Anthropogenic changes in the environment of the Near East: the impact of the first farmers

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Summary

Farming developed shortly after the Pleistocene-Holocene transition, c. 10,000 uncalibrated radiocarbon years before present in the Fertile Crescent, a mountaneous arc in the Near East. The environment at that time, reconstructed through palynological research, was dominated by steppe vegetation. The wild ancestors of the crops that still form an important part of our daily diet, were then taken into cultivation, after which they developed domestication traits.

The impact of the scarce first settlers upon their natural environment is not demonstrated by palynology, but this discipline is eminently capable of indicating large-scale changes in climate. The study of botanical macrofossils from archaeological excavations informs us about agriculture and its history and on the further impact of early farming. The example of 'Ain Ghazal, excavated by Köhler and Rollefson, demonstrates that early farmers destroyed a complete ecosystem by over-exploiting their environment.

Introduction

It may be assumed that early farming, starting around 10,000 BP, had some impact upon the environment. The question is how great this impact was, and especially whether the changes which were caused by these early farmers are still detectable after 10,000 years. Immediately following this question, other questions arise that have to be answered first. What did the environment at the time of the first farmers look like? Were there any mechanisms other than farming that had an impact, maybe overriding the impact of the early settlers?

The decision to study the possible impact of the first farmers especially in the Near East requires some explanation. The Near East was chosen because archaeological and paleobiological investigations have revealed that the earliest agriculture on this planet was practised in the foothills of the mountain arc that runs through the Levant from Israel through northwestern Syria, along the south Anatolian Taurus and down again along the Iranian Zagros (fig. 1). The wild ancestors of various crops are found even now in these foothills, which are called the 'Fertile Crescent' because this was the cradle of agriculture. Various crops were found in excavations of early sites in this region and these crops show certain characteristics that point to domestication. This agricultural food production is dated by radiocarbon, beginning, at Tell Aswad for instance, around 9750 BP, soon after the transition of the Pleistocene to the Holocene (Van Zeist and Bakker-Heeres 1979).

The earliest settlements with evidence of food production in the Fertile Crescent are indicated by Gebel (1982) on TAVO map BI 11. Most of the early sites are found at altitudes that are described as foothills, but some occur lower, towards the Syrian plain, at an elevation of 300 m. The vegetation of the landscape where the early farming villages arose has been reconstructed by means of palynology.

The earliest known appearance of farming and farmers took place at a time when the world numbered about 4 million inhabitants (Ponting, 1991). For every living person around 10,000 BP the world now contains 1500 people. The present world population is almost entirely fed by agriculture, whereas 10,000 years ago most of the 4 million people were hunter-gatherers and only a small number initially turned to farming. This reduces the potential impact resulting from the activity of the earliest Neolithic people to a minimum. The traces of this small impact are very likely to remain unnoticed and at any rate will not have caused any global effect.

The paleoenvironment

The Late Quaternary climate change

At the end of the Late Glacial a global change in climate took place as the temperature rose. From ice cores collected in Greenland and the Antarctic and from marine cores taken in the Atlantic Ocean, changes in the value of various indicators have been traced (for instance, δ O18 as an indicator of temperature change, snow accumulation, dust accumulation as an indicator of steppe or ammonia as a measure of the amount of wetlands). The rapid change of these values at the Pleistocene/Holocene transition is particularly striking. The evidence suggests that the global temperature increased from the low Glacial temperatures to the much higher Holocene temperatures within a few decades. For more information the reader is referred to the literature quoted in PAGES (1994).

Calculations of temperature in the polar areas do not necessarily imply that the temperature in the Near East behaved in a parrallel fashion. Yet microchemical investigations on annually laminated cores from Lake Van in eastern Anatolia do suggest that a similar rapid change in environmental conditions occurred in the Near East at the Pleistocene/Holocene transition (Lemcke, 1994).

The early-Holocene environment

A first prerequisite for analysing any early Holocene anthropogenic change in the environment of the Fertile Crescent is to define the basic environment itself. Only after the natural environment has been described can we try to look for early anthropogenic impact.

The reconstruction of the Pleistocene and Holocene landscape is first of all based upon paleobotanical research. In these reconstructions the most important part is played by palynological studies. Macrofossils obtained from excavations, mostly charred seeds but also parts of plants or pieces of wood, are a source of information on agriculture especially, but may give supplementary evidence about general vegetation patterns. We must be well aware that, although vegetation to a large extent defines the visual aspect of the landscape, there are other agents playing an important part in the shaping of past landscapes. Sea-level rise caused losses in habitation when coastal plains, for instance in the Levant or in southern Greece, were flooded. The abiotic factors of soil and climate largely define the presence and type of the vegetation. Geomorphological research, for instance, is necessary to reconstruct the past shape of the landscape and the way this landscape evolved. Since vegetation is largely conditioned by climate, vegetation studies enable us to obtain information on past climate from the subfossil pollen record.

Palynological evidence

The reconstruction of the Quaternary vegetation of the Fertile Crescent is based upon the evidence supplied by pollen cores taken in various parts of the Near East (fig. 1). Five pollen sites in the area concerned have been studied: the Hula marshes in northern Israel (Baruch and Bottema, 1991), the Ghab Valley in northwestern Syria (Niklewski and Van Zeist, 1970; Van Zeist and Woldring, 1980), Lake Van in eastern Anatolia (Van Zeist and Woldring, 1978; Van Zeist and Bottema, 1991; Bottema, 1995), and Lake Zeribar and Lake Mirabad in the Zagros mountains in northwestern Iran (Van Zeist and Bottema, 1977). Many of the other sites shown in the map of figure 1 contribute to our understanding of the past vegetation of the Near Eastern landscape.

Glacial conditions in the Near East had formed a steppe vegetation that included *Artemisia*, Chenopodiaceae, *Ephedra distachya* and various umbelliferous plants, such as *Ferula*. Trees were absent or had found refuge in very small numbers in the mountains in edaphically favourable spots. Still the Fertile Crescent did not act as a homogeneous terrain. This is of course not to be expected, since nowadays the area does not carry a homogeneous vegetation either. One might expect the Crescent to display a climatic development that showed the same trend throughout, in terms of increasing drought or moisture. For the Late Glacial period the pollen evidence indicates that the major part of

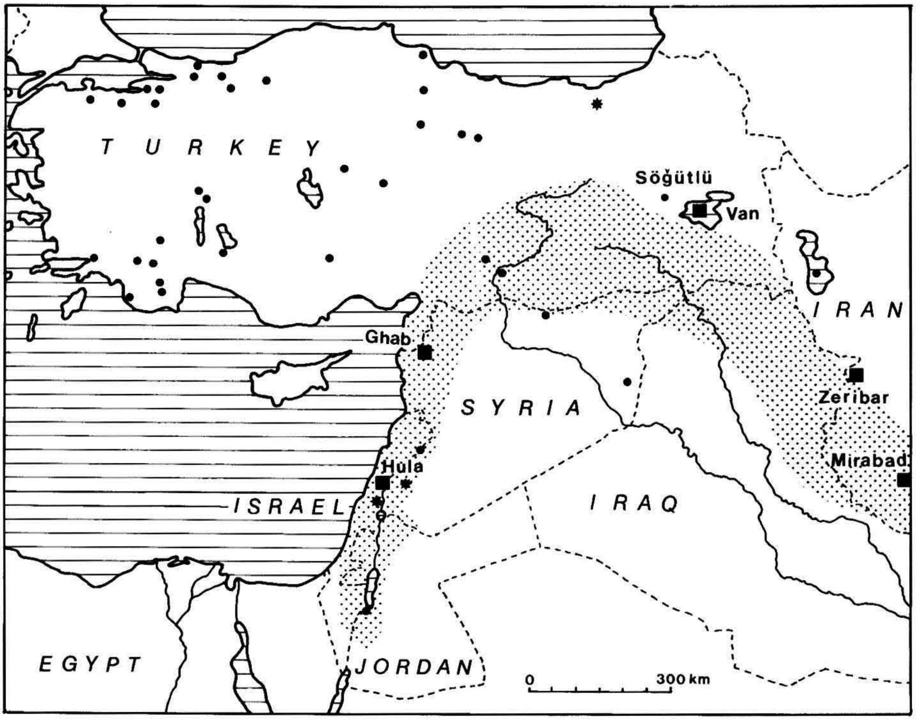

Fig. 1. Map of the Near East indicating the Fertile Crescent and the pollen core locations. The pollen sites used in this study are indicated with a black square.

the Near East was dominated by cold-dry steppe, apart from the Hula marshes in northwestern Israel, which showed a different development (Baruch and Bottema, 1992). On the hills around the Hula Basin a forest steppe had developed around 14,000 BP. From that time on, conditions progressively improved for the development of Tabor oak forest and by 12,000 BP a fairly dense forest was found in northern Israel. Around 11,500 BP conditions in northern Israel suddenly changed, as is deduced from the sharp decrease in deciduous oak pollen. During the Late Glacial other parts of the Fertile Crescent maintained an almost treeless, steppic character. A change from steppe conditions towards forest took place somewhat before the Pleistocene/Holocene transition in northwestern Syria, where the slopes of the Jebel Alaouite were covered with oak, pistachio, cedar and oriental hornbeam (Niklewski and Van Zeist, 1970), at the very time when further south in Israel a strong decrease in tree cover came to an end. In other parts of the Fertile Crescent, treeless vegetations persisted and it would take several millennia before vegetations developed that resembled those present nowadays. In the neighbouring Pisidian Lake district in southwestern Anatolia this occurred after 9000 BP (Van Zeist *et al.*, 1975; Van Zeist and Woldring, 1980), around Lake Van in eastern Anatolia at about 7000 BP (Van Zeist and Bottema, 1991; Bottema, 1995), while near Lake Zeribar Zagros oak forest developed only after 6000 BP (Van Zeist and Bottema, 1977) (fig. 2).

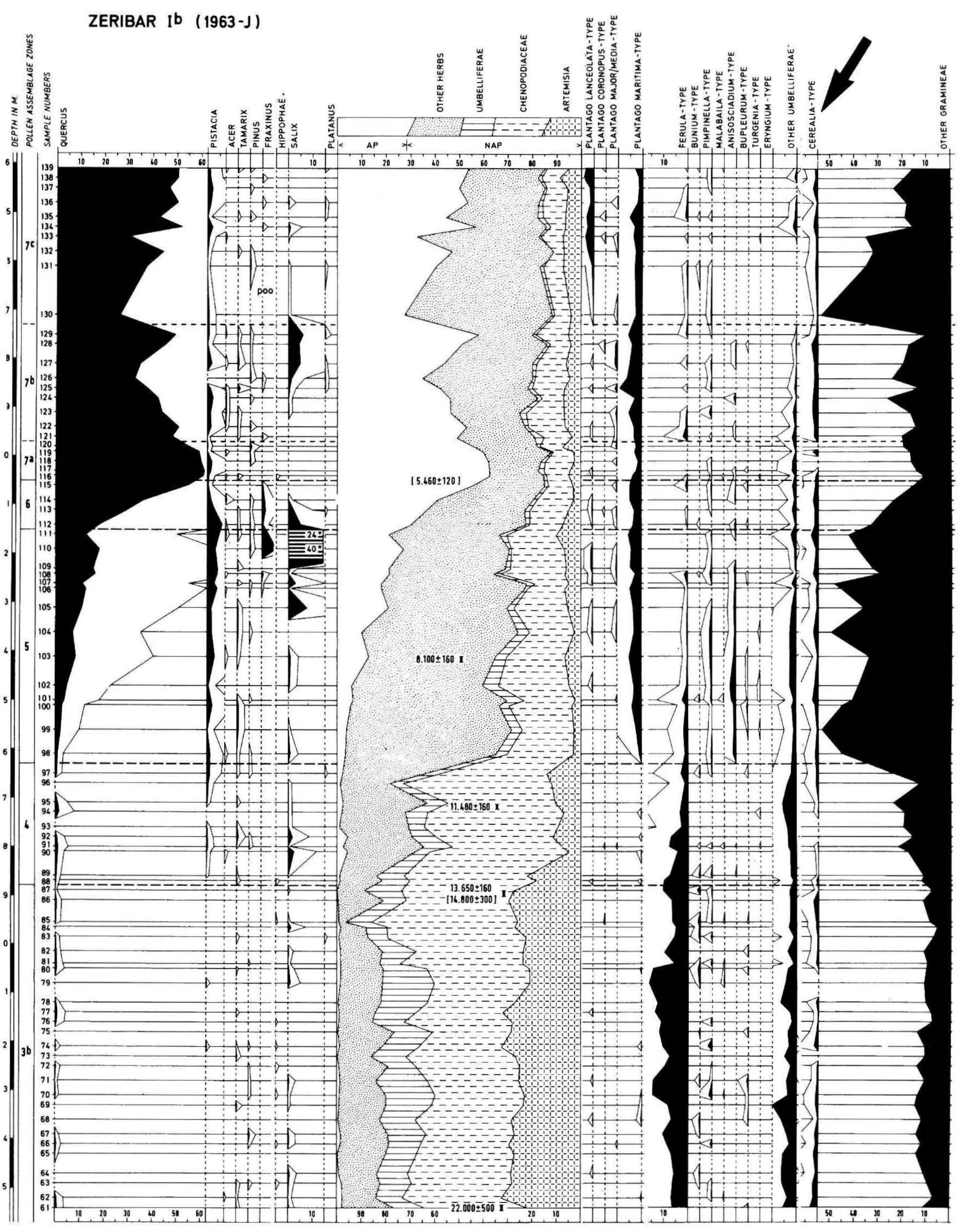

Fig. 2. Pollen diagram of Lake Zeribar showing a Cerealia-type curve for the time before the evolution of agriculture (after Van Zeist and Bottema, 1977).

The potential crop plants

The foregoing presented some aspects of the naturally occurring changes in the vegetation of the Fertile Crescent. For this paper we shall focus upon the beginning of the Holocene when farming started. The main trend in the Near East then was an open steppic landscape, at the lower levels dominated by grass steppe with some *Artemisia* and Chenopodiaceae, whereas in higher parts some forbs, bushes or small trees such as pistachio, almond and hawthorn were found in the grass steppe.

It is this open space which is the natural habitat for a series of fruit- or seed-bearing plants which will have played a role in the life of hunter-gatherers, and which certainly played an important part in early farming because they formed the initial crop plants. It was stated above that the Fertile Crescent witnessed important climatic changes during the transition from Pleistocene to Holocene, which mainly concerned a major rise in temperature. Increasing warmth in a dry system is not exactly the means to stimulate biomass production, and moisture increase sometimes may have taken millennia to become effective but this also meant that profitable plants such as wild einkorn, wild emmer wheat, wild lentil, flax and various peas still did not need to compete with forest. Early farming developed during a time that was warm compared with the preceding Late Glacial and where the landscape was predominantly open. We have no pollen evidence of changes in the amount of wild crops and their distribution as the Late Glacial turned to the Holocene, but the changing climate will certainly have had an influence.

Proof of crops

How can we be sure that the various crop-plant species wheat, barley, lentil and various peas that are found in a carbonized state in excavations, were in fact grown by farmers and not collected from the wild by settled hunters? Soon after prehistoric farmers took the wild plants into cultivation, certain characteristic changes took place that can still be seen in the carbonized remnants. These characteristics are often found as heterozygotic recessive traits in a population and come to the fore when they are – often passively – selected upon. For instance, the ratio of non-brittle to brittle ears of cereals, shifts towards non-brittle ears under influence of the harvest system. A simple act like sowing favours the largest seeds which have less trouble in breaking through the soil than the smaller ones. The presence of various recessive characteristics, which in homozygote form are fatal flaws in the wild plant, in particular explains the rapid change to domesticates. Selection upon mutants would take a much longer time.

The indicative value of palynology

Palynology informs us about the general vegetational and climate history of the Late Quaternary of the Near East. Seeking to reveal the possible impact of the early farmers upon their natural environment we turn again to this obvious method for obtaining botanical evidence. However, pollen diagrams from the Fertile Crescent do not show changes in the early-Holocene pollen assemblages that point to human activity. There are several reasons why palynological methods are not adequate in this case. Firstly, one must realize that the initial steps towards farming were taken by a small group of hunter-gatherers and their impact was unimportant compared with the large stretches of terrain that remained intact. The area of vegetation that had changed under man's influence was very small compared with the amount of untouched vegetation.

But an even more important question is: to what extent do we expect the farmed vegetation to be different from the preceding natural one? The farmers had promoted naturally growing plant species in their own habitat or close to their original habitat. For instance, wild emmer wheat in the Jebel Druz (southwest of Damascus), at present still forms extensive grain fields that much resemble farmed fields (pictorial information: Patty Anderson, Jalès, France). Clearly, a man-made field would not alter the pollen precipitation noticeably, at any rate in the initial stages. This is especially true for the early period when crops had not yet been bred to change from cross-fertilization (through wind-pollination) to self-fertilization and hence poor pollen dispersal. By the end of the tenth millennium, when the first farmers had grown to a larger number of well-established agriculturalists, one might expect a visible change in the pollen precipitation to have taken place. Unfortunately, even then no solid proof of the farming effect in the Fertile Crescent could be shown because of the small share of crop plants in the pollen precipitation. The wheat and barley varieties which were used were naturally selfing plants, einkorn scoring highest with up to 9% cross-fertilization. The large (40–60 μ) pollen grains remained mostly in the bracts and only a very small number ended up in the pollen precipitation (Bottema, 1992). These then need to be separated from the pollen of those wild grasses that had the same pollen type. For this reason pollen diagrams from the Near East always show a category of 'Cerealia-type' that includes pollen of wild and domesticated cereals and some grass species (fig. 2). Henry (1992) suggests that the Late Glacial mobile and settled foragers in the Levant benefited from an increase in wild cereals, which he thought, took place after 13,000 BP. Pollen diagrams of the Fertile Crescent, however, demonstrate that Cerealia-type pollen occurred with about the same values during the last glacial as in the Holocene.

Wild and domesticated lentils, vetches, peas and chick-peas all are leguminous species which are insect-pollinated and under-represented in the pollen precipitation in sediments that mainly receive wind-blown pollen. Identification of these species raises problems, since some of them can only be ascribed to the level of the genus or higher and thus cannot be attributed to a specific crop. One may wonder to what extent pollen analysis does contribute to the demonstration of human impact upon the vegetation. One has to realize that most agriculture, after it spread from the original locus in the Fertile Crescent to other parts of Asia and to Europe, took place in areas where the wild ancestors of the crops were lacking and, even more important, where forest formed the natural vegetation. The beginning of agriculture in such regions further away from the original source resulted in far-reaching vegetation changes, including the destruction of the original vegetation, in most cases forest, and the introduction of a series of crops, new plant species (albeit often hardly detectable palynologically), as well as accompanying species that became known as weeds and secondary vegetation that appeared after fields were laid fallow or abandoned.

In those parts where the natural vegetation was forest, agricultural activity is palynologically far more demonstrable than in the Fertile Crescent itself. But the first signs in pollen diagrams even from forested areas, for instance Anatolia, are visible only from about 4000 BP (Bottema and Woldring, 1986; Bottema *et al.*, 1995). The part of the pollen assemblage indicative of vegetation changes caused by human activity, starting in the late third millennium, seems more to be the effect of grazing by herds of domestic animals than the effect of crop cultivation. The effect of herding reaches far beyond the direct settlement activity. Especially after disturbance of the natural vegetation through *transhumance* (seasonal migration of herds and herdsmen, see among others Reinders, 1994), the replacement of the original vegetation by weeds and secondary vegetation must have played an important role in the pollen rain.

Impact demonstrated by archaeological evidence

There are, however, other ways to measure the influence of early farming upon its surroundings: a careful excavation and thorough interpretation of the results. An impressive example of such work is the excavation of the early-Neolithic site of 'Ain Ghazal by Ilse Köhler and Gary Rollefson. In the following demonstration of early impact, quotations mainly are from Köhler-Rollefson and Rollefson (1990).

The early farming site 'Ain Ghazal was found in a suburb of Amman, the capital of Jordan. The elevation of the prehistoric settlement is about 700 m above sea level. The average annual precipitation is between 250 and 300 mm. Locally the area is defined by the urban sprawl and outside of it not much vegetation has been preserved in a rather desolate landscape.

The culture periods found by the excavators include the Pre-Pottery Neolithic B (PPNB) dated 9200–8000 BP, Late-Aceramic Neolithic C (PPNC) from about 8000–7500 BP, and the Yarmuk Ceramic Neolithic from 7500–7000 BP. The excavators show that the PPNB farmers of 'Ain Ghazal provided their vegetal food by growing einkorn and emmer wheat, two-row hulled barley, lentils, peas and chickpeas. Their protein supply, according to the study of the bone finds, came mainly from hunting. The animals that were bagged, or that ended up in the settlement, are an interestig mix. They include badger, pine marten and squirrel, very characteristic of forest and more especially forest as is found in central and northern Europe. Typically boreal animals found are hedgehog and goshawk. The list of animal species is very long and includes species with a broader ecological range that covers forest as well as more open terrain, such as aurochs, red fox and wild cat. The presence of these typically forest-dwelling mammals and birds demonstrates that the 'Ain Ghazal area carried forest, whereas nowadays even the memory of trees in this area seems absurd. The scarce presence of Tabor oak north of Amman is an indication that especially deciduous oak forests with a forest fauna were found in this region.

The excavation shows that the inhabitants of 'Ain Ghazal lived in houses with large-diameter postholes which show that heavy trees were used which must have grown in the vicinity. The excavators explain that house-building did not only require heavy trees for construction purposes. The extensive use of plaster will have demanded more wood for lime-burning than for construction purposes.

The bone assemblage and the use of wood changed rather abruptly shortly after 8200 BP. Goat bones then formed 70% of the total. Bones of goat were present in small numbers even at the beginning of the PPNB-settlement but they strongly increased in number towards the end of the ninth millennium BP.

Towards the end of the PPNB massive posts disappeared from the houses and the use of wood became restricted to thinner pieces; finally around 8200 BP wood was no longer used in house building and people took to stone piers and interior walls. Charcoal was now found in small amounts only and in very small pieces. The nature of the ashes in fireplaces points to the use of dried dung for fuel.

From the above it is clear that a very characteristic forest fauna was destroyed and its habitat, the forest itself, finished by the demands of house-building and above all the enormous energy demand of lime-burning. Even when the forest tried to regenerate after lumbering, this was prevented by the growing number of goats that would browse away any sapling that appeared on the forest floor.

Thus the first clear impact of farmers upon their environment, demonstrated by Köhler-Rollefson and Rollefson (1990) for the Jordanian Pre-Pottery Neolithic, was the destruction of a diverse forest community of Tabor oaks and characteristic mammal and bird species. In about a thousand years, not so much the arable land with its crops had changed the landscape, as the thoughtless exploitation of the forest outside the settlement together with 'the machine' that during the Holocene would devastate most of the Mediterranean, the Near East and large parts of Asia.

This agent was to be called 'the black plague of the Middle East' but the domestic goat was in fact created and kept by man himself. During the millennium of the Pre-Pottery Neolithic the effect of some phenomena increased considerably. The population of 'Ain Ghazal grew and the number of inhabitants by the beginning of the PPNB is estimated to have grown fourfold (Köhler-Rollefson and Rollefson, 1990). The population exacted its toll from the environment and the existing ecosystem was consequently disappearing. The loss of the wild fauna forced people to breed more domestic animals for their meat supply. Apart from this change from wild resources that were overkilled, the constantly growing population also caused an increasing demand for meat that was met by breeding goats.

The growth of the flocks prevented any regeneration of the forest and finally even secondary and following vegetation types gave up in the struggle against the ever-browsing goat flocks. The biomass of the 'Ain Ghazal area had been reduced to a fraction of what was there initially. Indeed a conflict must have arisen between crop cultivation and goat herding. The feeding behaviour of goats had to be controlled by herdsmen of the 'Ain Ghazal site because these early farmers practised a mixed farming from the start. This in contrast with their predecessors who had domesticated crops before they domesticated animals. It is only after a certain period that grazing had to take place increasingly far from the settlement because there was no longer any food available in the vicinity. The large numbers of goats were a threat to the crops and near the village the fields had to be watched over constantly.

This situation may have led to a changed agro-economic setup in the settlement during the Ceramic Neolithic of the Yarmuk. The number of inhabitants of 'Ain Ghazal dropped in that period and it is assumed that part of the population had moved to the steppe with the goats; an assumption that is supported by the fact that Köhler-Rollefson and Rollefson (1990) mention imports of stone from the steppe. Thus the impact of the grazing is extended to the open landscape, where the herding of sheep and goat soon started to influence the original steppe.

One factor was able to curb human impact in the steppe. Those parts that were devoid of natural springs could not easily be used by nomads, who had to water their flocks. Thus the central part of Syria, low mountains up to about 800 metres, retained a pistachio forest-steppe up to recent times when finally water was brought in with small trucks or when deep wells were sunk. The northern steppe in Syria shows a vegetation of *Carex stenophylla* and lichens as a final stage of overgrazing that hardly produces any food for flocks.

The finding of bones of a medium-sized half-ass (*Equus* cf. *hemionus*) and a desert monitor (*Varanus* sp.) in 'Ain Ghazal during the PPNC (8000–7500 BP) demonstrates that the steppe encroached upon the former woodland site, clearly manifesting the changes in environment caused by its early inhabitants.

The grazing effect, first around the PPNB-site and later further away in the steppe, is due to the difference in numbers of the wild herbivores and the domestic flocks. Köhler-Rollefson and Rollefson (1990) report a modern density of 0.6–4.1 wild goat per square kilometre in Pakistan. At the same time the Greek island Theodorou numbers 134 head per square kilometre under domestic conditions.

One must realize that it is very difficult to estimate potential populations because the natural conditions have significantly changed. Not only has the potential vegetation as a grazing source fundamentally changed, the absence of natural (non-human) predators also plays a considerable role. Still it is clear that between grazing by natural fauna and by protected herds there is great difference. The keeping of goats was profitable for man but, biologically speaking, also for goats. The latter category prospered but at the same time exerted extreme pressure upon the vegetation, first around villages and later at greater distances in the steppe.

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