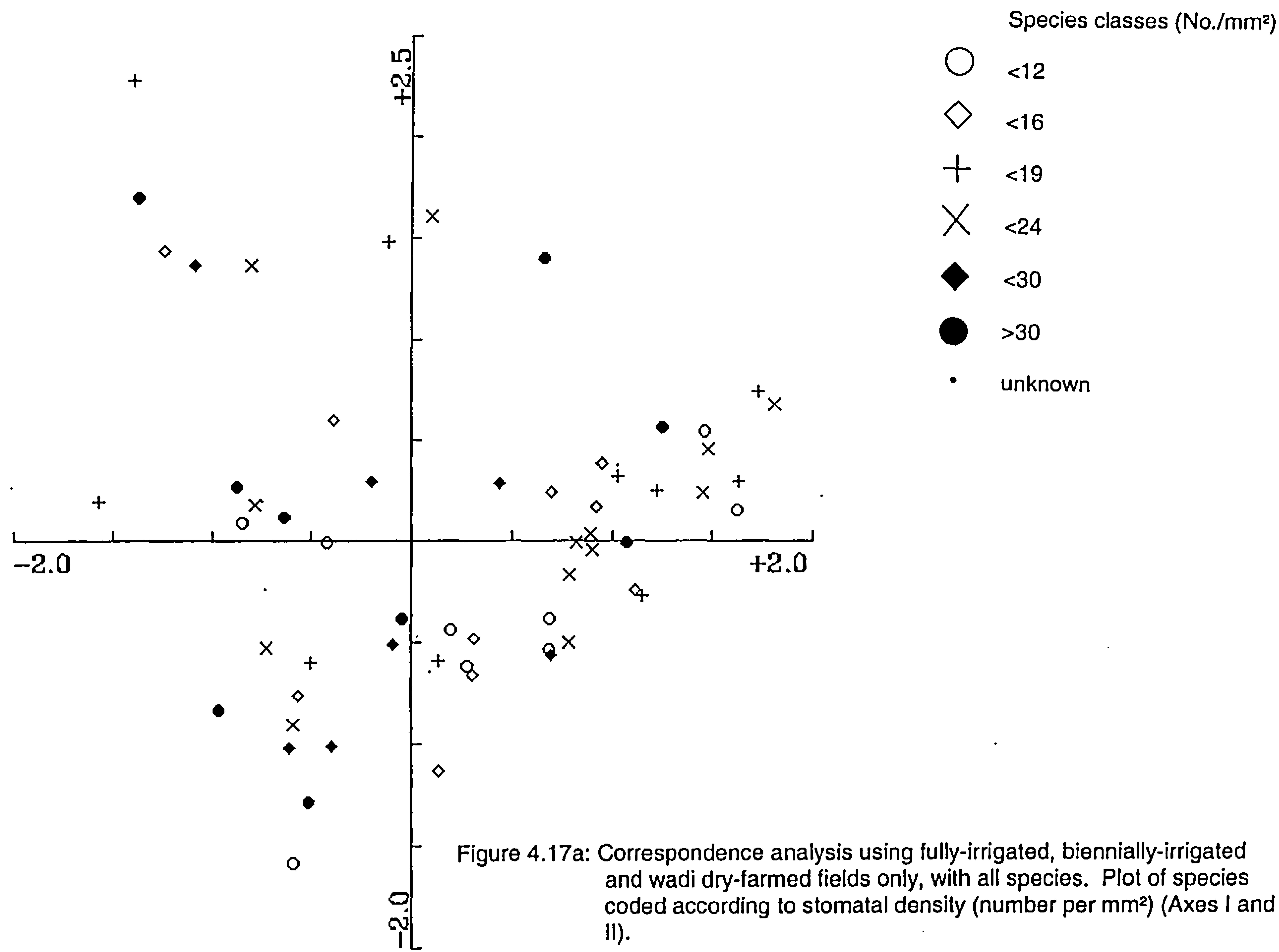


Figure 4.17a: Correspondence analysis using fully-irrigated, biennially-irrigated and wadi dry-farmed fields only, with all species. Plot of species coded according to stomatal density (number per mm²) (Axes I and II).

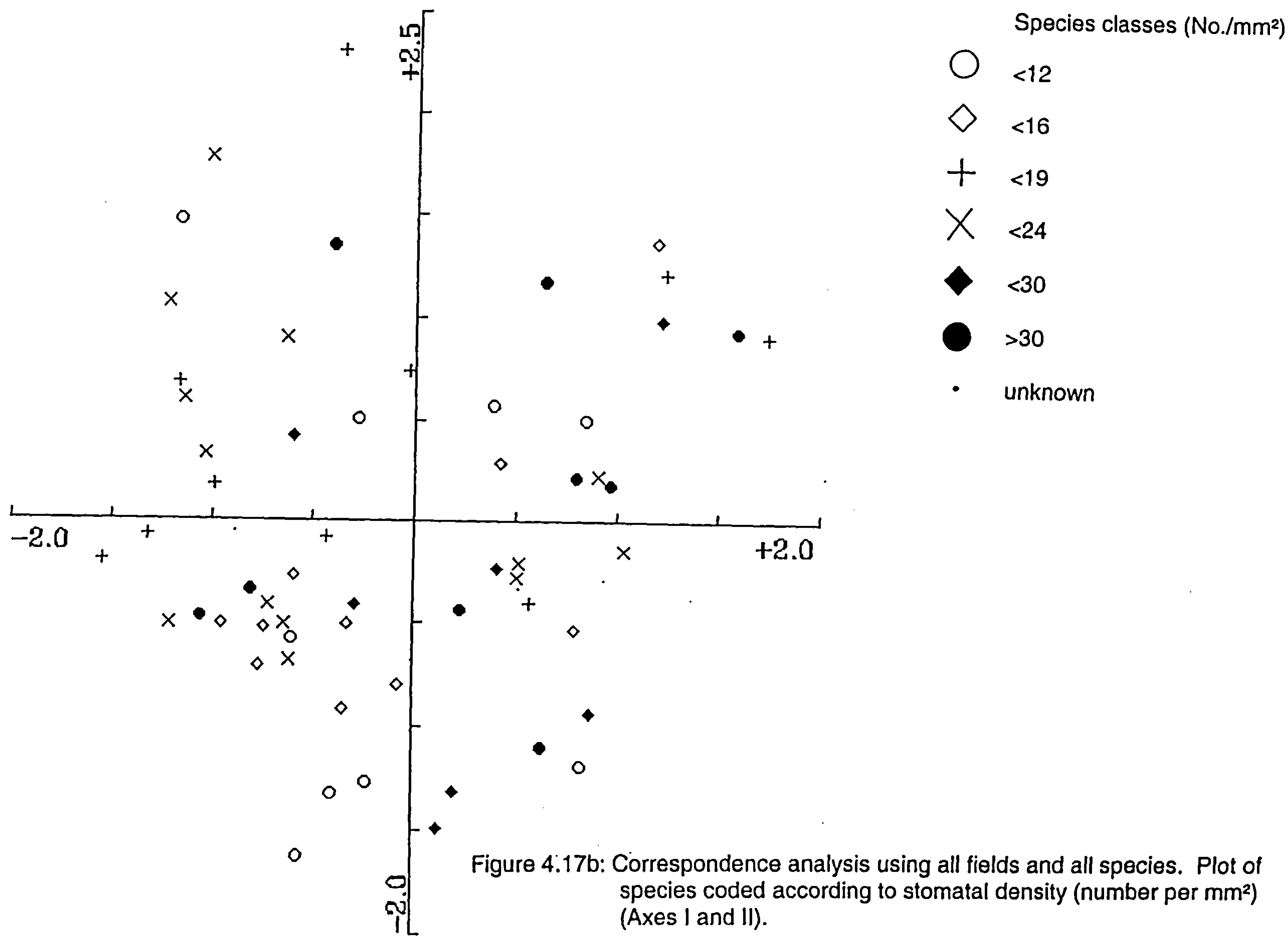


Figure 4.17b: Correspondence analysis using all fields and all species. Plot of species coded according to stomatal density (number per mm²) (Axes I and II).

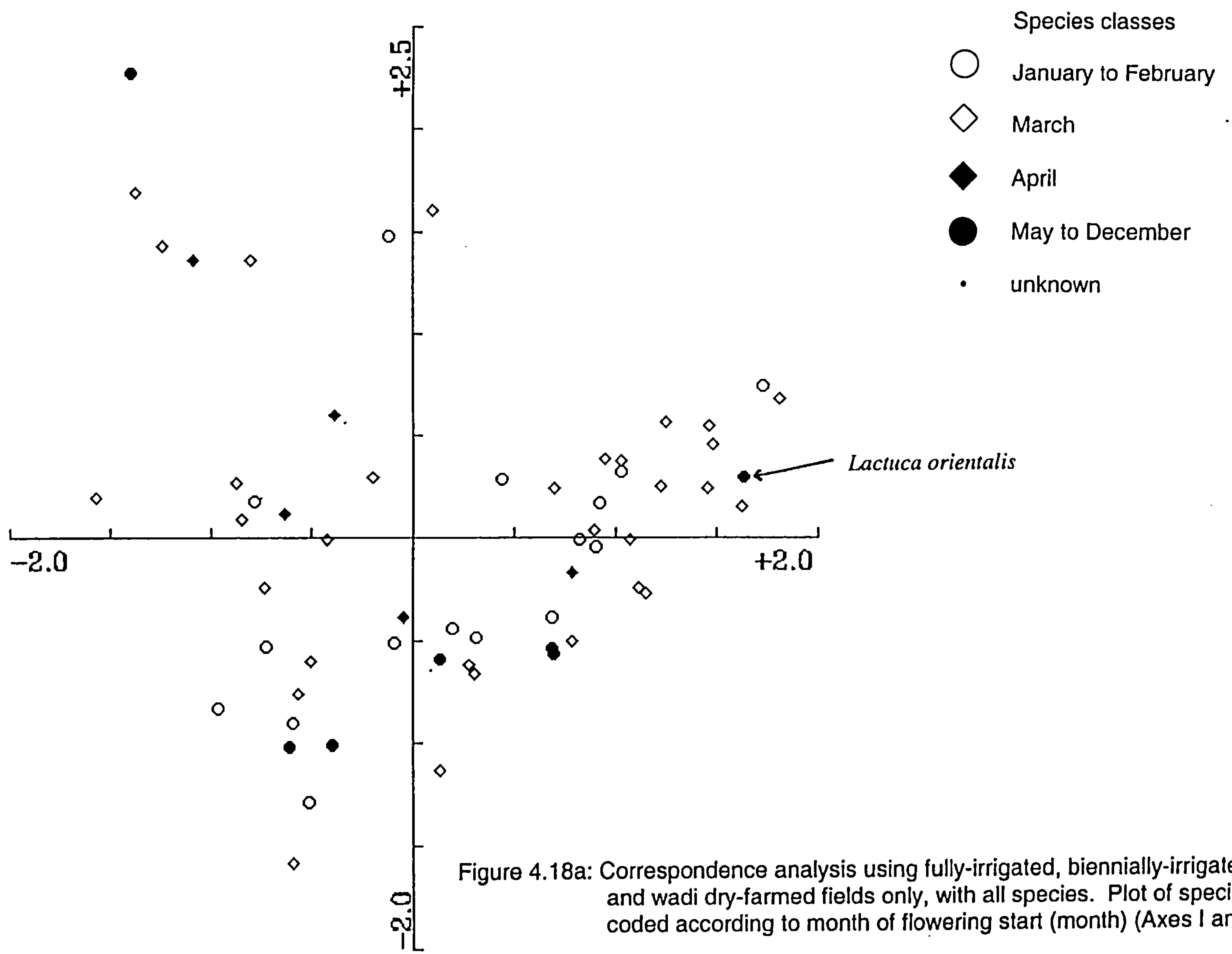


Figure 4.18a: Correspondence analysis using fully-irrigated, biennially-irrigated and wadi dry-farmed fields only, with all species. Plot of species coded according to month of flowering start (month) (Axes I and II).

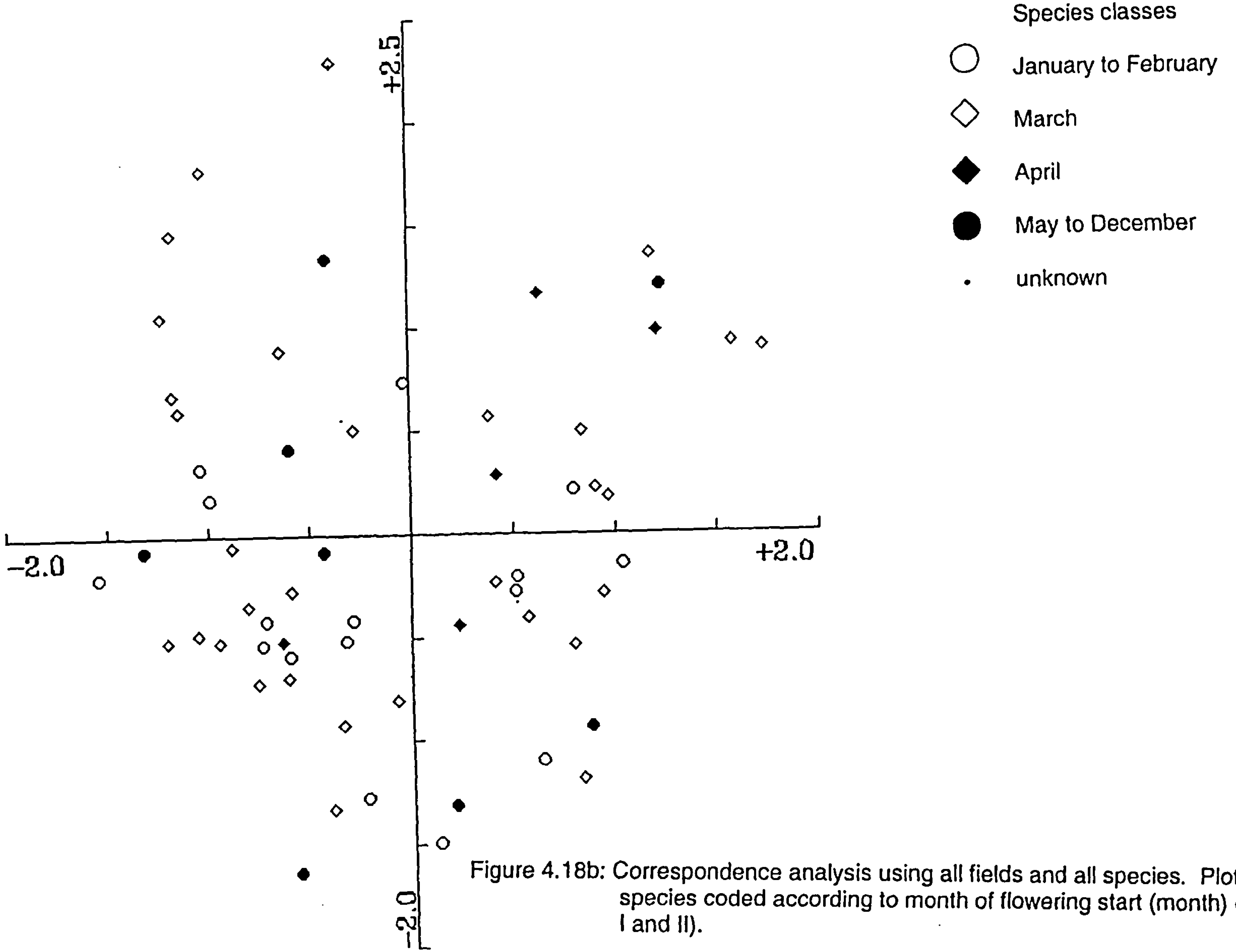


Figure 4.18b: Correspondence analysis using all fields and all species. Plot of species coded according to month of flowering start (month) (Axes I and II).

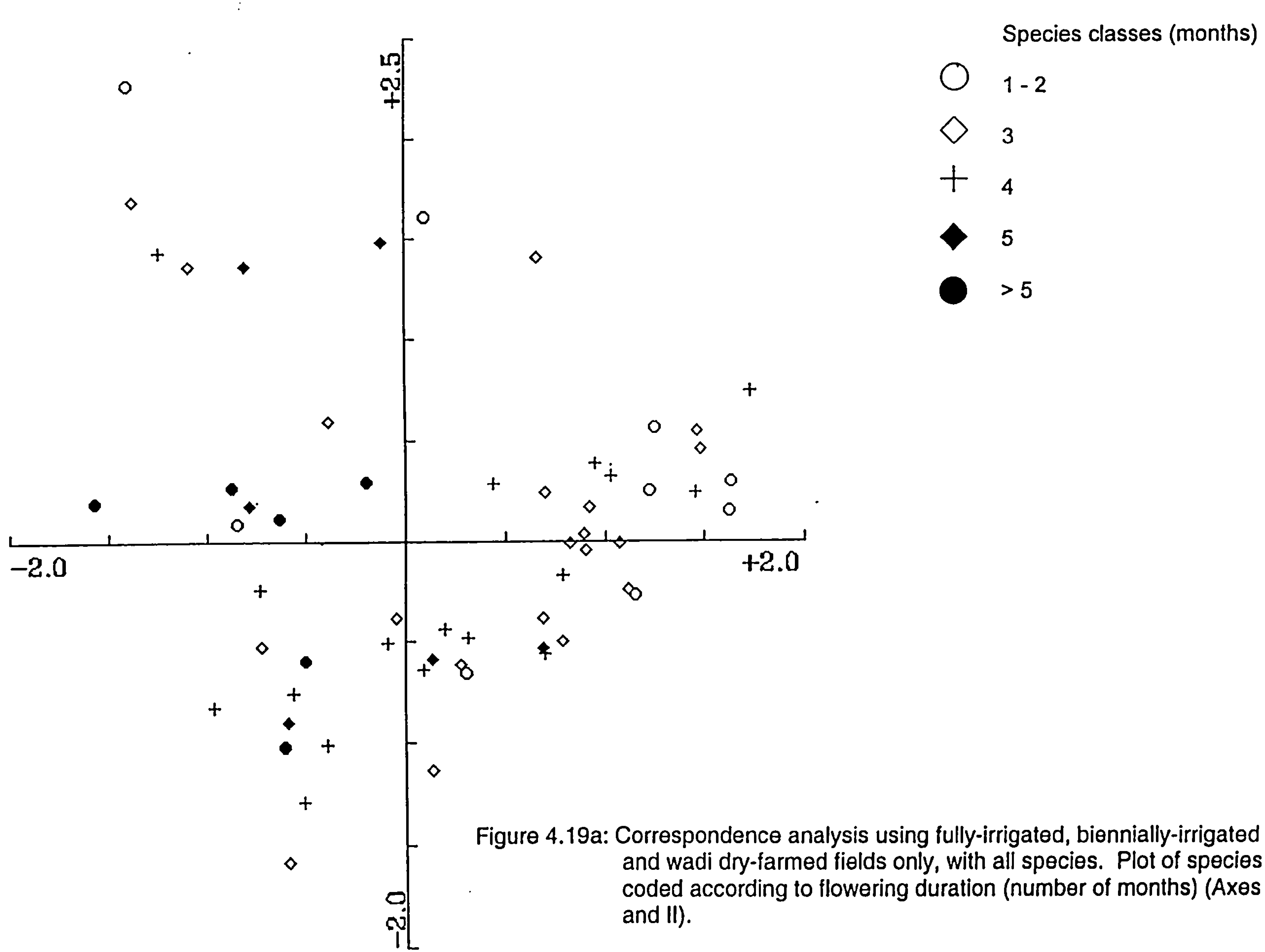


Figure 4.19a: Correspondence analysis using fully-irrigated, biennially-irrigated and wadi dry-farmed fields only, with all species. Plot of species coded according to flowering duration (number of months) (Axes I and II).

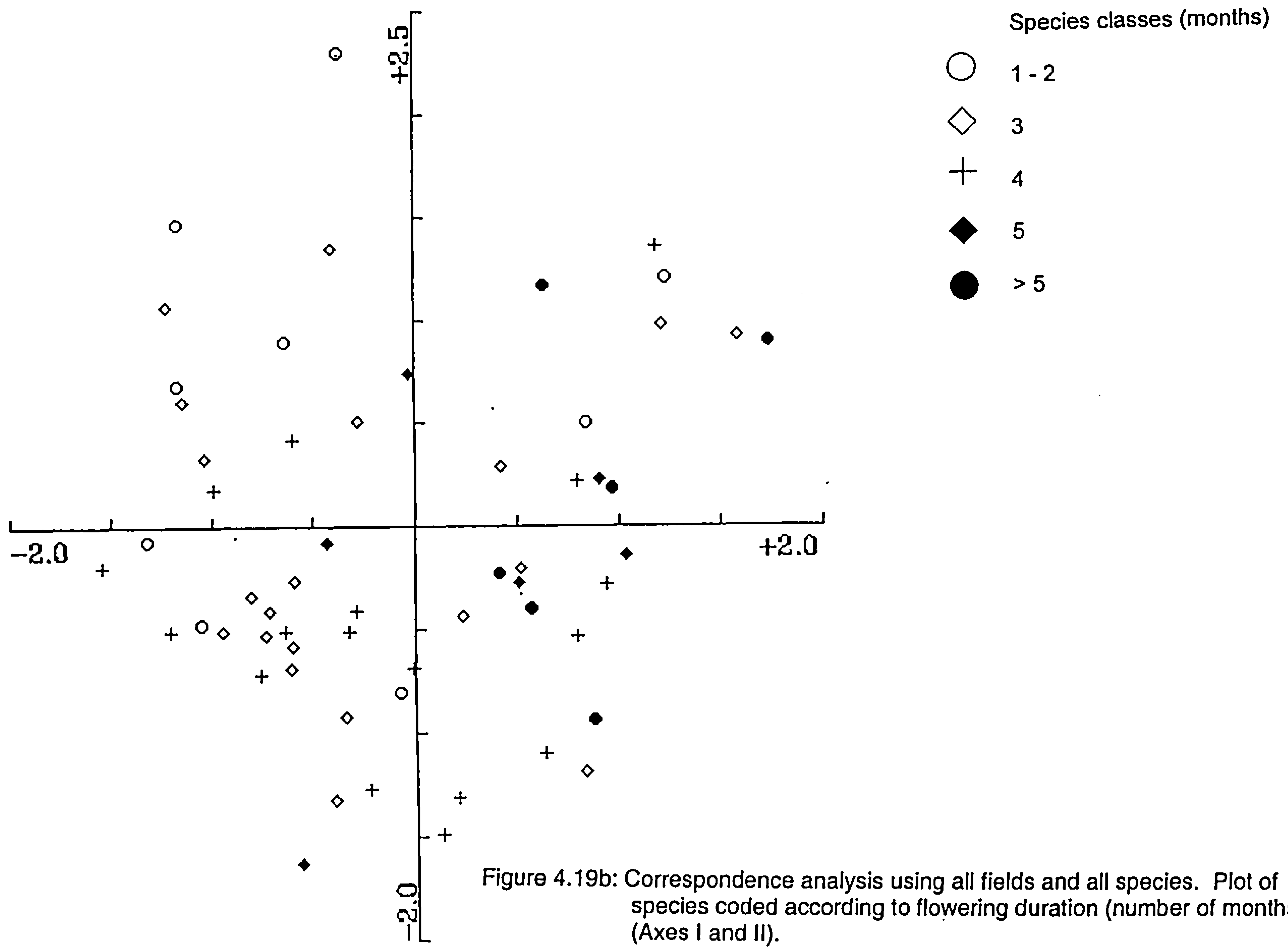


Figure 4.19b: Correspondence analysis using all fields and all species. Plot of species coded according to flowering duration (number of months) (Axes I and II).

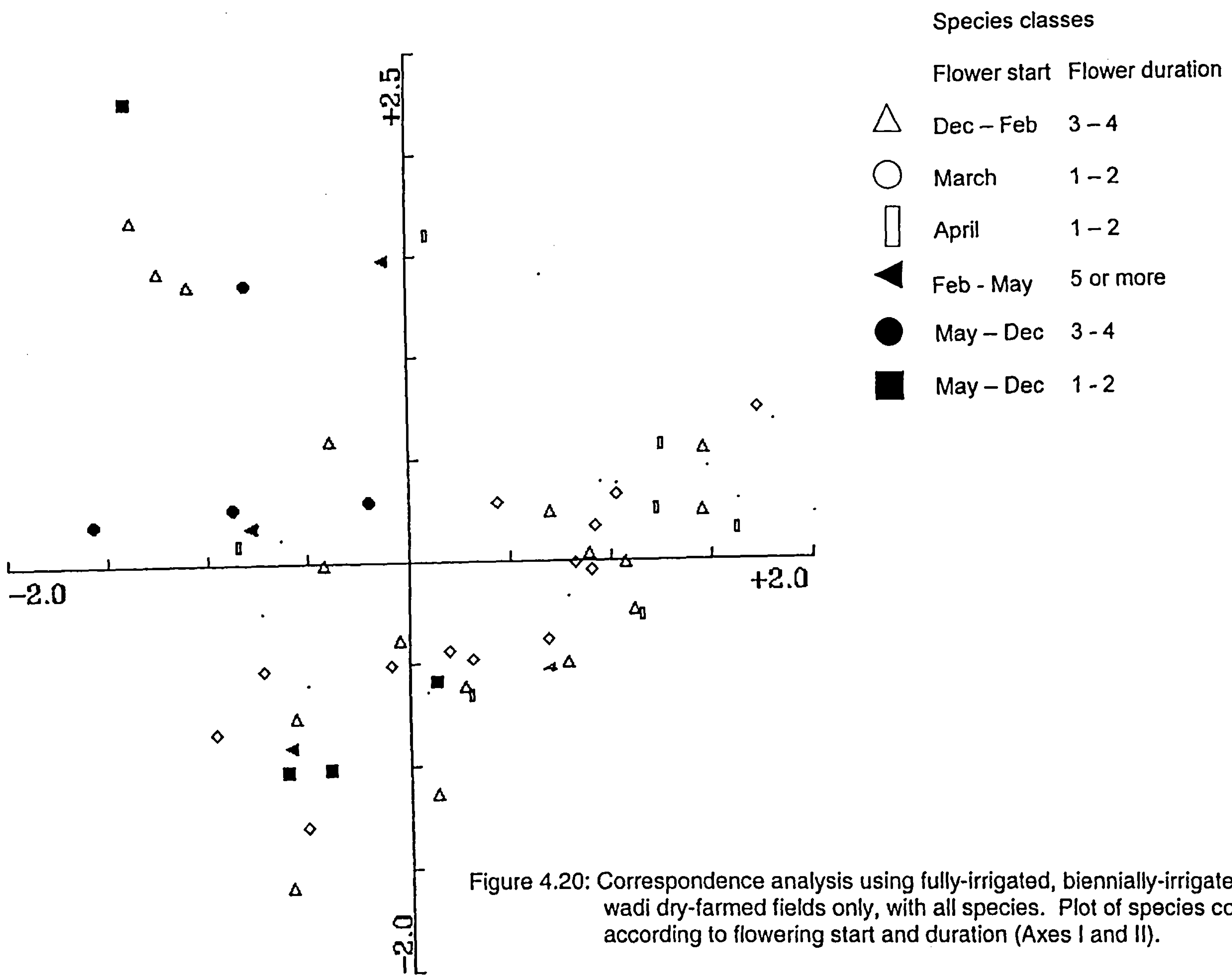


Figure 4.20: Correspondence analysis using fully-irrigated, biennially-irrigated and wadi dry-farmed fields only, with all species. Plot of species coded according to flowering start and duration (Axes I and II).

Figure 4.21a: Discriminate analysis 1: chart with all field groups plotted (all attributes included).

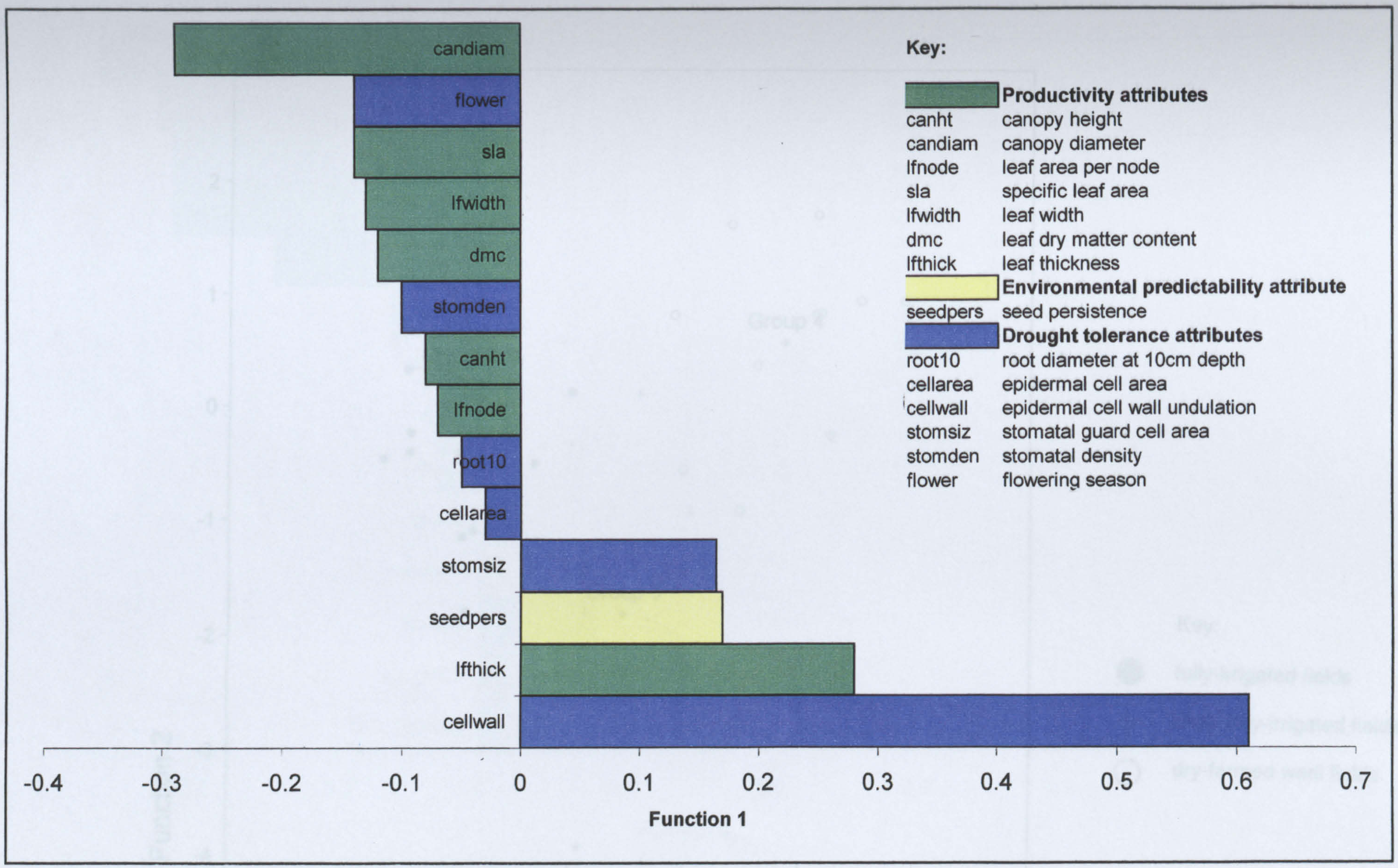


Figure 4.21b: Discriminate analysis 1: chart of all attribute types (all field groups included).

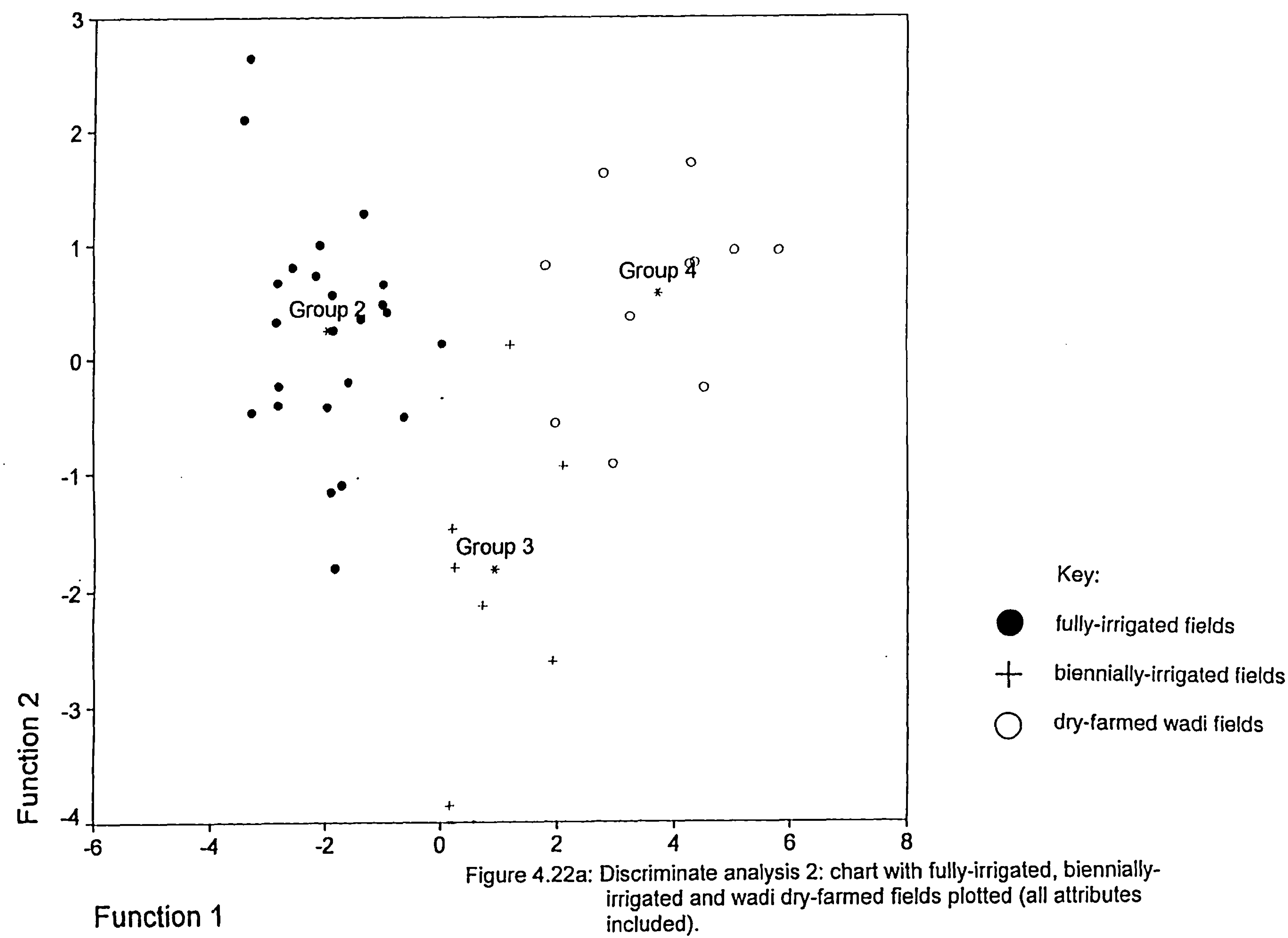


Figure 4.22a: Discriminate analysis 2: chart with fully-irrigated, biennially-irrigated and wadi dry-farmed fields plotted (all attributes included).

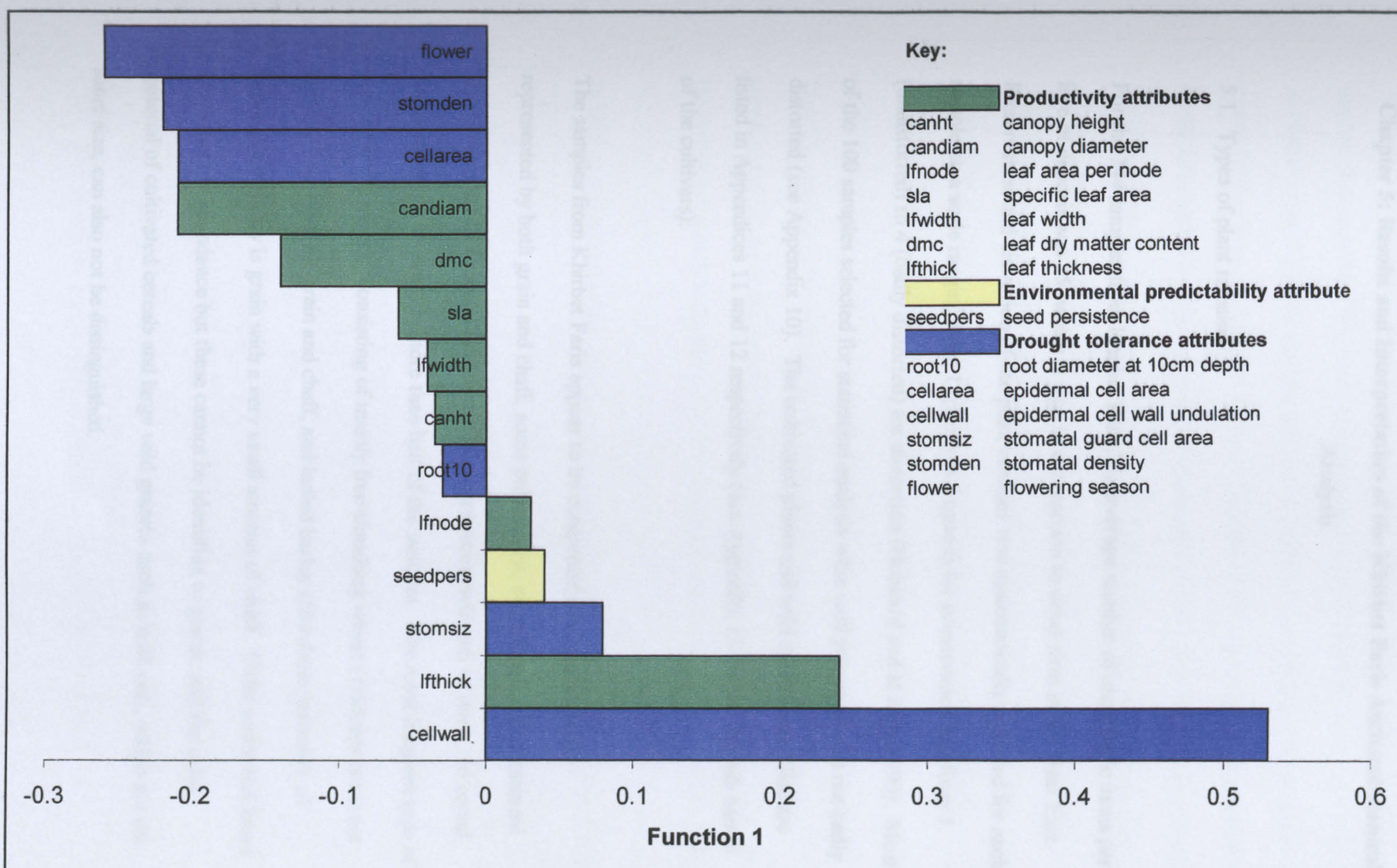


Figure 4.22b: Discriminate analysis 2: chart of all attribute types (fully-irrigated, biennially-irrigated and wadi dry-farmed fields included).

Chapter 5: Results and Interpretation of the Khirbet Faris Archaeobotanical Analysis

5.1. Types of plant remains:

For the 344 samples from Khirbet Faris, the average number of identifiable items per litre of deposit was 35, which is high in comparison to other sites in the Near East. Preservation and distortion of the plant remains was systematically recorded for each sample on a scale ranging from 1 (poor) to 5 (good) for preservation and from 1 (undistorted) to 4 (badly distorted) for distortion (Hubbard and al Azm, 1990). Most of the 100 samples selected for statistical analysis were well preserved and not badly distorted (see Appendix 10). The cultivated plants and wild species identified are listed in Appendices 11 and 12 respectively (see Appendix 13 for the English names of the cultivars).

The samples from Khirbet Faris appear to be comprised of cereal remains, represented by both grain and chaff, some pulse crops, crop weeds and occasional nuts and stones of fruits. 37 cultivar types were recovered and, of these, 16 cereal and pulse types occurred in more than half of the samples. The most frequent type of cultivar is the cereals, consisting of mainly free-threshing wheat (*Triticum aestivum* and *Triticum durum*), grain and chaff, and hulled barley (*Hordeum sativum*), of which the majority is grain with a very small amount of chaff. Culm nodes and bases are present in abundance but these cannot be identified to genus, and the culm material of cultivated cereals and large wild grasses such as wild oats, which are the same size, can also not be distinguished.

Other cultivars include pulses, fruits and nuts but these are less frequent in the samples than cereals. Of the cultivated pulses, the seeds of lentil (*Lens culinaris*) and bitter vetch (*Vicia ervilia*) are the most frequent. Common pea (*Pisum sativum*), grass pea (*Lathyrus sativus*), broad bean (*Vicia faba*) and chickpea (*Cicer arietinum*) are all less common. There are eight fruit and nut species represented in the samples: fig (*Ficus carica*), grape (*Vitis vinifera*), olive (*Olea europaea*), pistacio (*Pistacia atlantica* and *Pistacia terebinthus*), date (*Phoenix dactylifera*), plum (*Prunus* sp.), watermelon (*Citrullus vulgaris*) and a citrus fruit (*Citrus* sp.) but none are particularly abundant. Cotton (*Gossypium arboreum/herbacum*) and sorghum (*Sorghum bicolor*) are also present but rare.

Possible changes in the cultivation of different cultivar types through time was investigated by tabulating them for different periods (see Appendix 14 for a species by species tabulation and table 5.1 where the data is summarised by broad categories.

Table 5.1: Summary of the change in crop cultivation through time at Khirbet Faris:

	5th – 9th C. (5 Samples) % of Samples	**5th – 13th C.** (19 Samples) % of Samples	**13th C.** (24 Samples) % of Samples	**14th – 17th C.** (5 Samples) % of Samples
Glume wheat (grain and chaff)	80	63	46	80
Free Threshing wheat (grain)	100	100	100	100
2 and 6 Row Hulled Barley (grain)	100	95	100	100
Sorghum	0	0	21	20
Bitter Vetch	80	84	83	100
Lentil	60	74	67	80
Pea	40	37	33	20
Fig	100	68	71	100
Plum	0	0	0	20
Pistacio	0	11	0	0
Olive	20	5	8	0
Vine	60	42	58	60
Watermelon	0	0	4	0
Citrus fruit type	0	0	4	0
Cotton	0	26	29	20

*N.B. The values are percentages of samples each cultivar is present in.

Certain cereal crops seem to be continuously cultivated throughout the periods represented on the site. These include free-threshing wheats (*Triticum aestivum* and *Triticum durum*), two and six row hulled barley (*Hordeum sativum*) and, to some extent, glume wheats (*Triticum monococcum* and *Triticum dicoccum*), though the last occurs in low frequency in all periods. Some pulse crops and fruits were also constantly cultivated: lentil, pea, bitter vetch, fig, vine and olive, though the last declines somewhat through time. Other crops seem to have been introduced from the 13^{th} century. These are watermelon, a citrus fruit, sorghum and probably cotton, though the last is possibly an earlier introduction as it is found in the 5 – 13^{th} century deposits. Plum only occurs on the site from the 14^{th} century onwards. There are, therefore, some definite trends in the cultivation of different crops through time at Khirbet Faris.

There are 153 wild taxa (other than fruits and nuts), identified in abundance from the Khirbet Faris samples, from a range of different families. The largest family represented are the wild grasses (Gramineae). Of the grasses, the seeds of *Lolium temulentum* are the most frequent. The other frequent grass types are: *Phalaris* sp., small *Lolium* sp., wild *Hordeum* sp. and *Bromus* sp. The second largest group of wild species are the small wild legumes (Papillionaceae). By far the most abundant genus amongst the small legumes is *Astragalus* sp.. Also making up a large proportion of this family are: *Medicago* sp. (especially *Medicago rotata*), *Trigonella astroites*, *Coronilla scorpiodes* and *Scorpiurus muricatus*. Other well represented families include: Caryophyllaceae (especially *Silene* sp. and *Vaccaria pyramidata*), Chenopodiaceae (mainly *Chenopodium album* and *Chenopodium murale*) and Cruciferae (mainly *Neslia apiculata* and *Sinapis arvensis*).

Charred dung pellets were also observed in 15% of samples. The pellets were identified from surface texture and the distinctive shape of the pellet ends. The pellets were quantified by counting the pointed end only. These pellets closely resemble modern sheep/goat dung observed at the site. Sheep and goat were by far the most abundant species present in the archaeozoological remains from Khirbet Faris (see table 2.3).

5.2. Influence of crop processing:

G. Jones (1983b, 1984, 1987, 1990) devised a method by which archaeobotanical samples could be compared with ethnographic data recorded from traditional crop processing in Amorgos, Greece. This method uses the relative proportions of cereal grain, chaff and weed seeds as well as weed seed properties and is described above (section 3.4.2.1.). Using this method, the Khirbet Faris samples were compared with the ethnographic data from Amorgos in order to determine which processing stages could be identified in the samples. First, the proportions of grain, rachis and weeds in each Khirbet Faris sample were calculated (see Appendix 15).

Using the ratios of grain, chaff and weeds it is possible to define groups within the samples from Khirbet Faris (see Appendix 15, which is summarised in table 5.2). Group 1 is fully processed mixed wheat and barley, dominated by grain with very little rachis or weeds. Group 2 represents barley from the later stages of crop processing (again dominated by grain with little rachis) mixed with partially processed or unprocessed wheat (as wheat rachis tends to be more frequent than for barley and the rachis to grain ratio approaches the c. 4:1 ratio expected for whole ears). There are three groups with a lower grain content with high chaff or weed content, perhaps indicating a mixture of both early and late stages of crop processing. These range from group 3 with a high weed content but low rachis, indicative of later stages of crop processing, to group 5 which tends to have a low weed content but more rachis indicating a greater representation of the early stages of crop processing. In group 5, the barley is mostly grain, and the wheat is both grain and chaff, suggesting that the barley was in a late stage of processing but the wheat at an early stage. In group 3 barley is again apparently at a late stage of processing but there is also less wheat chaff suggesting that some of the wheat in these samples was also at a later stage of processing or was unprocessed (with a grain to chaff ratio of c. 4:1). Group 4 is intermediate between groups 3 and 5. Group 6 represents early stages of crop processing with rachis internodes outnumbering grains for wheat, and with barley rachis internodes in greater quantities than in other samples. The majority of samples (73 in total) belong to the three mixed sample groups (3, 4 and 5).

Comparing these groups with ethnographic data from Amorgos (G. Jones, 1983b, 1984, 1987, 1990), it appears that the groups defined for Khirbet Faris do not correspond exactly with individual stages of crop processing from Amorgos, but appear to be mixed crops from different stages of crop processing. It is unlikely that the wheat and barley crops from Khirbet Faris were grown together in a maslin as they are from different stages of crop processing, suggesting they were not processed together (which would be expected had they been grown in the same fields).

Table 5.2: Summary of crop processing sample groups (herein referred to as 'ratio' groups):

Sample group	% Grain	% Rachis	Ratio Grain : Rachis		% Weed c.	% culm nodes	No. of samples	Crop processing stages		% of samples with dung	% of samples with pasture weeds*
			wheat	barley				wheat	barley		
1	≥ 80	≤ 2	48		< 20	11	2	Fully processed grain	Fully processed grain	0	0
2	50-80	< 10	4	8	10-50	23	13	Mixed, partially processed or unprocessed	Later stages of crop processing	7	0
3	10-50	< 10	4	45	40-90	34	13	Mixed, intermediate between groups 2 and 4	Later stages of crop processing	23	7
4	10-50	10-30	0.7	5.8	40-80	72	26	Mixed, intermediate between groups 3 and 5	Later stages of crop processing	15	7
5	10-50	> 30	0.4	7	10-60	84	34	Mixed, more early stages of crop processing	Later stages of crop processing	15	6
6	<30	20-60	0.4	0.6	10-70	93	7	Mixed, more early stages of crop processing	Mixed, more early stages of crop processing	28	14

*See definition in section 5.3 (page 137)

To compliment the grain, chaff and weed proportions, the seeds of wild taxa were categorised according to their headedness, size, and aerodynamic properties, attributes which determine their behaviour during the crop processing sequence (see Appendix 16 for a breakdown of this categorisation for each taxon). These values were then transformed (as described in G. Jones, 1984, 1987) for direct comparison with the Amorgos crop processing data.

A discriminant analysis was performed comparing the Khirbet Faris samples to groups of Amorgos samples from different crop processing stages using these transformed weed seed categories (see figure 5.1 and Appendix 15 for the results of this analysis). In figure 5.1, the four crop processing groups from Amorgos (fine sieve product, fine sieve by-product, coarse sieve by-product, winnowing by-product) are clearly separated. The Khirbet Faris samples are plotted in relation to these groups, their location depending on the relative amounts of the weed seed types in each. As can be seen from the plot, the Khirbet Faris samples fall mainly between the groups, indicating their mixed nature. As the Khirbet Faris samples are coded according to sample group it can be seen that five samples from ratio groups 1 and 2 are plotted near the Amorgos fine sieve products, in accordance with their earlier categorisation as grain rich samples from the later stages of crop processing. Four other samples (from group 6) are plotted near the Amorgos winnowing by-products, again, as would be predicted from their high rachis content.

The discriminant analysis assigns all samples to a crop processing group (even those which do not match any group particularly well) but also assigns a probability for those categorisations so that the reliability of these classifications can be assessed (see Appendix 15 for the classification of each Khirbet Faris sample and the probability of its classification). For ratio group 1 (crop products), both samples were assigned as fine-sieve products on the basis of the weed seed categories, as would be expected, but one of these was classified with a higher probability than the other. For ratio group 2, most samples were assigned as fine-sieve products or by-products (often with high probability) perhaps indicating that the weeds are derived from the barley crop, not the wheat, as the latter seems to be unprocessed or only partially processed (based on grain to rachis ratios) and would, therefore, be expected to include some weeds usually removed at an early stage of crop processing. The samples from the mixed ratio groups (groups 3 to 5), were assigned to various processing stages (sometimes with low probability) as would be expected. The ratios of grain to rachis in sample groups 3 to 5 suggest barley is of late crop processing stage and wheat is of early crop processing stage so presumably the weeds from early crop processing stages in these samples come from the processing of wheat. The last ratio group (group 6), thought to be from early crop processing stages, on grain, chaff and weed ratios, was also assigned to various processing groups (often with low probability), but two of the three samples classified as winnowing by-products, by virtue of their weed seed properties, were classified with high probability. This again suggests an element of mixing in the samples but groups 5 and 6 include proportionally more samples assigned to the earlier stages of crop processing (see Appendix 15). In general, the relatively low probability of the classifications is in agreement with the conclusion that the Khirbet Faris samples are predominantly of mixed crop processing origin, and identification of the more distinct ratio groups (groups 1, 2 and 6) tends to be supported by the discriminant analysis. These two elements of the crop processing analysis complement each other very satisfactorily and so the groups summarised in table 5.2 were retained as the crop processing groups for Khirbet Faris.

Correspondence analysis was used, on all taxa and all 100 Khirbet Faris samples, to see how much of a contribution crop processing makes to sample composition. The results were plotted in two separate plots: the plot of plant remains (see figure 5.2) shows the main sample components (grain, chaff, weeds, straw and other cultivars), and the plot of samples coded according to sample groups (see figure 5.3) shows the sample groups 1 to 6, as assigned above. In figure 5.2 grain occurs mostly at the top left, other cultivars on the left and chaff at the bottom with wild species ubiquitous across the plot. The main dichotomy seems to be between grain at the positive end of axis 2 and chaff at the negative end. This is also apparent in figure 5.2 where the grain rich samples (from groups 1 and 2) are mostly at the positive end of axis 2, and the chaff rich samples (from groups 5 and 6) are mostly at the negative end of axis 2. This analysis shows that most variation in the species composition of samples is due to differences in crop processing stage. It is, therefore, unlikely that this form of analysis will further the exploration of the differences between samples due to crop management practices. However, the crop processing differences in sample composition were further examined in relation to the context, date and site location of samples to look for patterns in the way plant material was disposed of across the site (see section 5.4).

5.3. Source of the archaeobotanical material:

The Khirbet Faris samples are composed mostly of barley (usually cleaned crop from a late stage of crop processing) and free threshing wheat (mostly unprocessed or from an early stage of crop processing). The different character (in terms of crop processing stage) of the two crops implies they were not grown together as a maslin but mixed after processing. For wheat, there seems to be a continuous range from early to late crop processing remains in the samples. One possible explanation for some of this mixing is the use of barley grain and wheat by-products as animal fodder which, once converted to dung, may have been used as fuel (dung pellets are also present in the samples). However, if some of the samples are derived from dung used as fuel then the source of the fodder must be considered. Fodder can be provided by direct grazing of wild pasture or field stubble or from stall fodder, usually crop processing residue. The source of fodder is of particular importance if wild taxa are to be used to detect changes in crop management practices. If the wild taxa in the samples did not derive from crop fields, it is not possible to use them to indicate crop growing conditions. It was, therefore, necessary first to identify the source of each sample group (groups 1 to 6) as defined above (see table 5.2) and, for groups suspected to be derived from fodder, to ascertain the source: pasture or crop or both.

It is clear from table 5.2 that, not only does the proportion of rachis increase from groups 1 to 6, but so too does the percentage of culm nodes (another indicator of early processing stages) and the percentage of samples containing dung fragments and pasture weeds. This strongly suggests that the groups towards the bottom of table 5.2 contain more dung-derived material than the groups towards the top. So, while it is likely that most of the plant material in samples of the lower groups represents animal fodder, it appears that human food is increasingly contributing to samples of the upper groups. Hillman (1981) describes fricke making where whole ears of wheat are charred before further processing and this is one possible explanation for the incorporation of unprocessed wheat in the upper groups of table 5.2. It appears though that barley grain, together with wheat chaff and straw, were used as animal fodder and that the animals also grazed some natural pasture, as evidenced by the pasture species. The relative contribution of crops and wild pasture to the animal diet must, however, be assessed on the basis of other evidence.

The flowering times of the major wild species found in the samples was examined to determine whether they could, at least in theory, have been harvested, in seed, along with the crop. Flowering and fruiting times can be grouped into 3 major phases: winter (Feb-Apr), early summer (May-Jun) and late summer (July onwards) (Charles, 1998). If many species flowered and fruited beyond July (i.e. after harvest) then the most likely route for incorporation into the samples would be by dung from animals grazing pasture. (Note: weeds from summer crops such as sorghum are unlikely to be collected along with the crop due to the nature of these crops). The vast majority of Khirbet Faris species flower and fruit in the early summer period and, thus, could have been harvested alongside crops. Table 5.3 summarises the flowering and fruiting times (given in the Flora Palestina) of the most common species, i.e. those that occur in more than 20% of samples.

Table 5.3: Flowering and fruiting times of the most common wild species:

Species	Flowering & fruiting time	% of samples in which species occurs	Previously recorded as field weed
Lolium temulentum	Mar - May	85	yes
Medicago rotata	Apr - May	67	no
Coronilla scorpiodes	Mar - June	55	yes
Scorpiurus muricatus	Mar - Apr	52	yes
Asperula arvensis	Mar - Jul	49	yes
Trigonella astroites	Mar - May	44	no
Galium spurium	Apr - Jun	32	yes
Echinaria capitata	Mar - Jun	29	yes
Medicago minima	Mar - May	21	yes

Most of the common species from Khirbet Faris not only flower and fruit at the right time of year for harvest but have also been recorded as field weeds in modern botanical studies. *Ornithogalum* sp. was recorded in 23% of samples but was only identified to genus level. Some of the species from this genus do flower outside of the harvest time but their main habitat is on the tops of mountains. Only one species does not inhabit this type of environment, *Ornithogalum brachystachys*, which flowers between March and May and fruits from April to June (i.e. within the harvest period).

M. Charles (1998) noted the high occurrence of *Prosopis farcta* in samples from Bronze Age Abu Salibikh. This species flowers from July to September, and is currently often grazed by sheep and goats in the autumn and winter. Charles concluded that the most likely route of carbonisation was wild pasture with subsequent incorporation into dung used as fuel. This species is noted as an endemic plant in wadi bottoms in the area of Khirbet Faris by Al-Eisawi (1985). It is recorded from Khirbet Faris but only in 4% of samples. The low occurrence of very late (post-harvest) flowering and fruiting species supports the hypothesis that most of the wild taxa from Khirbet Faris became incorporated in the archaeobotanical record as weeds harvested along with the field crops. They would, therefore, have been part of crop processing material that may have been fed to animals as fodder, the dung then used for fuel and charred, becoming one of the major constituents of most sample types from Khirbet Faris. It is, therefore, valid to use weed species to infer the growing environment (and therefore crop management practices) in fields around Khirbet Faris (see section 5.5).

5.4. Spatial and chronological changes in sample composition:

The sample plots (coded by context type, date and excavation area) are interpreted by comparing them to the species plot coded by plant types, described in section 5.2 (see figure 5.2). The plot of samples from the correspondence analysis using all 100 Khirbet Faris samples and all species / plant categories was coded according to archaeological period (see figure 5.4). Overall, there is a tendency for samples containing the earliest pottery (5^{th} to 9^{th} centuries AD) to be clustered towards the top of the diagram where the samples are mostly grain rich, and for samples containing 14^{th} to 17^{th} century pottery to be located at the bottom of the diagram where they are mostly chaff rich. Samples containing 13^{th} century pottery occur in all parts of the plot. Samples from the earlier period, therefore, appear to be characterised by later stages of crop processing, and samples from the later period by earlier stages of crop processing. This may reflect a bias due to the different context types represented in the different periods: in the earliest samples, the only contexts represented are pits, surfaces and middens; in the later phase, the samples are mostly from the cistern, ovens and hearths.

To explore this possibility, the same correspondence analysis plot of samples, coded according to context type, (see figure 5.5), was examined alongside the plot of plant remain types (see figure 5.2) in order to indicate the relationship between context type and sample composition. The midden, rubble, packing and pit samples occur in all parts of the plot, and so include all sample types from grain rich to chaff rich. Most floor surfaces, the cistern, hearths and ovens all occur at the negative end of axis 2 and contain large amounts of chaff, though some ovens occur towards the positive end and have more grain. Samples from different context types do, therefore, seem to have somewhat different compositions.

The area from which samples came was also used to code samples in the correspondence analysis plot (see figure 5.6) in order to examine the differential discard of plant material across the site. Most grain rich samples (at the positive end of axis 2) are from the FAR V area of the site, while samples from FAR I are mostly chaff rich. Thus it would seem a lot of material from late stages of crop processing was deposited in thc FAR V area of the settlement and, indeed, the only cleaned product samples from the assemblage (group 1) are from the FAR V area. The type of crop processing stage represented is, therefore, related to the area of the site in which it was deposited.

There are then some general trends through time with more grain rich deposits in early periods and more chaff rich deposits later. This may bc related to differential discard of crop processing material in different context types: hearths, ovens and the cistern (containing most chaff), which occur in the later periods, and are located in the FAR I area of the site. This perhaps indicates changes in the use of different areas of the site through time.

5.5. The identification of irrigation using the functional attributes of weed species:

In order to interpret an assemblage of weeds from archaeological contexts in terms of cultivation practices, it is important to ensure the weed assemblages from the different samples are homogenous in general character. Samples derived from different stages of crop processing cannot be compared ecologically, as the differences observed may be due to the different weed species removed at different crop processing stages, rather than due to habitat origins. It was, therefore, necessary to choose a group of Khirbet Faris samples similar in crop processing character. Sample groups 3, 4 and 5 from the crop processing categorisation of samples (see section 5.2) were used for this analysis as they are all more or less mixed in terms of crop processing and are, therefore, unlikely to exhibit large differences in weed species due to crop processing.

The most useful species attribute for distinguishing weed floras from irrigated and unirrigated fields in the Wadi Ibn Hammad study was the season of flowering and so this attribute was considered for the weed species in the archaeological samples from Khirbet Faris. A correspondence analysis of all 100 Khirbet Faris samples, using wild species only, was carried out, and species points were coded according to the start and duration of the flowering season where this was known (see figure 5.7). A dichotomy between early (wet period: December to April) and late (dry period: May onwards) flowering species was apparent in the archaeobotanical assemblage at Khirbet Faris. The late flowering species occur towards the negative end of axes 1 and 2 (bottom left), with the early flowering species towards the positive ends of both axes (top right).

The pattern observed in figure 5.7 could indicate that both dry-farmed and irrigated fields were represented by the weed species at Khirbet Faris, as is the case in Wadi Ibn Hammad. This depends, however, on the actual numbers of early and late flowering plants: if there are very few late flowering plants represented at Khirbet Faris compared to those in irrigated fields in Wadi Ibn Hammad, then the observed pattern may be due to minor differences in, for example, rainfall or location. Quantification of the late flowering species from the Khirbet Faris samples was therefore carried out, in order to assess the likelihood of them being analogous to the 'few' that occurred in dry-farmed fields or the 'many' that occurred in irrigated fields from Wadi Ibn Hammad. From the 100 Khirbet Faris samples examined, 60% contained late flowering species, ranging in frequency from 1 to 50% of the seeds in the sample. Out of these only 14 samples contained 10% or more seeds of late flowering species. As the data from Wadi Ibn Hammad is in the form of number of quadrats in which a species is present, and the Khirbet Faris data is in the form of numbers of seeds of each species, the two data sets are not directly comparable. It was, however, concluded that at least some of the samples contained sufficient quantities of late flowering species to suggest irrigation while other samples clearly did not.

When examining the archaeological variables of those samples containing more than 10% seeds of late flowering species (and so most likely to be derived from irrigated fields), few similarities are apparent (Appendix 17). The crop processing stage, varies from group 2 (grain rich) to group 6 (chaff rich), the samples come from the part of the site referred to as FAR I (as do the majority of samples) - except for 1 sample from House 1 - and from a mixture of different context types (ovens, hearths, middens, rubble and surfaces). Of those samples with dates assigned (7 out of 14), six belong to the pottery phase of the 13th century AD and one to the 5th to 13th centuries AD. There are no samples with late flowering species from the most securely dated groups (5th to 9th centuries AD and 14th to 17th centuries AD), but these periods are represented by very few samples. If the late flowering species in these 14 samples are indicative of irrigation, as suggested, it seems that irrigation is indicated for the 13th century but it is uncertain at what date it was introduced or whether it continued beyond the 13th century.

The flowering time of weed species also allows the inference of crop sowing time. The weeds from Khirbet Faris mainly flower and fruit from March to May, implying autumn sowing as, if the crop was autumn sown, later flowering/fruiting species would not be able to compete. If the crop was spring sown, these early flowering species would have been ploughed up before the crop was sown and later flowering species would dominate (Bogaard, in press). Autumn sowing is not unexpected, as it is carried out in the region today and coincides with the period of most rainfall from December to March.

5.6. Summary of the Khirbet Faris archaeobotanical analysis:

The Khirbet Faris samples represent a mixture of crop processing stages from barley (mostly from late processing stages) and wheat (unprocessed or from early processing stages). These crops do not seem to have been grown together but rather were mixed for use as fodder, the resulting animal dung being used as fuel. Some charred human food was perhaps burnt accidentally or the result of cleaning storage installations and became mixed with the charred dung. The distribution of plant material across the site seems to indicate that most of the grain rich samples were deposited in the early phase of the site in area FAR V, with chaff rich samples deposited in the later phase of the site in area FAR I, in oven, hearth and cistern contexts.

From the ecological characteristics of the wild taxa, it seems that the fodder derived mostly from crops and not wild pasture. It was, therefore, possible to use functional attributes of the weed species accompanying these crops to investigate crop management practices. The flowering season of weeds showed that crops from Khirbet Faris could be derived from dry-farmed and irrigated fields. Irrigation seems to have been introduced in the 13th century AD. New crops (e.g. sorghum, cotton, watermelon) also seem to have been introduced by the 13th century, though free-threshing wheats, that have been thought of as an Islamic introduction, may have been cultivated from the Byzantine period.

Figure 5.1: Discriminate analysis: Khirbet Faris samples plotted in relation to ethnographic crop processing groups, coded according to sample groups.

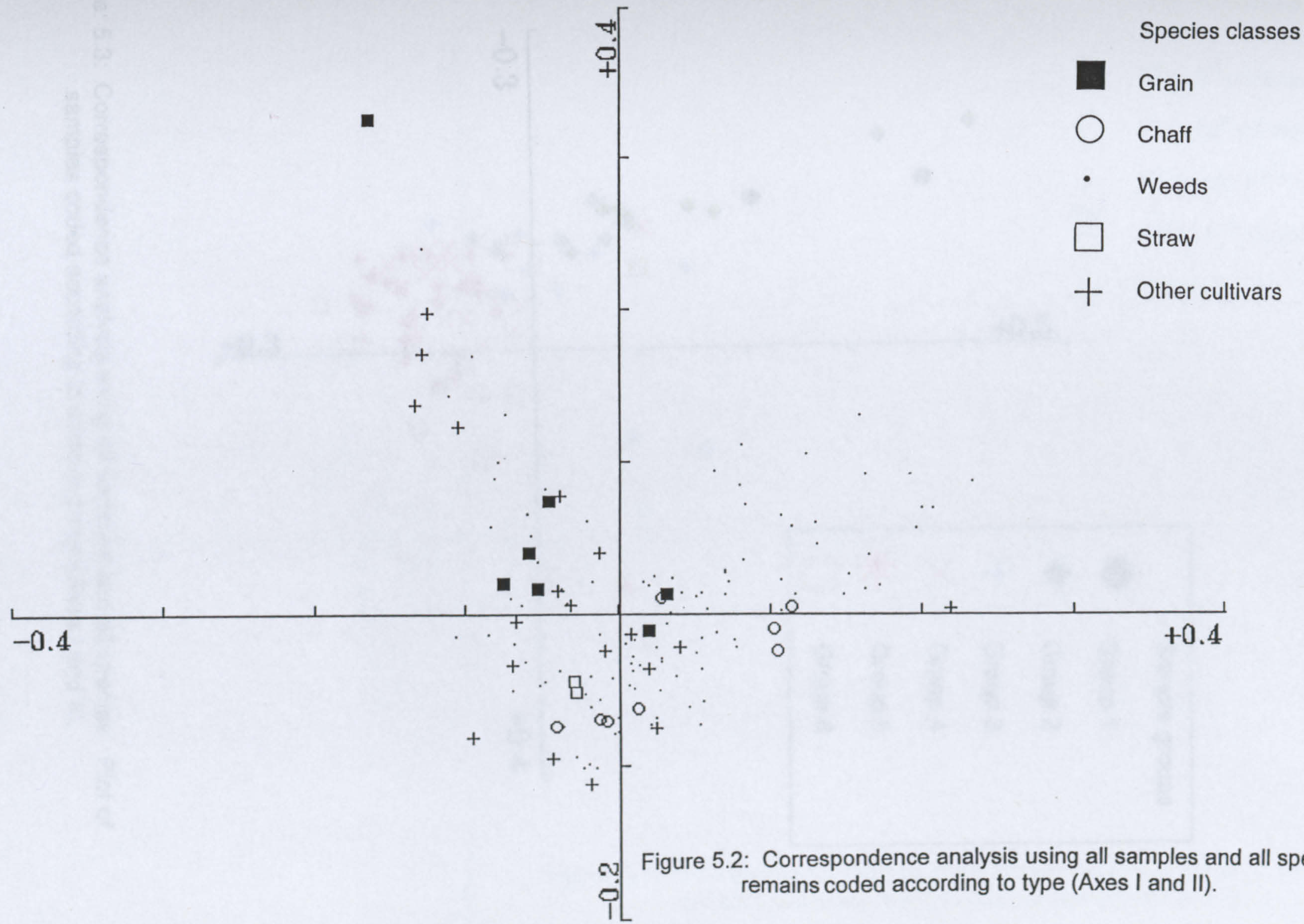


Figure 5.2: Correspondence analysis using all samples and all species. Plot of remains coded according to type (Axes I and II).

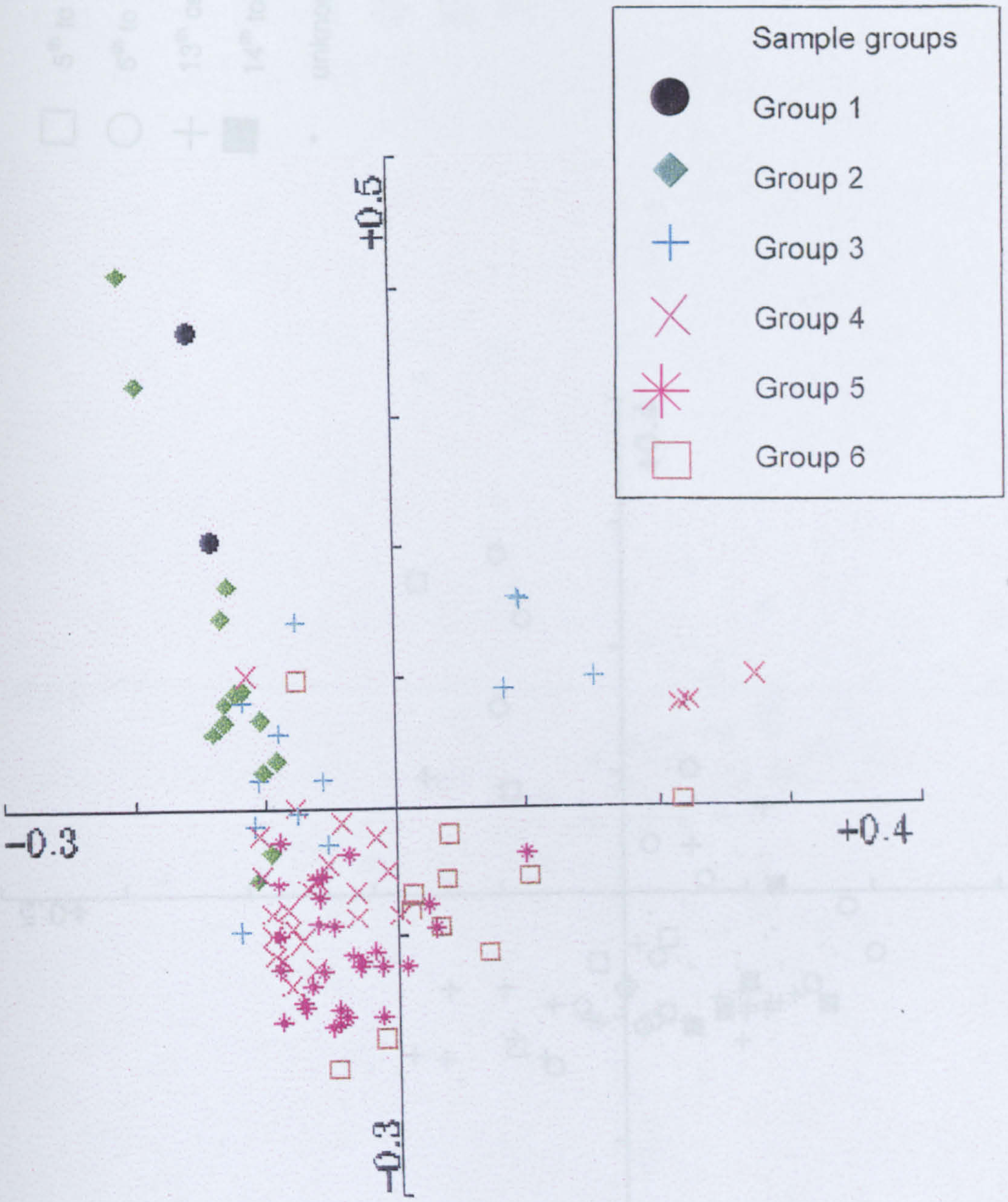


Figure: 5.3: Correspondence analysis using all samples and all species. Plot of samples coded according to sample group (Axes I and II).

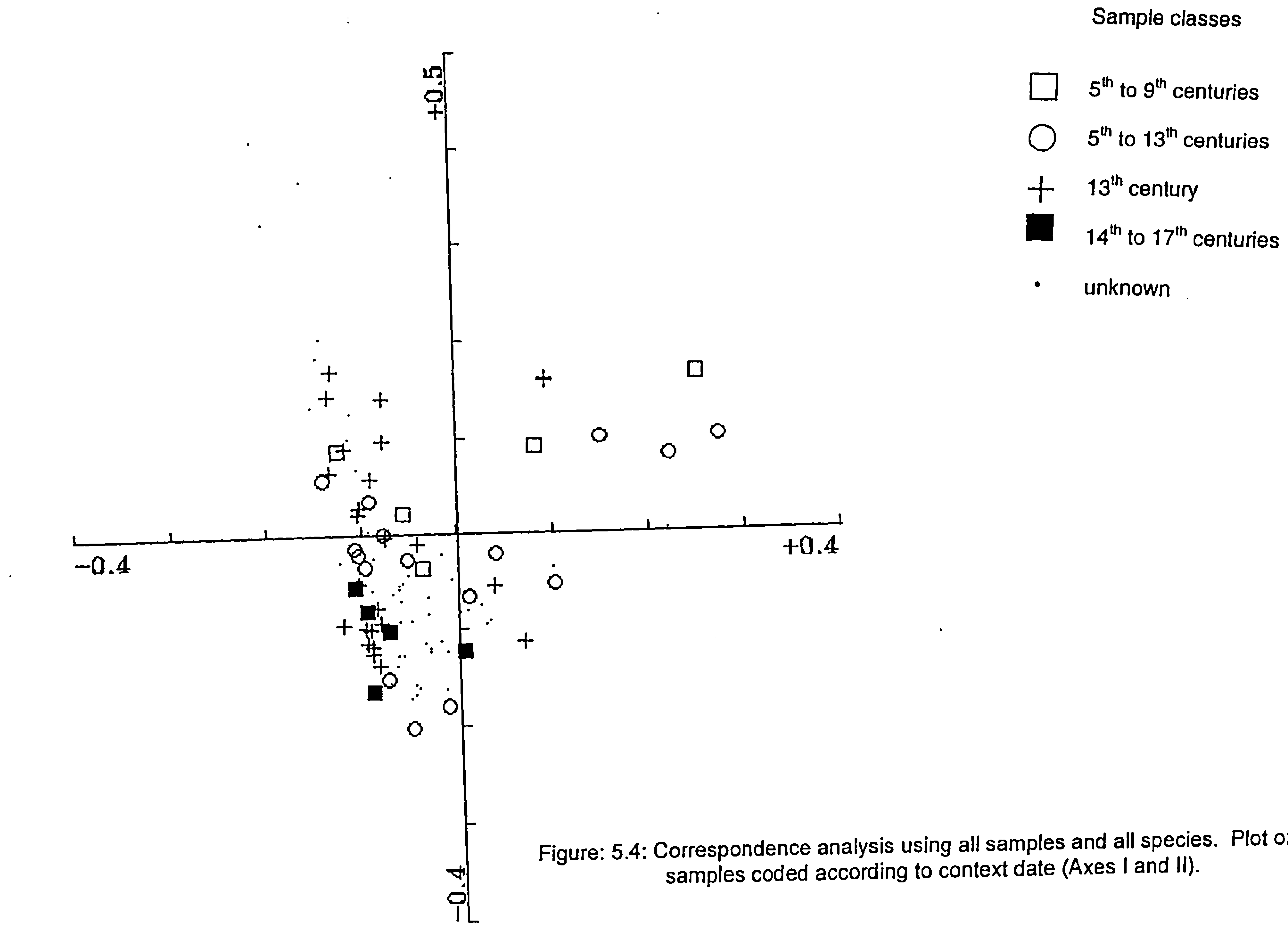


Figure: 5.4: Correspondence analysis using all samples and all species. Plot of samples coded according to context date (Axes I and II).

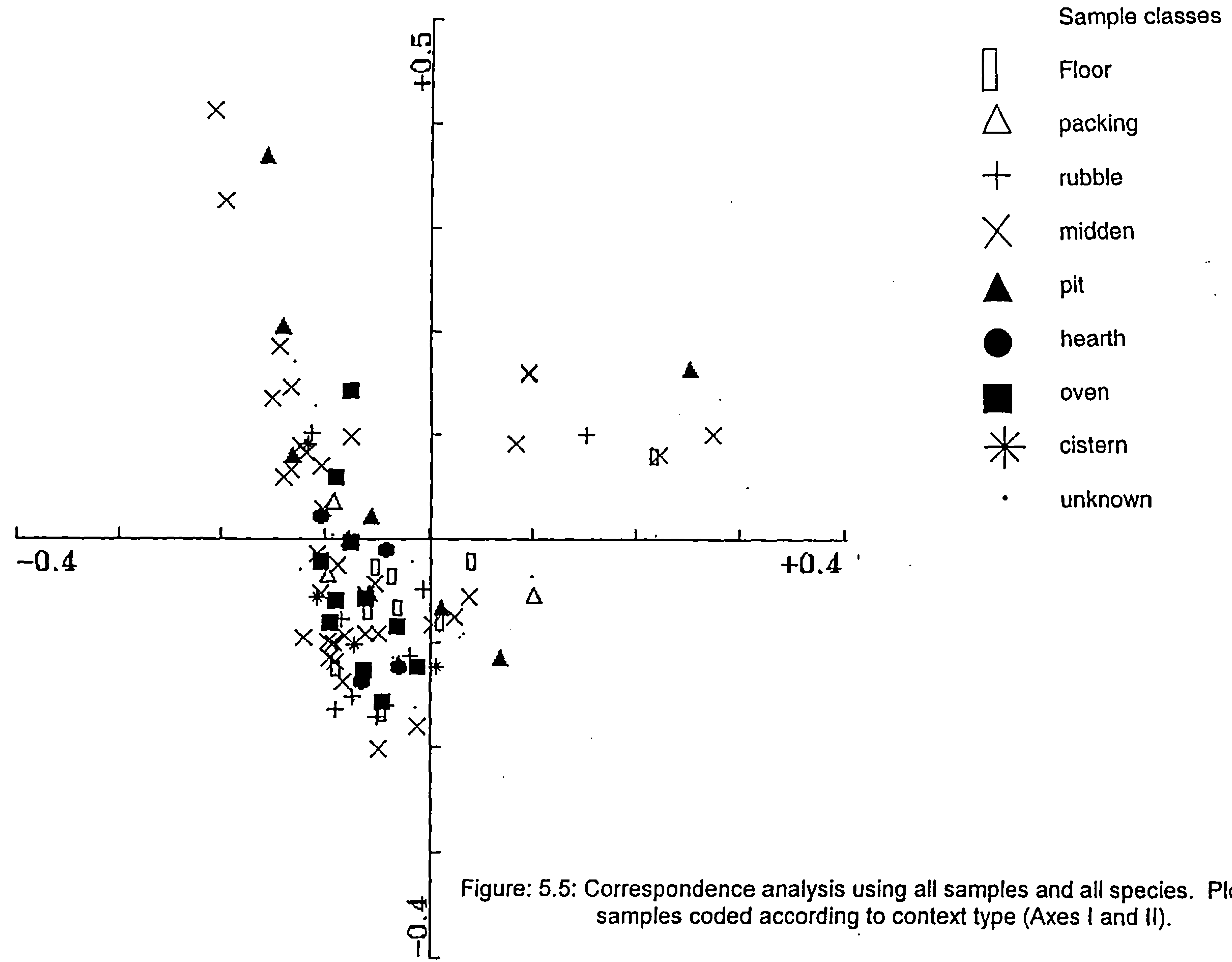


Figure: 5.5: Correspondence analysis using all samples and all species. Plot of samples coded according to context type (Axes I and II).

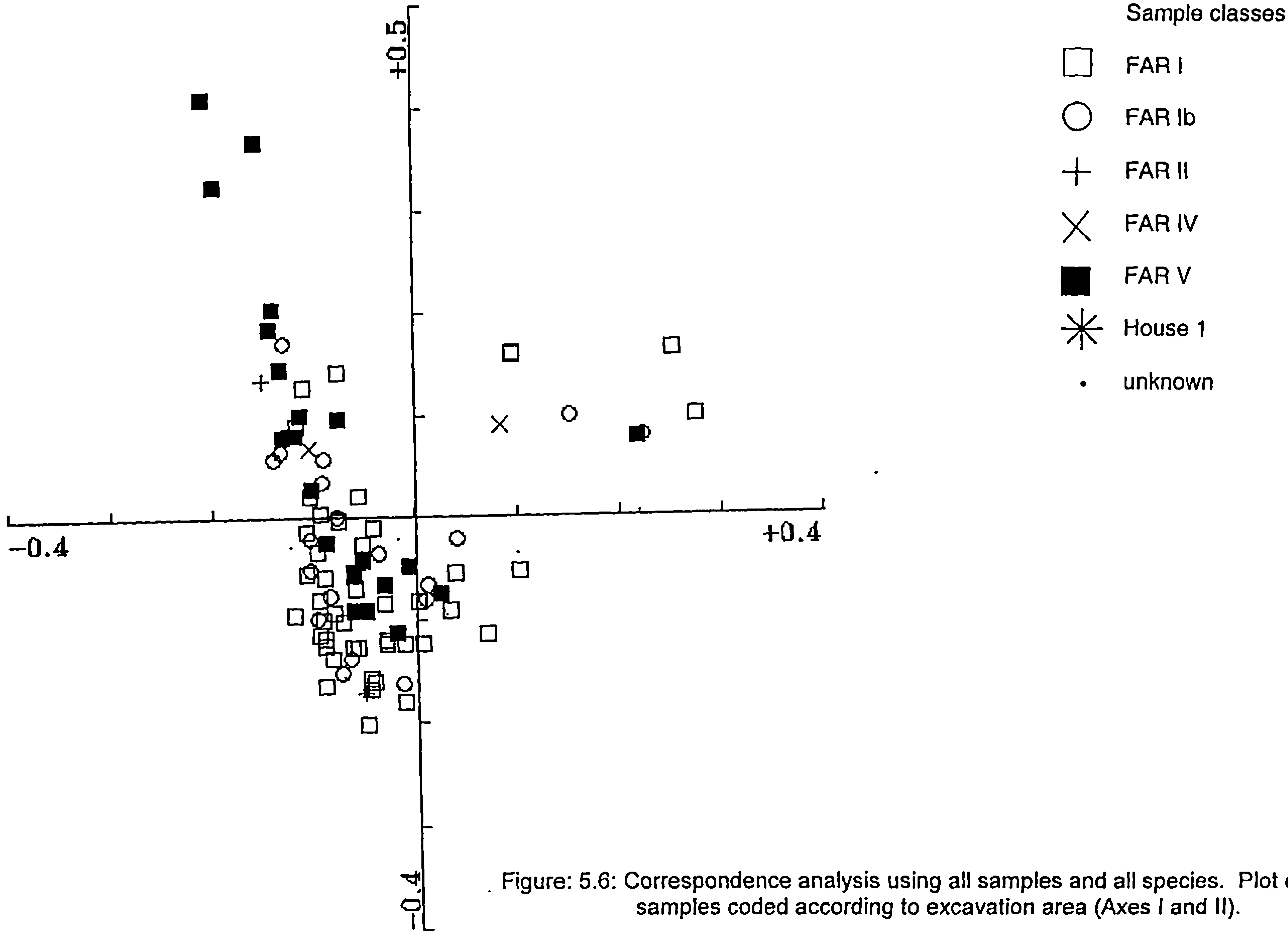


Figure: 5.6: Correspondence analysis using all samples and all species. Plot of samples coded according to excavation area (Axes I and II).

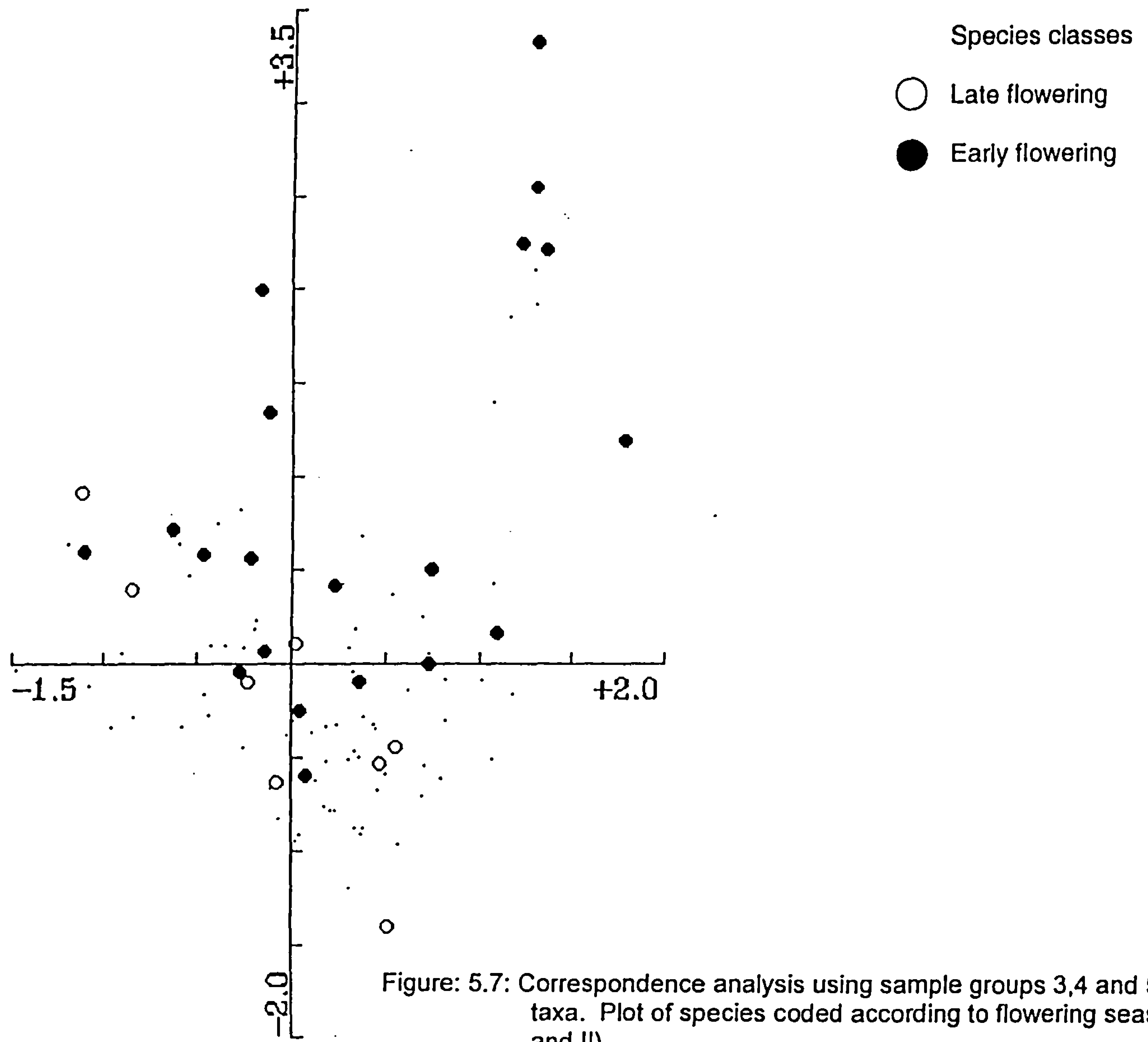


Figure: 5.7: Correspondence analysis using sample groups 3,4 and 5 and wild taxa. Plot of species coded according to flowering season (Axes I and II).

Chapter 6: Discussion

6.1 A summary of the sources and distribution of archaeobotanical remains at Khirbet Faris:

The samples from Khirbet Faris were rich, well preserved and varied, consisting of cereal grain and chaff, pulse crops, nuts, fruit stones and weed seeds. The most common cereal crops were free-threshing wheat and hulled barley, with a very small amount of glume wheat. Pulse crops were fairly common, though not as abundant as cereals, and included lentils, bitter vetch, common pea, grass pea, broad bean and chickpea. Nuts and fruit stones were present in low numbers and included fig, grape and olive, with traces of other more 'exotic' types (see section 6.2). Weed seeds ocurred in great abundance in most samples and were represented by a wide range of different genera and species from various families.

Samples were compared to ethnographic evidence in order to assign them to crop processing stages. The inference was made that they contained cereals derived from differing amounts of early (usually wheat) and late (usually barley) crop processing stages and so it is unlikely that wheat and barley were grown together as a maslin crop.

Blench (1995), in a modern study of the area, noted that, when rainfall allows, macaroni wheat tends to replace barley as the preferred cereal for domestic consumption suggesting that barley grain may have been used for other purposes such as fodder. In an environment where trees are scarce, due to deforestation and over-grazing, it is likely that dung would have been used for fuel, and thus the plant remains would have become carbonised and incorporated in the archaeological record: indeed dung fragments were found in many samples. Lancaster and Lancaster (1995) noted the use of dung fuel in ethnographic studies in the area and McQuitty (1997) describes modern *tawabeen* ovens that are fuelled by dung in modern villages on the Kerak plateau. These *tawabeen* ovens have been excavated at Khirbet Faris from the mid-Islamic period onwards. Characteristic dung pellets and the dominance of sheep and goat bones in the archaeozoological remains suggests the source of the dung is likely to have been sheep and goat herds.

The large amounts of grain in some samples suggests that they also contain varying amounts of human food. The inclusion of human food in the samples may be due to parching prior to storage, the cleaning out of storage facilities such as pits or the discard from accidental burning during food preparation.

It seems that most of the plant material is derived originally, from the dung used to fuel ovens and hearths, the waste remaining around these contexts and being dumped on floors and the cistern. Some of the oven contexts are also rich in grain suggesting that some of the waste from accidental food burning remained *in situ*, though human food remains were also found in pits and discarded on middens. Samples rich in human food tend to be more abundant in the early period samples (Byzantine to early Islamic period), especially from area FAR V, whereas samples rich in dung fuel tend to be from the later period (mid-Islamic to early Ottoman period) from area FAR I of the site. More ovens seem to have been constructed in the middle to later Islamic period in FAR I (A. McQuitty, 1997), perhaps explaining why more chaff-rich samples occur in the later period.

M. Jones (1985) has argued that the ratio of grain/chaff/weed can be used to distinguish producer and consumer sites, grain-dominated samples being indicative of local crop production. However, Hillman (1981) argues that crop processing by-products, particularly those from early stages of crop processing (winnowing and coarse sieve by-products) and straw remains (culm nodes), indicates producer activity. Both early and late stages of processing are represented at Khirbet Faris suggesting that cereal production may have been local (Hillman, 1981). There is, however, no evidence for or against the local cultivation of other types of crops such as the 'exotic' species (see section 6.2).

6.2. The introduction of new crops in the Islamic period:

Watson (1983) described an agricultural revolution of substantial proportions starting at the beginning of the Islamic period. Part of this 'revolution', it is asserted, involved the introduction of new crops such as free-threshing wheats, sorghum, citrus fruits, watermelon, and cotton. Watson describes an economic boom at this time with the introduction of a variety of crops, using many different and hardier crops to spread the risk of crop failure, inferring that this was not practiced before Islamic expansion. Evidence for this 'revolution' is based entirely on written sources due to the lack of Islamic period excavations. Watson contends that crops such as *Triticum durum* were not cultivated before Islamic expansion as there are no records prior to this. As Rowley-Conwy (1989) pointed out, however, there is a lack of written sources devoted to agricultural activities before the Islamic period, thus earlier cultivation of such crops may have occurred but not been recorded. Archaeological material is needed to test these theories. At the Islamic site of Qasr Ibrim, Egypt, Rowley-Conwy (1989) found that free-threshing wheats, sorghum and cotton were introduced much earlier (AD 0 – 55). Khirbet Faris provides an opportunity to compare this evidence to another site that was occupied before and during the Islamic period, and which also has rich, well preserved archaeobotanical remains.

Free-threshing wheat (*Triticum durum/aestivum*) was found in large quantity at Khirbet Faris from the earliest phased samples of the site (Byzantine to early Islamic period). It is certainly possible, therefore, that free threshing wheat was cultivated from as early as the Byzantine period in this area. Six and two row hulled barley, some pulses (mainly lentils, bitter vetch and peas), some fruits (fig, olive and vine), along with free-threshing wheats, were cultivated during all phases of the site. This is perhaps unsurprising in an environment marginal to the cultivation of crops. For example, barley is hardy and can withstand drought better than wheat varieties and is, therefore, a good stable crop at times of environmental pressure. Interviews with farmers in Wadi Ibn Hammad revealed that the current choice of cropping strategy, in such a marginal environment, was very much related to spreading economic risks, cultivating both cereal, pulse, orchard and vegetable crops as an insurance against failure of one or the other (Blench, 1995). This may have been the reason for the cultivation of the variety of crops at Khirbet Faris.

Other 'exotic' crops (watermelon, a citrus fruit, pistacio, sorghum and cotton) do seem to have been introduced or imported during the Islamic period, but not until the mid-Islamic, Ayyubid – Mamluk, era (13th century). The introduction of varied 'exotic' crops, many of tropical origin, alongside more temperate crops like cereals may have been possible around Khirbet Faris due to the varied nature of the environment. As described in chapter 1, the environment in the immediate vicinity of the site encompasses different agro-climatic zones: the more temperate plateau, with higher rainfall, lower temperatures and humidity; down to the Ghor at the Dead Sea, with much higher temperatures and humidity, lower rainfall, but with springs allowing irrigation. Today this allows the cultivation of a mixture of different crop types in the region, with the traditional cereal and pulse crops grown on the plateau, orchard crops on the plateau and in the wadis and modern introduced crops such as vegetables and bananas in the wadis and the Ghor. The 'exotic' crops in the Islamic period may have been cultivated in the wadi bottoms and Ghor where the climate and irrigation allows more tropical vegetation.

It is also possible, however, as the 'exotics' occur in very low frequency in the Khirbet Faris samples, that these crops were not cultivated locally and were instead imported products from elsewhere. There are no historical records of the cultivation of these 'exotic' crops, though the records are scant and cannot be used as a detailed record of cultivation in the region during the Islamic period. 12th century Latin chroniclers from the Crusades describe the rich harvests of wheat, barley, olives and vines and an annual fair that was held at Kerak (Deschamps, 1939). Trade on the Dead Sea, from Zhugar to Jericho and the West Bank, included wheat, barley, oil, wine, dates, refined sugar, bitumen and salt (William of Tyre, 1986). It seems that from the 12th century, at least, Kerak had a well established trade network that could have facilitated the import of these 'exotics' in the mid-Islamic period.

The delay in introduction or importation of the 'new' crops in the Islamic period may have been due to the marginal location of Khirbet Faris, on the Kerak plateau, far from the Islamic centers in Egypt and Syria. Indeed Johns (1994) describes Kerak as an area independent of centralised government control for much of its history, often being governed by local tribal groups. It may, therefore, have taken some time for new 'exotic' crop types to reach the Kerak region. It was not until the 13th century that Kerak became an important route between Egypt and Syria (Johns, 1994) perhaps facilitating the introduction or importation of new crops.

The evidence from Khirbet Faris seems to concur with evidence from Qasr Ibrim in Egypt (Rowley-Conwy, 1989) in that some crops were cultivated before the Islamic expansion, namely free-threshing wheat at Khirbet Faris, together with a variety of other cereal, pulse and orchard crops. However, in agreement with Watson (1983), some 'exotic' crops do seem to have been introduced or imported during the Islamic expansion, though not until the mid-Islamic period and with uncertain impact on agricultural practices.

6.3. The introduction of new technology (i.e. irrigation) in the Islamic period:

The attraction of irrigation is apparent from modern ethnographic studies in Wadi Ibn Hammad. Irrigated cereal crops tend to yield twice as much as rain-fed crops, and the use of irrigation allows more intensive rotation systems, with vegetable and cereal crops being grown in the same year, or continuous cereal cultivation without a fallow period (Blench, 1995).

Watson (1983) maintains that with the influx of new crops came the introduction of new technology, particularly irrigation, at the beginning of the Islamic period. He describes the landscape before the Islamic expansion as barren during the summer months but, with the introduction of new crops of tropical origin, the summer became productive with widespread uptake of irrigation allowing more intensive rotation. However, recent studies are beginning to question this idea. Rowley-Conwy (1989) noted the presence of irrigation systems at Qasr Ibrim much earlier than the Islamic period. At Khirbet Faris an attempt was made to identify irrigation by comparing the archaeobotanical data to ethnographically collected data from irrigated and unirrigated cereal fields.

The FIBS method was applied to modern weed data from Wadi Ibn Hammad, the water catchment area of Khirbet Faris, and it was concluded that differences in the functional attributes of weed species, relating to irrigation, could be identified. Some attributes were found to be more useful for identifying irrigation than others. Canopy dimensions and leaf area per node (surrogate measures of growth rate and productivity) relate to both irrigation and fertility but season of flowering was unambiguously associated with irrigation. Weed species growing into the summer drought (beyond May) were mostly able to survive only in irrigated fields while, in dry-farmed fields, most species flowered early and for a short period, avoiding drought by growing in the wetter part of the year.

As season of flowering was the strongest of the attributes distinguishing weed species from irrigated and dry-farmed fields in Wadi Ibn Hammad, species identified from the Khirbet Faris archaeobotanical study were categorised according to flowering season to see if there were any differences which could be related to irrigation. There was a distinct tendency for late and early flowering species to occur in different samples. It was, therefore, suggested that crops could have originated from both dry-farmed and irrigated fields as the numbers of seeds of late flowering species were sufficiently high in some samples to support this. The samples with late flowering weed species all dated to the 13th century though one also contained earlier pottery (dated to the 5th century) and so irrigation appears to have been introduced by the mid-Islamic period, and probably not before. It appears Watson's suggestion that irrigation was introduced in the Islamic period is probably correct for Khirbet Faris, unlike at Qasr Ibrim where irrigation was practiced much earlier.

6.4. Implications for the debate surrounding settlement and agricultural change or continuity from the Byzantine to early Ottoman period:

In recent times interpretations about Islamic period settlement and agriculture have been primarily based on literary material, survey data and associated ceramic studies. The interpretation of such material is problematic, as discussed in chapter 2, and there has been a dearth of Islamic period excavations from rural sites, with integrated analysis of environmental as well as material evidence. The traditional sources suggest a strong rural economy from the Byzantine to mid-Islamic period, followed by a steady decline (see table 6.1). A brief bloom is supposed to have occurred in the mid-Islamic period under Ayyubid and Mamluk control who, from Egypt, provided increased regional security considered to be necessary for rural investment (Johns, 1994). There is debate over the date of onset of the subsequent decline, with a return to nomadic pastoralsim and abandonment of permanent settlement, but it is generally believed to have reached its lowest point in the 17th to 19th centuries (Brown, 1984). Johns (1994) has questioned these interpretations of settlement and economy, particularly the influence of centralised government on rural activities. Johns argues, as do Lancaster and Lancaster (1995), for continuity in settlement and agriculture during much of the Islamic period despite political fluctuations, as Kerak has always remained fairly independent of political control.

Table 6.1: Summary of current orthodoxy with regards settlement and agriculture from the Byzantine to early Ottoman period:

Period	**The state of settlement and agriculture**
Byzantine period (4th to 7th centuries AD)	Agricultural and settlement boom.
Early Islamic period (7th to 12th centuries AD)	Steady agricultural activity with a mixed economy: Plateau = cereal cultivation; wadis = orchards; Ghor = dates and sugar; transhumant pastoral activity between the Ghor and plateau. Questionable decline in settlement based on ceramic evidence.
Mid-Islamic period (13th century AD)	Kerak was an important route between Egypt and Syria. Some say that strong central administration led to a strong rural economy. Brown (1992) suggests, from pottery evidence, that rural economy declined into subsistence.
Ottoman period (16th to 19th centuries AD)	Ottoman tax register shows a decline in the number of settlements. It is said that at this time sedentary agriculture was abandoned in favour of pastoralism due to high taxation. Lancaster and Lancaster (1995) argue for continuity in agricultural activity.

Changes in agricultural practices through time may help to inform the debate surrounding the issue of continuity or change in settlement. At Khirbet Faris an attempt was made to identify changes in agricultural activities that may support or conflict with current theories about changes in agriculture and settlement.

Evidence for continuity and change in agricultural practices may be inferred from the archaeobotanical data with reference to the types of crops cultivated and the introduction of new agricultural practices (i.e. irrigation) in the Islamic period. A few 'traditional' crops were grown through the whole period (5^{th} century AD to the present). These crops include free-threshing wheats, barley, a few pulses (mostly lentil), fig, vine and olive. Thus, as Lancaster and Lancaster (1995) suggested, agricultural activities may have remained constant in the region even if the use of settlement changed. Change came with the introduction of new crops (cotton, sorghum, watermelon, citrus fruit and pistacio) in the mid-Islamic period (13^{th} century AD). If these crops were imports (rather than locally cultivated), their impact on the agricultural environment in terms of new land being put under cultivation and more intense cropping rotations being imposed (Watson,1983) is questionable, as is any resulting conflict between nomadic pastoralist and settled farmers. The literary evidence supporting the notion of Kerak as a marginal region in the Islamic political structure (Johns, 1994), and the marginal nature of the environment for agriculture (Blench, 1995), perhaps explains why these 'exotics' were not introduced or even imported until the mid-Islamic period.

The wadis and Ghor region, west of Khirbet Faris provide the climate and supply of irrigation water necessary for cultivating such crops (see section 1.3) and the archaeobotanical evidence from the site points to the introduction of irrigation in the 13^{th} century AD, if not earlier. However, the evidence for irrigation is available only from the weeds of cereal crops, not for other crops such as the 'exotics'. Watson (1983) saw the landscape before the Islamic expansion as dead during the summer months due to the lack of irrigation, with long fallow periods. He saw the introduction of new irrigated crops into the rotation cycle as bringing productivity in the summer months. The introduction of irrigation may have increased productivity, at least in cereal production, but as it is uncertain whether the new 'exotic' crops were cultivated locally, or imported, the effect on agricultural practices, such as intensified rotation and the increase of land under cultivation, is unknown.

Samples from all periods seem to be derived from a mixture of burnt dung fuel containing primarily grain and wheat chaff, and accidentally charred human food, mostly wheat. This suggests continuity in the use of cereals through time though the contribution of human food seems to be greater in the earlier periods (Byzantine to Umayyad) and that of dung fuel greater in the later periods (Mamluk to Ottoman).

It is possible that these changes merely reflect changes in the use of fuel on the site. McQuitty (1997) has noted an increase in the building of ovens from the mid-Islamic period, and archaeobotanical samples in the later period are mostly derived from ovens, floors and the cistern. Perhaps chaff-rich dung was favoured as fuel in the *tawabeen* bread ovens of the later phases, the waste from which was dumped on floors and into the cistern. Charles's (1998) study has shown that dung can either be burnt directly or made into dung cakes by adding combustible temper such as straw. This makes the dung a relatively clean, easy to store and flexible fuel. Fuel properties can be matched to heat requirements by varying the composition of the dung cake. According to Charles (1998), bread making ovens in Iraq require rapid heating which necessitates more chaff-rich dung cakes. It is, therefore, possible that the differences noted in the samples may simply reflect the increased use of chaff-rich dung as fuel for bread ovens as opposed to fuel for other types of cooking. Other activities, such as accidental burning of food, the parching of grain for storage or cleaning of storage facilities by burning, also seem to have made a greater contribution to samples from the earlier periods.

The source of plant material is of interest to the debate surrounding the continuity or change in the relationship between settled farmers and nomadic pastoralists. Lancaster and Lancaster (1995) describe a multi-resource economy of arable cultivation, herding, irrigated orchard and vegetable cultivation on the Kerak plateau and an inter-dependant relationship between pastoralists and settled mixed farmers with the former providing labour, dung for manure, plough animals and dairy products and the latter providing fodder and grain (see section 1.3.3 and Blench, 1995). Herds spend the winter in the Ghors, moving up wadi, exploiting natural vegetation and stubble from fields after harvest on the plateau. Watson (1983) claims that the intensification of agriculture that came with the Islamic expansion caused conflict between pastoralists and farmers causing disruption to agriculture at times of relaxed government control (Johns, 1994).

The source of animal fodder at Khirbet Faris is mostly crop processing material as opposed to wild pasture. The only evidence for wild pasture is the occurrence of *Prosopis farcta* in some samples – a species often associated with dung (Charles, 1988). This could be indicative of dung derived from pastoral flocks but it occurs in very low frequency and, in mixed farming strategies, the animals are occasionally taken out to the wadi slopes (the local habitat of *Prosopis farcta)* to graze (Blench, 1995). The dung used to fuel *tawabeen* ovens is normally supplied by stalled animals in villages on the Kerak plateau today (McQuitty, 1997) and stalled animals are most likely to be fed on crop processing material, as was the case at Khirbet Faris, in a mixed farming economy. On the Kerak plateau today a mixed farming economy exists but with the additional interaction with nomadic pastoralists (see section 1.3.3.). If nomadic pastoralists were part of the local economy in the past they do not seem to be obviously visible in the archaeobotanical remains from Khirbet Faris. This may suggest discontinuity between the present situation and the Islamic period but it is equally possible that nomadic pastoralists did exist but did not contribute to the plant material deposited on the site. This is perhaps not surprising as the modern transhumant system involves the pastoralists visiting the cultivated land after harvest to graze their herds on the stubble and so provide manure, also rich in crop remains and, in any case, deposited in the fields, away from the site (see section 1.3.2.).

Modern ethnographic studies have shown that farmers use resources from different elements of the environment (Blench, 1995). Today, cereals and pulses are mainly cultivated on the plateau; orchards, irrigated cereals and new vegetable crops are located in wadi bottoms where springs occur; more tropical fruits and vegetables are grown in the warmer climate of the Ghor where irrigation is available. If most of the Khirbet Faris samples are derived from cereal crops, weed species will reflect the different parts of the environment used for cereal cultivation. Al-Eisawi (1985) identified the most common species from the different vegetation zones (see section 1.2.6.) in the Kerak area. Table 6.2 gives a list of those genera or species also identified from the Khirbet Faris samples. There are a number of taxa from the Khirbet Faris samples that El-Aisawi identified as endemic to different areas of the

Kerak environment and so it seems that cereals were cultivated on the plateau and in the wadi as occurs in the region today, perhaps using the spring in the wadi for irrigation. There are also many remains of cisterns on the plateau, around the site of Khirbet Faris, which could possibly have been used for the irrigation of crops on the terraced fields in the vicinity.

Table 6.2: Comparison of Al-Eisawi's vegetation zones with taxa identified from Khirbet Faris samples:

Species of each vegetation zone (after Al-Eisawi, 1985)	Taxa identified from Khirbet Faris samples
Mediterranean non-forest (plateau top)	
Capparis spinosa	*Capparis* spp.
Teucrium polium	*Teucrium* spp.
Ononis natrix	*Ononis* spp.
Hordeum bulbosum	*Hordeum* spp.
Steppe (plateau margins, wadi sides)	
Pistacia atlantica	*Pistacia atlantica / terebinthus*
Gypsophila arabica	*Gypsophila arabica / viscosa*
Capparis decidua	*Capparis* spp.
Astragalus spinosus	*Astragalus* spp.
Hammada (wadi bottom)	
Astragalus spp.	*Astragalus* spp.
Prosopis farcta	*Prosopis farcta*

It would have been desirable to compare the archaeobotanical data from Khirbet Faris with environmental data from other sites of similar location and period. At the beginning of the project it was hoped that a suitable site for comparison was Deir 'Ain 'Abata in the Ghor, west of Kerak town. The plant remains from this Byzantine monastery and Islamic site were studied by the author but they were of insufficient abundance for useful comparison, consisting mainly of destruction layers of burnt palm wood and fruit stones. Currently an Islamic period rural settlement site, Khirbet al-Mudaybi, is being excavated on the Kerak plateau, and the archaeobotanical analysis being carried out by M. Charles, Sheffield University. This may be a useful comparison in the future to help clarify some of the issues surrounding agricultural activities in the Islamic period addressed in this project.

6.5. Conclusions:

- Some crops were cultivated from the Byzantine through to the early Ottoman period. These were free-threshing wheats (bread wheat and macaroni wheat), barley, pulses (lentil, bitter vetch, pea), fruits (fig, olive, vine). The use of a wide range of crops may have been a risk spreading strategy to facilitate agricultural production in a marginal environment, and this strategy seems to have been constant from the Byzantine to early Ottoman period. Free-threshing wheat, previously thought to be an Islamic introduction, was cultivated from the earliest periods, the same as at Qasr Ibrim, Egypt (Rowley-Conwy, 1989) and again supports the theory of agricultural continuity in the region.
- 'Exotic' crops were introduced or imported in the mid-Islamic period (13th century). These were cotton, sorghum, watermelon, pistacio and citrus fruit. The late introduction of 'exotic' crops and irrigation supports Watson's (1983) idea of changes in agricultural activities in the Islamic period. However, these changes were delayed (mid-Islamic) and of questionable impact as the 'exotics' may have been imported, not cultivated locally, and there is no direct evidence for their irrigation.

- The most abundant source of cereal remains was a mixture of wheat (early crop processing stage) and barley (late crop processing stage), interpreted as animal fodder resulting in dung used as fuel. The consistent use of crop processing material as fodder and the use of dung as fuel throughout the periods represented at the site, and in the region today, provides further evidence of agricultural continuity.
- Human food was apparently mixed with the dung fuel to varying degrees. Samples rich in human food were mostly from pits and middens in early periods. Samples rich in dung were mostly from ovens, hearths, floors and the cistern in later periods. These differences are probably due to changes in the type of dung fuel used and/or the incorporation of human food in the samples.
- Khirbet Faris probably produced its own cereal crops as part of a mixed farming strategy and there is no direct evidence of nomadic pastoralists. However, it is likely that pastoralists would be fairly 'invisible' in the archaeobotanical record if present. It is, therefore, impossible to detect either continuity or discontinuity in the interaction between mixed farmers and pastoralists.
- The FIBS method was successful in differentiating between the weed floras of present-day irrigated and unirrigated cereal fields at Wadi Ibn Hammad and could, therefore, be applied to the Khirbet Faris archaeobotanical data.
- Cereal irrigation was probably introduced to Khirbet Faris in the mid-Islamic period (13th century) at about the same time as the first appearance of 'exotic' crops, though no direct link can be made between the two.
- There may be continuity between the past and present in that similar regions, the plateau and wadi, seem to have been used for cereal cultivation, the latter perhaps being used for spring-fed irrigated cultivation.

- The archaeobotanical evidence has contributed to the wider debate surrounding Islamic period settlement and economy, indicating a basic continuity, despite political fluctuations, with overlying changes such as the introduction of new crops and irrigation technology, of questionable impact on the local economy.
- The success of the application of FIBS to the interpretation of this archaeobotanical assemblage, in terms of crop management practices, is encouraging for future archaeobotanical research that may take advantage of this interpretational aid.

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APPENDICES

Appendix 1: Example of a Wadi Ibn Hammad Quadrat recording sheet

				Q	U	A	D	R	A	T	S
Species	0	1	2	3	4	5	6	7	8	9	10
		Information recorded:									
		V = vegetative									
		Fl = flowering									
		Fr = fruiting									
		Flr = flowering and fruiting									
		D = dehisced									
slope	1-5 where 5 = steep										
aspect	N, E, S, W										
stoniness	1-5 where 5 = very dense stone cover										
crop cover	%										
crop height	cm										

Appendix 2: Field variables recorded and codes used for analysis:

Irrigation:

Dry	=	1
Plateau (rainfed)	=	2
Biennial irrigation	=	3
Full irrigation	=	4

Slope:

Flat	=	1
Uneven	=	2
Gentle	=	3
Moderate	=	4
Steep	=	5

Soil:

Su'Eidat	=	1
Tell Alluba	=	2
Su'Eidat/Tell Alluba	=	3
Humud	=	4

Crop:

2 row barley	=	1
6 row barley	=	2
durum wheat	=	3

Stoniness

few	=	1
occasional	=	2
moderate	=	3
abundant	=	4
very dense	=	5

Others:

Ph	=	value
Soil organic content	=	%
Crop cover	=	%
Crop height	=	cm

Appendix 3: Example of a Wadi Ibn Hammad plant measurement recording sheet

Plant species:

Location 1:
Basal semi-basal leafy prostate
True canopy height: (cm)
Basal canopy height:
Max canopy height:
Plant height:
Height of lowest flower:
Canopy diameter:
Rooted patch diam (perennials only):

V F P FP
Root: tap other
fresh leaf weight:
fresh leaf thickness:
SLA leaves:
acetate peels:
root:
root diam@10 cm:

Location 2:
True canopy height: (cm)
Basal canopy height:
Max canopy height:
Plant height:
Height of lowest flower:
Canopy diameter:
Rooted patch diam (perennials only):

V F P FP
fresh leaf weight:
fresh leaf thickness:
SLA leaves:
acetate peels:

Location 3:
True canopy height: (cm)
Basal canopy height:
Max canopy height:
Plant height:
Height of lowest flower:
Canopy diameter:
Rooted patch diam (perennials only):

V F P FP
fresh leaf weight:
fresh leaf thickness:
SLA leaves:
acetate peels:

Location 4:
V F P FP
True canopy height: (cm)
Basal canopy height:
Max canopy height:
Plant height:
Height of lowest flower:
Canopy diameter:
Rooted patch diam (perennials only):

Location 5:
V F P FP
True canopy height: (cm)
Basal canopy height:
Max canopy height:
Plant height:
Height of lowest flower:
Canopy diameter:
Rooted patch diam (perennials):

Herbarium specimen: Cleaned seed: Uncleaned seed:

Appendix 4: Archaeological variables of samples from Khirbet Faris

Sample number	Site Area	Excavation year	Context number	Context description	Phase	Sample Volume (L)	Flot Volume (ml)	Full Analysis
7	FAR I	1988	14	Oven fill	13th C.	2	15	
9	FAR I	1988	15	Oven fill	13th C.	2	10	YES
{10	FAR I	1988	17	Dump (outside buiding)	13th C.	2	25	{ YES
{13	FAR I	1988	17	Dump (outside buiding)	13th C.	2	25	{ YES
14	FAR I	1988	15	Oven fill	13th C.	2	20	
15	FAR I	1988	19	Dump (under oven [16])	13th C.	2	37	YES
17	FAR I	1988	25	Dump	13th C.	2	25	YES
{18	FAR I	1988	11	Oven fill	15th C.	2	15	{ YES
{22	FAR I	1988	11	Oven fill	15th C.	2	20	{ YES
23	FAR I	1988	20	Surface - earth /clay (associated with oven [16])	13th C.	2	40	YES
24	FAR I	1988	55	Hearth fill (associated with hearth [77])	13th C.	2	45	YES
25	FAR I	1988	48	Ash dump	13th C.	2	40	YES
26	FAR I	1988	48	Ash dump	13th C.	2	20	YES
29	FAR I	1988	78	Surface - earth / clay (associated with hearth [77])	13th C.	2	10	
30	FAR I	1988	46	Rubble matrix	14/15th C.	2	50	YES
31	FAR I	1988	76	Hearth fill (associated with hearth [77])		2	50	YES
32	FAR I	1988	54	Ash accumulation (associated with hearth [77])	13th C.	2	52	YES
34	FAR I	1989	203	Ash dump	13th C.	2	30	YES
35	FAR I	1989	221	Ash accumulation (associated with hearth [210])	13th C.	2	10	
35a	FAR IV	1988	67	Ash dump	5 - 9th C.	5	15	YES
42	FAR II	1989	552	Surface - earth / clay (associated with oven [548])	5 - 13th C.	1	5	
43a	FAR I	1988	83	Rubble matrix		2	10	
44	FAR II	1989	550	Surface - earth / clay	13th C.	1	40	
45	FAR II	1989	558	Ash dump (on flagged floor [559])	5 - 9th C.	2	5	YES
46	FAR II	1989	557	Dump	5 - 13th C.	1	15	YES
47a	FAR I	1988				2	10	
51a	FAR I	1988	337			2	45	YES
53	FAR IV	1989	354			2	5	

Appendix 4: Continued

Sample number	Site Area	Excavation year	Context number	Context description	Phase	Sample Volume (L)	Flot Volume (ml)	Full Analysis
54	FAR I	1989	364			2	5	YES
56	FAR IV	1989	452	Ash accumulation (compact)		1	10	
66	FAR Vd	1989	177	Dump	5 - 13th C.	1	35	
67	FAR Vd	1989	663	Oven fill	5 - 13th C.	1	25	
68	FAR Vd	1989	671	Dump	5 - 13th C.	1	25	
69	FAR Vd	1989	673	Ash accumulation (hearth fill ?)	5 - 13th C.	1	10	
70	FAR Vd	1989	676	Ash dump	5 - 13th C.	2	40	
72	FAR I	1989	511	Surface - clay (same as [196])	13th C.	1	30	
73	FAR I	1989	518	Pit fill (associated with cut [512])	5 - 9th C.	2	60	YES
82	FAR I	1989	486	Oven fill (associated with oven [592])	13th C.	2	15	YES
90	FAR I	1989	632	Hearth fill (associated with hearth [631])		2	45	YES
98	FAR II	1990	737			18	10	
102	FAR II	1990	744			6.5	10	
113	FAR Vc	1990	753	Dump (compact - used as a surface ?)		18	50	YES
117	FAR Vd	1990	885	Ash dump		18	15	YES
120	FAR Vd	1990	890	Surface - earth / clay (same as [178])		18	39	YES
121	FAR Vd	1990	892	Pit fill (associated with cut [893])		18	25	
127	FAR I	1990	942	Pit fill (associated with cut [943=939])	13th C.	18	39	YES
130	FAR Vb	1989	538	Ash dump	13th C.	2	60	YES
131	FAR Vb	1989	647	Ash dump (similar to / same as [538])	13th C.	2	50	YES
142	FAR II	1990	803	Pit fill (associated with cut [806])		20	30	YES
149	FAR I	1994	408	Dump		50	50	
150	FAR I	1994	416	Cistern fill	17th C.	50	40	YES
151	FAR I	1994	417	Cistern fill	17th C.	50	10	
154	HOUSE 2	1991	1002	Hearth fill		40	155	YES
156	HOUSE 2	1991	1087	Dump		50	40	YES
164	FAR I	1991	1059	Pit fill (associated with cut [1058])	5 - 13th C.	50	48	YES
165	FAR I	1991	1056	Oven fill (associated with oven [1102])	13th C.	70	78	YES

Appendix 4: Continued

Sample number	Site Area	Excavation year	Context number	Context description	Phase	Sample Volume (L)	Flot Volume (ml)	Full Analysis
167	FAR I	1991	1102	Oven base	5 - 13th C.	20	28	YES
168	FAR I	1991	1110	Dump	5 - 13th C.	50	52	YES
171a	HOUSE I	1993	1484	Rubble matrix (rubble infill from roof and walls)		20	15	YES
172	FAR I	1991	954	Feature fill (feature [955] = bench / bin ?)	5 - 13th C.	20	45	YES
176								
179	FAR I	1994	1704	Cistern fill	17th C.	50	50	YES
180	FAR I	1994	1705	Cistern fill	17th C.	50	15	
182	FAR I	1994	1706	Floor packing / levelling (associated with paving [1521])	5 - 13th C.	50	60	YES
183	FAR I	1994	1711	Cistern fill	13th C.	50	10	YES
186	FAR IV	1991	1095	Dump (associated with feature / pit [1077])	5 - 9th C.	50	9	
187	FAR IV	1991	1097	Dump (associated with feature / pit [1077])	5 - 9th C.	50	18	
189	FAR I	1992	1115	Pit fill (associated with cut [957])	13th C.	30	150	
191	FAR I	1992	1120	Dump	5 - 13th C.	30	40	YES
192	FAR I	1992	1108	Surface - earth / clay	5 - 13th C.	60	50	
193	FAR I	1992	1193	Pit fill (associated with cut 1195])	5 - 13th C.	60	50	
194	FAR I	1992	1197	Pit fill (associated with cut [1198])	5 - 9th C.	30	40	YES
195	FAR I	1992	1194	Surface - gravel	5 - 13th C.	50	40	YES
196	FAR I	1992	1204	Ash dump	13th C.	60	100	YES
198	FAR Ia	1992	1203	Ash dump	5 - 13th C.	50	110	YES
199	FAR Ib	1992	1244	Ash dump	5 - 13th C.	40	70	YES
200	FAR Ib	1992	1247	Ash dump (same as [1250])	13th C.	40	50	
201	FAR Ib	1992	1246	Dump	5 - 13th C.	60	50	YES
202	FAR Ib	1992	1248	Rubble matrix	5 - 13th C.	60	20	YES
204	FAR Ib	1992	1250	Ash dump (same as [1247])	13th C.	60	60	YES
205	FAR Ib	1992	1251	Rubble matrix (associated with roof collapse)	5 - 13th C.	60	50	YES
208	FAR Ib	1992	1254	Rubble matrix (same as [1251] ?)	5 - 13th C.	60	50	YES
211	FAR Vd	1992	1292	Pit fill (associated with cut [1294])		20	20	YES
213	FAR V	1992	1296	Pit fill (associated with cut [1298])		40	20	

Appendix 4: Continued

Sample number	Site Area	Excavation year	Context number	Context description	Phase	Sample Volume (L)	Flot Volume (ml)	Full Analysis
262	FAR Ib	1992	1265	Surface - earth / clay	5 - 9th C.	60	50	YES
263	FAR Ib	1992	1266	Layer	13th C.	60	160	YES
265	FAR Ib	1992	1279	Dump	13th C.	50	70	YES
266	FAR Ib	1992	1280	Rubble matrix	5 - 13th C.	60	20	
267	FAR Ib	1992	1281	Hearth fill		60	40	YES
268	FAR Ib	1992	1282			50	40	
269	FAR Ib	269	1283	Pit fill	5 - 13th C.	60	45	YES
270	FAR Ib	1992	1401	Dump	13th C.	60	190	YES
272	FAR Ib	1992	1404	Surface -earth / clay	5 - 13th C.	60	80	YES
273	FAR Ib	1992	1405	Oven fill (associated with oven [1406])	5 - 13th C.	60	50	YES
274	FAR Ib	1992	1406	Oven base	13th C.	60	60	YES
277	FAR Ib	1992	1409	Floor packing (associated with cobble surface [1276])	5 - 13th C.	50	20	YES
280	FAR I	1993	852	Oven fill (associated with oven [1239])		60	80	YES
282	FAR I	1993	855	Oven fill (associated with oven [1239])		40	200	YES
283	FAR I	1993	1121			40	10	YES
284	FAR I	1993	857	Oven fill (associated with oven [1239])		10	250	YES
285	FAR I	1993	871	Oven fill (associated with oven [1239])		60	80	YES
286	FAR I	1993	870	Dump		60	60	
287	FAR I	1992	1136	Dump	5 - 13th C.	60	20	YES
290	FAR I	1992	1221	Dump	5 - 13th C.	60	20	YES
291	FAR I	1993	873	Rubble matrix		60	40	YES
292	FAR I	1993	875	Surface - earth / clay (associated with oven house [1239])		60	120	YES
294	FAR I	1993	878	Cistern fill	17th C.	100	50	YES
295	FAR I	1993	1519	Surface - earth / clay (2nd surface associated with cistern)		30	30	
328	FAR V	1993	1040	Rubble matrix (associated with structural collapse [1388])		40	80	
329	FAR V	1993	1128	Foundation fill (associated with wall [1366])(same as [1418])		60	30	
330	FAR V	1993	1426	Rubble matrix (associated with rubble [1424])		50	50	YES
331	FAR V	1993	1418	Foundation fill (associated with wall [1366])(same as [1128])		30	50	

Appendix 4: Continued

Sample number	Site Area	Excavation year	Context number	Context description	Phase	Sample Volume (L)	Flot Volume (ml)	Full Analysis
332	FAR V	1993	1420	Rubble matrix (same as [1448])		30	30	
333	FAR V	1993	1445	Ash dump (burnt pot & bone: mammal & fish)		60	500	YES
334	FAR V	1993	1444	Rubble matrix		60	20	YES
338	FAR V	1993	1448	Rubble matrix (same as [1420])		50	25	
339	FAR V	1993	1451	Dump		40	100	YES
340	FAR V	1993	1453	Dump		40	60	YES
341	FAR V	1993	1454	Rubble matrix (Rubble infill from roof collapse [1100])		35	50	YES
342	FAR V	1993	1460	Dump		40	100	
344	FAR V	1993	1463	Dump / Rubble matrix		50	200	
347	FAR V	1993	1467	Dump / Rubble matrix		20	40	
348	FAR V	1993	1471	Dump		25	500	
354	FAR V	1993	1503	Dump / Rubble matrix		40	25	
357	FAR V	1993	1511	Dump / Rubble matrix		50	30	YES
358	FAR V	1993	1511	Dump / Rubble matrix		50	60	YES
363	FAR V	1993	1558	Surface - earth / clay (associated with staircase [357])		40	20	YES
	FAR Vb		650	Ash dump	13th C.			YES
TOTAL 164								TOTAL 100

344 samples were processed initially.
164 samples were found to contain charred plant remains.
All 164 samples have been recorded.
100 samples (containing >50 cultivar items in each) have been statistically analysed

Appendix 5: Example of a Khirbet Faris DAFOR recording sheet

SAMPLE No	FLOT VOL	CER GR	CER FC	CER CU	OTH CULT	WEED	WOOD	GRASS	DUNG	BONE	SNAIL	MOD BEET	MOD PLT	MOD WEED	STONE	MUD	RICH
e.g. 031	50ml	D	O	R	O	R			F				F			A	

D = dominant
A = abundent
F = frequent
O = occasional
R = rare

0 no carbonised remains
1
2
3
4
5 very rich

Key:
CER GR = cereal grain
CER FC = cereal fine chaff
CER CU = cereal culm nodes
OTH CULT = other cultivars
MOD BEET = modern beetle remains
MOD PLT = modern plant material
MOD WEED = modern weeds

Appendix 6: Wadi Ibn Hammad field variables

FIELD No.	CROP IRRIGATION REGIME	CROP TYPE	LOCATION	PLOUGH METHOD	CEREAL SOWING TIME	ADDED NUTRIENTS	CROP HEIGHT (cm)	CROP COVER (%)	STONE CONTENT (1 to 5)	FIELD ASPECT	FIELD SLOPE (0 to 5)	PRECIP-ITATION (mm)	SOIL TYPE	SOIL ORGANIC CARBON %	pH
1	Biennial irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Fertiliser + manure	88	70	2.6	NW	1	180 - 220	Su'Eidat	0.98	8.3
2	Biennial irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Fertiliser + manure	75	51	2.8	NW	1	180 - 220	Su'Eidat	1.23	7.7
3	Biennial irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Fertiliser + manure	80	50	1.4			180 - 220	Su'Eidat	0.73	8.0
4	Full irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Manure	132	79	1.6	flat	0	180 - 220	Su'Eidat	0.92	8.4
5	Full irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Manure	103	74	3.1	NW	1	180 - 220	Su'Eidat	1.08	7.9
6	Biennial irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Fertiliser + manure	93	55	2.9	N-NW	4	180 - 220	Su'Eidat	1.16	8.3
7	Full irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Manure	101	58	2.3	NW	1	180 - 220	Su'Eidat		7.9
8	Full irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Manure	108	72	3.0	N	1	180 - 220	Su'Eidat	1.72	8.2
9	Full irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Manure	115	85	3.7	N	1	180 - 220	Su'Eidat		8.2
10	Full irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Manure	99	55	1.3	N	2	180 - 220	Su'Eidat		8.1
11	Biennial irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Fertiliser + manure	94	71	2.5	W	3	180 - 220	Su'Eidat	1.18	8.4
12	Full irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Manure	103	77	1.0	N	2	180 - 220	Su'Eidat		8.3
13	Full irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Manure	95	69	1.4	NW	2	180 - 220	Su'Eidat	0.92	8.2
14	Biennial irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Fertiliser + manure	73	64	2.2	NW	3	180 - 220	Su'Eidat	1.24	8.3
15	Full irrigation	6 row Barley	Wadi bottom	animal	Dec / Jan	Manure	81	79	1.8	NE	2	180 - 220	Su'Eidat	1.83	8.1
16	Biennial irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Fertiliser + manure	77	57	1.8	SW	3	180 - 220	Su'Eidat	1.17	8.4
17	Full irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Manure	125	85	1.0	N	1	180 - 220	Su'Eidat		8.3
18	Full irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Manure	101	51	2.3	N	1	180 - 220	Su'Eidat	1.27	8.4
19	Full irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Manure	112	64	2.2	N	1	180 - 220	Su'Eidat	0.69	8.4
20	Full irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Manure	121	91	1.0	N	1	180 - 220	Su'Eidat		8.4

Appendix 6: Continued

FIELD No.	CROP IRRIGATION REGIME	CROP TYPE	LOCATION	PLOUGH METHOD	CEREAL SOWING TIME	ADDED NUTRIENTS	CROP HEIGHT (cm)	CROP COVER (%)	STONE CONTENT (1 to 5)	FIELD ASPECT	FIELD SLOPE (0 to 5)	PRECIP-ITATION (mm)	SOIL TYPE	SOIL ORGANIC CARBON %	pH
21	Full irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Manure	76	54	2.4	N	4	180 - 220	Su'Eidat		8.5
22	Full irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Manure	83	73	1.7	N	4	180 - 220	Su'Eidat	1.45	8.2
23	Full irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Manure	92	87	1.5	N	2	180 - 220	Su'Eidat	1.59	8.2
24	Full irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Manure	107	90	1.6	N	1	180 - 220	Su'Eidat	0.96	8.4
25	Full irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Manure	103	75	3.3	NW	5	180 - 220	Su'Eidat	0.70	8.2
26	Full irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Manure	114	84	2.0	S	3	180 - 220	Su'Eidat	2.05	7.8
27	Full irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Manure	83	42	2.6	N	1	180 - 220	Su'Eidat	1.23	8.2
28	Dry	6 row Barley	Wadi bottom	animal	Dec / Jan	Manure	38	11	3.4	flat	0	180 - 220	Su'Eidat	1.49	8.3
29	Dry	Durum wheat	Wadi bottom	animal	Dec / Jan	Manure	42	30	2.3	N	1	180 - 220	Su'Eidat	1.22	8.6
30	Dry	Durum wheat	Wadi bottom	animal	Dec / Jan	Manure	73	43	2.6	W	2	180 - 220	Su'Eidat	1.44	8.3
31	Full irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Manure	74	58	1.3	SE	3	180 - 220	Su'Eidat		8.3
32	Full irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Manure	76	65	1.9	SE	3	180 - 220	Su'Eidat	1.50	8.3
33	Full irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Manure	78	65	1.3	S	2	180 - 220	Su'Eidat	1.17	8.1
34	Full irrigation	Durum wheat	Wadi bottom	animal	Dec / Jan	Manure	90	65	3.2	NW	5	180 - 220	Su'Eidat	1.40	7.7
35	Dry	2 row Barley	Wadi side	animal	Dec / Jan	Manure	55	57	2.8	flat	0	180 - 220	Tell Alluba	1.95	8.2
36	Dry	Durum wheat	Wadi side	animal	Dec / Jan	Manure	85	55	2.7	flat	0	180 - 220	Tell Alluba	1.75	7.9
37	Dry	Durum wheat	Wadi side	animal	Dec / Jan	Manure	76	38	3.4	SW	2	180 - 220	Tell Alluba	0.90	8.1
38	Dry	2 row Barley	Wadi side	animal	Dec / Jan	Manure	41	34	3.4	S	2	180 - 220	Tell Alluba	1.63	8.1
39	Dry	Durum wheat	Wadi side	animal	Dec / Jan	Manure	71	32	3.2	E	2	180 - 220	Tell Alluba	1.68	8.0
40	Dry	Durum wheat	Wadi side	animal	Dec / Jan	Manure	31	62	1.0	E + W	2	180 - 220	Tell Alluba		8.6
41	Dry	Durum wheat	Wadi side	animal	Dec / Jan	Manure	33	63	1.4	E + W	2	180 - 220	Tell Alluba	1.43	8.5
42	Dry	6 row Barley	Plateau	tractor	Dec / Jan	Manure	56	56	2.5	E	2	300 - 400	Humud	0.47	8.0
43	Dry	Durum wheat	Plateau	tractor	Dec / Jan	Manure	62	49	2.2	NE	2	300 - 400	Humud	0.69	8.2
44	Dry	2 row Barley	Wadi side	animal	Dec / Jan	Manure	31	47	2.2	SW	2	180 - 220	Tell Alluba		8.3

Appendix 6: Continued

FIELD No.	CROP IRRIGATION REGIME	CROP TYPE	LOCATION	PLOUGH METHOD	CEREAL SOWING TIME	ADDED NUTRIENTS	CROP HEIGHT (cm)	CROP COVER (%)	STONE CONTENT (1 to 5)	FIELD ASPECT	FIELD SLOPE (0 to 5)	PRECIP-ITATION (mm)	SOIL TYPE	SOIL ORGANIC CARBON %	pH
45	Dry	Durum wheat	Plateau	tractor	Dec / Jan	Manure	62	50	2.3	N	2	300 - 400	Humud	0.53	8.3
46	Dry	Durum wheat	Plateau	tractor	Dec / Jan	Manure	63	42	1.2	N	3	300 - 400	Humud	0.37	8.2
47	Dry	Durum wheat	Plateau	tractor	Dec / Jan	Manure	65	49	2.6	N	2	300 - 400	Humud	0.97	8.3
48	Dry	Durum wheat	Plateau	tractor	Dec / Jan	Manure	74	56	2.3	N	1	300 - 400	Humud	1.16	8.2
49	Dry	Durum wheat	Plateau	tractor	Dec / Jan	Manure	91	71	3.2	N	2	300 - 400	Humud	0.76	8.3
50	Dry	2 row Barley	Plateau	tractor	Dec / Jan	Manure	50	56	1.0	NE	1	300 - 400	Humud	0.91	8.0
51	Dry	2 row Barley	Plateau	tractor	Dec / Jan	Manure	32	29	1.2	N	1	300 - 400	Humud	0.94	8.2
52	Dry	6 row Barley	Plateau	tractor	Dec / Jan	Manure	42	45	1.4	NE	2	300 - 400	Humud	1.04	8.1

Appendix 7: List of Wadi Ibn Hammad field species found in 10% or more fields

Code	Species	Family
ACHISAN	Achillea santolina	Compositae
ANAGFOE	Anagallis foemina*	Primulaceae
	Anagallis sp.*	Primulaceae
ANCHSTR	Anchusa strigosa	Boraginaceae
ANTHHEB	Anthemis hebronica	Compositae
ANTHPAL	Anthemis palaestina	Compositae
ANTHSPE	Anthemis pseudocotula	Compositae
ANTIORO	Antirrhinum oronteum	Scrophulariaceae
ASPEARV	Asperula arvensis	Rubiaceae
AVENSPP	Avena barbata subsp. barbata*	Gramineae
	Avena sterilis subsp. sterilis*	Gramineae
BIFOTES	Bifora testiculata	Umbelliferae
BROMLAN	Bromus lanceolatus	Gramineae
CALEARV	Calendula arvensis	Compositae
CALERHA	Calendula arvensis/Rhagadiolus stellatus	Compositae
CARDDRA	Cardaria draba	Cruciferae
CARTGLA	Carthamus glaucus	Compositae
TORILEP	Torilis leptophylla	Umbelliferae
CENTSPP	Centaurea hyalolepis*	Compositae
	Centaurea iberica*	Compositae
CERADIC	Cerastium dichotomum	Caryophyllaceae
CHENALB	Chenopodium album	Chenopodiaceae
CHRYCOR	Chrysanthemum coronarium	Compositae
CICHPUM	Cichorum pumilum	Compositae
CONVDOR	Convolvulus dorycnium	Convolvulaceae
CONVSPP	Convolvulus altheoides*	Convolvulaceae
	Convolvulus arvensis*	Convolvulaceae
CREPASP	Crepis aspera	Compositae
CYNADAC	Cynadon dactylon	Gramineae
ERODMAL	Erodium cf. malacoides	Geraniaceae
ERYNCRE	Eryngium creticum	Umbelliferae
FALCVUL	Falcaria vulgaris	Umbelliferae
FILAPYR	Filago pyramidata	Compositae
FUMAPAR	Fumaria parviflora	Fumariaceae
GALITRI	Galium tricornutum	Rubiaceae
HIRSINC	Hirschfeldia incana	Cruciferae
HORDGLA	Hordeum glaucum	Gramineae
LACTORI	Lactuca orientalis*	Compositae
	Lactuca sp.*	Compositae
LINACHA	Linaria chalepensis	Scrophulariaceae
LOLISPP	Lolium perenne*	Gramineae
	Lolium rigidum*	Gramineae
LOPHBER	Lophochloa berythea	Gramineae
MALVPAR	Malva parviflora	Malvaceae
MEDITUR	Medicago turbinata	Leguminosae
NESLAPI	Neslia apiculata	Cruciferae
NOTASYR	Notobasis syriaca	Compositae
ONONANT	Ononis antiquorum	Leguminosae
ONONNAT	Ononis natrix	Leguminosae
PAPAHYB	Papaver hybridum	Papaveraceae
PAPARHO	Papaver polytrichum	Papaveraceae
PHALBRA	Phalaris brachystachys	Gramineae
PHALPAR	Phalaris paradoxa	Gramineae
POLYPAT	Polygonum patulum	Polygonaceae
RESESPP	Reseda lutea*	Resedaceae
	Reseda muricata*	Resedaceae
RHAGSTE	Rhagadiolus stellatus	Compositae
RIDOSEG	Ridolfia segetum	Umbelliferae
ROEMHYB	Roemeria hybrida	Papaveraceae
SCOLMAC	Scolymus maculatus	Compositae
SILECON	Silene conoidea	Caryophyllaceae
SILYMAR	Silybum marianum	Compositae
SINAARV	Sinapis arvensis	Cruciferae
SONCOLE	Sonchus oleraceus	Compositae
TORYAEG	Torydlium aegypticum	Umbelliferae
TRIFCLU	Trifolium clusii	Leguminosae
UMBESP1	Umbellifer sp. 1 (Ammi majus?)	Umbelliferae
VACCPYR	Vaccaria pyramidata	Caryophyllaceae
VICIPER	Vicia peregrina	Leguminosae
VICISAT	Vicia sativa subsp. angustifolium	Leguminosae

* = lumped groups, as certain species were not differentiated correctly in the field

Appendix 8: Species common in different field types at Wadi Ibn Hammad (using a 70% cut-off)

code	dominant regime	Percentage occurrence in fields: Irrigated	Biennially irrigated	wadi dry	Plateau	Total No. of Quadrats
ACHISAN	Plateau -dry	2.9	0.0	20.6	76.5	34
ASPEARV	Plateau -dry	0.0	0.0	9.5	90.5	21
CALERHA	Plateau -dry	0.0	0.0	28.0	72.0	6
ONONNAT	Plateau -dry	0.0	0.0	12.5	87.5	8
ANTHHEB	Wadi -dry	3.2	9.2	70.0	17.6	94
BROMLAN	Wadi -dry	0.0	30.0	70.0	0.0	6
CARDDRA	Wadi -dry	14.3	7.1	78.6	0.0	23
CREPASP	Wadi -dry	0.0	14.3	71.4	0.0	7
FALCVUL	Wadi -dry	30.0	0.0	70.0	0.0	21
LACTORI	Wadi -dry	0.0	16.7	72.2	11.1	18
TORYAEG	Wadi -dry	20.3	0.0	73.6	9.1	11
VICIPER	Wadi -dry	3.7	9.9	83.9	2.5	81
ANAGFOE	Irrig/Bien	68.3	10.2	12.7	8.9	79
AVENSPP	Irrig/Bien	60.2	10.2	9.2	20.4	98
CHRYCOR	Irrig/Bien	56.7	32.4	8.1	2.7	37
GALITRI	Irrig/Bien	64.6	6.1	6.2	23.0	65
HORDGLA	Irrig/Bien	16.2	54.1	29.7	0.0	37
LOPHBER	Irrig/Bien	49.0	23.0	16.0	12.0	50
MALVPAR	Irrig/Bien	57.7	42.2	0.0	0.0	13
AMMIMAJ	Irrigated	78.6	0.0	5.3	16.1	56
ANTHPAL	Irrigated	90.7	0.0	9.3	0.0	54
ANTIORO	Irrigated	100.0	0.0	0.0	0.0	16
CALEARV	Irrigated	85.7	0.0	14.3	0.0	7
CHENALB	Irrigated	100.0	0.0	0.0	0.0	7
CICHPUM	Irrigated	73.6	5.9	19.1	1.5	68
CONVSPP	Irrigated	87.3	7.7	4.2	0.7	142
CYNADAC	Irrigated	77.2	5.2	7.9	9.6	114
ERODMAL	Irrigated	75.0	12.5	0.0	12.5	8
FUMAPAR	Irrigated	71.8	18.8	6.2	3.1	32
HIRSINC	Irrigated	85.7	8.2	3.6	2.4	84
LOLISPP	Irrigated	76.4	20.8	2.8	0.0	72
MEDITUR	Irrigated	92.6	7.4	0.0	0.0	27
NESLAPI	Irrigated	83.3	0.0	4.2	12.5	24
PAPAHYB	Irrigated	80.0	0.0	20.0	0.0	5
PAPARHO	Irrigated	75.0	0.0	12.5	12.5	8
PHALBRA	Irrigated	70.5	6.6	3.3	19.7	61
PHALPAR	Irrigated	95.2	0.0	0.0	4.8	21
POLYPAT	Irrigated	88.9	0.0	0.0	11.1	36
RIDOSEG	Irrigated	71.8	15.4	2.6	10.3	39
SCOLMAC	Irrigated	100.0	0.0	0.0	0.0	9
SILYMAR	Irrigated	100.0	0.0	0.0	0.0	32
SINAARV	Irrigated	74.2	1.9	1.9	22.1	53
SONCOLE	Irrigated	72.7	9.1	18.2	0.0	11
VICISAT	Irrigated	81.2	6.2	12.5	0.0	16
ANCHSTR	Mixed	17.2	40.3	32.6	9.5	26
ANTHSPE	Mixed	29.2	40.3	23.6	7.0	18
BIFOTES	Mixed	26.6	26.6	13.3	33.3	45
CARTGLA	Mixed	44.7	8.9	14.6	31.8	70
CENTSPP	Mixed	53.7	16.9	14.0	15.2	171
CERADIC	Mixed	13.3	20.0	48.0	18.7	75
CONVDOR	Mixed	40.0	20.0	40.0	0.0	5
ERYNCRE	Mixed	39.1	0.0	26.0	34.8	23
FILAPYR	Mixed	24.1	10.3	27.6	37.9	29
LINACHA	Mixed	46.4	17.9	21.4	14.3	28
NOTASYR	Mixed	36.9	16.9	36.9	9.3	40
ONONANT	Mixed	46.4	7.1	7.1	39.3	28
RESESPP	Mixed	16.4	29.0	36.4	18.2	55
RHAGSTE	Mixed	27.7	22.3	40.6	9.4	93
ROEMHYB	Mixed	40.3	7.0	45.8	7.0	18
SILECON	Mixed	13.6	3.4	18.6	64.4	59
TORILEP	Mixed	23.8	10.2	60.2	5.6	22
TRIFCLU	Mixed	0.0	50.0	50.0	0.0	4
VACCPYR	Mixed	40.8	23.1	30.7	5.4	79

Appendix 9: The key attribute values of Wadi Ibn Hammad species according to watering regime and flowering season

code	species	dominant regime	flowering season	life history	canopy dimension	leaf area per node	stomatal size	stomatal density
ANTHHEB	Anthemis hebronica	Wadi -dry	early	ann	36	229	3.60	18.82
BROMLAN	Bromus lanceolatus	Wadi -dry	early	ann	31	661	4.97	7.93
CARDDRA	Cardaria draba	Wadi -dry	early	per	28	1169	2.92	21.43
CREPASP	Crepis aspera	Wadi -dry	early	ann	43	1303	2.08	23.57
FALCVUL	Falcaria vulgaris	Wadi -dry	early	bien/per	34	1689	2.85	43.07
LACTORI	Lactuca orientalis	Wadi -dry	early	bien/per	21	938	2.88	17.20
TORYAEG	Tordylium aegypticum var. palaestinum	Wadi -dry	early	ann	45	4613	3.38	15.08
VICIPER	Vicia peregrina	Wadi -dry	early	ann	53	747	2.93	17.84
Average					41	1511	3.39	16.65
ANAGFOE	Anagallis foemina	Irrig/Bien	early	ann/bien	19	172	4.17	14.20
AVENSPP	Avena sterilis sterilis/Avena barbata barb	Irrig/Bien	early	ann	62	1520	5.50	11.22
CHRYCOR	Chrysanthemum coronarium	Irrig/Bien	early	ann	36	1109	4.58	9.47
GALITRI	Galium tricornutum	Irrig/Bien	early	ann	88	504	4.69	11.08
HORDGLA	Hordeum murinum glaucum	Irrig/Bien	early	ann	27	364	3.65	14.03
LOPHBER	Lophochloa berythea	Irrig/Bien	early	ann	15	238	3.56	13.54
MALVPAR	Malva parviflora	Irrig/Bien	early	ann	40	3728	2.45	25.67
ANTHPAL	Anthemis palestina	Irrigated	early	ann	41	369	4.29	13.07
CICHPUM	Cichorium pumilum	Irrigated	early	ann	59	453	2.48	32.13
FUMAPAR	Fumaria parviflora	Irrigated	early	ann	67	1456	3.21	10.40
HIRSINC	Hirschfeldia incana	Irrigated	early	ann/per	75	8840	2.53	38.50
LOLISPP	Lolium perenne/Lolium rigidum	Irrigated	early	ann/per	53	807	3.84	11.58
MEDITUR	Medicago turbinata	Irrigated	early	ann	51	469	2.02	40.43
NESLAPI	Neslia paniculata thracica	Irrigated	early	ann	38	1485	3.04	19.72
PAPAHYB	Papaver hybridum	Irrigated	early	ann	18	476	3.42	12.27
PAPARHO	Papaver rhoeas	Irrigated	early	ann	27	2090	3.65	14.83
PHALBRA	Phalaris brachystachys	Irrigated	early	ann	48	1331	4.19	14.93

Appendix 9: Continued

code	species	dominant regime	flowering season	life history	canopy dimension	leaf area per node	stomatal size	stomatal density
RIDOSEG	Ridolfia segetum	Irrigated	early	ann	100	3995	2.20	26.67
SILYMAR	Silybum marianum	Irrigated	early	ann	64	32072	3.79	9.20
SINAARV	Sinapis arvensis	Irrigated	early	ann	44	7186	2.25	52.33
Average					53	4695	3.15	22.77
AMMIMAJ	Ammi majus	Irrigated	late	ann	53	2160	2.78	58.40
ANTIORO	Misopates orontium	Irrigated	late	ann	16	398	2.37	19.33
CALEARV	Calendula arvensis	Irrigated	late	ann	32	344	3.91	9.87
CHENALB	Chenopodium album	Irrigated	late	ann	43	1582	2.83	25.65
CONVSPP	Convolvulus arvensis/Convolvulus althae	Irrigated	late	per	48	983	3.36	15.72
CYNADAC	Cynodon dactylon	Irrigated	late	per	60	53	2.12	18.25
ERODMAL	Erodium malacoides	Irrigated	late	ann	58	1614	2.78	22.23
PHALPAR	Phalaris paradoxa	Irrigated	late	ann	75	658	3.61	16.13
POLYPAT	Polygonum patulum	Irrigated	late	ann	60	443	2.80	16.23
SCOLMAC	Scolymus maculatus	Irrigated	late	ann	90	2841	3.14	24.93
SONCOLE	Sonchus oleraceus	Irrigated	late	ann	49	5626	2.70	25.97
VICISAT	Vicia sativa nigra	Irrigated	late	ann	69	2799	2.54	20.96
Average					54	1847	2.95	23.97
ACHISAN	Achillea santolina	Plateau -dry	early	ann	24	33	3.42	9.61
ASPEARV	Asperula arvensis	Plateau -dry	early	ann	32	448	4.02	18.13
CALERHA	Rhagadiolus stellatus	Plateau -dry	early	ann	28	241	3.72	13.87
ONONNAT	Ononis natrix	Plateau -dry	early	per	15	143	2.45	22.23
Average					28	241	3.72	13.87
ANCHSTR	Anchusa strigosa	Mixed	early	per	96	5441	4.29	13.87
ANTHSPE	Anthemis pseudocotula	Mixed	early	ann	39	294	5.46	13.00
BIFOTES	Bifora testiculata	Mixed	early	ann	41	584	3.47	19.18
CENTSPP	Centaurea hyalolepis/Centaurea iberica	Mixed	early	ann/bien	87	6883	2.98	18.54

Appendix 9: Continued

code	species	dominant regime	flowering season	life history	canopy dimension	leaf area per node	stomatal size	stomatal density
CERADIC	Cerastium dichotomum	Mixed	early	ann	46	400	3.38	17.83
CONVDOR	Convolvulus dorycnium	Mixed	early	per	57	835	2.66	23.47
FILAPYR	Filago pyramidata	Mixed	early	ann	29	49	2.35	23.40
NOTASYR	Notobasis syriaca	Mixed	early	ann	72	55100	3.37	19.47
ONONANT	Ononis spinosa antiquorum	Mixed	early	per	80	429	2.75	30.63
RESESPP	Reseda lutea/Reseda muricata	Mixed	early	ann/per	51	788	3.92	16.31
RHAGSTE	Rhagadiolus stellatus	Mixed	early	ann	39	5682	3.32	21.95
ROEMHYB	Roemeria hybrida	Mixed	early	ann	50	2048	3.26	8.93
SILECON	Silene conoidea	Mixed	early	ann	25	1044	3.54	23.48
TORILEP	Torilis leptophylla	Mixed	early	ann	32	1056	1.67	35.00
TRIFCLU	Trifolium resupinatum	Mixed	early	ann	46	216	2.07	36.65
VACCPYR	Vaccaria pyramidata	Mixed	early	ann	61	11128	2.93	26.67
CARTGLA	Carthamus tenuis	Mixed	late	ann	49	1496	3.05	18.47
ERYNCRE	Eryngium creticum	Mixed	late	bien/per	53	1317	3.60	27.82
LINACHA	Linaria chalepensis	Mixed	late	ann	13	125	2.63	16.80

Appendix 10: Khirbet Faris sample variables

Context number	Sample number	Sample volume litres	Total Number of Items	Number of identifiable items/litre	Preservation score	Distortion score
15	9	2	150	75.00	2	2
19	15	2	542	271.00	2	1
25	17	2	246	123.00	2	2
20	23	2	339	169.50	3	3
55	24	2	316	158.00	3	2
48	25	2	300	150.00	3	2
48	26	2	277	138.50	2	3
46	30	2	292	146.00	3	3
76	31	2	534	267.00	2	1
54	32	2	256	128.00	2	1
203	34	2	648	324.00	3	2
221	35	2	135	67.50	3	2
558	45	2	1204	602.00	2	2
557	46	1	141	141.00	4	2
48	51	2	424	212.00	2	2
	54	2	465	232.50	3	3
451	55	1	268	268.00	3	3
518	73	2	847	423.50	2	2
486	82	2	218	109.00	3	3
632	90	2	297	148.50	2	2
751	112	18	293	16.28	2	2
885	117	18	288	16.00	3	2
890	120	18	273	15.17	2	2
942	127	18	475	26.39	2	2
538	130	2	240	120.00	1	2
647	131	2	299	149.50	2	3
803	142	20	290	14.50	2	3
416	150	50	225	4.50	2	1
1002	154	40	707	17.68	2	3
1087	156	50	170	3.40	2	2
419	159	50	175	3.50	3	2
1701	162	50	215	4.30	2	2
1059	164	50	749	14.98	2	3
1056	165	70	2538	36.26	3	2
1102	167	20	524	26.20	2	3
1484	171	20	227	11.35	2	2
954	172	20	627	31.35	2	3
	176		127		3	3
1704	179	50	214	4.28	3	2
1706	182	50	156	3.12	2	2
1711	183	50	136	2.72	3	2
1120	191	30	256	8.53	2	3
1197	194	30	327	10.90	4	3
1194	195	50	311	6.22	3	3
1204	196	60	349	5.82	3	4
1203	198	50	2632	52.64	3	3
1244	199	40	177	4.43	2	2
1246	201	60	1949	32.48	3	4
1250	204	60	147	2.45	3	2
1251	205	60	208	3.47	2	2
1254	208	60	375	6.25	2	1
1292	211	20	152	7.60	4	3
1336	225	30	145	4.83	2	1

Appendix 10: Continued

Context number	Sample number	Sample volume litres	Total Number of Items	Number of identifiable items/litre	Preservation score	Distortion score
1370	240	220	177	0.80	3	2
1377	245	100	646	6.46	4	3
1378	246	60	1166	19.43	4	3
1378	248	60	781	13.02	4	3
714	249	50	462	9.24	2	2
784	250	40	314	7.85	3	2
714	252	50	850	17.00	4	3
848	255	50	544	10.88	3	3
846	256	60	1563	26.05	2	3
1256	257	50	228	4.56	3	2
1296	259	60	259	4.32	2	2
1262	260	60	906	15.10	3	2
1265	262	60	363	6.05	3	3
1266	263	60	839	13.98	1	1
1279	265	50	332	6.64	2	3
1281	267	60	172	2.87	3	2
1282	268	50	112	2.24	3	2
1283	269	60	217	3.62	3	2
1401	270	60	851	14.18	4	3
1404	272	60	1172	19.53	4	3
1405	273	60	186	3.10	3	2
1406	274	60	390	6.50	2	3
1409	277	50	144	2.88	3	2
852	280	60	638	10.63	2	3
855	282	40	671	16.78	2	3
1121	283	40	178	4.45	3	3
857	284	10	214	21.40	2	2
871	285	60	956	15.93	3	3
1136	287	60	148	2.47	4	2
1221	290	60	205	3.42	2	2
873	291	60	785	13.08	2	3
875	292	60	681	11.35	3	4
878	294	100	708	7.08	2	3
1426	330	50	567	11.34	3	3
1445	333	60	103	1.72	5	3
1444	334	60	354	5.90	2	3
1451	339	40	825	20.63	2	3
1453	340	40	362	9.05	3	2
1454	341	35	141	4.03	4	4
1511	357	50	202	4.04	4	4
1511	358	50	265	5.30	3	2
1558	363	40	175	4.38	3	2
650	1000		633		2	2
17	1013	4	255	63.75	2	2
67	1035	5	596	119.20	2	2
11	1822	4	189	47.25	3	2
420	154a	40	103	2.58	3	2
Totals		3772	46503	5443.13		
Averages		38.4898	465.03	55.54	2.65	2.42

Appendix 11: Cultivars in Khirbet Faris samples

	CONTEXT NUMBER	15	17	19	25	11	20	55	48	48	46	76	54	203
	SAMPLE NUMBER	9	10 + 13	15	17	18+22	23	24	25	26	30	31	32	34
	Triticum monococcum L.	2						2						5
	Triticum dicoccum (Shrank.) Schubl.						3				1	5		4
S	*Triticum monococcum* L. / *dicoccum* L.							6				1		3
N	*Triticum dicoccum* L. / *durum* Desf. / *aestivum* Schiem.			5		1	4				6			
I	*Triticum durum* L. / *aestivum* Schiem.	28	30	101	27	26	35	27	18	29	29	15	18	20
A	*Triticum* sp. indeterminate	5	9	17	3	5	11	5	3	3	1	1	2	4
R	**SUB-TOTAL: WHEAT GRAINS**	**35**	**39**	**123**	**30**	**32**	**53**	**40**	**21**	**32**	**37**	**22**	**20**	**36**
G	*Hordeum sativum* L. var. *hexastichum* (hulled, twisted)					2	2	1		1	1	2	3	7
	Hordeum sativum L. cf var. *hexastichum* (hulled, cf. twisted)		2			1						1		
L	*Hordeum sativum* L. indeterminate (hulled, straight)			5						1		2		
A	*Hordeum sativum* L. indeterminate (hulled, cf.straight)									5		2	3	
E	*Hordeum sativum* L. indeterminate (hulled)	21	11	27	7	3	11	49	7	14	3	11	12	84
R	*Hordeum sativum* L. indeterminate (cf. hulled)												4	
E	*Hordeum sativum* L. *hexastichum* var. *nudum* (naked)							1						2
C	*Hordeum sativum* L. cf. *hexastichum* var. *nudum* (cf. naked)													
	SUB-TOTAL: BARLEY GRAINS	**21**	**13**	**32**	**7**	**6**	**13**	**51**	**7**	**21**	**4**	**18**	**22**	**93**
	Triticum / *Hordeum* sp.		6	4			9		2	12	10		4	
	Sorghum bicolor L.				3					9			1	
	TOTAL: CEREAL GRAINS	**56**	**58**	**159**	**40**	**38**	**75**	**91**	**30**	**74**	**51**	**40**	**47**	**129**
	Triticum monococcum L. glume base													2
	Triticum dicoccum (Shrank.) Schubl. glume base													1
	Triticum monococcum L. / *dicoccum* (Shrank) Schubl. glume base													3
	SUB-TOTAL: WHEAT GLUME BASES	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6**
	Triticum durum Desf. rachis internode	8	12	47	20	18	65		39	27	62	5	30	3
F	*Triticum aestuvum* Schiem. rachis internode	1	2	30	1	2	11	10	8	14	21	1	7	4
F	*Triticum durum* Desf. / *aestivum* Schiem. rachis internode	2	1	14		5	5	14	3	6	6	3	1	
A	*Triticum durum* Desf. / *aestivum* Shiem. top of culm	2		7		2	6	5	2	2	9	3	2	
H	**SUB-TOTAL: WHEAT RACHIS**	**13**	**15**	**98**	**21**	**27**	**87**	**29**	**52**	**49**	**98**	**12**	**40**	**7**
C	*Hordeum sativum* L. var. *distichum* rachis internode													
	Hordeum sativum L. var. *hexastichum* rachis internode							2					1	
	Hordeum sativum L. indeterminate rachis internode													
	SUB-TOTAL: BARLEY RACHIS	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**1**	**0**
	Gramineae / Cerealia spp. culm node	18	40	149	14	10	90		51	53	63	26	38	14
	Gramineae / Cerealia spp. basal culm node	8	6	53	8	2	27	10	15	16	10	5	12	12
	Cicer arietinum L. seed													
	Vicia faba L. seed		1						2	2		2		
S	*Vicia ervilia* L. seed	8	12	2	1	5	3	4	1	1	6	5	5	50
R	*Lathyrus sativus* L. seed		3			1								
A	*Lathyrus sativus* L. / *Vicia ervilia* L. seed		2											9
V	*Lens culinaris* Medik. Seed	1						2			1		3	5
I	*Pisum sativum* L. seed	1						1						1
T	Leguminoseae spp. Indeterminate seed	2	6	1	2	1				2	1		3	17
L	**SUB-TOTAL: PULSE SEEDS**	**12**	**24**	**3**	**3**	**7**	**3**	**7**	**3**	**5**	**8**	**7**	**11**	**82**
U	*Ficus carica* L. seed	3		2	19	9	5	5	1		2	46	11	9
C	cf. *Ficus carica* L. fruit													
	Prunus domestica L. seed					1								
R	*Prunus armeniaca* L. seed													
E	*Prunus amygdalus* Batsch. seed													
H	*Pistacia atlantica* L. type seed													
T	*Pistacia terebinthus* L. type seed													
O	*Olea europaea* L. seed													
	Vitis vinifera L. seed			1		2	3		4		2	5	1	
	cf. *Vitis vinifera* L. fruit													
	Citrullus vulgaris Schrad. seed													
	cf. *Citrus* sp. peel													
	Phoenix dactylifera L.													
	SUB-TOTAL: FRUITS AND NUTS SEEDS	**3**	**0**	**3**	**19**	**12**	**8**	**5**	**5**	**0**	**4**	**51**	**12**	**9**
	Gossypium arboreum / *herbaceum*				1	4								
	TOTAL: OTHER CUTLIVARS	**15**	**24**	**8**	**23**	**23**	**11**	**12**	**8**	**5**	**12**	**58**	**23**	**91**
	TOTAL NUMBER OF CULTIVATED ITEMS	**110**	**143**	**465**	**106**	**100**	**290**	**144**	**156**	**197**	**234**	**141**	**161**	**259**

Appendix 11: Continued

	CONTEXT NUMBER	221	67	558	557	48	364	518	486	632	885	890	942	538	647
	SAMPLE NUMBER	35	35a	45	46	51	54	73	82	90	117	120	127	130	131
	Triticum monococcum L.					3	4	5			2	2			
	Triticum dicoccum (Shrank.) Schubl.			2		3	26	9		8			6		
S	*Triticum monococcu*m L. / *dicoccum* L.						19	4							
N	*Triticum dicoccum* L. / *durum* Desf. / *aestivum* Schiem.		2		1	10	38		1	2		2			1
I	*Triticum durum* L. / *aestivum* Schiem.	12	59	637	81	12	62	15	14	8	29	11	23	33	54
A	*Triticum* sp. indeterminate		10	88	17		10	8	1	14	4	2	10	9	11
R	**SUB-TOTAL: WHEAT GRAINS**	**12**	**71**	**727**	**99**	**28**	**159**	**41**	**16**	**32**	**35**	**17**	**39**	**42**	**66**
G	*Hordeum sativum* L. var. *hexastichum* (hulled, twisted)		1	8		4	2	3				1			
	Hordeum sativum L. cf var. *hexastichum* (hulled, cf. twisted)					2				1					
L	*Hordeum sativum* L. indeterminate (hulled, straight)	4	26	7	1	3	6	16	2	1		6		9	5
A	*Hordeum sativum* L. indeterminate (hulled, cf.straight)			24			5				6	8		6	14
E	*Hordeum sativum* L. indeterminate (hulled)	7	60	80	10	29	97	34	9	8	23	18	4	29	55
R	*Hordeum sativum* L. indeterminate (cf. hulled)		11		2									2	
E	*Hordeum sativum* L. *hexastichum* var. *nudum* (naked)									4			1		
C	*Hordeum sativum* L. cf. *hexastichum* var. *nudum* (cf. naked)		1											1	4
	SUB-TOTAL: BARLEY GRAINS	**11**	**99**	**119**	**13**	**38**	**110**	**53**	**11**	**14**	**29**	**33**	**5**	**47**	**78**
	Triticum / *Hordeum* sp.	2	7	42	11				4					6	12
	Sorghum bicolor L.														
	TOTAL: CEREAL GRAINS	**25**	**177**	**888**	**123**	**66**	**269**	**94**	**31**	**46**	**64**	**50**	**44**	**95**	**156**
	Triticum monococcum L. glume base														
	Triticum dicoccum (Shrank.) Schubl. glume base									2					
	Triticum monococcum L. / *dicoccum* (Shrank) Schubl. glume base							2		1					
	SUB-TOTAL: WHEAT GLUME BASES	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**3**	**0**	**0**	**0**	**0**	**0**
	Triticum durum Desf. rachis internode	2	6	51		57	12	9	7	47	42	9	87	32	6
F	*Triticum aestuvum* Schiem. rachis internode	2	2	29		10	3	8	1	7	4	2	4	2	2
F	*Triticum durum* Desf. / *aestivum* Schiem. rachis internode			76	3	31	1	19		60	37	37			
A	*Triticum durum* Desf. / *aestivum* Shiem. top of culm			9	1	8	1				2	5		3	2
H	**SUB-TOTAL: WHEAT RACHIS**	**4**	**8**	**165**	**4**	**106**	**17**	**36**	**8**	**114**	**85**	**53**	**91**	**37**	**10**
C	*Hordeum sativum* L. var. *distichum* rachis internode	1			1	7				2					12
	Hordeum sativum L. var. *hexastichum* rachis internode			2		16				4			35		
	Hordeum sativum L. indeterminate rachis internode			9		11					6	1	10		
	SUB-TOTAL: BARLEY RACHIS	**1**	**0**	**11**	**1**	**34**	**0**	**0**	**0**	**6**	**6**	**1**	**45**	**0**	**12**
	Gramineae / Cerealia spp. culm node	7	21	23	7	10	66	40	27	39	31	9	65	26	23
	Gramineae / Cerealia spp. basal culm node	5	5	1		2	21	10	11	26	15	6	26	11	0
	Cicer arietinum L. seed										1				
	Vicia faba L. seed					2		1							1
S	*Vicia ervilia* L. seed		14			1	35	21		2	2	1	2	9	16
R	*Lathyrus sativus* L. seed	2						5	21						
A	*Lathyrus sativus* L. / *Vicia ervilia* L. seed	1					4	1	1						
V	*Lens culinaris* Medik. Seed	1				1	20	5	18	4		3	1	2	10
I	*Pisum sativum* L. seed					1	6	1	1		1	1	1		
T	Leguminoseae spp. Indeterminate seed	1	2				12	3	4				9	3	5
L	**SUB-TOTAL: PULSE SEEDS**	**5**	**16**	**0**	**0**	**5**	**77**	**37**	**45**	**6**	**4**	**5**	**13**	**14**	**32**
U	*Ficus carica* L. seed	4	13	1		8		3		1	4	1		2	1
C	cf. *Ficus carica* L. fruit														
	Prunus domestica L. seed														
R	*Prunus armeniaca* L. seed														
E	*Prunus amygdalus* Batsch. seed			1											
H	*Pistacia atlantica* L. type seed					1									
T	*Pistacia terebinthus* L. type seed														
O	*Olea europaea* L. seed									1	1				
	Vitis vinifera L. seed		1				2	1		8				4	4
	cf. *Vitis vinifera* L. fruit														
	Citrullus vulgaris Schrad. seed														
	cf. *Citrus* sp. peel														
	Phoenix dactylifera L.						1				3				
	SUB-TOTAL: FRUITS AND NUTS SEEDS	**4**	**14**	**2**	**0**	**9**	**3**	**4**	**0**	**10**	**8**	**1**	**0**	**6**	**5**
	Gossypium arboreum / *herbaceum*												2		
	TOTAL: OTHER CUTLIVARS	**9**	**30**	**2**	**0**	**14**	**80**	**41**	**45**	**16**	**12**	**6**	**15**	**20**	**37**
	TOTAL NUMBER OF CULTIVATED ITEMS	**51**	**241**	**1090**	**135**	**232**	**453**	**223**	**122**	**250**	**213**	**125**	**286**	**189**	**238**

Appendix 11: Continued

	CONTEXT NUMBER	803	416	1002	1087	1059	1056	1102	1484	954		1704	1706
	SAMPLE NUMBER	142	150	154	156	164	165	167	171a	172	176	179	182
	Triticum monococcum L.										1		
	Triticum dicoccum (Shrank.) Schubl.	5	2				6	1				2	3
S	*Triticum monococcu*m L. / *dicoccum* L.	3						1		4			1
N	*Triticum dicoccum* L. / *durum* Desf. / *aestivum* Schiem.	1		3	4	9		9	1	6	6		4
I	*Triticum durum* L. / *aestivum* Schiem.	15	24	1	15	28	33	42	12	20	9	43	27
A	*Triticum* sp. indeterminate	2	4		3	6	7	8	7	1		6	2
R	SUB-TOTAL: WHEAT GRAINS	26	30	4	22	43	46	61	20	31	16	51	37
G	*Hordeum sativum* L. var. *hexastichum* (hulled, twisted)			2			2						1
	Hordeum sativum L. cf var. *hexastichum* (hulled, cf. twisted)		1	4						2		1	
L	*Hordeum sativum* L. indeterminate (hulled, straight)	5	2	6		6	3	1		5		3	2
A	*Hordeum sativum* L. indeterminate (hulled, cf.straight)		1	14									1
E	*Hordeum sativum* L. indeterminate (hulled)	17	5	87	14	22	55	12	2	30	10	11	9
R	*Hordeum sativum* L. indeterminate (cf. hulled)											2	
E	*Hordeum sativum* L. *hexastichum* var. *nudum* (naked)			2				5			1		
C	*Hordeum sativum* L. cf. *hexastichum* var. *nudum* (cf. naked)												
	SUB-TOTAL: BARLEY GRAINS	22	9	115	14	28	60	18	2	37	11	17	13
	Triticum / Hordeum sp.		2						4			4	15
	Sorghum bicolor L.								2				
	TOTAL: CEREAL GRAINS	48	41	119	36	71	106	79	28	68	27	72	65
	Triticum monococcum L. glume base												
	Triticum dicoccum (Shrank.) Schubl. glume base												
	Triticum monococcum L. / *dicoccum* (Shrank) Schubl. glume base					1							
	SUB-TOTAL: WHEAT GLUME BASES	0	0	0	0	1	0	0	0	0	0	0	0
	Triticum durum Desf. rachis internode	18	6	64	29	170	56	90	30	63	29	6	6
F	*Triticum aestuvum* Schiem. rachis internode	2	6	12	5	9	21	10	9	9	7	3	5
F	*Triticum durum* Desf. / *aestivum* Schiem. rachis internode	88	2	38	56	35	80	78	33	104	7	1	
A	*Triticum durum* Desf. / *aestivum* Shiem. top of culm	9	2	10	3	18		8	2		5	4	1
H	SUB-TOTAL: WHEAT RACHIS	117	16	124	93	232	157	186	74	176	48	14	12
C	*Hordeum sativum* L. var. *distichum* rachis internode			26		4	29	1		6			
	Hordeum sativum L. var. *hexastichum* rachis internode			16		2	50						
	Hordeum sativum L. indeterminate rachis internode			2	3	2	95	1		14	1		
	SUB-TOTAL: BARLEY RACHIS	0	0	44	3	8	174	2	0	20	1	0	0
	Gramineae / Cerealia spp. culm node	33	63	54	3	70	133	62	31	38	7	17	21
	Gramineae / Cerealia spp. basal culm node	3	7	21	2	4	33	14	18	2	5	5	1
	Cicer arietinum L. seed												
	Vicia faba L. seed			1	1			1					
S	*Vicia ervilia* L. seed	17	4	10	3	14	2	12	1	10	6	5	
R	*Lathyrus sativus* L. seed			1		3		1			1		
A	*Lathyrus sativus* L. / *Vicia ervilia* L. seed	1		2		1				4			
V	*Lens culinaris* Medik. Seed	20	1	18	2	8		4	1	6	8	1	
I	*Pisum sativum* L. seed	1					1	1			3		
T	Leguminoseae spp. Indeterminate seed	11		6		3	4	6	1		2		
L	SUB-TOTAL: PULSE SEEDS	50	5	38	6	29	7	25	3	20	20	6	0
U	*Ficus carica* L. seed		4	4	2	5	50	5	1	8		5	
C	cf. *Ficus carica* L. fruit												
	Prunus domestica L. seed												
R	*Prunus armeniaca* L. seed												
E	*Prunus amygdalus* Batsch. seed												
H	*Pistacia atlantica* L. type seed									1			
T	*Pistacia terebinthus* L. type seed												
O	*Olea europaea* L. seed						3				5		
	Vitis vinifera L. seed		2	1	1		3	1	1		2		
	cf. *Vitis vinifera* L. fruit												
	Citrullus vulgaris Schrad. seed												
	cf. *Citrus* sp. peel						1						
	Phoenix dactylifera L.												
	SUB-TOTAL: FRUITS AND NUTS SEEDS	0	6	5	3	5	57	6	2	9	7	5	0
	Gossypium arboreum / herbaceum						3						
	TOTAL: OTHER CUTLIVARS	50	11	43	9	34	67	31	5	29	27	11	0
	TOTAL NUMBER OF CULTIVATED ITEMS	251	138	405	146	420	670	374	156	333	115	119	99

Appendix 11: Continued

	CONTEXT NUMBER	803	416	1002	1087	1059	1056	1102	1484	954		1704	1706
	SAMPLE NUMBER	142	150	154	156	164	165	167	171a	172	176	179	182
	Triticum monococcum L.										1		
	Triticum dicoccum (Shrank.) Schubl.	5	2				6	1				2	3
S	*Triticum monococcum* L. / *dicoccum* L.	3						1		4			1
N	*Triticum dicoccum* L. / *durum* Desf. / *aestivum* Schiem.	1		3	4	9		9	1	6	6		4
I	*Triticum durum* L. / *aestivum* Schiem.	15	24	1	15	28	33	42	12	20	9	43	27
A	*Triticum* sp. indeterminate	2	4		3	6	7	8	7	1		6	2
R	**SUB-TOTAL: WHEAT GRAINS**	**26**	**30**	**4**	**22**	**43**	**46**	**61**	**20**	**31**	**16**	**51**	**37**
G	*Hordeum sativum* L. var. *hexastichum* (hulled, twisted)			2			2						1
	Hordeum sativum L. cf var. *hexastichum* (hulled, cf. twisted)		1	4						2		1	
L	*Hordeum sativum* L. indeterminate (hulled, straight)	5	2	6		6	3	1		5		3	2
A	*Hordeum sativum* L. indeterminate (hulled, cf.straight)		1	14									1
E	*Hordeum sativum* L. indeterminate (hulled)	17	5	87	14	22	55	12	2	30	10	11	9
R	*Hordeum sativum* L. indeterminate (cf. hulled)											2	
E	*Hordeum sativum* L. *hexastichum* var. *nudum* (naked)			2				5			1		
C	*Hordeum sativum* L. cf. *hexastichum* var. *nudum* (cf. naked)												
	SUB-TOTAL: BARLEY GRAINS	**22**	**9**	**115**	**14**	**28**	**60**	**18**	**2**	**37**	**11**	**17**	**13**
	Triticum / *Hordeum* sp.		2						4			4	15
	Sorghum bicolor L.								2				
	TOTAL: CEREAL GRAINS	**48**	**41**	**119**	**36**	**71**	**106**	**79**	**28**	**68**	**27**	**72**	**65**
	Triticum monococcum L. glume base												
	Triticum dicoccum (Shrank.) Schubl. glume base												
	Triticum monococcum L. / *dicoccum* (Shrank) Schubl. glume base					1							
	SUB-TOTAL: WHEAT GLUME BASES	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	Triticum durum Desf. rachis internode	18	6	64	29	170	56	90	30	63	29	6	6
F	*Triticum aestuvum* Schiem. rachis internode	2	6	12	5	9	21	10	9	9	7	3	5
F	*Triticum durum* Desf. / *aestivum* Schiem. rachis internode	88	2	38	56	35	80	78	33	104	7	1	
A	*Triticum durum* Desf. / *aestivum* Shiem. top of culm	9	2	10	3	18		8	2		5	4	1
H	**SUB-TOTAL: WHEAT RACHIS**	**117**	**16**	**124**	**93**	**232**	**157**	**186**	**74**	**176**	**48**	**14**	**12**
C	*Hordeum sativum* L. var. *distichum* rachis internode			26		4	29	1		6			
	Hordeum sativum L. var. *hexastichum* rachis internode			16		2	50						
	Hordeum sativum L. indeterminate rachis internode			2	3	2	95	1		14	1		
	SUB-TOTAL: BARLEY RACHIS	**0**	**0**	**44**	**3**	**8**	**174**	**2**	**0**	**20**	**1**	**0**	**0**
	Gramineae / Cerealia spp. culm node	33	63	54	3	70	133	62	31	38	7	17	21
	Gramineae / Cerealia spp. basal culm node	3	7	21	2	4	33	14	18	2	5	5	1
	Cicer arietinum L. seed												
	Vicia faba L. seed			1	1			1					
S	*Vicia ervilia* L. seed	17	4	10	3	14	2	12	1	10	6	5	
R	*Lathyrus sativus* L. seed			1		3		1			1		
A	*Lathyrus sativus* L. / *Vicia ervilla* L. seed	1		2		1				4			
V	*Lens culinaris* Medik. Seed	20	1	18	2	8		4	1	6	8	1	
I	*Pisum sativum* L. seed	1					1	1			3		
T	Leguminoseae spp. Indeterminate seed	11		6		3	4	6	1		2		
L	**SUB-TOTAL: PULSE SEEDS**	**50**	**5**	**38**	**6**	**29**	**7**	**25**	**3**	**20**	**20**	**6**	**0**
U	*Ficus carica* L. seed		4	4	2	5	50	5	1	8		5	
C	cf. *Ficus carica* L. fruit												
	Prunus domestica L. seed												
R	*Prunus armeniaca* L. seed												
E	*Prunus amygdalus* Batsch. seed												
H	*Pistacia atlantica* L. type seed									1			
T	*Pistacia terebinthus* L. type seed												
O	*Olea europaea* L. seed						3				5		
	Vitis vinifera L. seed		2	1	1		3	1	1		2		
	cf. *Vitis vinifera* L. fruit												
	Citrullus vulgaris Schrad. seed												
	cf. *Citrus* sp. peel						1						
	Phoenix dactylifera L.												
	SUB-TOTAL: FRUITS AND NUTS SEEDS	**0**	**6**	**5**	**3**	**5**	**57**	**6**	**2**	**9**	**7**	**5**	**0**
	Gossypium arboreum / *herbaceum*						3						
	TOTAL: OTHER CUTLIVARS	**50**	**11**	**43**	**9**	**34**	**67**	**31**	**5**	**29**	**27**	**11**	**0**
	TOTAL NUMBER OF CULTIVATED ITEMS	**251**	**138**	**405**	**146**	**420**	**670**	**374**	**156**	**333**	**115**	**119**	**99**

Appendix 11: Continued

	CONTEXT NUMBER	1711	1120	1197	1194	1204	1203	1244	1246	1250	1251	1254
	SAMPLE NUMBER	183	191	194	195	196	198	199	201	204	205	208
	Triticum monococcum L.					1	16		9			
	Triticum dicoccum (Shrank.) Schubl.	4	3	2	4	6	7		5	1		
S	*Triticum monococcum* L. / *dicoccum* L.		3	2		1						
N	*Triticum dicoccum* L. / *durum* Desf. / *aestivum* Schiem.	7	2	5	1				1			
I	*Triticum durum* L. / *aestivum* Schiem.	28	52	55	49	28	205	27	95	40	19	26
A	*Triticum* sp. indeterminate	2	14	12	9	3	18	1	11	3		2
R	**SUB-TOTAL: WHEAT GRAINS**	**41**	**74**	**76**	**63**	**39**	**246**	**28**	**121**	**44**	**19**	**28**
G	*Hordeum sativum* L. var. *hexastichum* (hulled, twisted)			2			8		2			3
	Hordeum sativum L. cf var. *hexastichum* (hulled, cf. twisted)											
L	*Hordeum sativum* L. indeterminate (hulled, straight)		2	4		5	14	3		1		4
A	*Hordeum sativum* L. indeterminate (hulled, cf.straight)		2						2			5
E	*Hordeum sativum* L. indeterminate (hulled)	6	12	23	17	17	87	4	34	10	4	25
R	*Hordeum sativum* L. indeterminate (cf. hulled)		1	4	1				2			
E	*Hordeum sativum* L. *hexastichum* var. *nudum* (naked)						3					
C	*Hordeum sativum* L. cf. *hexastichum* var. *nudum* (cf. naked)											
	SUB-TOTAL: BARLEY GRAINS	**6**	**17**	**33**	**18**	**22**	**112**	**7**	**40**	**11**	**4**	**37**
	Triticum / *Hordeum* sp.	6	10	16	9	11		3	9	7	4	6
	Sorghum bicolor L.											
	TOTAL: CEREAL GRAINS	**53**	**101**	**125**	**90**	**72**	**358**	**38**	**170**	**62**	**27**	**71**
	Triticum monococcum L. glume base						11		17			
	Triticum dicoccum (Shrank.) Schubl. glume base						9		12			
	Triticum monococcum L. / *dicoccum* (Shrank) Schubl. glume base					2	15		16			
	SUB-TOTAL: WHEAT GLUME BASES	**0**	**0**	**0**	**0**	**2**	**35**	**0**	**45**	**0**	**0**	**0**
	Triticum durum Desf. rachis internode	3	2	9	14	27	101	10	54	3	16	2
F	*Triticum aestuvum* Schiem. rachis Internode		1	2	1	32	53		39	2	14	2
F	*Triticum durum* Desf. / *aestivum* Schiem. rachis internode		2		2	16	50		88	1	4	
A	*Triticum durum* Desf. / *aestivum* Shiem. top of culm			1	3			2	1		5	
H	**SUB-TOTAL: WHEAT RACHIS**	**3**	**5**	**12**	**20**	**75**	**204**	**12**	**182**	**6**	**39**	**4**
C	*Hordeum sativum* L. var. *distichum* rachis internode					8	3		1			
	Hordeum sativum L. var. *hexastichum* rachis internode			6		1	2		4			8
	Hordeum sativum L. indeterminate rachis internode					2	41		2			
	SUB-TOTAL: BARLEY RACHIS	**0**	**0**	**6**	**0**	**11**	**46**	**0**	**7**	**0**	**0**	**8**
	Gramineae / Cerealia spp. culm node	11	20	28	24	45	130	13	123	19	54	12
	Gramineae / Cerealia spp. basal culm node	1	8	11	16	8	33	12	49	8	20	3
	Cicer arietinum L. seed											
	Vicia faba L. seed		1					2				
S	*Vicia ervilia* L. seed		7	6	9		2	9	7	6	10	5
R	*Lathyrus sativus* L. seed			1					2			
A	*Lathyrus sativus* L. / *Vicia ervilia* L. seed				1			2	3			2
V	*Lens culinaris* Modik. Seed		2	5	1	4	4	9	6	2		4
I	*Pisum sativum* L. seed		1				3		8			
T	Leguminoseae spp. Indeterminate seed		3	2	3		3	4	14	3	2	2
L	**SUB-TOTAL: PULSE SEEDS**	**0**	**14**	**14**	**14**	**4**	**12**	**26**	**40**	**11**	**12**	**13**
U	*Ficus carica* L. seed	4	2	3	7		59		66		2	14
C	cf. *Ficus carica* L. fruit											
	Prunus domestica L. seed											
R	*Prunus armeniaca* L. seed											
E	*Prunus amygdalus* Batsch. seed											
H	*Pistacia atlantica* L. type seed								1			
T	*Pistacia terebinthus* L. type seed											
O	*Olea europaea* L. seed											1
	Vitis vinifera L. seed	20	1	1		1	2		2			
	cf. *Vitis vinifera* L. fruit											
	Citrullus vulgaris Schrad. seed											
	cf. *Citrus* sp. peel											
	Phoenix dactylifera L.											
	SUB-TOTAL: FRUITS AND NUTS SEEDS	**24**	**3**	**4**	**7**	**1**	**61**	**0**	**69**	**0**	**2**	**15**
	Gossypium arboreum / *herbaceum*							1	3	3	2	
	TOTAL: OTHER CUTLIVARS	**24**	**17**	**18**	**21**	**5**	**73**	**27**	**112**	**14**	**16**	**28**
	TOTAL NUMBER OF CULTIVATED ITEMS	**92**	**151**	**200**	**171**	**218**	**879**	**102**	**688**	**109**	**156**	**126**

Appendix 11: Continued

	CONTEXT NUMBER	1292	1336	1370	1377	1378	1378	714	784	714	848	846	1256
	SAMPLE NUMBER	211	225	240	245	246	248	249	250	252	255	256	257
	Triticum monococcum L.												
	Triticum dicoccum (Shrank.) Schubl.	1			4	9	1			1	1		
S	*Triticum monococcum* L. / *dicoccum* L.												
N	*Triticum dicoccum* L. / *durum* Desf. / *aestivum* Schiem.	1		2									2
I	*Triticum durum* L. / *aestivum* Schiem.	60	22	50	29	466	110	35	25	104	35	139	27
A	*Triticum* sp. indeterminate	8		5	5	21	10	5	1	12	4	9	2
R	**SUB-TOTAL: WHEAT GRAINS**	**70**	**22**	**57**	**38**	**496**	**121**	**40**	**26**	**117**	**40**	**148**	**31**
G	*Hordeum sativum* L. var. *hexastichum* (hulled, twisted)		1		9	1	1					1	
	Hordeum sativum L. cf var. *hexastichum* (hulled, cf. twisted)		1	1		1			1	2			
L	*Hordeum sativum* L. indeterminate (hulled, straight)		6	6	22	3	3		1	4	2	2	
A	*Hordeum sativum* L. indeterminate (hulled, cf.straight)			7	26	5	8			3	5		
E	*Hordeum sativum* L. indeterminate (hulled)	8	21	25	159	68	72	9	11	12	27	20	11
R	*Hordeum sativum* L. indeterminate (cf. hulled)	3		5	102	28	45			6			
E	*Hordeum sativum* L. *hexastichum* var. *nudum* (naked)				2								
C	*Hordeum sativum* L. cf. *hexastichum* var. *nudum* (cf. naked)				17	6	10						
	SUB-TOTAL: BARLEY GRAINS	**11**	**29**	**44**	**337**	**112**	**139**	**9**	**13**	**27**	**34**	**23**	**11**
	Triticum / *Hordeum* sp.	11	4	5	32	42	26	7	10	21	12	12	6
	Sorghum bicolor L.												
	TOTAL: CEREAL GRAINS	**92**	**55**	**106**	**407**	**650**	**286**	**56**	**49**	**165**	**86**	**183**	**48**
	Triticum monococcum L. glume base												
	Triticum dicoccum (Shrank.) Schubl. glume base												
	Triticum monococcum L. / *dicoccum* (Shrank) Schubl. glume base						1						
	SUB-TOTAL: WHEAT GLUME BASES	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**
	Triticum durum Desf. rachis internode	2	2	2		12	10	39	25	40	33	268	20
F	*Triticum aestuvum* Schiem. rachis internode					3	1	17	12	29	9	95	5
F	*Triticum durum* Desf. / *aestivum* Schiem. rachis internode	1				7	3	28	30	31	37	123	5
A	*Triticum durum* Desf. / *aestivum* Shiem. top of culm					6		2	3	14	6	47	3
H	**SUB-TOTAL: WHEAT RACHIS**	**3**	**2**	**2**	**0**	**28**	**14**	**86**	**70**	**114**	**85**	**533**	**33**
C	*Hordeum sativum* L. var. *distichum* rachis internode										1	5	
	Hordeum sativum L. var. *hexastichum* rachis internode											3	
	Hordeum sativum L. indeterminate rachis internode											1	
	SUB-TOTAL: BARLEY RACHIS	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**9**	**0**
	Gramineae / Cerealia spp. culm node	9	31	8	10	27	19	98	33	84	48	259	45
	Gramineae / Cerealia spp. basal culm node	3	12	2	2	2	5	17	25	21	26	89	14
	Cicer arietinum L. seed												
	Vicia faba L. seed		3		2								
S	*Vicia ervilia* L. seed	1		14	18	10	5	17	2	48	3	25	9
R	*Lathyrus sativus* L. seed			1	4	4	3				1		
A	*Lathyrus sativus* L. / *Vicia ervilia* L. seed			2	4			4		11			
V	*Lens culinaris* Medik. Seed	2	5	10	84	225	193	4	1	16	3	12	2
I	*Pisum sativum* L. seed			3	4	1	1					7	1
T	Leguminoseae spp. Indeterminate seed	3	2		12	2	3	8	3	12	5	6	3
L	**SUB-TOTAL: PULSE SEEDS**	**6**	**10**	**30**	**128**	**242**	**205**	**33**	**6**	**87**	**12**	**50**	**15**
U	*Ficus carica* L. seed		7	4	9		8	11	9	72	14	26	
C	cf. *Ficus carica* L. fruit					1							
	Prunus domestica L. seed												
R	*Prunus armeniaca* L. seed												
E	*Prunus amygdalus* Batsch. seed												
H	*Pistacia atlantica* L. type seed							1					
T	*Pistacia terebinthus* L. type seed												
O	*Olea europaea* L. seed	1		1	2	3	3						
	Vitis vinifera L. seed	1			3	16	33	1		6	1		3
	cf. *Vitis vinifera* L. fruit												
	Citrullus vulgaris Schrad. seed												
	cf. *Citrus* sp. peel												
	Phoenix dactylifera L.												
	SUB-TOTAL: FRUITS AND NUTS SEEDS	**2**	**7**	**5**	**14**	**20**	**44**	**13**	**9**	**78**	**15**	**26**	**3**
	Gossypium arboreum / *herbaceum*											1	
	TOTAL: OTHER CUTLIVARS	**8**	**17**	**35**	**142**	**262**	**249**	**46**	**15**	**165**	**27**	**77**	**18**
	TOTAL NUMBER OF CULTIVATED ITEMS	**115**	**117**	**153**	**561**	**969**	**574**	**303**	**192**	**549**	**273**	**1150**	**158**

Appendix 11: Continued

	CONTEXT NUMBER	1296	1262	1265	1266	1279	1281	1282	1283	1401	1404	1405
	SAMPLE NUMBER	259	260	262	263	265	267	268	269	270	272	273
	Triticum monococcum L.	3	10								7	
	Triticum dicoccum (Shrank.) Schubl.	6	5	1	4					1	4	
S	*Triticum monococcum* L. / *dicoccum* L.	1										
N	*Triticum dicoccum* L. / *durum* Desf. / *aestivum* Schiem.	3							4			6
I	*Triticum durum* L. / *aestivum* Schiem.	27	79	30	172	28	17	14	31	98	182	31
A	*Triticum* sp. indeterminate		9	1	8				4	8	10	2
R	SUB-TOTAL: WHEAT GRAINS	40	103	32	184	28	17	14	39	107	203	39
G	*Hordeum sativum* L. var. *hexastichum* (hulled, twisted)			1	25							
	Hordeum sativum L. cf var. *hexastichum* (hulled, cf. twisted)	1		1								
L	*Hordeum sativum* L. indeterminate (hulled, straight)	2		12	18				2	1		
A	*Hordeum sativum* L. indeterminate (hulled, cf.straight)				6					5		
E	*Hordeum sativum* L. indeterminate (hulled)	8	41	28	69	14	3		15	22	29	9
R	*Hordeum sativum* L. indeterminate (cf. hulled)											
E	*Hordeum sativum* L. *hexastichum* var. *nudum* (naked)		3	2							3	
C	*Hordeum sativum* L. cf. *hexastichum* var. *nudum* (cf. naked)											
	SUB-TOTAL: BARLEY GRAINS	11	44	44	118	14	3	0	17	28	32	9
	Triticum / *Hordeum* sp.	4	21		19	9	9	2	7	17	35	3
	Sorghum bicolor L.					1				2		
	TOTAL: CEREAL GRAINS	55	168	76	321	52	29	16	63	154	270	51
	Triticum monococcum L. glume base		26								15	
	Triticum dicoccum (Shrank.) Schubl. glume base		14								9	
	Triticum monococcum L. / *dicoccum* (Shrank) Schubl. glume base		29	3							12	
	SUB-TOTAL: WHEAT GLUME BASES	0	69	3	0	0	0	0	0	0	36	0
	Triticum durum Desf. rachis internode	17	40	62	14	21	22		8	54	41	7
F	*Triticum aestuvum* Schiem. rachis internode	39	21	4	1	10	16		3	42	40	5
F	*Triticum durum* Desf. / *aestivum* Schiem. rachis internode	31	68	14	7	10	17		4	22	68	2
A	*Triticum durum* Desf. / *aestivum* Shiem. top of culm	4		7	2	2	4		4	8		1
H	SUB-TOTAL: WHEAT RACHIS	91	129	87	24	43	59	0	19	126	149	15
C	*Hordeum sativum* L. var. *distichum* rachis internode		6				1			1	2	
	Hordeum sativum L. var. *hexastichum* rachis internode		1		3					6	4	
	Hordeum sativum L. Indeterminate rachis internode	8	38	3							8	
	SUB-TOTAL: BARLEY RACHIS	8	45	3	3	0	1	0	0	7	14	0
	Gramineae / Cerealia spp. culm node	34	147	39	20	90	32	11	23	182	169	29
	Gramineae / Cerealia spp. basal culm node	8	49	22	12	26	8	5	8	43	43	7
	Cicer arietinum L. seed											
	Vicia faba L. seed				1							
S	*Vicia ervilia* L. seed	1	4	4	21	9	3		5	7	6	5
R	*Lathyrus sativus* L. seed		2								1	
A	*Lathyrus sativus* L. / *Vicia ervilia* L. seed				2			1				
V	*Lens culinaris* Medik. Seed	2	3	18	28	4	3	2	3	1	4	5
I	*Pisum sativum* L. seed		2	3	2						2	1
T	Leguminoseae spp. Indeterminate seed	2	6		3	3	2		3		3	2
L	SUB-TOTAL: PULSE SEEDS	5	17	25	57	16	8	3	11	8	16	13
U	*Ficus carica* L. seed		2	3	48	7	1		7	15	10	2
C	cf. *Ficus carica* L. fruit											
	Prunus domestica L. seed											
R	*Prunus armeniaca* L. seed											
E	*Prunus amygdalus* Batsch. seed											
H	*Pistacia atlantica* L. type seed											
T	*Pistacia terebinthus* L. type seed										1	
O	*Olea europaea* L. seed			1	2							
	Vitis vinifera L. seed		3		70	2			1	2	3	
	cf. *Vitis vinifera* L. fruit											
	Citrullus vulgaris Schrad. seed				1							
	cf. *Citrus* sp. peel											
	Phoenix dactylifera L.											
	SUB-TOTAL: FRUITS AND NUTS SEEDS	0	5	4	121	9	1	0	8	17	14	2
	Gossypium arboreum / *herbaceum*				6	7			2	42		3
	TOTAL: OTHER CUTLIVARS	5	22	29	184	32	9	3	21	67	30	18
	TOTAL NUMBER OF CULTIVATED ITEMS	201	629	259	564	243	138	35	134	579	711	120

Appendix 11: Continued

	CONTEXT NUMBER	1406	1409	852	855	1121	857	871	1136	1221	873	875	878	1426
	SAMPLE NUMBER	274	277	280	282	283	284	285	287	290	291	292	294	330
	Triticum monococcum L.								2		1			
	Triticum dicoccum (Shrank.) Schubl.		3	2				2	2				1	
S	*Triticum monococcu* m L. / *dicoccum* L.		2											
N	*Triticum dicoccum* L. / *durum* Desf. / *aestivum* Schiem.		2				2							
I	*Triticum durum* L. / *aestivum* Schiem.	73	22	52	57	6	23	124	10	16	40	91	25	41
A	*Triticum* sp. Indeterminate	5		6	4			12			7	8	4	5
R	**SUB-TOTAL: WHEAT GRAINS**	**78**	**29**	**60**	**61**	**6**	**25**	**138**	**14**	**16**	**48**	**99**	**30**	**46**
G	*Hordeum sativum* L. var. *hexastichum* (hulled, twisted)				2	2								
	Hordeum sativum L. cf var. *hexastichum* (hulled, cf. twisted)											3	4	1
L	*Hordeum sativum* L. indeterminate (hulled, straight)	1	2	6	1	3		5				4	3	4
A	*Hordeum sativum* L. indeterminate (hulled, cf.straight)	5			2			12					1	2
E	*Hordeum sativum* L. Indeterminate (hulled)	36	17	15	11	9	12	28	2		14	30	12	26
R	*Hordeum sativum* L. indeterminate (cf. hulled)													
E	*Hordeum sativum* L. *hexastichum* var. *nudum* (naked)										1			
C	*Hordeum sativum* L. cf. *hexastichum* var. *nudum* (cf. naked)													
	SUB-TOTAL: BARLEY GRAINS	**42**	**19**	**21**	**16**	**14**	**12**	**45**	**2**	**0**	**15**	**37**	**20**	**33**
	Triticum / *Hordeum* sp.	8	5	12	10	3	5	18	3	11	9	29	6	11
	Sorghum bicolor L.												1	
	TOTAL: CEREAL GRAINS	**128**	**53**	**93**	**87**	**23**	**42**	**201**	**19**	**27**	**72**	**165**	**57**	**90**
	Triticum monococcum L. glume base													
	Triticum dicoccum (Shrank.) Schubl. glume base													
	Triticum monococcum L. / *dicoccum* (Shrank) Schubl. glume base													
	SUB-TOTAL: WHEAT GLUME BASES	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	Triticum durum Desf. rachis internode	4	4	51	115	16	22	89	21	18	62	51	54	53
F	*Triticum aestuvum* Schiem. rachis internode	4	2	33	28	14	3	15	20	27	35	29	36	37
F	*Triticum durum* Desf. / *aestivum* Schiem. rachis internode	3	1	84	99	6	10	86	20	15	109	46	58	65
A	*Triticum durum* Desf. / *aestivum* Shiem. top of culm	1	1	7	21		4	14		4	17	14	11	7
H	**SUB-TOTAL: WHEAT RACHIS**	**12**	**8**	**175**	**263**	**36**	**39**	**204**	**61**	**64**	**223**	**140**	**159**	**162**
C	*Hordeum sativum* L. var. *distichum* rachis internode						1						3	8
	Hordeum sativum L. var. *hexastichum* rachis internode		1					4					1	
	Hordeum sativum L. indeterminate rachis internode			1					1					4
	SUB-TOTAL: BARLEY RACHIS	**0**	**1**	**1**	**0**	**0**	**1**	**4**	**1**	**0**	**0**	**0**	**4**	**12**
	Gramineae / Cerealia spp. culm node	48	16	62	50	32	58	95	31	35	144	106	92	61
	Gramineae / Cerealia spp. basal culm node	13	8	29	26	8	9	33	12	12	49	30	26	26
	Cicer arietinum L. seed													
	Vicia faba L. seed	1		1	2			3				1		
S	*Vicia ervilia* L. seed	10	14	18	10	8	6	11	1		8	14	10	6
R	*Lathyrus sativus* L. seed	1				1					2			
A	*Lathyrus sativus* L. / *Vicia ervilia* L. seed			1										
V	*Lens culinaris* Medik. Seed	1	2	4	8		10	8			4	10	7	4
I	*Pisum sativum* L. seed				1		1					1	1	1
T	Leguminoseae spp. Indeterminate seed	2	1	5	3	3	3	5	2	3	4	3	3	4
L	**SUB-TOTAL: PULSE SEEDS**	**15**	**17**	**29**	**24**	**12**	**20**	**27**	**3**	**3**	**18**	**29**	**21**	**15**
U	*Ficus carica* L. seed	8		27	14	6	3	62			18	30	24	5
C	cf. *Ficus carica* L. fruit						1							
	Prunus domestica L. seed													
R	*Prunus armeniaca* L. seed													1
E	*Prunus amygdalus* Batsch. seed													
H	*Pistacia atlantica* L. type seed					1								
T	*Pistacia terebinthus* L. type seed													
O	*Olea europaea* L. seed													
	Vitis vinifera L. seed	1	3		1	2	1	2			1	1		
	cf. *Vitis vinifera* L. fruit				1									
	Citrullus vulgaris Schrad. seed													
	cf. *Citrus* sp. peel													
	Phoenix dactylifera L.													
	SUB-TOTAL: FRUITS AND NUTS SEEDS	**9**	**3**	**27**	**16**	**9**	**5**	**64**	**0**	**0**	**19**	**31**	**24**	**6**
	Gossypium arboreum / *herbaceum*							1						
	TOTAL: OTHER CUTLIVARS	**24**	**20**	**56**	**40**	**21**	**25**	**92**	**3**	**3**	**37**	**60**	**45**	**21**
	TOTAL NUMBER OF CULTIVATED ITEMS	**225**	**106**	**416**	**466**	**120**	**174**	**629**	**127**	**141**	**525**	**501**	**383**	**372**

Appendix 11: Continued

	CONTEXT NUMBER	1445	1444	1451	1453	1454	1511	1511	1558	650	Total No. of
	SAMPLE NUMBER	333	334	339	340	341	357	358	363	xxx	taxa
	Triticum monococcum L.			2				1			76
	Triticum dicoccum (Shrank.) Schubl.		2	6		1					175
S	*Triticum monococcum* L. / *dicoccum* L.			2	7						60
N	*Triticum dicoccum* L. / *durum* Desf. / *aestivum* Schiem.	2	2		3	6			2		169
I	*Triticum durum* L. / *aestivum* Schiem.	19	16	114	39	22	20	14	11	21	4985
A	*Triticum* sp. indeterminate	1	9	7	3	5	2	8	2	2	583
R	SUB-TOTAL: WHEAT GRAINS	22	29	131	52	34	22	23	15	23	6048
G	*Hordeum sativum* L. var. *hexastichum* (hulled, twisted)								1		102
	Hordeum sativum L. cf var. *hexastichum* (hulled, cf. twisted)	1			3		1	2		3	41
L	*Hordeum sativum* L. indeterminate (hulled, straight)			14	5			3	4	6	305
A	*Hordeum sativum* L. indeterminate (hulled, cf.straight)						3			8	196
E	*Hordeum sativum* L. indeterminate (hulled)	7	14	60	23	2	28	18	9	164	2433
R	*Hordeum sativum* L. indeterminate (cf. hulled)	5	2		4	2	3				234
E	*Hordeum sativum* L. *hexastichum* var. *nudum* (naked)				1						31
C	*Hordeum sativum* L. cf. *hexastichum* var. *nudum* (cf. naked)	2									41
	SUB-TOTAL: BARLEY GRAINS	15	16	74	36	4	35	23	14	181	3383
	Triticum / *Hordeum* sp.	8	10	19	9	7	14	12	5		765
	Sorghum bicolor L.			2							21
	TOTAL: CEREAL GRAINS	45	55	226	97	45	71	58	34	204	10217
	Triticum monococcum L. glume base										71
	Triticum dicoccum (Shrank.) Schubl. glume base										47
	Triticum monococcum L. / *dicoccum* (Shrank) Schubl. glume base										85
	SUB-TOTAL: WHEAT GLUME BASES	0	0	0	0	0	0	0	0	0	203
	Triticum durum Desf. rachis internode	5	11	51	10	3	18	15	9	57	2981
F	*Triticum aestuvum* Schiem. rachis internode	1	2	46	6		12	21	4	6	1164
F	*Triticum durum* Desf. / *aestivum* Schiem. rachis internode	1	35	52	39	10	19	20	6	14	2313
A	*Triticum durum* Desf. / *aestivum* Shiem. top of culm		6	15			3	3	1	7	392
H	SUB-TOTAL: WHEAT RACHIS	7	54	164	55	13	52	59	20	84	6850
C	*Hordeum sativum* L. var. *distichum* rachis internode			15				2	4	63	213
	Hordeum sativum L. var. *hexastichum* rachis internode		1								173
	Hordeum sativum L. indeterminate rachis internode			2						33	299
	SUB-TOTAL: BARLEY RACHIS	0	1	17	0	0	0	2	4	96	685
	Gramineae / Cerealia spp. culm node	14	16	159	47	15	32	21	14	80	4628
	Gramineae / Cerealia spp. basal culm node	5	11	58	25	4	7	19	7	38	1503
	Cicer arietinum L. seed										1
	Vicia faba L. seed										31
S	*Vicia ervilia* L. seed	2	4	22	2	3	3	2	1	26	741
R	*Lathyrus sativus* L. seed	2		4	2						69
A	*Lathyrus sativus* L. / *Vicia ervilia* L. seed			1						5	65
V	*Lens culinaris* Medik. Seed	12	12	6	1	10	6	4		33	954
I	*Pisum sativum* L. seed			2	2					1	69
T	Leguminoseae spp. Indeterminate seed	5	5	12	6	3	4	3	2	17	322
L	SUB-TOTAL: PULSE SEEDS	21	21	47	13	16	13	9	3	82	2252
U	*Ficus carica* L. seed		13	9	6	2		1	9		880
C	cf. *Ficus carica* L. fruit										2
	Prunus domestica L. seed										1
R	*Prunus armeniaca* L. seed										1
E	*Prunus amygdalus* Batsch. seed	1									2
H	*Pistacia atlantica* L. type seed					1					6
T	*Pistacia terebinthus* L. type seed										1
O	*Olea europaea* L. seed					1			1		26
	Vitis vinifera L. seed			2		9			1	1	246
	cf. *Vitis vinifera* L. fruit										1
	Citrullus vulgaris Schrad. seed										1
	cf. *Citrus* sp. peel										1
	Phoenix dactylifera L.										4
	SUB-TOTAL: FRUITS AND NUTS SEEDS	1	13	11	6	13	0	1	11	1	1172
	Gossypium arboreum / *herbaceum*		2								83
	TOTAL: OTHER CUTLIVARS	22	36	58	19	29	13	10	14	83	3507
	TOTAL NUMBER OF CULTIVATED ITEMS	93	173	682	243	106	175	169	93	585	27593

Appendix 11: Continued

	CONTEXT NUMBER	No. of samples
	SAMPLE NUMBER	taxa occur in
	Triticum monococcum L.	19
	Triticum dicoccum (Shrank.) Schubl.	44
S	*Triticum monococcum* L. / *dicoccum* L.	16
N	*Triticum dicoccum* L. / *durum* Desf. / *aestivum* Schiem.	39
I	*Triticum durum* L. / *aestivum* Schiem.	95
A	*Triticum* sp. indeterminate	80
R	**SUB-TOTAL: WHEAT GRAINS**	**95**
G	*Hordeum sativum* L. var. *hexastichum* (hulled, twisted)	31
	Hordeum sativum L. cf var. *hexastichum* (hulled, cf. twisted)	24
L	*Hordeum sativum* L. indeterminate (hulled, straight)	59
A	*Hordeum sativum* L. indeterminate (hulled, cf.straight)	30
E	*Hordeum sativum* L. indeterminate (hulled)	93
R	*Hordeum sativum* L. indeterminate (cf. hulled)	20
E	*Hordeum sativum* L. *hexastichum* var. *nudum* (naked)	14
C	*Hordeum sativum* L. cf. *hexastichum* var. *nudum* (cf. naked)	7
	SUB-TOTAL: BARLEY GRAINS	**93**
	Triticum / *Hordeum* sp.	71
	Sorghum bicolor L.	8
	TOTAL: CEREAL GRAINS	**95**
	Triticum monococcum L. glume base	5
	Triticum dicoccum (Shrank.) Schubl. glume base	6
	Triticum monococcum L. / *dicoccum* (Shrank) Schubl. glume base	11
	SUB-TOTAL: WHEAT GLUME BASES	**11**
	Triticum durum Desf. rachis internode	91
F	*Triticum aestuvum* Schiem. rachis internode	86
F	*Triticum durum* Desf. / *aestivum* Schiem. rachis internode	78
A	*Triticum durum* Desf. / *aestivum* Shiem. top of culm	65
H	**SUB-TOTAL: WHEAT RACHIS**	**93**
C	*Hordeum sativum* L. var. *distichum* rachis internode	26
	Hordeum sativum L. var. *hexastichum* rachis internode	23
	Hordeum sativum L. indeterminate rachis internode	25
	SUB-TOTAL: BARLEY RACHIS	**44**
	Gramineae / Cerealia spp. culm node	94
	Gramineae / Cerealia spp. basal culm node	93
	Cicer arietinum L. seed	1
	Vicia faba L. seed	20
S	*Vicia ervilia* L. seed	85
R	*Lathyrus sativus* L. seed	24
A	*Lathyrus sativus* L. / *Vicia ervilia* L. seed	23
V	*Lens culinaris* Medik. Seed	75
I	*Pisum sativum* L. seed	36
T	Leguminoseae spp. Indeterminate seed	74
L	**SUB-TOTAL: PULSE SEEDS**	**91**
U	*Ficus carica* L. seed	72
C	cf. *Ficus carica* L. fruit	2
	Prunus domestica L. seed	1
R	*Prunus armeniaca* L. seed	1
E	*Prunus amygdalus* Batsch. seed	2
H	*Pistacia atlantica* L. type seed	6
T	*Pistacia terebinthus* L. type seed	1
O	*Olea europaea* L. seed	14
	Vitis vinifera L. seed	52
	cf. *Vitis vinifera* L. fruit	1
	Citrullus vulgaris Schrad. seed	1
	cf. *Citrus* sp. peel	1
	Phoenix dactylifera L.	2
	SUB-TOTAL: FRUITS AND NUTS SEEDS	**81**
	Gossypium arboreum / *herbaceum*	16
	TOTAL: OTHER CUTLIVARS	**93**
	TOTAL NUMBER OF CULTIVATED ITEMS	**100**

Appendix 12: Wild taxa in Khirbet Faris samples

CONTEXT NUMBER:	15	17	19	25	11	20	55	48	48	46	76	54	203	221	67
SAMPLE NUMBER:	9	10 + 13	15	17	18+22	23	24	25	26	30	31	32	34	35	35a
Urtica urens L. type															
Urtica cf. *dubia* L. type															
Urtica pilulifera L. type															
Polygonum patulum M.B. type															
Polygonum L. sp.															
Rumex conglomeratus Murr.															
Rumex pulcher L.															
Rumex L. sp. type 1															
Rumex L. sp.															
Aizoon hispanicum L.															
Portulaca oleraceae L.															
Silene vulgaris (Moench) Garke. type							1								
Silene cf. *hussonii* Boiss. type		1		1							3			1	
Silene muscipula L. type		1													
Silene conoidea L. type															
Silene L. sp. type 1								1		1		1			
Silene L. sp.															
Gypsophila arabica Barkoudah / *viscosa* Murr.															
Vaccaria pyramidata Medik													6		
Cerastium dichotomum L.															
Spergula L. sp. type															
Chenopodiaceae spp.											1				
Chenopodium album L.															
Chenopodium murale L.															
Chenopodium L. sp. (kurnels)								1							
Adonis dentata Del.															
Fumaria parviflora Lam.													1		
Capparis L. sp.															
Cruciferae spp. type 1															
Cruciferae spp. type 2							1								
Cruciferae spp. type 3															
Cruciferae spp. type 4															
Cruciferae spp. (pods)															
Octhodium aegypticum (L.) DC.															
Neslia apiculata Fisch.													2		
Sinapis arvensis L.													2		
Reseda lutea L. type				1				1							
Reseda muricata C. Presl. type															
Rosaceae spp.															
Rosa canina L. / *phoenicia* Boiss.															
Sorbus L. sp.							1								
Acacia Mill. / *Prosopis* L. sp.															
Prosopis farcta (Bank & Sol.) Macbride				1											
Papilionaceae spp.							17	2						38	41
Astragalus sp. type 1															1
Astragalus sp. type 2															57
Astragalus sp. type 3									1						12
Astragalus sp. type 4															11
Astragalus sp. type 5									1						
Scorpiurus muricatus L.								4							3
Coronilla scorpiodes (L.) Koch			1	1			3		1	1				2	3
Coronilla L. sp. type 1							1								
Coronilla L. sp. type 2														1	
Hippocrepis L. sp.						1								2	6
Onobrychis caput-galli (L.) Lam. type				1											
Onobrychis Mill. sp. type 1				2	2			1							
Ononis L. sp.															1
Trigonella astroites Fisch. & Meg.														2	72
Trigonella berythea Boiss. & Bl. type				3											
Medicago radiata L.															1
Medicago orbicularis (L.) Bart.															
Medicago orbicularis (L.) Bart. (pod)															1
Medicago scutellata (L.) Mill.				1		1		1							
Medicago rotata Boiss.			3	3			2	3	4	1	2	2		1	2

Appendix 12: Continued

CONTEXT NUMBER:	15	17	19	25	11	20	55	48	48	46	76	54	203	221	67
SAMPLE NUMBER:	9	10 + 13	15	17	18+22	23	24	25	26	30	31	32	34	35	35a
Medicago rotata Boiss. (pod)															1
Medicago minima (L.) Bart.			1	1								1			
Medicago turbinata (L.) All.															
Medicago intertexta (L.) Mill.								1							
Medicago L. sp.															
Erodium L'Her. sp.				3	5	23	15	11	1		53	5			
Linum bienne Mill. type															
Malvaceae spp.															
Malva parviflora L. type (seed + coat)															
Malva L. sp.	2		1				2		1	1	2				2
Thymelaea Mill. sp.															
Torilis Adans sp.															
Bifora testiculata (L.) Spreng.															
cf. *Bifora* Hoffm. sp.								1							
Bupleurum subovatum Link ex Spreng															
Ammi majus L.											1				
Umbelliferae spp. type 1					1						1				
Umbelliferae spp. type 2															
Androsace maxima L.															
Anagallis arvensis L. / *foemina* Mill.						1				1					
Buglossoides arvensis (L.) I.M. Johnston								1							
Buglossoides tenuiflora (L.Fil.) I.M. Johnston															
Arnebia decumbens (Vent.) Coss. & Kral.														1	
cf. *Onosma aleppica* Boiss. type															
Podonosma cf. *galalensis* Shenf. Ex Boiss.type							1		1						
Echium L.sp.															
Alkanna cf. *galilaea* Boiss. type															
Ajuga L. sp.					1										
Teucrium L. sp. type 1															
Teucrium L. sp. type 2															
Ziziphora capitata L.															
Ziziphora tenuior L.															
Hyoscyamus L. sp.															
Solanum L. sp.															
Plantago lagopus L. type								6							
Plantago cf. *chamaepsyllium* Zohary type															
Asperula arvensis L.					2				1	1				2	
Asperula L. sp. type 1									1						1
Galium L. / *Asperula* L. sp.															
Galium L. sp.															
Galium spurium L.				3											
Galium tricornutum Dandy				1						1					
Cephalaria syriaca (L.) Schrad.				2	4			1			5	1			
Compositae spp. type 1				1											
Compositae spp. type 2															
Compositae spp. type 3		1	1		1			2				1			
Chrysanthemum coronarium L.					1										
Calendula L. sp.															1
Onopordum L. sp.															
Centaurea cyanoides Berggren & Wahlenb.															
Centaurea cf. *sinaica* DC. type															
Centaurea hyalolepis Boiss. type					1										
Centaurea cf. *pallescens* Del. type											1			1	2
Centaurea L. sp. type 1															
cf. Liliaceae spp. (tuber)															
Liliaceae spp.															
Ornithogalum L. sp.												1			
Bellevalia Lapeyr. sp.													31		
Gramineae spp. type 1														2	1
Gramineae spp. type 2															
Gramineae spp. Indeterminate	11		19	6		5	13	10	4		14	10			1
Eremopyrum distans Jaub. & Spach. type															
Aegilops L. sp.			2												1
Aegilops L. sp. (glume base)															

Appendix 12: Continued

CONTEXT NUMBER:	15	17	19	25	11	20	55	48	48	46	76	54	203	221	67
SAMPLE NUMBER:	9	10 + 13	15	17	18+22	23	24	25	26	30	31	32	34	35	35a
Hordeum spontaneum C. Koch type															
Hordeum L. sp. (small)											2				2
Hordeum L. sp. (cultivated/wild?)				2				3							
Bromus L. sp. type 1				1		1		2	1	2					
Bromus L. sp. type 2									1		2				3
Bromus L. sp. type 3										1					
Bromus L. sp.									2						
Avena L. sp.									2						1
cf. *Lophochloa* Reichenb. sp.		1	7	1		1								1	
Phalaris L. sp. type 1		1		3	7		9	6	6	4	6	11			9
Phalaris L. sp. type 2	4	1	2	3	4		2		1	3	1				
Phalaris L. sp. type 3				4		1	8			2	2				
Lolium temulentum L. (with ergot)	8	69	27	64	24	6	77	59	37	32	109	40		6	
Lolium persicum Boiss. / *temulentum* L. (without ergot)			3			1	4	1		2	1	1		1	4
Lolium L. sp. type 1								1	1			2			2
Lolium L. sp. type 2	1		2			2	1	1	1		2	4			21
Lolium L. sp. type 3	2					3	8	2	2					1	40
Lolium L. sp.					5							3			
Echinaria capitata (L.) Desf.				1	1							1			
Stipa L. sp.															
Cyperaceae spp. (kernels)															
Carex divulsa Stocks type															
Carex flacca Shreb. type				1											
INDETERMINATE	22	37	8	29	30	3		22	10	5	45	11			53
total number of wild taxon per sample	**50**	**112**	**77**	**140**	**89**	**49**	**166**	**144**	**80**	**58**	**253**	**95**	**42**	**62**	**356**

Appendix 12: Continued

CONTEXT NUMBER:	558	557	48		518	486	632	885	890	942	538	647	803	416	1002
SAMPLE NUMBER:	45	46	51	54	73	82	90	117	120	127	130	131	142	150	154
Urtica urens L. type															
Urtica cf. *dubia* L. type															
Urtica pilulifera L. type								3							
Polygonum patulum M.B. type															
Polygonum L. sp.					1										
Rumex conglomeratus Murr.															
Rumex pulcher L.			2		1					1					
Rumex L. sp. type 1										1					
Rumex L. sp.															
Aizoon hispanicum L.															
Portulaca oleraceae L.															
Silene vulgaris (Moench) Garke. type															
Silene cf. *hussonii* Boiss. type												2		1	
Silene muscipula L. type															
Silene conoidea L. type							1								
Silene L. sp. type 1															1
Silene L. sp.											2				
Gypsophila arabica Barkoudah / *viscosa* Murr.														1	
Vaccaria pyramidata Medik					15										1
Cerastium dichotomum L.															
Spergula L. sp. type															
Chenopodiaceae spp.															
Chenopodium album L.															17
Chenopodium murale L.						2									2
Chenopodium L. sp. (kurnels)						1									
Adonis dentata Del.			1		1										5
Fumaria parviflora Lam.															2
Capparis L. sp.			2								1				
Cruciferae spp. type 1						1									
Cruciferae spp. type 2															
Cruciferae spp. type 3															
Cruciferae spp. type 4															6
Cruciferae spp. (pods)															1
Octhodium aegypticum (L.) DC.				1	1										1
Neslia apiculata Fisch.					5					1					2
Sinapis arvensis L.															
Reseda lutea L. type										1					2
Reseda muricata C. Presl. type															1
Rosaceae spp.															
Rosa canina L. / *phoenicia* Boiss.															
Sorbus L. sp.															
Acacia Mill. / *Prosopis* L. sp.															
Prosopis farcta (Bank & Sol.) Macbride										1					
Papilionaceae spp.			1		52			9	46	2					
Astragalus sp. type 1			8		17			1	10	33					
Astragalus sp. type 2	1		6		20			14	51	23					1
Astragalus sp. type 3			3					9	12	5	1			3	
Astragalus sp. type 4															
Astragalus sp. type 5	1														
Scorpiurus muricatus L.		1	1		4		1	3	21	1				1	
Coronilla scorpiodes (L.) Koch	2				2			4	1	6			1		5
Coronilla L. sp. type 1		1	1		3		1	1	1					1	2
Coronilla L. sp. type 2										3				2	
Hippocrepis L. sp.	1					1								1	2
Onobrychis caput-galli (L.) Lam. type															
Onobrychis Mill. sp. type 1															
Ononis L. sp.					1										6
Trigonella astroites Fisch. & Meg.	1										1	1			2
Trigonella berythea Boiss. & Bl. type															
Medicago radiata L.															
Medicago orbicularis (L.) Bart.															
Medicago orbicularis (L.) Bart. (pod)				1	3										
Medicago scutellata (L.) Mill.															
Medicago rotata Boiss.	2		4		43		7		1	3	1		1	3	7

Appendix 12: Continued

CONTEXT NUMBER:	558	557	48		518	486	632	885	890	942	538	647	803	416	1002
SAMPLE NUMBER:	45	46	51	54	73	82	90	117	120	127	130	131	142	150	154
Medicago rotata Boiss. (pod)															
Medicago minima (L.) Bart.					3		1			11				2	
Medicago turbinata (L.) All.															
Medicago intertexta (L.) Mill.										2					
Medicago L. sp.			1					1							
Erodium L'Her. sp.															
Linum bienne Mill. type															
Malvaceae spp.															8
Malva parviflora L. type (seed + coat)					3		2								2
Malva L. sp.	6		3		42	2	2	1	1	3			1		24
Thymelaea Mill. sp.															
Torilis Adans sp.															
Bifora testiculata (L.) Spreng.															
cf. *Bifora* Hoffm. sp.															
Bupleurum subovatum Link ex Spreng															
Ammi majus L.															
Umbelliferae spp. type 1			1												
Umbelliferae spp. type 2														1	
Androsace maxima L.															
Anagallis arvensis L. / *foemina* Mill.															
Buglossoides arvensis (L.) I.M. Johnston															
Buglossoides tenuiflora (L.Fil.) I.M. Johnston			1		11					3			2		19
Arnebia decumbens (Vent.) Coss. & Kral.							1					2			
cf. *Onosma aleppica* Boiss. type															
Podonosma cf. *galalensis* Shenf. Ex Boiss.type															
Echium L.sp.															3
Alkanna cf. *galilaea* Boiss. type															
Ajuga L. sp.			2							1					
Teucrium L. sp. type 1															
Teucrium L. sp. type 2									1						
Ziziphora capitata L.															
Ziziphora tenuior L.												1			
Hyoscyamus L. sp.												1			
Solanum L. sp.			8												
Plantago lagopus L. type	2			1	1										
Plantago cf. *chamaepsyllium* Zohary type														1	5
Asperula arvensis L.			1	2	1	2					1	1			1
Asperula L. sp. type 1												1			
Galium L. / *Asperula* L. sp.										1					
Galium L. sp.															
Galium spurium L.	1												2		
Galium tricornutum Dandy					1										
Cephalaria syriaca (L.) Schrad.															
Compositae spp. type 1										1				1	
Compositae spp. type 2															
Compositae spp. type 3											1				3
Chrysanthemum coronarium L.	1				23										1
Calendula L. sp.															2
Onopordum L. sp.														1	
Centaurea cyanoides Berggren & Wahlenb.															
Centaurea cf. *sinaica* DC. type															
Centaurea hyalolepis Boiss. type					2										2
Centaurea cf. *pallescens* Del. type															41
Centaurea L. sp. type 1										2					
cf. Liliaceae spp. (tuber)															1
Liliaceae spp.															
Ornithogalum L. sp.			12												
Bellevalia Lapeyr. sp.					17										
Gramineae spp. type 1															
Gramineae spp. type 2			4												
Gramineae spp. indeterminate	23		32	3	17	14	7	12		17	1	3	4	5	22
Eremopyrum distans Jaub. & Spach. type			1												
Aegilops L. sp.				1											
Aegilops L. sp. (glume base)			1	2											

Appendix 12: Continued

CONTEXT NUMBER:	558	557	48		518	486	632	885	890	942	538	647	803	416	1002
SAMPLE NUMBER:	45	46	51	54	73	82	90	117	120	127	130	131	142	150	154
Hordeum spontaneum C. Koch type			2		1				2						
Hordeum L. sp. (small)			10		3	1	1			6					1
Hordeum L. sp. (cultivated/wild?)	3		5			3					7				
Bromus L. sp. type 1			2												1
Bromus L. sp. type 2			2		1										
Bromus L. sp. type 3			8												
Bromus L. sp.								2							2
Avena L. sp.			4								1				2
cf. *Lophochloa* Reichenb. sp.										1					
Phalaris L. sp. type 1	24	2	11			8		1		6	6	2		7	3
Phalaris L. sp. type 2	1	1	3		4	5	2			4	2	3			1
Phalaris L. sp. type 3	6				8	2		1	1		6		7		5
Lolium temulentum L. (with ergot)	2		11	3	9	1	1			26		4	2	16	20
Lolium persicum Boiss. / *temulentum* L. (without ergot)			5		10	1		1		1			4		8
Lolium L. sp. type 1															1
Lolium L. sp. type 2			5			1								4	2
Lolium L. sp. type 3		1	4		2	5		4		10			4		9
Lolium L. sp.						16									3
Echinaria capitata (L.) Desf.			2		2										1
Stipa L. sp.			2												1
Cyperaceae spp. (kernels)						1									
Carex divulsa Stocks type					1										
Carex flacca Shreb. type			1				1								
INDETERMINATE	7		19		29	17	14	8					11	36	42
total number of wild taxon per sample	**84**	**6**	**192**	**14**	**360**	**84**	**42**	**75**	**148**	**176**	**31**	**21**	**39**	**87**	**302**

Appendix 12: Continued

CONTEXT NUMBER:	1087	1059	1056	1102	1484	954		1704	1706	1711	1120	1197
SAMPLE NUMBER:	156	164	165	167	171a	172	176	179	182	183	191	194
Urtica urens L. type												
Urtica cf. *dubia* L. type												
Urtica pilulifera L. type												
Polygonum patulum M.B. type			3									
Polygonum L. sp.												
Rumex conglomeratus Murr.												
Rumex pulcher L.			5									
Rumex L. sp. type 1												
Rumex L. sp.			4									
Aizoon hispanicum L.												
Portulaca oleraceae L.												
Silene vulgaris (Moench) Garke. type												
Silene cf. *hussonii* Boiss. type						2					1	
Silene muscipula L. type			1									3
Silene conoidea L. type												
Silene L. sp. type 1			4		1							
Silene L. sp.						1						
Gypsophila arabica Barkoudah / *viscosa* Murr.												
Vaccaria pyramidata Medik	1		1	1		1						
Cerastium dichotomum L.						1						
Spergula L. sp. type							1					
Chenopodiaceae spp.						1						
Chenopodium album L.												1
Chenopodium murale L.					2				1	1		
Chenopodium L. sp. (kumels)												
Adonis dentata Del.			1									
Fumaria parviflora Lam.		1										
Capparis L. sp.												
Cruciferae spp. type 1												
Cruciferae spp. type 2		1										
Cruciferae spp. type 3												
Cruciferae spp. type 4												
Cruciferae spp. (pods)												
Octhodium aegypticum (L.) DC.		1										
Neslia apiculata Fisch.												
Sinapis arvensis L.												
Reseda lutea L. type												1
Reseda muricata C. Presl. type						1						
Rosaceae spp.												
Rosa canina L. / *phoenicia* Boiss.												
Sorbus L. sp.												
Acacia Mill. / *Prosopis* L. sp.												
Prosopis farcta (Bank & Sol.) Macbride												
Papilionaceae spp.		67	131	12		14						
Astragalus sp. type 1		41	148	38	1	77			1			8
Astragalus sp. type 2		15	289	10		24						4
Astragalus sp. type 3		6	90	2	1	2		1	2	1		2
Astragalus sp. type 4		1	10									1
Astragalus sp. type 5			2									
Scorpiurus muricatus L.	1	2	26	3		5	4			1		3
Coronilla scorpiodes (L.) Koch		9	10	7	7	1					1	
Coronilla L. sp. type 1		1	4	2	2	3		2				
Coronilla L. sp. type 2					1						1	
Hippocrepis L. sp.		1	2		2	1		1		1	1	1
Onobrychis caput-galli (L.) Lam. type												
Onobrychis Mill. sp. type 1												
Ononis L. sp.			5									
Trigonella astroites Fisch. & Meg.			16		1	2			1		2	5
Trigonella berythea Boiss. & Bl. type												
Medicago radiata L.												
Medicago orbicularis (L.) Bart.		1	2	1								
Medicago orbicularis (L.) Bart. (pod)												
Medicago scutellata (L.) Mill.			2									
Medicago rotata Boiss.		6	19	3	8	8				1		6

Appendix 12: Continued

CONTEXT NUMBER:	1087	1059	1056	1102	1484	954		1704	1706	1711	1120	1197
SAMPLE NUMBER:	156	164	165	167	171a	172	176	179	182	183	191	194
Medicago rotata Boiss. (pod)					1							
Medicago minima (L.) Bart.			4		2				1	2		3
Medicago turbinata (L.) All.												
Medicago intertexta (L.) Mill.			12									
Medicago L. sp.				1								
Erodium L'Her. sp.												
Linum bienne Mill. type												
Malvaceae spp.												
Malva parviflora L. type (seed + coat)		2				1						
Malva L. sp.		5	32	2		8				1		
Thymelaea Mill. sp.			2									
Torilis Adans sp.			1									
Bifora testiculata (L.) Spreng.												
cf. *Bifora* Hoffm. sp.												
Bupleurum subovatum Link ex Spreng												
Ammi majus L.						1			1			
Umbelliferae spp. type 1			1									
Umbelliferae spp. type 2												
Androsace maxima L.			1									2
Anagallis arvensis L. / *foemina* Mill.			1		1	2						
Buglossoides arvensis (L.) I.M. Johnston												
Buglossoides tenuiflora (L.Fil.) I.M. Johnston		1	3			3						
Amebia decumbens (Vent.) Coss. & Kral.												
cf. *Onosma aleppica* Boiss. type												
Podonosma cf. *galalensis* Shenf. Ex Boiss.type	1	4		1		1						
Echium L.sp.												
Alkanna cf. *galilaea* Boiss. type												
Ajuga L. sp.			1									
Teucrium L. sp. type 1												
Teucrium L. sp. type 2		1	6									
Ziziphora capitata L.												
Ziziphora tenuior L.										1		
Hyoscyamus L. sp.			1			1				1	1	
Solanum L. sp.												
Plantago lagopus L. type												1
Plantago cf. *chamaepsyllium* Zohary type		2	1			5						
Asperula arvensis L.		2	2	1	2	1	1			1		
Asperula L. sp. type 1			1									
Galium L. / *Asperula* L. sp.		1	1		1			1				2
Galium L. sp.						1						
Galium spurium L.	2		2		1						1	
Galium tricornutum Dandy												
Cephalaria syriaca (L.) Schrad.								1	1			
Compositae spp. type 1		1										
Compositae spp. type 2												
Compositae spp. type 3			6		1			1				
Chrysanthemum coronarium L.		1				4						
Calendula L. sp.												
Onopordum L. sp.												
Centaurea cyanoides Berggren & Wahlenb.						1						
Centaurea cf. *sinaica* DC. type												
Centaurea hyalolepis Boiss. type			2									
Centaurea cf. *pallescens* Del. type			2								1	
Centaurea L. sp. type 1												
cf. Liliaceae spp. (tuber)												
Liliaceae spp.												
Ornithogalum L. sp.			10	3		1						
Bellevalia Lapeyr. sp.												
Gramineae spp. type 1									1			
Gramineae spp. type 2			2									
Gramineae spp. indeterminate		9	51	2	3	10		1	3	6		5
Eremopyrum distans Jaub. & Spach. type			2									
Aegilops L. sp.			3									1
Aegilops L. sp. (glume base)			7									

Appendix 12: Continued

CONTEXT NUMBER:	1087	1059	1056	1102	1484	954		1704	1706	1711	1120	1197
SAMPLE NUMBER:	156	164	165	167	171a	172	176	179	182	183	191	194
Hordeum spontaneum C. Koch type						6						
Hordeum L. sp. (small)		3	12			1						
Hordeum L. sp. (cultivated/wild?)	3		4								1	
Bromus L. sp. type 1			2									
Bromus L. sp. type 2			3									
Bromus L. sp. type 3			18									
Bromus L. sp.		1	8									
Avena L. sp.		1	2	3		3						1
cf. *Lophochloa* Reichenb. sp.					1				1		6	
Phalaris L. sp. type 1		1	54		1	2		2		2	10	9
Phalaris L. sp. type 2		8	6			4		1	1		3	4
Phalaris L. sp. type 3	8	4	16	5	2	2						1
Lolium temulentum L. (with ergot)		15	9	10	4	10		23	17	8	28	8
Lolium persicum Boiss. / *temulentum* L. (without ergot)		1	16			3				1	1	2
Lolium L. sp. type 1			1							1		
Lolium L. sp. type 2		2	31			3		3		3		9
Lolium L. sp. type 3	3	19	97	8		11					4	2
Lolium L. sp.			18			4			2		4	
Echinaria capitata (L.) Desf.			1	2		5				1		
Stipa L. sp.												
Cyperaceae spp. (kernels)												
Carex divulsa Stocks type	1	1										
Carex flacca Shreb. type			2									
INDETERMINATE	4	3	40	18	26	21	6	8	4	11	39	42
total number of wild taxon per sample	**24**	**241**	**1272**	**135**	**72**	**259**	**12**	**45**	**37**	**44**	**105**	**127**

Appendix 12: Continued

CONTEXT NUMBER:	1194	1204	1203	1244	1246	1250	1251	1254	1292	1336	1370	1377
SAMPLE NUMBER:	195	196	198	199	201	204	205	208	211	225	240	245
Urtica urens L. type												
Urtica cf. *dubia* L. type												
Urtica pilulifera L. type												
Polygonum patulum M.B. type												
Polygonum L. sp.												
Rumex conglomeratus Murr.												
Rumex pulcher L.			2				2					
Rumex L. sp. type 1												
Rumex L. sp.												
Alzoon hispanicum L.			1		2							
Portulaca oleraceae L.					2							
Silene vulgaris (Moench) Garke. type					6							
Silene cf. *hussonii* Boiss. type					4			4				
Silene muscipula L. type										1		
Silene conoidea L. type					17							
Silene L. sp. type 1			3									2
Silene L. sp.	1											
Gypsophila arabica Barkoudah / *viscosa* Murr.					4							
Vaccaria pyramidata Medik					11							
Cerastium dichotomum L.			1									
Spergula L. sp. type												
Chenopodiaceae spp.					1							
Chenopodium album L.		1			11							1
Chenopodium murale L.	2				6							3
Chenopodium L. sp. (kurnels)					14						3	2
Adonis dentata Del.										1		
Fumaria parviflora Lam.												1
Capparis L. sp.												
Cruciferae spp. type 1												
Cruciferae spp. type 2												
Cruciferae spp. type 3												
Cruciferae spp. type 4												
Cruciferae spp. (pods)		1	1									
Octhodium aegypticum (L.) DC.												
Neslia apiculata Fisch.												
Sinapis arvensis L.					6							
Reseda lutea L. type					1							
Reseda muricata C. Presl. type												
Rosaceae spp.					1							
Rosa canina L. / *phoenicia* Boiss.												
Sorbus L. sp.												
Acacia Mill. / *Prosopis* L. sp.												
Prosopis farcta (Bank & Sol.) Macbride												
Papilionaceae spp.	9	1	172					19				
Astragalus sp. type 1	1	36	237		31			30				
Astragalus sp. type 2	1	11	76		44			12				
Astragalus sp. type 3	1	6	49		25		1	28				3
Astragalus sp. type 4			24					21				
Astragalus sp. type 5		1										
Scorpiurus muricatus L.	1	5	29		7	2		7	1			9
Coronilla scorpiodes (L.) Koch	1	2	6		4		2	1				
Coronilla L. sp. type 1		1	1		1		1					
Coronilla L. sp. type 2	1						1					
Hippocrepis L. sp.	2	2	3		2							
Onobrychis caput-galli (L.) Lam. type												
Onobrychis Mill. sp. type 1												
Ononis L. sp.		1	3									
Trigonella astroites Fisch. & Meg.	4		8		17			19	2	2		12
Trigonella berythea Boiss. & Bl. type												
Medicago radiata L.					1							
Medicago orbicularis (L.) Bart.			2									
Medicago orbicularis (L.) Bart. (pod)												
Medicago scutellata (L.) Mill.							1					2
Medicago rotata Boiss.		10	16		12	2	5	9				

Appendix 12: Continued

CONTEXT NUMBER:	1194	1204	1203	1244	1246	1250	1251	1254	1292	1336	1370	1377
SAMPLE NUMBER:	195	196	198	199	201	204	205	208	211	225	240	245
Medicago rotata Boiss. (pod)												
Medicago minima (L.) Bart.												
Medicago turbinata (L.) All.			2									
Medicago intertexta (L.) Mill.			6		2	1		4				
Medicago L. sp.												
Erodium L'Her. sp.					3	2						
Linum bienne Mill. type					2							
Malvaceae spp.					1							
Malva parviflora L. type (seed + coat)		1	8									
Malva L. sp.		1	15		2			1		3		4
Thymelaea Mill. sp.					6							
Torilis Adans sp.												
Bifora testiculata (L.) Spreng.												
cf. *Bifora* Hoffm. sp.												
Bupleurum subovatum Link ex Spreng			1									
Ammi majus L.												
Umbelliferae spp. type 1	1											
Umbelliferae spp. type 2												
Androsace maxima L.			1									
Anagallis arvensis L. / *foemina* Mill.	1		6				1			2		
Buglossoides arvensis (L.) I.M. Johnston												
Buglossoides tenuiflora (L.Fil.) I.M. Johnston		1			7							
Amebia decumbens (Vent.) Coss. & Kral.												1
cf. *Onosma aleppica* Boiss. type					1							
Podonosma cf. *galalensis* Shenf. Ex Boiss.type			3		2				2			
Echium L.sp.												
Alkanna cf. *galilaea* Boiss. type								1				2
Ajuga L. sp.												
Teucrium L. sp. type 1					1							
Teucrium L. sp. type 2					4							
Ziziphora capitata L.												
Ziziphora tenuior L.												
Hyoscyamus L. sp.			2		7							
Solanum L. sp.												
Plantago lagopus L. type	2											
Plantago cf. *chamaepsyllium* Zohary type			4					2				
Asperula arvensis L.	2		3	1	3	1				2	2	1
Asperula L. sp. type 1				3	3			1		2		
Galium L. / *Asperula* L. sp.					1					1		
Galium L. sp.					2							
Galium spurium L.				1	5			1		3	2	
Galium tricornutum Dandy												
Cephalaria syriaca (L.) Schrad.												
Compositae spp. type 1												
Compositae spp. type 2												
Compositae spp. type 3			4		5							
Chrysanthemum coronarium L.			1									
Calendula L. sp.												
Onopordum L. sp.											1	
Centaurea cyanoides Berggren & Wahlenb.												
Centaurea cf. *sinaica* DC. type												
Centaurea hyalolepis Boiss. type		1										
Centaurea cf. *pallescens* Del. type												
Centaurea L. sp. type 1												
cf. Liliaceae spp. (tuber)												
Liliaceae spp.					6							
Ornithogalum L. sp.					6							
Bellevalia Lapeyr. sp.												
Gramineae spp. type 1			4					14				
Gramineae spp. type 2												
Gramineae spp. indeterminate	17	4	25		41	1	7	7	4	2		
Eremopyrum distans Jaub. & Spach. type												
Aegilops L. sp.	2						1					
Aegilops L. sp. (glume base)	1											

Appendix 12: Continued

CONTEXT NUMBER:	1194	1204	1203	1244	1246	1250	1251	1254	1292	1336	1370	1377
SAMPLE NUMBER:	195	196	198	199	201	204	205	208	211	225	240	245
Hordeum spontaneum C. Koch type			3									2
Hordeum L. sp. (small)					6			5				
Hordeum L. sp. (cultivated/wild?)		2	1		1			3				8
Bromus L. sp. type 1					1							
Bromus L. sp. type 2								2				
Bromus L. sp. type 3												
Bromus L. sp.			2									
Avena L. sp.	1						1	1				
cf. *Lophochloa* Reichenb. sp.							1		1			
Phalaris L. sp. type 1		1	18		26			6	3	4		2
Phalaris L. sp. type 2	12		19		6		5	2	1			
Phalaris L. sp. type 3			15		7			3			5	
Lolium temulentum L. (with ergot)	8	1	5	22	10	9	18	15	13	15	2	7
Lolium persicum Boiss. / *temulentum* L. (without ergot)	1		4		4			7				
Lolium L. sp. type 1					1							
Lolium L. sp. type 2	5		6		7		1	4				
Lolium L. sp. type 3		4	36		27			9	2			2
Lolium L. sp.												
Echinaria capitata (L.) Desf.		2	1									
Stipa L. sp.			1		1							
Cyperaceae spp. (kernels)												
Carex divulsa Stocks type												
Carex flacca Shreb. type					4							
INDETERMINATE	64	33	11	1	81		4	11	8	20	9	20
total number of wild taxon per sample	**141**	**129**	**841**	**28**	**522**	**18**	**52**	**249**	**37**	**58**	**24**	**84**

Appendix 12: Continued

CONTEXT NUMBER:	1378	1378	714	784	714	848	846	1256	1296	1262	1265	1266	1279
SAMPLE NUMBER:	246	248	249	250	252	255	256	257	259	260	262	263	265
Urtica urens L. type			1	2		7	3				3		
Urtica cf. *dubia* L. type						1	1						
Urtica pilulifera L. type													
Polygonum patulum M.B. type													
Polygonum L. sp.													
Rumex conglomeratus Murr.													
Rumex pulcher L.				1		2	3			2	2		
Rumex L. sp. type 1													
Rumex L. sp.													
Alzoon hispanicum L.													
Portulaca oloraceae L.					1								
Silene vulgaris (Moench) Garke. type				1		4							
Silene cf. *hussonii* Boiss. type		1			2								
Silene muscipula L. type		1		1	1	1				4		2	
Silene conoidea L. type					2					2			
Silene L. sp. type 1				3		2							
Silene L. sp.				1									
Gypsophila arabica Barkoudah / *viscosa* Murr.							2						
Vaccaria pyramidata Medik		1			2					1		11	
Cerastium dichotomum L.						1						1	
Spergula L. sp. type													
Chenopodiaceae spp.													
Chenopodium album L.		1		1	6	2						2	
Chenopodium murale L.						1	2			1			
Chenopodium L. sp. (kumels)				3	1							5	
Adonis dentata Del.				1							1		
Fumaria parviflora Lam.	2	1				1	1			3		2	
Capparis L. sp.													
Cruciferae spp. type 1													
Cruciferae spp. type 2													
Cruciferae spp. type 3													
Cruciferae spp. type 4													
Cruciferae spp. (pods)										1			
Octhodium aegypticum (L.) DC.												1	
Neslia apiculata Fisch.													
Sinapis arvensis L.	2												
Reseda lutea L. type													
Reseda muricata C. Presl. type													
Rosaceae spp.													
Rosa canina L. / *phoenicia* Boiss.													
Sorbus L. sp.													
Acacia Mill. / *Prosopis* L. sp.													
Prosopis farcta (Bank & Sol.) Macbride											1		1
Papilionaceae spp.		1										1	
Astragalus sp. type 1				3	2	2	3			17	5		
Astragalus sp. type 2		2		3	1	18	8			5	3		
Astragalus sp. type 3		1		3	1	21	5			2	3	5	
Astragalus sp. type 4													
Astragalus sp. type 5													
Scorpiurus muricatus L.				4	2	3		7		8		4	1
Coronilla scorpiodes (L.) Koch		1	24	4	39	3	36			7	8		2
Coronilla L. sp. type 1		2	3	1	5	2	14			1			
Coronilla L. sp. type 2		2					4	1					
Hippocrepis L. sp.			1		1		2	1		1		1	
Onobrychis caput-galli (L.) Lam. type													
Onobrychis Mill. sp. type 1												2	
Ononis L. sp.							1			3			
Trigonella astroites Fisch. & Meg.		9	2	1	1	18	5			8			
Trigonella berythea Boiss. & Bl. type													
Medicago radiata L.													
Medicago orbicularis (L.) Bart.												1	
Medicago orbicularis (L.) Bart. (pod)													
Medicago scutellata (L.) Mill.													
Medicago rotata Boiss.	2		14	3	32	9	25			10	9	8	4

Appendix 12: Continued

CONTEXT NUMBER:	1378	1378	714	784	714	848	846	1256	1296	1262	1265	1266	1279
SAMPLE NUMBER:	246	248	249	250	252	255	256	257	259	260	262	263	265
Medicago rotata Boiss. (pod)					1								
Medicago minima (L.) Bart.				1									
Medicago turbinata (L.) All.													
Medicago intertexta (L.) Mill.		1								1			
Medicago L. sp.											1		
Erodium L'Her. sp.				1								38	3
Linum bienne Mill. type													
Malvaceae spp.													
Malva parviflora L. type (seed + coat)					3		1						
Malva L. sp.	1	1	3	4	12	3	9			12	14		
Thymelaea Mill. sp.						3							
Torilis Adans sp.													
Bifora testiculata (L.) Spreng.			1		3								
cf. *Bifora* Hoffm. sp.													1
Bupleurum subovatum Link ex Spreng													
Ammi majus L.				1	1		1						
Umbelliferae spp. type 1					1								
Umbelliferae spp. type 2													
Androsace maxima L.							2						
Anagallis arvensis L. / *foemina* Mill.			1				2						2
Buglossoides arvensis (L.) I.M. Johnston	2	1								1			
Buglossoides tenuiflora (L.Fil.) I.M. Johnston	1									5			
Amebia decumbens (Vent.) Coss. & Kral.	2	2											
cf. *Onosma aleppica* Boiss. type													
Podonosma cf. *galalensis* Shenf. Ex Boiss.type						1	1						
Echium L.sp.													
Alkanna cf. *galilaea* Boiss. type													
Ajuga L. sp.				1	3		1						
Teucrium L. sp. type 1				1	1								
Teucrium L. sp. type 2											2		
Ziziphora capitata L.					1								
Ziziphora tenuior L.								1					1
Hyoscyamus L. sp.						1	8						
Solanum L. sp.													
Plantago lagopus L. type					1								
Plantago cf. *chamaepsyllium* Zohary type		1				2	4						
Asperula arvensis L.	34	60	2	1	2		7			3		11	3
Asperula L. sp. type 1		3	1			1					1	8	
Galium L. / *Asperula* L. sp.	3	5					1					2	
Galium L. sp.													
Galium spurium L.	23	14		1						2		5	1
Galium tricornutum Dandy												23	4
Cephalaria syriaca (L.) Schrad.	3												2
Compositae spp. type 1													
Compositae spp. type 2													
Compositae spp. type 3					3	2	2				1	1	
Chrysanthemum coronarium L.				1								1	
Calendula L. sp.	1												
Onopordum L. sp.					1								
Centaurea cyanoides Berggren & Wahlenb.													
Centaurea cf. *sinaica* DC. type													
Centaurea hyalolepis Boiss. type													
Centaurea cf. *pallescens* Del. type				1	1	3	5			1			
Centaurea L. sp. type 1							2						
cf. Liliaceae spp. (tuber)													
Liliaceae spp.													
Ornithogalum L. sp.	1	1			2	3	2			1	3		
Bellevalia Lapeyr. sp.													
Gramineae spp. type 1							1					2	
Gramineae spp. type 2										4		1	
Gramineae spp. indeterminate	31	14	12	3	19	21	22	14		26		13	8
Eremopyrum distans Jaub. & Spach. type													
Aegilops L. sp.												2	
Aegilops L. sp. (glume base)													

Appendix 12: Continued

CONTEXT NUMBER:	1378	1378	714	784	714	848	846	1256	1296	1262	1265	1266	1279
SAMPLE NUMBER:	246	248	249	250	252	255	256	257	259	260	262	263	265
Hordeum spontaneum C. Koch type	3												
Hordeum L. sp. (small)	1		1		1	6	16			3			
Hordeum L. sp. (cultivated/wild?)	4		9				2					7	
Bromus L. sp. type 1					1		1						
Bromus L. sp. type 2							1						
Bromus L. sp. type 3						1	1						1
Bromus L. sp.						3	2						
Avena L. sp.	1	3				1	1						1
cf. *Lophochloa* Reichenb. sp.		2		2	1	1	1						1
Phalaris L. sp. type 1		6	1	2	15	10	17	4		4	4	2	4
Phalaris L. sp. type 2			2	9	1	1	9			14	5	1	2
Phalaris L. sp. type 3		1	6	2	3	4	9			7	26		
Lolium temulentum L. (with ergot)	31	9	20	4	79	13	86	25		25	4	11	32
Lolium persicum Boiss. / *temulentum* L. (without ergot)	1		4		6		11	1		2			
Lolium L. sp. type 1												1	
Lolium L. sp. type 2			1		9	8				1			
Lolium L. sp. type 3			6	5	9	6	34			20		1	1
Lolium L. sp.							3						
Echinaria capitata (L.) Desf.				1		1	4			5			1
Stipa L. sp.													
Cyperaceae spp. (kernels)													
Carex divulsa Stocks type			1			3						1	
Carex flacca Shreb. type							1						
INDETERMINATE		40	43	45	23	75	28	16		55	9	28	13
total number of wild taxon per sample	**149**	**187**	**159**	**122**	**302**	**271**	**413**	**70**	**0**	**268**	**105**	**205**	**89**

Appendix 12: Continued

CONTEXT NUMBER:	1281	1282	1283	1401	1404	1405	1406	1409	852	855	1121	857	871
SAMPLE NUMBER:	267	268	269	270	272	273	274	277	280	282	283	284	285
Urtica urens L. type									7	1			6
Urtica cf. *dubia* L. type													1
Urtica pilulifera L. type									6	1			
Polygonum patulum M.B. type													
Polygonum L. sp.													
Rumex conglomeratus Murr.													
Rumex pulcher L.				1	2				3	2			4
Rumex L. sp. type 1													
Rumex L. sp.													
Aizoon hispanicum L.													
Portulaca oleraceae L.													
Silene vulgaris (Moench) Garke. type									1				
Silene cf. *hussonii* Boiss. type							1					2	3
Silene muscipula L. type			2	1					1	2			2
Silene conoidea L. type					1				2				
Silene L. sp. type 1			2			1	3			2			1
Silene L. sp.													
Gypsophila arabica Barkoudah / *viscosa* Murr.							1						
Vaccaria pyramidata Medik					2						1	1	1
Cerastium dichotomum L.					2								
Spergula L. sp. type													
Chenopodiaceae spp.													
Chenopodium album L.							4		3				2
Chenopodium murale L.							5		3				4
Chenopodium L. sp. (kernels)			1	1	6		1		3				
Adonis dentata Del.									2				
Fumaria parviflora Lam.					1						1		1
Capparis L. sp.													
Cruciferae spp. type 1													
Cruciferae spp. type 2				1									
Cruciferae spp. type 3													
Cruciferae spp. type 4													
Cruciferae spp. (pods)					1								
Octhodium aegypticum (L.) DC.							1						
Neslia apiculata Fisch.													
Sinapis arvensis L.				1									
Reseda lutea L. type							12						
Reseda muricata C. Presl. type							16						
Rosaceae spp.													
Rosa canina L. / *phoenicia* Boiss.		1		1									
Sorbus L. sp.													
Acacia Mill. / *Prosopis* L. sp.	1												
Prosopis farcta (Bank & Sol.) Macbride													
Papilionaceae spp.			2										
Astragalus sp. type 1					10			1	9	1			6
Astragalus sp. type 2	2				1				6	8	1	1	8
Astragalus sp. type 3			1	2		1			4	2			6
Astragalus sp. type 4						1			1				1
Astragalus sp. type 5													
Scorpiurus muricatus L.		2	2	3	5			5		1		1	1
Coronilla scorpiodes (L.) Koch	2			2	19		1		2	2	11		7
Coronilla L. sp. type 1				3	6				1	1	1		
Coronilla L. sp. type 2						1							
Hippocrepis L. sp.			1					2	1				
Onobrychis caput-galli (L.) Lam. type													
Onobrychis Mill. sp. type 1													
Ononis L. sp.													
Trigonella astroites Fisch. & Meg.			2		1	1			11	10	1		21
Trigonella berythea Boiss. & Bl. type													
Medicago radiata L.													
Medicago orbicularis (L.) Bart.													
Medicago orbicularis (L.) Bart. (pod)													
Medicago scutellata (L.) Mill.													
Medicago rotata Boiss.	4	2	1	38	9	1		1	7	2	1		6

Appendix 12: Continued

CONTEXT NUMBER:	1281	1282	1283	1401	1404	1405	1406	1409	852	855	1121	857	871
SAMPLE NUMBER:	267	268	269	270	272	273	274	277	280	282	283	284	285
Medicago rotata Boiss. (pod)				1					1				
Medicago minima (L.) Bart.			2	2		2		1			1		
Medicago turbinata (L.) All.													
Medicago intertexta (L.) Mill.					1		1			2		1	
Medicago L. sp.				2						1			
Erodium L'Her. sp.				25	1					2			2
Linum bienne Mill. type									1				
Malvaceae spp.													
Malva parviflora L. type (seed + coat)									1		1		
Malva L. sp.		1		1	4		2		6	1	1		5
Thymelaea Mill. sp.													1
Torilis Adans sp.													
Bifora testiculata (L.) Spreng.													
cf. *Bifora* Hoffm. sp.													
Bupleurum subovatum Link ex Spreng													
Ammi majus L.									1				
Umbelliferae spp. type 1				1			1						
Umbelliferae spp. type 2				1									
Androsace maxima L.													
Anagallis arvensis L. / *foemina* Mill.			1	1			3		2				2
Buglossoides arvensis (L.) I.M. Johnston													
Buglossoides tenuiflora (L.Fil.) I.M. Johnston					2				1	1			
Amebia decumbens (Vent.) Coss. & Kral.													
cf. *Onosma aleppica* Boiss. type							3						
Podonosma cf. *galalensis* Shenf. Ex Boiss.type	4	1			16		60						1
Echium L.sp.													
Alkanna cf. *galilaea* Boiss. type	1				2	1	2						
Ajuga L. sp.				1	2		1						
Teucrium L. sp. type 1					3				1	1			4
Teucrium L. sp. type 2					2								
Ziziphora capitata L.													
Ziziphora tenuior L.													
Hyoscyamus L. sp.									1				
Solanum L. sp.													
Plantago lagopus L. type			1	3	2	3	1						1
Plantago cf. *chamaepsyllium* Zohary type				2	1		2		4				1
Asperula arvensis L.			4	30	2	3							2
Asperula L. sp. type 1				1						2		1	1
Galium L. / *Asperula* L. sp.				10									
Galium L. sp.				1									
Galium spurium L.				39			4	1	2	1			
Galium tricornutum Dandy				4		1							
Cephalaria syriaca (L.) Schrad.				2		1							
Compositae spp. type 1													
Compositae spp. type 2											1		
Compositae spp. type 3	1			4					2		2		
Chrysanthemum coronarium L.													1
Calendula L. sp.				4									
Onopordum L. sp.													
Centaurea cyanoides Berggren & Wahlenb.					1								
Centaurea cf. *sinaica* DC. type			1										
Centaurea hyalolepis Boiss. type					3								
Centaurea cf. *pallescens* Del. type		1			4	1	5		4	2		1	1
Centaurea L. sp. type 1													
cf. Liliaceae spp. (tuber)													
Liliaceae spp.													
Ornithogalum L. sp.	4	2			4		3		2				2
Bellevalia Lapeyr. sp.					4								
Gramineae spp. type 1													1
Gramineae spp. type 2										3			
Gramineae spp. indeterminate	1		14	6	27	8	11	6	18	14	6	1	23
Eremopyrum distans Jaub. & Spach. type									4				
Aegilops L. sp.													
Aegilops L. sp. (glume base)													

Appendix 12: Continued

CONTEXT NUMBER:	1281	1282	1283	1401	1404	1405	1406	1409	852	855	1121	857	871
SAMPLE NUMBER:	267	268	269	270	272	273	274	277	280	282	283	284	285
Hordeum spontaneum C. Koch type				1									1
Hordeum L. sp. (small)			2	1	5				18	5	1	1	9
Hordeum L. sp. (cultivated/wild?)			5				3	1					
Bromus L. sp. type 1					2								
Bromus L. sp. type 2					1								
Bromus L. sp. type 3		2							7	1			11
Bromus L. sp.					1				1				2
Avena L. sp.					1		1		3				1
cf. *Lophochloa* Reichenb. sp.			1				2		1	1			
Phalaris L. sp. type 1	1		1		10	1	8		10	2			35
Phalaris L. sp. type 2		1	3	1	6	4	4	1	5	4		2	2
Phalaris L. sp. type 3	1		3	2	4				2	1			3
Lolium temulentum L. (with ergot)	8	2	10	52	63	21	4	14	4	9	12	7	27
Lolium persicum Boiss. / *temulentum* L. (without ergot)				2		1	2	1		3			5
Lolium L. sp. type 1										1		1	2
Lolium L. sp. type 2	2		3		1		8		2	1		3	15
Lolium L. sp. type 3		2		2	25				3	4	1	1	26
Lolium L. sp.													
Echinaria capitata (L.) Desf.				1	1			1	1				
Stipa L. sp.													
Cyperaceae spp. (kernels)			1				1						
Carex divulsa Stocks type										2			1
Carex flacca Shreb. type													1
INDETERMINATE			17	16	41	13	38	3	42	108	15	17	57
total number of wild taxon per sample	**32**	**17**	**83**	**273**	**308**	**66**	**215**	**38**	**223**	**207**	**58**	**41**	**327**

Appendix 12: Continued

CONTEXT NUMBER:	1136	1221	873	875	878	1426	1445	1444	1451	1453	1454	1511	1511
SAMPLE NUMBER:	287	290	291	292	294	330	333	334	339	340	341	357	358
Urtica urens L. type	1									1			1
Urtica cf. *dubia* L. type					1			1					
Urtica pilulifera L. type	1			1					1			3	
Polygonum patulum M.B. type					1								
Polygonum L. sp.													
Rumex conglomeratus Murr.			1										
Rumex pulcher L.					1				1				
Rumex L. sp. type 1									1				
Rumex L. sp.													
Alzoon hispanicum L.													
Portulaca oleraceae L.				1									
Silene vulgaris (Moench) Garke. type				1									
Silene cf. *hussonii* Boiss. type				3		1							
Silene muscipula L. type				1	3	2		1					
Silene conoidea L. type					1								
Silene L. sp. type 1			3	1	4	1		1		1			
Silene L. sp.			1		2	2							
Gypsophila arabica Barkoudah / *viscosa* Murr.									1				
Vaccaria pyramidata Medik									7				
Cerastium dichotomum L.													
Spergula L. sp. type													
Chenopodiaceae spp.													
Chenopodium album L.				1	1				1		1		
Chenopodium murale L.			1		5								
Chenopodium L. sp. (kurnels)				2	4								
Adonis dentata Del.						1							
Fumaria parviflora Lam.			1								1		
Capparis L. sp.													
Cruciferae spp. type 1													
Cruciferae spp. type 2													
Cruciferae spp. type 3													
Cruciferae spp. type 4													
Cruciferae spp. (pods)													
Octhodium aegypticum (L.) DC.													
Neslia apiculata Fisch.							1						
Sinapis arvensis L.													
Reseda lutea L. type					1								
Reseda muricata C. Presl. type				2									
Rosaceae spp.													
Rosa canina L. / *phoenicia* Boiss.													
Sorbus L. sp.													
Acacia Mill. / *Prosopis* L. sp.													
Prosopis farcta (Bank & Sol.) Macbride													
Papilionaceae spp.			1										
Astragalus sp. type 1	8		3		16	6			1	1			2
Astragalus sp. type 2	1	1	2	7	14	9		22	4			1	2
Astragalus sp. type 3			3	3	19			12		3			1
Astragalus sp. type 4									1				
Astragalus sp. type 5													
Scorpiurus muricatus L.	1		4		3	4		6	2	1			1
Coronilla scorpiodes (L.) Koch	1	18	14	6	7	5			1	2			
Coronilla L. sp. type 1			4		3	5		1	2				
Coronilla L. sp. type 2					1				1				
Hippocrepis L. sp.	1		2		1	2		1	1	1		1	1
Onobrychis caput-galli (L.) Lam. type													
Onobrychis Mill. sp. type 1													
Ononis L. sp.				2			2		1	2			
Trigonella astroites Fisch. & Meg.			3	12	11	4		9	5	3	1		4
Trigonella berythea Boiss. & Bl. type													
Medicago radiata L.													
Medicago orbicularis (L.) Bart.			1										
Medicago orbicularis (L.) Bart. (pod)													
Medicago scutellata (L.) Mill.				2									
Medicago rotata Boiss.	6		8	3	8	8		2	8		1	2	3

Appendix 12: Continued

CONTEXT NUMBER:	1136	1221	873	875	878	1426	1445	1444	1451	1453	1454	1511	1511
SAMPLE NUMBER:	287	290	291	292	294	330	333	334	339	340	341	357	358
Medicago rotata Boiss. (pod)												1	
Medicago minima (L.) Bart.					1			2					
Medicago turbinata (L.) All.													
Medicago intertexta (L.) Mill.				2	2	3							
Medicago L. sp.										1			
Erodium L'Her. sp.				1		1							
Linum bienne Mill. type				1									
Malvaceae spp.													
Malva parviflora L. type (seed + coat)									1	1			
Malva L. sp.			2	1	4	9	2		9	9	3	1	2
Thymelaea Mill. sp.													
Torilis Adans sp.													
Bifora testiculata (L.) Spreng.													
cf. *Bifora* Hoffm. sp.													
Bupleurum subovatum Link ex Spreng													
Ammi majus L.			1			1			4				
Umbelliferae spp. type 1					2								
Umbelliferae spp. type 2													
Androsace maxima L.													
Anagallis arvensis L. / *foemina* Mill.				1	1						2		
Buglossoides arvensis (L.) I.M. Johnston													
Buglossoides tenuiflora (L.Fil.) I.M. Johnston						2				1			
Arnebia decumbens (Vent.) Coss. & Kral.													
cf. *Onosma aleppica* Boiss. type													
Podonosma cf. *galalensis* Shenf. Ex Boiss.type	2									1			
Echium L.sp.													
Alkanna cf. *galilaea* Boiss. type													
Ajuga L. sp.										1			
Teucrium L. sp. type 1			1		2					1			
Teucrium L. sp. type 2								1					
Ziziphora capitata L.													
Ziziphora tenuior L.					1								
Hyoscyamus L. sp.				1	2			1		1			
Solanum L. sp.													
Plantago lagopus L. type										1			
Plantago cf. *chamaepsyllium* Zohary type			1	1	10								
Asperula arvensis L.			5	2	1	1			3	9	2		
Asperula L. sp. type 1			3								2		
Galium L. / *Asperula* L. sp.			2			2							
Galium L. sp.													
Galium spurium L.			1	2	2	2		3				1	1
Galium tricornutum Dandy													
Cephalaria syriaca (L.) Schrad.			1										1
Compositae spp. type 1				1									
Compositae spp. type 2													
Compositae spp. type 3									1		1	1	
Chrysanthemum coronarium L.												1	1
Calendula L. sp.													
Onopordum L. sp.				1									
Centaurea cyanoides Berggren & Wahlenb.													
Centaurea cf. *sinaica* DC. type					3	1							
Centaurea hyalolepis Boiss. type			2	1									
Centaurea cf. *pallescens* Del. type				4	2	1				1			
Centaurea L. sp. type 1													
cf. Liliaceae spp. (tuber)													
Liliaceae spp.													
Ornithogalum L. sp.				1	1	1				3			
Bellevalia Lapeyr. sp.													
Gramineae spp. type 1					3								
Gramineae spp. type 2			1										
Gramineae spp. indeterminate			21	20	12	6		6	18	7	5		2
Eremopyrum distans Jaub. & Spach. type													
Aegilops L. sp.													
Aegilops L. sp. (glume base)													

Appendix 12: Continued

CONTEXT NUMBER:	1136	1221	873	875	878	1426	1445	1444	1451	1453	1454	1511	1511
SAMPLE NUMBER:	287	290	291	292	294	330	333	334	339	340	341	357	358
Hordeum spontaneum C. Koch type													
Hordeum L. sp. (small)			5	1	11	4		1	3	1	1		
Hordeum L. sp. (cultivated/wild?)													
Bromus L. sp. type 1			1									1	
Bromus L. sp. type 2					3								
Bromus L. sp. type 3			2	4	2								
Bromus L. sp.			1	2	2								2
Avena L. sp.									1	1			
cf. *Lophochloa* Reichenb. sp.			2			3		1	3	2		1	1
Phalaris L. sp. type 1			3	17	26	14	2	8	20	9	4	1	4
Phalaris L. sp. type 2				3	3	12		3		7	1	1	
Phalaris L. sp. type 3		3	5	4	2	16	1	6	1			1	
Lolium temulentum L. (with ergot)	6	9	20	25	19	8		1	4	7	3	2	
Lolium persicum Boiss. / *temulentum* L. (without ergot)		2	1		3	4				1		2	
Lolium L. sp. type 1			3			2							
Lolium L. sp. type 2			12	2	6	11				3		1	
Lolium L. sp. type 3		4	4	2	4	11		4	6	6		3	1
Lolium L. sp.			8	3	5	2		2	3				
Echinaria capitata (L.) Desf.	2		1	3		5							1
Stipa L. sp.													
Cyperaceae spp. (kernels)										1			
Carex divulsa Stocks type				2					1				
Carex flacca Shreb. type				1							1		
INDETERMINATE		20	99	23	83	23	2	86	26	29	6	3	65
total number of wild taxon per sample	**30**	**57**	**260**	**180**	**325**	**195**	**10**	**181**	**143**	**119**	**35**	**28**	**96**

Appendix 12: Continued

CONTEXT NUMBER:	1558	650	TOTAL No. OF	TOTAL No.
SAMPLE NUMBER:	363	xxx	EACH TAXA	OF SAMPLES
Urtica urens L. type	1		34	12
Urtica cf. *dubia* L. type			5	5
Urtica pilulifera L. type			16	7
Polygonum patulum M.B. type			4	2
Polygonum L. sp.			1	1
Rumex conglomeratus Murr.			1	1
Rumex pulcher L.			37	18
Rumex L. sp. type 1			2	2
Rumex L. sp.			4	1
Aizoon hispanicum L.			3	2
Portulaca oleraceae L.			4	3
Silene vulgaris (Moench) Garke. type			14	6
Silene cf. *hussonii* Boiss. type			33	17
Silene muscipula L. type	2		33	20
Silene conoidea L. type			26	7
Silene L. sp. type 1			39	21
Silene L. sp.			10	7
Gypsophila arabica Barkoudah / *viscosa* Murr.			9	5
Vaccaria pyramidata Medik			64	17
Cerastium dichotomum L.			6	5
Spergula L. sp. type			1	1
Chenopodiaceae spp.			3	3
Chenopodium album L.			56	17
Chenopodium murale L.			41	16
Chenopodium L. sp. (kumels)			48	15
Adonis dentata Del.			14	9
Fumaria parviflora Lam.			20	15
Capparis L. sp.			3	2
Cruciferae spp. type 1			1	1
Cruciferae spp. type 2			3	3
Cruciferae spp. type 3			0	0
Cruciferae spp. type 4			6	1
Cruciferae spp. (pods)			5	5
Octhodium aegypticum (L.) DC.			6	6
Neslia apiculata Fisch.			11	5
Sinapis arvensis L.			11	4
Reseda lutea L. type			20	8
Reseda muricata C. Presl. type			20	4
Rosaceae spp.			1	1
Rosa canina L. / *phoenicia* Boiss.			2	2
Sorbus L. sp.			1	1
Acacia Mill. / *Prosopis* L. sp.			1	1
Prosopis farcta (Bank & Sol.) Macbride			4	4
Papilionaceae spp.			638	21
Astragalus sp. type 1			815	36
Astragalus sp. type 2	7		796	43
Astragalus sp. type 3	4		368	45
Astragalus sp. type 4			72	10
Astragalus sp. type 5			5	4
Scorpiurus muricatus L.		7	224	50
Coronilla scorpiodes (L.) Koch		3	311	52
Coronilla L. sp. type 1			85	36
Coronilla L. sp. type 2			20	13
Hippocrepis L. sp.	1	1	57	39
Onobrychis caput-galli (L.) Lam. type			1	1
Onobrychis Mill. sp. type 1			7	4
Ononis L. sp.			28	12
Trigonella astroites Fisch. & Meg.	4		317	43
Trigonella berythea Boiss. & Bl. type			3	1
Medicago radiata L.			2	2
Medicago orbicularis (L.) Bart.			8	6
Medicago orbicularis (L.) Bart. (pod)			5	3
Medicago scutellata (L.) Mill.			10	7
Medicago rotata Boiss.			437	64

Appendix 12: Continued

CONTEXT NUMBER:	1558	650	TOTAL No. OF	TOTAL No.
SAMPLE NUMBER:	363	xxx	EACH TAXA	OF SAMPLES
Medicago rotata Boiss. (pod)			6	6
Medicago minima (L.) Bart.			44	20
Medicago turbinata (L.) All.			2	1
Medicago intertexta (L.) Mill.			42	16
Medicago L. sp.			8	7
Erodium L'Her. sp.			195	19
Linum bienne Mill. type			4	3
Malvaceae spp.	1		10	3
Malva parviflora L. type (seed + coat)			27	13
Malva L. sp.	1	4	297	57
Thymelaea Mill. sp.			12	4
Torilis Adans sp.			1	1
Bifora testiculata (L.) Spreng.			4	2
cf. *Bifora* Hoffm. sp.			2	2
Bupleurum subovatum Link ex Spreng			1	1
Ammi majus L.			13	10
Umbelliferae spp. type 1			10	9
Umbelliferae spp. type 2			2	2
Androsace maxima L.			6	4
Anagallis arvensis L. / *foemina* Mill.			34	20
Buglossoides arvensis (L.) I.M. Johnston			5	4
Buglossoides tenuiflora (L.Fil.) I.M. Johnston			64	17
Arnebia decumbens (Vent.) Coss. & Kral.			9	6
cf. *Onosma aleppica* Boiss. type			4	2
Podonosma cf. *galalensis* Shenf. Ex Boiss.type			103	18
Echium L.sp.			3	1
Alkanna cf. *galilaea* Boiss. type			9	6
Ajuga L. sp.			15	11
Teucrium L. sp. type 1			16	10
Teucrium L. sp. type 2			17	7
Ziziphora capitata L.			1	1
Ziziphora tenuior L.			5	5
Hyoscyamus L. sp.			29	14
Solanum L. sp.			8	1
Plantago lagopus L. type	1		27	15
Plantago cf. *chamaepsyllium* Zohary type			49	18
Asperula arvensis L.		9	236	48
Asperula L. sp. type 1		3	40	20
Galium L. / *Asperula* L. sp.			34	15
Galium L. sp.			4	3
Galium spurium L.		11	140	31
Galium tricornutum Dandy			35	7
Cephalaria syriaca (L.) Schrad.			25	13
Compositae spp. type 1			5	5
Compositae spp. type 2			1	1
Compositae spp. type 3			48	24
Chrysanthemum coronarium L.			37	12
Calendula L. sp.			8	4
Onopordum L. sp.			4	4
Centaurea cyanoides Berggren & Wahlenb.			2	2
Centaurea cf. *sinaica* DC. type			5	3
Centaurea hyalolepis Boiss. type			14	8
Centaurea cf. *pallescens* Del. type			86	23
Centaurea L. sp. type 1			4	2
cf. Liliaceae spp. (tuber)			1	1
Liliaceae spp.			6	1
Ornithogalum L. sp.			69	23
Bellevalia Lapeyr. sp.			52	3
Gramineae spp. type 1			29	9
Gramineae spp. type 2			15	6
Gramineae spp. indeterminate	4		870	74
Eremopyrum distans Jaub. & Spach. type			7	3
Aegilops L. sp.			13	8
Aegilops L. sp. (glume base)			11	4

Appendix 12: Continued

CONTEXT NUMBER:	1558	650	TOTAL No. OF	TOTAL No.
SAMPLE NUMBER:	363	xxx	EACH TAXA	OF SAMPLES
Hordeum spontaneum C. Koch type			21	9
Hordeum L. sp. (small)			150	35
Hordeum L. sp. (cultivated/wild?)			77	21
Bromus L. sp. type 1			19	14
Bromus L. sp. type 2			19	10
Bromus L. sp. type 3			59	13
Bromus L. sp.			33	15
Avena L. sp.			38	24
cf. *Lophochloa* Reichenb. sp.			48	28
Phalaris L. sp. type 1	6		524	66
Phalaris L. sp. type 2	3		229	60
Phalaris L. sp. type 3	1		235	49
Lolium temulentum L. (with ergot)			1586	82
Lolium persicum Boiss. / *temulentum* L. (without ergot)	2		142	45
Lolium L. sp. type 1			20	14
Lolium L. sp. type 2			210	42
Lolium L. sp. type 3			512	54
Lolium L. sp.			81	15
Echinaria capitata (L.) Desf.		10	58	27
Stipa L. sp.			5	4
Cyperaceae spp. (kernels)			4	4
Carex divulsa Stocks type			14	10
Carex flacca Shreb. type			13	9
INDETERMINATE	46		2195	79
total number of wild taxon per sample	**84**	**48**	**14009**	**100**

Appendix 13: English names of cultivars in the Khirbet Fairs samples

Full Latin Name	Common Name
Triticum monococcum L.	Einkorn (a glume wheat)
Triticum dicoccum (Shrank.) Schubl.	Emmer (a glume wheat)
Triticum durum Desf.	Macaroni wheat (free-threshing)
Triticum aestivum Schiem.	Bread wheat (free-threshing)
Hordeum sativum L. var. *distichum*	Two row hulled barley
Hordeum sativum L. var. *hexastichum*	Six row hulled barley
Hordeum sativum L. indeterminate	Hulled barley (indeterminate between two and six row sub-species)
Hordeum sativum L. *hexastichum* var. *nudum* L.	Six row naked barley
Sorghum bicolor L.	Millet
Cicer arietinum L.	Chickpea
Vicia faba L.	Horse bean
Vicia ervilla L.	Bitter vetch
Lathyrus sativus L.	Grass pea
Lens culinaris Medik.	Lentil
Pisum sativum L.	Common pea
Leguminoseae spp.	Large cultived legumes (species indeterminate)
Ficus carica L.	Fig
Prunus domestica L.	Plum
Prunus armeniaca L.	Apricot
Prunus amygdalus Batsch.	Almond
Pistacia atlantica Desf.	Pistacio type
Pistacia terebinthus L.	Pistacio type
Olea europaea L.	Olive
Vitis vinifera L.	Grape
Citrullus vulgaris Schrad.	Watermelon
Citrus L. sp.	A Citrus fruit
Phoenix dactylifera L.	Date

Appendix 14: Changes in crop cultivation at Khirbet Faris fromt he Byzantine to early Ottoman periods

Major Crops	**% of Samples each taxon occurs in for each period**			
	5th - 9th C.	**5th - 13th C.**	**13th C.**	**14th - 17th C.**
Triticum monococcum L. / *dicoccum* L. (grain and chaff)	80	63	46	80
Triticum durum Desf. / *aestivum* Schiem.(grain)	100	100	100	100
Triticum durum Desf. rachis internode	100	95	96	100
Triticum aestivum Schiem. rachis internode	100	89	96	100
Triticum durum Desf. / *aestivum* Schiem. rachis	80	95	75	100
Hordeum sativum L. var. *hexastichum* (twisted grain)	100	26	33	100
Hordeum sativum L. indeterminate (straight and indet. grain)	100	95	100	100
Hordeum sativum L. *hexastichum* var. nudum (grain)	40	21	21	0
Hordeum sativum L. var. *distichum* rachis internode	0	42	21	20
Hordeum sativum L. var. *hexastichum* rachis internode	40	37	29	20
Hordeum sativum L. indeterminate rachis internode	40	42	13	0
Sorghum bicolor L.	0	0	21	20
Vicia faba L. seed	20	16	25	0
Vicia ervilia L. seed	80	84	83	100
Lathyrus sativus L. seed	40	26	17	20
Lens culinaris Medik. Seed	60	74	67	80
Pisum sativum L. seed	40	37	33	20
Ficus carica L. seed	100	68	71	100
Prunus domestica L. seed	0	0	0	20
Prunus amygdalus Batsch. seed	20	0	0	0
Pistacia atlantica L. type seed	0	11	0	0
Pistacia terebinthus L. type seed	0	5	0	0
Olea europaea L. seed	20	5	8	0
Vitis vinifera L. seed	60	42	58	60
Citrullus vulgaris Schrad. seed	0	0	4	0
cf. *Citrus* sp. peel	0	0	4	0
Gossypium arboreum / *herbaceum*	0	26	29	20

Appendix 15: Character of Khirbet Faris samples from the proportions of grians, rachis internodes, and weed seeds; weed categories and other information

		Percentages			Numbers					DA weed Groups		Other Information		
Sample number	Crop group	Gr.	Ra.	Wds	WHEAT		BARLEY		Total items	weed group	probability values	% Culm nodes	Dung	Pasture weeds
					Gr.	Ra.	Gr.	Ra.						
240	1	80	2	19	57	2	44	0	137	4	0.70	10		
245	1	82	0	18	38	0	337	0	472	4	0.48	12		
Group 1 Averages		**81**	**1**	**19**	**48**	**1**	**191**	**0**	**305**			**11**		
45	2	76	16	8	727	165	119	11	1160	3	0.73	24		
55	2	68	6	27	96	8	35	3	244	3	0.56	0		
130	2	57	24	20	42	37	47	0	214	3	0.92	37	x	
131	2	77	12	11	66	10	78	12	250	3	0.67	33		
179	2	54	11	35	51	14	17	0	199	4	0.79	22		
182	2	51	12	37	37	12	13	0	141	4	0.64	22		
183	2	50	3	47	41	3	6	0	106	1	0.64	12		
199	2	61	12	27	28	12	34	0	147	4	0.95	25		
204	2	74	6	19	55	6	18	0	125	4	0.95	27		
211	2	67	2	31	70	3	11	0	133	4	0.81	12		
246	2	77	4	20	496	28	112	0	862	4	0.98	29		
248	2	56	3	40	121	15	139	0	506	4	0.80	28		
263	2	57	5	38	184	24	118	3	636	4	0.80	32		
277	2	51	9	40	29	8	19	1	119	4	0.93	24		
Group 2 Averages		**61**	**11**	**27**	**138**	**29**	**63**	**8**	**359**			**23**		
9	3	46	9	45	30	10	21	0	137	4	0.74	26		
31	3	39	3	58	27	14	146	0	476	4	0.94	31		
34	3	24	2	73	36	13	93	0	557	1	0.78	26		
35	3	38	6	55	18	7	25	0	125	3	0.53	12		
73	3	11	5	84	37	38	53	0	806	3	0.52	50	x	1
82	3	44	5	51	32	8	40	0	172	3	0.79	38		
191	3	45	2	52	74	5	17	0	229	1	0.54	28		
194	3	43	7	50	76	12	33	6	293	3	0.86	39		
195	3	34	8	58	63	20	18	0	281	3	0.86	40		
208	3	20	4	76	28	4	37	8	341	1	0.77	15	x	
225	3	46	2	52	22	2	29	0	124	4	0.74	43	x	
274	3	35	3	62	78	12	42	0	358	4	0.46	61		
1013	3	29	8	63	39	15	13	0	225	4	0.97	46		
1035	3	32	2	67	71	8	99	0	559	3	0.76	26		
Group 3 Averages		**35**	**5**	**59**	**44**	**12**	**45**	**1**	**319**			**34**		
17	4	19	11	71	30	21	7	0	220	4	0.84	22		1
24	4	31	13	56	40	35	51	2	304	4	0.74	10		
25	4	13	23	64	21	52	7	0	290	4	0.86	66		
26	4	29	27	44	32	49	21	0	251	4	0.60	69		
32	4	24	23	53	20	40	22	1	228	4	0.58	50		
120	4	20	21	59	17	53	33	1	267	3	0.96	15		
150	4	27	11	61	30	16	9	0	212	3	0.67	70		
154	4	20	29	51	4	124	115	44	664	1	0.88	75		
159	4	35	19	46	37	24	7	0	160	1	0.66	0		
198	4	15	12	73	246	239	112	46	2559	3	0.89	163		
201	4	10	14	76	121	227	40	7	1828	3	0.90	172	x	
249	4	17	29	54	40	86	9	0	409	2	0.45	115	x	
252	4	26	20	54	117	114	27	0	664	1	0.72	105	x	
255	4	17	20	63	40	85	34	1	505	1	0.63	74		
257	4	29	23	48	31	33	11	0	204	4	0.92	59		
265	4	24	25	51	28	43	14	0	290	4	0.74	116		1
269	4	35	12	53	39	19	17	0	189	1	0.65	31		
270	4	25	25	50	107	126	28	7	765	4	0.82	225		
273	4	37	12	51	39	15	9	0	165	4	0.56	36	x	
285	4	25	29	46	138	204	45	4	846	1	0.83	128		
334	4	16	20	64	29	54	16	1	308	3	0.85	27		
340	4	34	21	45	52	55	36	0	334	1	0.85	72		

		Percentages			Numbers					DA weed Groups		Other Information		
Sample number	Crop group	Gr.	Ra.	Wds	WHEAT		BARLEY		Total items	weed group	probability values	% Culm nodes	Dung	Pasture weeds
					Gr.	Ra.	Gr.	Ra.						
341	4	44	15	41	34	13	4	0	105	1	0.55	19		
363	4	21	18	61	15	20	14	4	156	3	0.82	21		
1822	4	25	18	58	32	27	6	0	166	4	0.80	12		
Group 4 Averages		**24**	**20**	**56**	**54**	**73**	**29**	**5**	**499**			**72**		
15	5	47	30	23	123	98	32	0	532	1	0.89	202	x	
23	5	33	43	24	53	87	13	0	319	4	0.89	117		
30	5	21	50	29	37	98	4	0	270	4	0.67	73		
90	5	22	58	19	34	120	14	6	281	2	0.81	65	x	
112	5	28	50	22	26	114	40	2	268	3	0.83	0		
117	5	28	40	33	35	85	29	6	276	3	0.67	46		
142	5	24	57	19	26	117	22	0	240	3	0.49	36		
156	5	23	62	15	22	93	14	3	161	3	0.90	5		
162	5	24	36	40	25	49	7	0	204	1	0.99	0		
164	5	15	36	49	61	223	38	8	715	3	0.69	74		
167	5	24	44	32	79	182	24	8	493	4	0.49	76	x	
171	5	13	44	43	20	74	2	0	216	1	0.81	49		
205	5	20	34	46	19	39	4	0	188	1	0.54	74	x	
250	5	17	30	53	26	70	13	0	289	1	0.68	58		
256	5	15	48	37	148	533	23	9	1474	1	0.83	348	x	
262	5	28	34	38	32	90	44	3	334	3	0.51	61		1
267	5	18	54	29	17	59	3	1	154	3	0.65	40		1
268	5	16	51	33	14	43	0	0	112	1	0.97	16		
280	5	17	37	46	60	175	21	1	570	1	0.96	91		
282	5	14	48	38	61	263	16	0	622	1	0.94	76		
283	5	18	32	51	6	36	14	0	154	2	0.43	40		
284	5	31	34	35	25	39	12	1	185	3	0.54	67		
291	5	12	41	48	48	223	15	0	739	1	0.92	193		
292	5	30	31	39	99	140	37	0	592	1	0.70	136		
294	5	9	30	60	30	159	20	4	656	1	0.87	118		
330	5	18	39	44	46	162	33	12	535	1	0.85	87		
339	5	39	34	27	131	164	74	17	746	1	0.94	217		
357	5	42	38	20	22	52	35	0	175	1	0.92	39		
358	5	23	30	47	23	59	23	2	243	1	0.96	40		
Group 5 Averages		**23**	**41**	**36**	**46**	**126**	**22**	**3**	**405**			**84**		
51	6	17	35	48	28	106	38	34	410	1	0.99	12	x	
127	6	15	37	48	52	91	5	45	460	1	0.53	91		1
165	6	9	25	67	117	313	74	236	2463	3	0.57	166	x	
172	6	15	39	46	47	192	37	24	598	4	0.52	40		
196	6	22	32	46	39	79	22	11	333	4	0.49	53		
259	6	25	52	23	40	95	11	10	245	3	0.93	42		
260	6	23	36	40	112	198	44	45	863	1	0.82	196		
272	6	26	23	50	203	185	32	24	1107	3	0.69	212		
287	6	15	57	28	14	61	2	1	142	4	0.67	43		
290	6	13	47	40	17	66	2	2	191	3	0.56	47		
1000	6	47	42	11	23	84	181	96	550	4	0.67	118		
Group 6 Averages		**18**	**38**	**44**	**67**	**139**	**27**	**43**	**681**			**93**		

key:
x = present, Gr = grains, Ra = rachis internodes, Wds = weeds, DA = discriminant analysis

Appendix 16: Weed seed categories for the Khirbet Faris wild taxa

Wild Taxon	Codes	Categories
Adonis dentata Del.	ADONDEN	BFH
Aegilops L. sp.	AEGILSP	BHH
Aizoon hispanicum L.	AIZOHIS	SFL
Ajuga L. sp.	AJUGSPP	BFH
Alkanna galilaea Boiss.	ALKAGAL	BFH
Ammi maju s L.	AMMIMAJ	SFH
Anagallis arvensi s L. / *foemina* Mill.	ANAGSPP	SFH
Androsace maxima L.	ANDRMAX	SFH
Amebia decumbens (Vent.) Coss. & Kral.	ARNEDEC	BFH
Asperula arvensis L.	ASPEARV	BFH
Asperula L. sp.	ASPESP1	SFH
Astragalus L. sp.	ASTRAG1	BFH
Astragalus L. sp.	ASTRAG2	SFH
Astragalus L. sp.	ASTRAG3	SFH
Astragalus L. sp.	ASTRAG4	SFH
Astragalus L. sp.	ASTRAG5	SFH
Avena L. sp.	AVENSPP	BFH
Bellevalia Lapeyr. sp.	BELLESP	SFH
Bifora testiculata (L.) Spreng.	BIFOTES	BFH
Bromus L. sp.	BROMSP1	SFL
Bromus L. sp.	BROMSP2	SFL
Bromus L. sp.	BROMSP3	SFL
Bromus L. sp.	BROMSPP	SFL
Buglassoides arvensis (L.) I.M.Johnston	BUGLARV	BFH
Buglassoides tenuiflora (L.Fil.) I.M.Johnston	BUGLTEN	BFH
Bupleurum subovatum (Lancifolium) Link ex Spre	BUPLSUB	SHH
Calendula L. sp.	CALESPP	BFH
Capparis L. sp.	CAPPSPP	BHH
Carex divulsa Stocks in With.	CAREDIV	SHH
Carex flacca Shreb.	CAREFLA	SHH
Centaurea cyanoides Berggren & Wahlenb.	CENTCYA	BFH
Centaurea hyalolepis Boiss.	CENTHYA	BFH
Centaurea pallescens Del.	CENTPAL	SFH
Centaurea cf. *sinaica* DC.	CENTSIN	SFH
Centaurea L. sp.	CENTSP1	SFH
Cephalaria syriaca (L.) Schrad.	CEPHSYR	BFH
Cerastium dichotomum L.	CERADIC	SFH
Chenopodium album L.	CHENALB	SFH
Chenopodium murale L.	CHENMUR	SFH
cf. *Onosma aleppica* Boiss.	CHENSPP	BFH
Chrysanthemum coronarium L.	CHRYCOR	BFH
Compositae spp.	COMPSP1	BFH
Compositae spp.	COMPSP2	SFH
Compositae spp.	COMPSP3	SFH
Coronilla scorpiodes (L.) Koch	COROSCO	SHH
Coronilla L. sp.	COROSP1	SHH
Coronilla L. sp.	COROSP2	SHH
Cruciferae spp.	CRUCSP1	BHH
Cruciferae spp.	CRUCSP2	SHL
Cruciferae spp.	CRUCSP3	SHL
Cruciferae spp.	CRUCSP4	SHL
Cruciferae spp. (PODS)	CRUCSPP	BHH
Cyperaceae spp.	CYPESPP	SHH
Echinaria capitata (L.) Desf.	ECHICAP	SFH
Echium L. sp.	ECHISPP	BFH
Eremopyrum distans Jaub. & Spach.	EREMDIS	SFH
Erodium L'Her. sp.	ERODSPP	BHL
Fumaria parviflora Lam.	FUMAPAR	BFH
Galium L. / *Asperula* L. sp.	GAL/ASP	BFH
Galium sp.	GALISPP	BFH
Galium spurium L.	GALISPU	BFH
Galium tricomutum Dandy	GALITRI	BFH
Gramineae spp.	GRAMSP1	SFL
Gramineae spp.	GRAMSP2	SFL

Appendix 16: Continued

Wild Taxon	Codes	Categories
Gramineae spp.	GRAMSPP	BFH
Gypsophila arabica Barkoudah / viscosa Murr.	GYPSOPH	SHH
Hippocrepis L. sp.	HIPPSPP	BHH
Hordeum L. sp.	HORDSP1	BHL
Hordeum L. sp.	HORDSP2	SHL
Hordeum spontaneum C.Koch	HORDSPO	BHL
Hyoscyamus L. sp.	HYSOSPP	SFH
Liliaceae spp.	LILISPP	SFH
Linum bienne Mill.	LINUBIE	SFH
Lolium L. sp.	LOLISP1	SFH
Lolium L. sp.	LOLISP2	SFH
Lolium L. sp.	LOLISP3	SFH
Lolium L. sp.	LOLISPP	SFH
Lolium temulentum L.	LOLITEM	BFH
Lophochloa Reichenb. sp.	LOPHSPP	SFL
Malva parviflora L.	MALVPAR	BHH
Malvaceae spp.	MALVSPP	BHH
Medicago intertexta (L.) Mill.	MEDIINT	BHH
Medicago minima (L.) Bart.	MEDIMIN	SHH
Medicago orbicularis (L.) Bart.	MEDIORB	BHH
Medicago radiata L.	MEDIRAD	BHH
Medicago rotata Boiss.	MEDIROT	SHH
Medicago scutellata (L.) Mill.	MEDISCU	BHH
Medicago L. sp.	MEDISPP	BHH
Medicago turbinata (L.) All.	MEDITUR	BHH
Neslia apiculata Fisch.	NESLAPI	BFH
Octhodium aegypticum (L.) DC.	OCTHAEG	BHH
Onobrychis caput-galli (L.) Lam.	ONOBCAP	BHH
Onobrychis Mill. sp.	ONOBSPP	BHH
Ononis L. sp.	ONONSPP	SFH
Onopordum L. sp.	ONOPSPP	BFH
Ornithogalum L sp.	ORNITSP	SFH
Papilionaceae spp.	PAPISPP	SFH
Phalaris L. sp.	PHALSP1	SFH
Phalaris L. sp.	PHALSP2	SFH
Phalaris L. sp.	PHALSP3	SFH
Plantago chamaepsyllium Zohary	PLANCHA	SFH
Plantago lagopus L.	PLANLAG	SFH
Podonosma cf. *galalensis* Shenf. ex Boiss.	PODOGAL	BFH
Polygonum patulum M.B.	POLYPAT	SFH
Portulaca oleraceae L.	PORTOLE	SFH
Prosopis farcta (Banks et sol.) Macbride	PROSFAR	BHH
Reseda lutea L.	RESELUT	BFH
Reseda muricata C.Presl	RESEMUR	SFH
Rosaceae spp.	ROSASPP	SHH
Rosa canina L. / *phoenicia* Boiss.	ROSCAPH	BHH
Rumex conglomeratus Murr.	RUMECON	SFH
Rumex pulcher L.	RUMEPUL	BFH
Rumex L. sp. (TYPE1)	RUMESP1	BFH
Rumex L. sp. (FRAG'S)	RUMESPP	BFH
Scorpiurus muricatus L.	SCORMUR	BFH
Silene conoidea L.	SILECON	SHH
Silene cf. *hussonii* Boiss.	SILEHUS	SHH
Silene muscipula L.	SILEMUS	SHH
Silene L. sp. (TYPE1)	SILESP1	SHH
Silene L. sp.(FRAG'S)	SILESPP	SHH
Silene vulgaris (Moench) Garcke	SILEVUL	SHH
Sinapis arvensis L.	SINAARV	BFH
Solanum L. sp.	SOLASPP	BHH
Sorbus L. sp.	SORBSPP	BHH
Spergula L. sp.	SPERSPP	BFH
Stipa L. sp.	STIPSPP	SFH
Teucrium L. sp.	TEUCSP1	SFH
Teucrium L. sp.	TEUCSP2	SFH

Appendix 16: Continued

Wild Taxon	Codes	Categories
Thymelaea Mill. sp.	THYMSPP	SHH
Torilis Adans. sp.	TORISPP	SFH
Trigonella astroites Fisch. et Meg.	TRIGAST	SFH
Trigonella berythea Boiss. et Bl.	TRIGBER	BFH
Umbelliferae spp.	UMBESP1	BFH
Umbelliferae spp.	UMBESP2	SFH
Urtica dubia L.	URTIDUB	SFH
Urtica pilulifera L.	URTIPUL	BFH
Urtica urens L.	URTIURE	SFH
Vaccaria pyramidata Medik.	VACCPYR	BFH
Ziziphora capitata L.	ZIZICAP	SFL
Ziziphora tenuior L.	ZIZITEN	SFL

Key:
SFL = small, free, light
SHL = small, headed, heavy
SHH = small, headed, heavy
BHH = big, headed, heavy
SFH = small, free, heavy
BFH = big, free, heavy

Appendix 17: Archaeological variables for those samples from Khirbet Faris that contain >10% seeds of late flowering species

Sample number	Site Area	Context number	Context description	Phase	Sample Group
23	FAR I	20	Surface - earth /clay	13th C.	5
290	FAR I	1221	Midden	5 - 13th C.	6
252	FAR I	714	Oven fill		4
31	FAR I	76	Hearth fill		3
263	FAR Ib	1266	Layer	13th C.	2
283	FAR I	1121			5
249	FAR I	714	Oven fill		4
171a	HOUSE I	1484	Rubble matrix		3
24	FAR I	55	Hearth fill	13th C.	4
204	FAR Ib	1250	Midden	13th C.	2
262	FAR Ib	1265	Surface - earth / clay		5
274	FAR Ib	1406	Oven base	13th C.	3
256	FAR I	846	Surface - gravel		5
270	FAR Ib	1401	Midden	13th C.	4