PART I

# The Framework

CHAPTER ONE

# Introduction to Geography, Climate, Topography, and Hydrology

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## 1 The Role of the Environment

In this chapter no attempt is made to detail the physical geography and environmental context for the entire Near East, because these are treated in key references on regional geography (e.g., Butzer 1971, 1995; Beaumont et al. 1976; Brice 1978; Fisher 1978; Sanlaville 2000). Emphasis is placed upon studies conducted over the past 15 years, and this study is intended to complement earlier reviews of the subject (e.g., Butzer 1995; Potts 1997a; Wilkinson 2003a; Cordova 2007); it also focuses upon topics that relate directly to human settlement, long-term historical trends and human responses to the environment. The narrative is primarily focused upon the Holocene, namely the last 10,000 years or so. The environmental framework extends beyond climate to include the physical geography of soil resources, the hydrology of ancient rivers, as well as trends in vegetation.

Debates concerning the interactions between past human societies and the environment continue to swing back and forth, and it is noteworthy that recent literature on this subject often revives earlier arguments of environmental determinism without any awareness of the original studies (Judkins et al. 2008). Around the turn of the 20th century, environmental determinism was a major intellectual movement which argued that the environment had a strong influence on human settlement, behavior, and even character (Huntington 1907). Elements of this persist in recent literature arguing for the forcing effect of climate

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on the rise and decline of settlements and states (e.g., de Menocal 2001; Staubwasser and Weiss 2006; Kennett and Kennett 2007) and suggesting that societal collapse and human evolution are driven by environmental factors. A second group, while acknowledging the significance of the environment, take a more nuanced approach that sees the environment as an important factor in decision-making, but only one of many social, economic, and political factors that influence human groups (e.g., Kuzucuoğlu and Marro 2007; Rosen 2007; Wossink 2009). Finally, a third group argues that melodramatic terms such as collapse are often exaggerated, whereas human societies show considerable long-term resilience to environmental shocks and stresses (McAnany and Yoffee 2010a). My own position is that although the environment does have a significant influence on daily life and the economy, this relationship is complex, intertwined and sometimes indirect.

## 2 Topography and the Role of Agricultural Basins

Contrary to popular misconception, the Near East is not mainly desert but, rather, consists of large areas of upland plateau (e.g., Anatolia and Iran, parts of Yemen), extensive sedimentary basins (e.g., Mesopotamia, coastal Palestine, and Khuzestan), straggling uplands (e.g., Palestine, Syria) as well as forbidding mountain belts (e.g., the Zagros and Alburz mountains of Iran; the Taurus and Amanus in Turkey; the Hajar Mountains of Oman and the Hijaz in Saudi Arabia) (see Figure 1.1). Between these, and forming part of the mid-latitude arid zone, extend the arid deserts of Jordan, Syria, and Arabia, as well as the semi-arid steppe to the north. The latter were particularly important as loci of so-called secondary state formation in northern Iraq and the Levant.

Early states of the 3rd and 2nd millennia BC and their characteristic settlement, the *tell* (Arabic meaning "mound"), were particularly concentrated in sedimentary basins, both the arid basins watered by the major river systems and those receiving sufficient rainfall for rain-fed cultivation. The latter were major hearths of prehistoric communities and of *tell*-based communities in the 4th, 3rd and 2nd millennia BC. Particularly significant for early states were the agricultural basins of the Khabur and Ghab (Syria), the Gorgan and Tehran/Qazvin plains (Iran), and the Amuq and the Konya plains (Turkey). Numerous archaeological mounds are concentrated in such plains, whereas in the neighboring uplands and valleys, Chalcolithic and Bronze Age settlements, although present, tend to be smaller and rather sparse. These basins were major centers for the cultivation of cereals and pulses as well as providing long-term pastoral resources for the large herds and flocks of Bronze Age cities. Whereas some basins extend over hundreds of square kilometers, others, such as the Titriş (southern Turkey) or the Mamasani plain (western Iran), provided sufficient land to support only a few small communities perhaps dominated by a single center. Nevertheless, their


**Figure 1.1** Map of the area discussed in the text.

settlement history frequently extends back to the very earliest stages of domestication.

Deep, fertile soils, characterized by mature calcareous horizons, are ideal for cereals and legumes, and, if fallowed, provide an in-built buffer against shortfalls in precipitation. Because fine-grained basin soils retain moisture better than shallow, frequently coarse upland soils, they can be used for long-term cultivation or pasturage, hence their choice for early settlements. Nevertheless, they were not the only land available and over the past 2,000–3,000 years settlement has spread considerably into the uplands of the Levant, Upper Mesopotamia, and parts of Turkey. This has resulted not only in the selection of more environmentally unstable locations for settlement, but in greater soil erosion.

The agricultural basins did not exist in isolation but were linked together by major rivers, particularly the Tigris-Euphrates system. Consequently, areas of high agricultural productivity were linked to networks of communication as well as to other agricultural heartlands. In contrast, and particularly significant for the development of early states and economies, were agricultural basins that incorporated routes *within* themselves, as was the case in southern Mesopotamia, where a network of rivers and artificial channels provided excellent, low-friction routes, ideal for the transport of bulk products.

In addition to the agricultural basins, the climatically marginal dry steppe of central and northern Syria was colonized intermittently during the early Bronze Age, a process that left its archaeological signature in the form of large, geometric *Kranzhügeln* and related sites. Given their climatically marginal location, it is not surprising that during periods of political weakness or climatic stress such steppe regions were deserted or perhaps reverted to extensive pastoralist use.

## 3 Rivers and River Systems

Middle Eastern rivers and lakes provide a long-term repository for environmental proxy records. However, because rivers tend to remove parts of their deposits, the terraces that flank the rivers provide only a partial record of the history of deposition and erosion. Whereas traditional assessments have been constrained by the lack of strata suitable for direct dating (Geyer and Monchambert 2003), new radiometric dating techniques on basalt flows interleaved with terrace gravels are pushing the chronology of the Euphrates and Orontes Rivers back to some 2–3 million years before present (BP), indicating that these river valleys are significantly older than originally thought (Demir et al. 2007).

The fertile riverine terraces provided extensive agricultural resources close to water and communications and therefore attracted large-scale settlement. However, rivers also provided recognizable boundaries and thus functioned as frontiers, as illustrated by the Syrian Euphrates in the Neo-Assyrian and Roman periods. Consequently, river valleys should not simply be seen as loci of sedentary communities. This tension between a valley's varied roles – in agricultural settlement, as the location of a boundary and as a corridor of movement – perhaps explains why some riverine corridors show oscillating patterns of human settlement, in one period acting as attractors, and in another being deserted. Hence, the Euphrates River in Syria and Turkey was a major locus of Early Bronze Age settlement during the 3rd millennium BC, with settlements frequently located on opposite banks of the river, presumably at crossing points (Wilkinson 1990). Equally though, river valleys such as that of the Sajur in northern Syria, were sparsely settled for much of the 4th and 3rd millennia BC, despite their apparent fertility, and only densely settled from the Iron Age onwards. Such examples are instructive in demonstrating that the environment should not be viewed as a single, monolithic resource, but as a set of potential resources affording opportunities that could be taken up at different times in different ways.

The Tigris-Euphrates river basin not only formed one hearth for the origins of agriculture, but was also a key for the urban revolution of the Early Bronze Age. As noted by Algaze, it formed "an enormous dendritic transportation system" (2001: 204a) available to float the products of Anatolia, Iran, and Syria down to the Mesopotamian lowlands.

Many Middle Eastern rivers exhibit ephemeral flow and vary considerably in their geometry. They include braided gravel-bed channels, meandering single-thread channels within silt-clay flood plains, as well as rather straight channels with very gentle gradients. The last named class of channel is particularly common in the Mesopotamian lowlands, where it forms part of the anastomosing system of channels that thread back and forth across the alluvial plains.

At first glance, the southern Mesopotamian plains appear flat, bleak, and arid, presenting an austere vista broken only by linear palm gardens, upstanding canal banks, archaeological mounds, and occasional dune fields. Further scrutiny reveals occasional low alluvial levees which have built up over the millennia as a result of the preferential deposition of sand and silt along rivers and other channels. These ancient levees form substantial landscape features that stand up to five meters above the surrounding flood basins and may be five kilometers wide.

The Mesopotamian alluvial plains developed over the Quaternary period of geological history, with much fine clay, silt and sand being deposited over the past 10,000 years (i.e., the Holocene; Buringh 1960: 162). Nevertheless, parts of the plain date back to the Pleistocene period, and occasional islands of Pleistocene deposits have been recognized in the northern plains near Sippar, as well as further south near Tell Oueli and Larsa (Geyer and Sanlaville 1996), possibly taking the form of "turtlebacks" near Uruk (Pournelle 2003: 6 n3). Rather than forming a stack of fine-grained sediments, they accumulated episodically with periods of sedimentation punctuated by gaps or hiatuses. Sediments preferentially accumulated along river channels so that the channel became raised and the flood plain aggraded. Floods accumulate in basins that become sumps for clay deposition as well as fresh or brackish marshes. If a river shifted its channel, or the protective cover of vegetation was lost (because of lack of soil moisture), the soils would dry out and become vulnerable to wind erosion, with the eroded topsoil being incorporated into dunes of sand and silt-clay aggregates. As a result of the two contrasting processes of alluvial accumulation and aeolian degradation, parts of the archaeological record may be buried whereas, nearby, the very earliest archaeological sites are revealed (Wilkinson 2003a). Whereas one area may reveal a wide range of settlement back to the Ubaid period (6th/5th millennia BC), other areas are confined to more recent settlements of Parthian, Sasanian, and Islamic date. Although not as complex as the Mesopotamian lowlands, the Khuzestan plain of southwestern Iran also shows critical lateral variations in sedimentation that result in differential preservation of prehistoric sites (Kouchoukos and Hole 2003).

River channels and associated levees provided a focus for settlements and their associated palm gardens, and a source for irrigation water which often flowed down the levee slopes along a branching or trellised system of canals. The archaeological surveys of Robert McCormick Adams (1981) demonstrate how settlements from the 4th millennium BC onward were preferentially sited along levees, and because many levees are associated with sites dating from prehistoric to Islamic times, it is clear that the associated channels formed long-term features of the landscape.

Whereas much has been made of the role of changing climate in the history of human settlement, rather less has been said about abrupt shifts in river channels known as avulsions (Gibson 1973). If the abrupt shift of a river channel occurred from the levee crest to a more convenient course, a king was often obligated to redirect flow back into the vacated channel or to dig new canals in order to guarantee the continued supply of water for irrigation (Cole and Gasche 1998: 14; cf. Potts 1997: 24–5a). Such abrupt shifts have been recorded in Mesopotamia in recent times, and hinted at in antiquity as, for example, when Sin-iddinam, king of Larsa (c.1849–1843 BC), stated that, "in order to provide sweet water for the cities of my country . . . [An and Enlil] commissioned me to excavate the Tigris [and] to restore it [to its original bed]" (Frayne 1990: 158–60). One of the roles of the king was to ensure that favorable conditions existed, and if a river shifted its course, it was necessary to try to shift it back again.

Geomorphological studies suggest that avulsions were probably a significant factor in antiquity as well. They have been documented at Kut on the Tigris (Verhoeven 1998; Hritz 2004; Heyvaert and Baeteman 2008), as well as near Samarra (Adams 1965), and the overall branching tendency of the lower Tigris and Euphrates rivers suggests that avulsion may have been the dominant process in the development of the anastomosing Mesopotamian rivers (Wilkinson 2003a: 83–9). Others have argued that it was even a significant factor in the cyclical changes of Mesopotamian civilizations (Gibson 1973; Morozova 2004). The branching channels of the Euphrates near Tell ed-Der and Sippar (Iraq) provide a good example of a node of avulsion, off which the Irnina, Purattum (main branch), and Purattum (Kish branch) of the Euphrates (Purattum) branched during the 3rd, 2nd and 1st millennia BC (Cole and Gasche 1998; Heyvaert and Baeteman 2008). Dealing with the physical problems created by such channel shifts is also reflected in ritual and religious practice, and it is probably no coincidence that texts from the Sippar region, an early cult center of the river god, contain an unusually high number of references to it (Woods 2005).

Avulsions and branching river channels are not limited to the Mesopotamian plains, however. Major channel shifts have also been recorded in the Khuzestan (Moghaddam and Miri 2007) and Gorgan plains (Omrani Rekavandi et al. 2007, 2008) in Iran.

An additional by-product of human activity is salinization, a significant problem for agricultural production in southern Mesopotamia, parts of southwestern and northeastern Iran, and the Konya basin in Turkey. Saline soils contain soluble salts in such quantities that they interfere with the growth of most crop plants, and salinization is the principal soil-forming process in central and southern Iraq

(Buringh 1960: 83). In southern Iraq the high salt content of river waters, high levels of evaporation, low soil permeability, raised water tables, low gradients, and application of too much irrigation water result in poor drainage and a progressive build up of salts which reduces crop yields. Fortunately, salt accumulations are mitigated by traditional crop husbandry. By fallowing the land every second year, vegetation growth is able to lower the water table so that accumulated salts are leached away by the next flush of irrigation waters, thereby reducing, but not eliminating, salinization. The old theory that salinization in southern Mesopotamia led to a shift from the cultivation of wheat to salt-tolerant barley, reduced cereal production, and perhaps led to the abandonment of cities has been widely criticized (Postgate 1992: 180–1; Powell 1985). Nevertheless, soil scientists have demonstrated that salinization is endemic in southern Mesopotamia and its eradication is difficult (Buringh 1960). Consequently, at a local level salinization must have posed significant problems for ancient agriculturalists.

Although the major rivers of the Middle East formed an enduring part of everyday life, those ancient communities that relied upon them for their livelihood also needed to deal with the instabilities inevitably associated with them. In addition to avulsion and salinization, these included the 3rd millennium BC mega floods characteristic of the Euphrates river (Oguchi and Oguchi 1998) and riverine incision that left flood plains high and dry, thereby making floodwater farming impossible (Rosen 2007: 177). Humans were agents in the creation of instabilities by narrowing rivers, thereby raising water levels and increasing the risk of flooding, and encouraging rivers to stay in their present channels. Levees were raised so that if a channel break did occur, the resultant flooding could be devastating. River banks were weakened by digging canal off-takes and over-irrigation encouraged the elevation of water tables and associated salinization. Finally, clearing woodland increased run-off to rivers, increasing chances of flooding.

However, humans could mitigate natural processes by irrigating to ensure against drought years, by employing fallow to accumulate soil moisture as insurance against seasons of low rainfall, by using fallow to lower the water table and limit the affects of waterlogging and salinization, and by investing in check dams across seasonal *wadis* to limit incision. The overzealous management of natural processes could result in problems which would either impact the communities themselves (e.g., salinization), or affect downstream communities, as occurred with water abstraction, avulsion, or deforestation near the headwaters of major rivers. Such problems may have been exacerbated by increasing population, over-ambitious kings or the use of natural resources as a weapon in times of conflict (Cole 1994). Ignoring land management practices such as fallowing may have pushed a theoretically sustainable system of agriculture toward a threshold where either two or three dry years (in the rain-fed north) or the annual application of irrigation water (in the irrigated south) would have precipitated agricultural failures that would not have happened if traditional, sustainable practices had been employed.

## 4 Climate and Climatic Change

The pioneering studies of Lamb (1977) and Butzer (1958) assembled a wide range of evidence indicating that over the last 10,000 years the climate has varied through cycles of increased moisture, heat, and storminess. Unfortunately, since the late 1960s a new orthodoxy has suggested that, over the past 6,000 years, and for perhaps virtually the entire Holocene, the climate has been essentially stable (Raikes 1967). This stable Holocene scenario was reinforced by initial interpretations of the Greenland ice cores, which indicated a much less tempestuous Holocene than had prevailed during the preceding glacial phases (Anderson, Goudie, & Parker 2007: 148–149). The earlier studies have now been vindicated, as investigations away from the polar regions have demonstrated the true variability of the Holocene climate. In addition to minor fluctuations, six episodes of "rapid climate change" have been identified over the last 8,200 years (Anderson, Goudie, & Parker 2007: Fig. 1.2). However, the definition of what constitutes a climatic "spike" is subjective, and their effect on past human activity in the Near East remains hotly contested (Weiss et al. 1993; Butzer 1997; Zettler 2003; Kuzucuoğlu and Marro 2007).

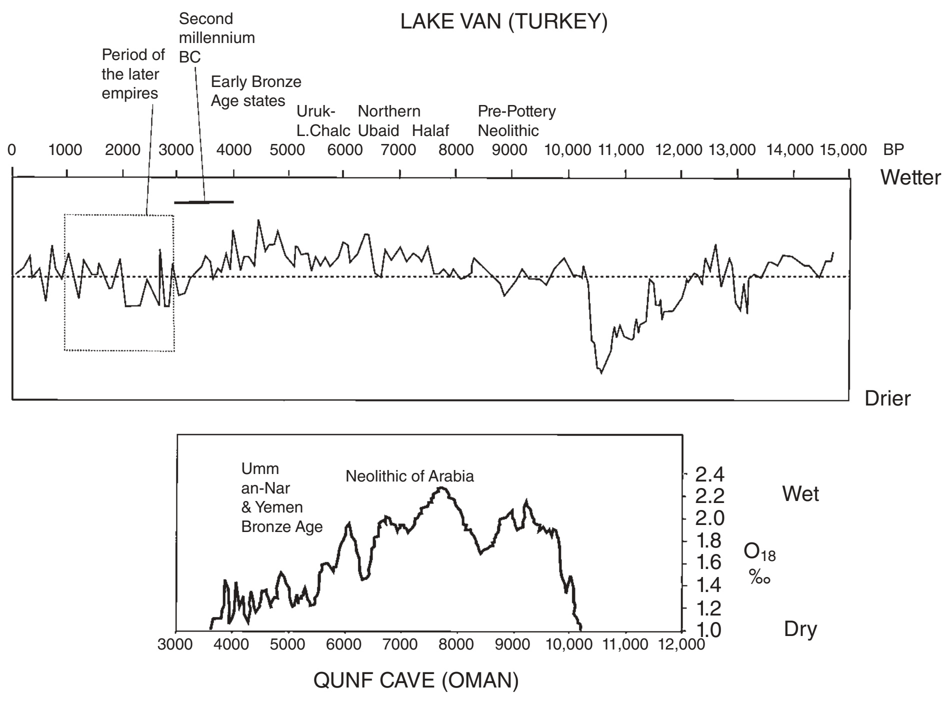


**Figure 1.2** Reconstruction of wetter and drier periods in the climate record of Lake Van (Turkey) and Qunf Cave (Oman).

Thanks to a substantial increase in the budget for environmental research during the past 30 years, as well as an increase in the number and sensitivity of techniques of analysis, the amount and geographical distribution of climate proxy records has increased tremendously.

Butzer (1978: 6–11) defined three broad paleoenvironmental zones within the Middle East:

- a northern highland perimeter consisting of Anatolia, Armenia, Kurdistan and Iran which receives much of its rainfall in winter;
- the hills and plains of the Fertile Crescent including the Levant and Mesopotamia;
- the desert belt of northeastern Africa and Arabia, the southern parts of which receive most rainfall (when it occurs) as summer monsoonal rain.

The Arabian desert, an ancient feature extending back millions of years, falls within the warm desert zone of the northern hemisphere (Anderson, Goudie, & Parker 2007: 121). As a result of differences in the earth's orbital parameters and the amount of solar radiation received, the Sahara, Arabian, and North Indian deserts received significantly more rainfall between about 10,000 and 6000 BP than they do today. Warmer ocean temperatures in the tropics were associated with a strengthened monsoonal system and greater atmospheric moisture (Kutzbach and Liu 1997; Brooks 2006). On the other hand, the northern highland perimeter and Fertile Crescent steppe receive significant precipitation in winter from depressions moving along the path of westerly circulation. It is noteworthy that the flow of the Tigris-Euphrates and tributaries, which fall within the first two regions, shows a partial correlation with the so-called North Atlantic Oscillation which governs the path of mid-latitude storm tracks and precipitation within the Mediterranean region (Cullen et al. 2000).

However, climate changes in the region are not simply a result of variations in the westerlies to the north versus the monsoonal system to the south. Recent high-resolution studies of lake sediments from Nar Gölü (central Turkey) show links to both the north Atlantic and Indian Ocean monsoons (Jones et al. 2006: 364; Cordova 2007: 130) so that increased summer aridity in central Turkey correlates with periods of enhanced Indian monsoonal rainfall (Jones et al. 2006: 363). In other words, drier conditions in the eastern Mediterranean can be linked to a regionally complex monsoon evolution which itself is related to patterns of upper atmosphere airflow in the sub-tropics (Staubwasser and Weiss 2006).

Because we lack tools for directly measuring climatic warmth or moisture, it is necessary to employ so-called proxy records – i.e., indirect indicators such as pollen, carbon/oxygen isotopes, and micro-organisms in lake sediments that vary according to climate. The most common proxy tools used include lake sediments, soils, and caves for carbon and oxygen isotope studies; lakes and marshes for palynology; and rivers for records of long-term hydrology. In addition, the surrounding seas and oceans provide long-term proxy records, especially for ocean temperature, patterns of global circulation, and continental river discharges. No technique provides a simple and straightforward record of the past environment because each record will have accumulated under different circumstances, so that breaks in the sequence may occur. For example, lake records have the great advantage of (frequently) providing continuous records of sedimentation from which the proxy indicators can be sampled. By contrast, rivers and *wadis* are characterized by spatial variability and a tendency for the river to remove earlier deposits creating gaps and discontinuities. Nevertheless, some lake sediments are remarkably discontinuous, Lake Konya being a particularly good example (Fontugne et al. 1999); others show considerable variations in the rate of sedimentation, which needs to be allowed for when computing the proxy records. Moreover, indicators such as carbon and oxygen isotopes are themselves formed within a complex geochemical environment, so that each record must be interpreted on its own merits (Jones and Roberts 2008: 37). Although precipitation and evaporation are generally seen as driving the hydrological context of these isotopes, the source area of the rainfall and the temperature of the lake water itself are significant. Consequently, identifications of wetter and drier phases in climatic records must always be regarded cautiously (Jones and Roberts 2008; Develle et al. 2010).

Pollen provides a record of past vegetation, but accounts vary according to pollen productivity as well as the size and catchment of the lake or marsh. Frustratingly, most lakes are located within the moister parts of the Middle East, hence many early sites in north Syria and Mesopotamia are far away from the nearest proxy climate record. However, the mere existence of lakes in areas where today the environment is arid, such as a Green Arabia that was rendered more verdant as a result of strengthened monsoon circulation (McClure 1978; Lézine et al. 2007; Parker et al. 2004), provides an indication of periods of increased atmospheric moisture.

Bearing the above caveats in mind, the following places provide valuable records of climate change for the Middle East (see Figure 1.1 above):

- Lake Van (Lemcke and Sturm 1997; Wick et al. 2003) and Eski Acigöl (Roberts, Reed et al. 2001) in Turkey;
- the Beqaa valley and mountains of Lebanon (Develle et al. 2010; Verheyden et al. 2008; Hajar et al. 2010);
- the Ghab valley in Syria (Yasuda et al. 2000);
- the Dead Sea (Neumann et al. 2010; Migowski et al. 2006; Leroy 2010) and Soreq Cave (Bar-Matthews et al. 1997; Bar Matthews and Ayalon 2011) in Israel, Palestine, and Jordan;
- Qunf Cave in Oman (Fleitmann et al. 2003);
- Hawa and Dhamar lakes in Yemen (Lézine et al. 2007; Davies 2006);
- Awafi lake in the United Arab Emirates (Parker et al. 2004);

- Lakes Zeribar, Miribad, and Almalou in Iran (Snyder et al. 2001; Djamali, de Beaulieu, Andrieu-Ponel et al. 2009: 1372).

Of these, Lake Van provides a valuable record of westerly circulation within Anatolia, and Qunf Cave acts as a sensitive indicator of monsoonal circulation in southern Arabia (see Figure 1.2). The Van record, which derives from annual laminations corresponding to seasonal deposition of silt, can be summarized as follows (Lemcke and Sturm 1997; Wick et al. 2003; Kuzucuoğlu 2007: 468):

- From approximately 5500 BC (later Neolithic) until around 3050 BC (beginning of the Early Bronze Age) the climate was moister than that of today.
- There followed a transition from 3050 to 2050 BC with increasing aridity interrupted by drier phases at 2400 and 2150 BC and generally drier conditions in the final quarter of the millennium.
- After 2050 BC (from the Middle Bronze Age), conditions remained drier, becoming similar to the present day around 1 BC.

Despite regional variations, there is some consensus on the broad trends in climate change for the northern Near East (Robinson et al. 2006: 1535; but see Roberts et al. 2011 for a variant chronology):

- The Late Glacial Maximum (23,000–19,000 BP) was cooler and more arid than the present day, but Lake Lisan, the predecessor of the Dead Sea, was high due to an excess of water supply from precipitation, runoff and groundwater discharge over evaporation.
- Localized warming trends followed, but the cold episode of the Younger Dryas (12,700–11,500 BP) ushered in a millennium or so of cold, arid conditions. Lake Lisan dropped significantly and large deposits of salt accumulated.
- The Early Holocene, from c.9500 to 7000 BP, was the wettest phase in the last 25,000 years in the Levant and eastern Mediterranean, and the margin of the Negev Desert migrated significantly further south; the level of the Dead Sea was relatively high.
- A brief moist episode followed around 5000 BP, after which the climate became significantly drier; there is consensus that the climate of the northern Near East became drier during and especially after the Early Bronze Age (c.4200 or 4000 BP) but the details vary depending upon the record.

The Dead Sea and Soreq Cave provide excellent, long-term records that are complemented by high-resolution records of tree rings from sub-fossil tamarix trees within Sedom Cave near the Dead Sea. Carbon and nitrogen isotopes, extracted from the cellulose of tamarix tree rings, show a gradual but fluctuating drying from 2265 to 1930 BC and maximum aridity between 2000 and 1900 BC (Frumkin 2009: Fig. 7). This relatively precise record, which corresponds to a significant drop in the level of the Dead Sea (Frumkin 2009: 326), provides an indicator of annual drought that would have been experienced by local communities.

By the Roman, Arsacid, and Sasanian periods (c.247/238 BC to 651 AD) conditions fluctuated around those of today, and again, detailed records provide evidence of specific fluctuations. For example, a comparison of Mediterranean Sea cores with the Soreq Cave isotope record suggests humid phases at c.1200 BC, 700 AD, and 1300 AD, and drier phases at 100 BC, 1100 AD, and 1700 AD (Bar-Matthews et al. 1997; Schilman et al 2002; Rosen 2007: 90). When compared with high-resolution proxy records from Nar Gölü in central Turkey, there is some overlap, specifically in humid intervals at 560–750 AD and 1000–1350 AD and a dry phase from 1400 to 1950 AD (Jones et al. 2006). Moreover, because the warm, humid phase of 1000–1350 AD and the dry, cool phase after 1400 AD fall within the medieval warm phase and the Little Ice Age, as known from historical sources, there is good reason to view these as credible.

Although such comparisons provide grounds for optimism, when these records are compared with the environmental crises noted by Michael the Syrian, the correspondence of climatic peaks and troughs are difficult to reconcile. This is partly because the textual records mention not only occasional droughts, but also frequent swarms of locusts and episodes of bubonic plague as well as cold winters, the latter often having a devastating effect on flocks and herds (Widell 2007). Although even fine-grained climate proxy records are difficult to harmonize with historical records, in part because very different types of record are being compared, they take us significantly beyond the previous generation of coarse-grained proxy records.

Whereas most proxy records from lakes and marshes are located far from major centers of Neolithic and Bronze Age settlement, calcareous accretions in archaeological sediments, although lacking the fine resolution of, for example the Van sequence, have the advantage of providing a proxy record from within core areas of settlement. Calcareous coatings on stones at Neolithic Göbekli Tepe provide a proxy record for upper Mesopotamia, a core region for the domestication of plants and animals as well as early state development (Pustovoytov et al. 2007). The two main periods of coating formation date to the Early (10,000–6000 BP) and Mid-Holocene (6000–4000 BP). Fluctuations of the oxygen and carbon isotopes suggest that whereas the Early Holocene coatings accumulated within a climate of rising temperature, in the Middle-Holocene both rate of growth and isotopic signatures of coatings imply maximum humidity between c.6000 and 4000 BP (Pustovoytov et al. 2007: 325). Although there is some discrepancy in the timing of the Middle-Holocene moist phases in the Göbekli and Van data, both agree that after 4000 BP (i.e. around 2000 BC) the climate of the Fertile Crescent became significantly drier.

Climate proxy records from the desert belts include that from Qunf Cave in southern Oman (Fleitmann et al 2003) where oxygen isotopes ($\delta^{18}$ O) from the growth rings of a stalagmite which grew from 10,300 to 2700 and from 1400 to 400 BP have been documented with a time resolution of 4–5 years. The isotopic record showed four main features:

- a rapid increase in monsoonal precipitation between 10,300 and 9600 BP;
- high monsoonal precipitation between 9600 and 5500 BP;
- a long-term decline in precipitation from 8000 to 2700 BP; and
- cessation of stalagmite formation at 2700 BP and regrowth from 1400 to 400 BP.

The latter growth phases are within the $\delta^{18}$ O range of modern stalagmites and are therefore equivalent to the present-day climate. Although records from paleolakes and oceanic sediments do not entirely agree with the Qunf Cave evidence, the general pattern of a moister Early and mid-Holocene is clear. A variant date comes from al-Hawa (Yemeni desert), where the onset of the wet Early Holocene began at c.12,000 BP (Lezine et al. 2007: 247), and the lakes in the Yemen highlands where it began at c.11,000 BP (Davies 2006; Parker 2009). In contrast, at Awafi in the UAE well to the north of Qunf Cave, the lake sequence started significantly later, at c.8500 BP, the onset of wet conditions there being related to the northward migration of the Inter-Tropical Convergence Zone (Parker et al. 2004).

Despite their location in different latitudinal zones, the trend of the isotope records from Qunf and Soreq is broadly similar but with differences in detail, especially during the later periods. The challenge now is to interpret the settlement and historical records in light of these records in a way that allows for the often idiosyncratic behavior of human populations.

## 5 Vegetation

The vegetation record in the Middle East derives mainly from carbonized plant remains and palynology. The representativeness of plant remains on archaeological sites is biased by their deliberate selection by humans. Thus, they do not necessarily reflect the totality of plant life in a given locale. On the other hand, pollen sequences are usually limited to those species present around lakes and marshes, which are not always in the vicinity of major archaeological sites (Miller 1998). Despite these biases, thanks to pioneering research by Van Zeist and Bottema (1991), together with more recent palynology, we now have a broad idea of the pattern of vegetation within the northern mountain fringe, and Fertile Crescent and Iran. According to Roberts and colleagues, the range of tree cover around the Mediterranean basin contracted during glacial phases and the Late

Glacial Maximum when much of the region was dominated by herb species such as Artemisia and various chenopods (Roberts, Meadows, & Dodson 2001: 632). Tree species such as European oak, *Pistacia*, and olive survived only within limited areas such as the southern Levant.

During the Early and Middle-Holocene the herbaceous Late Glacial steppe was replaced by sub-humid forest and, depending upon location, by broad-leaved, deciduous trees. However, forest re-advance was slow during the Holocene and pollen sequences from eastern Turkey and western Iran suggest that tree pollen approached modern values only by 7000–5000 BP, perhaps because its spread was inhibited by the drier, Early Holocene climate (Roberts, Meadows, & Dodson 2001: 632). However, in parts of the southern Levant where deciduous rather than evergreen oaks prevailed, the typical winter rainfall regime may have been replaced by summer rain (Roberts, Meadows, & Dodson 2001: 632).

The archaeobotanists Gordon Hillman and colleagues have employed rainfall and temperature levels, together with the distribution of present vegetation, to reconstruct the potential vegetation cover of semi-arid northern Syria (Hillman 2000). Their maps suggest that park woodland and woodland steppe extended into what is today the denuded and treeless north Syrian steppe. Such reconstructions suggest that massive loss of natural vegetation occurred during the Holocene and that grasslands and park woodlands were replaced by an essentially desertified steppe. This picture is now supplemented by carbonized wood (charcoal) analyses which reveal a much richer vegetation in the Bronze Age than today: riverine vegetation was more diverse, and oak park woodland occupied many parts of the northern Fertile Crescent, roughly along the line of the Turkish/Syrian border as well as in northern Syria (Deckers and Pessin 2010: 220–1). "Massive degradation including deforestation," as a result of both human and climatic impacts, the latter indicated by a northward shift of the Pistacia-woodland steppe, has caused the present virtually treeless landscape (Deckers and Pessin 2010: 225). In the Khabur basin, which is today devoid of trees, oak park woodland was still present as late as the 3rd century AD (Deckers and Riehl 2007: 347).

Historical sources also provide a strong case for human removal of woodland. For Mount Lebanon, textual records demonstrate how the original cedar and coniferous woodland was probably destroyed in part as a result of expeditions of the Assyrians and the Akkadians before them (Rowton 1967; Mikesell 1969).

Particularly convincing evidence of the loss of woodland and the appearance of orchard cultivation derives from small lakes with local catchments. The pollen diagram from the small crater lake of Birkat Ram, in the occupied Golan heights (Schwab et al. 2004), which covers the last 6,500 years, shows the first significant human impact on vegetation in the Chalcolithic with a decline in deciduous oak (see Figure 1.3). During the Middle and Late Bronze Ages and Early Iron Age, when the area was sparsely settled, woodland regenerated. This was followed by a sharp drop in deciduous oak in the mid-1st millennium BC, or slightly later, perhaps as a result of ore-smelting and land clearance associated with settlement

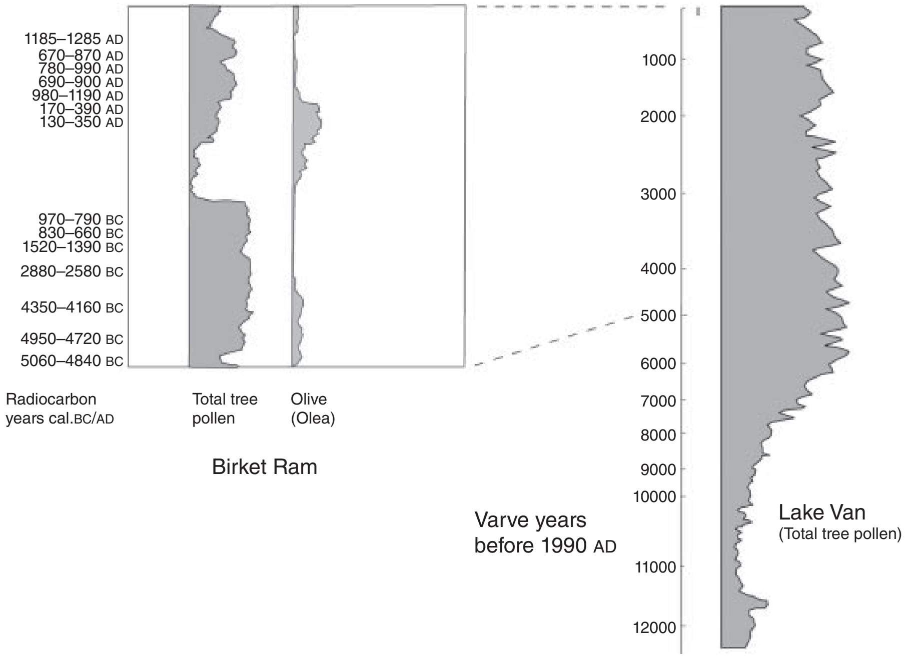


**Figure 1.3** Pollen diagrams from Birkat Ram (Golan Heights) and Lake Van (Turkey).

and agriculture (Dar 1993). The rising sedimentation rate at this time probably resulted from higher soil erosion associated with increased settlement. Human impact on vegetation structure is evident from the curves of olive and grape pollen which expanded rapidly during the Hellenistic, Roman, and Byzantine periods, after which olive production collapsed. There was then regrowth of evergreen oak, a characteristic feature of other pollen charts in the region (Baruch 1986). Overall, the woodland decline and associated growth of olive and grape between the 3rd/4th centuries BC and the 7th century AD appear to reflect the characteristic settlement pattern of the Levant when many upland or formerly marginal areas were settled and prospered, in part as a result of increased trade in olive oil and wine (Wilkinson 2003a: 128–50). This pattern is associated with the development of *maquis* (evergreen shrubs) and *garrigue* (perennial scrub) vegetation on many uplands as well as desertification in drier areas (Wilkinson 2003a: 150).

Despite the long settlement record of the Near East, human impacts on vegetation are less clear than might be expected, in part because Neolithic impacts often occurred before vegetation had stabilized following the last glaciation (Roberts 1998: 188). Nevertheless, the removal of oak woodland is indicated in the Ghab valley (Syria) during the Neolithic (Yasuda 2000), whereas clearance shows up in pollen diagrams by the 3rd millennium BC (Roberts, Meadows, & Dodson 2001: 634). A conspicuous clearance horizon is the so-called Beyşehir phase, which appears in southwestern Turkey c.3200–1250 BP (1250 BC and 800 AD) (Bottema and Woldring 1990; Eastwood et al. 1998; Roberts 1998: 188). In the Berakat basin, also in southwestern Turkey, this phase is dated c.2230–1550 BP, during a period of local Hellenistic and Roman settlement (Kaniewski, Paulissen, De Laet et al. 2008), and is associated with increased burning of woodland, as well as polyculture and significantly increased soil erosion, presumably resulting from forest clearance and agriculture (Kaniewski, Paulissen, De Laet et al. 2008: 234).

A similar phase of vegetation change recorded in the small Lake Almalou at 2500 meters in northwestern Iran shows high *Cerealia*-type pollen corresponding presumably to cultivation and mobile pastoralist activity. These episodes more closely relate to historical rather than climatic phases, under the Achaemenid empire (539–330 BC) and during a phase of large-scale fruit tree cultivation in the Sasanian period (c.240–640 AD) (Djamali, de Beaulier, Andrieu-Ponel et al. 2009: 1372).

The propagation of tree crops was not restricted to the later empires because Sumerian texts from the Ur III period (2100–2000 BC) demonstrate that around Garshana and Zabala in southern Mesopotamia, in addition to the expected date palms and tamarisks, some 25,000 pine trees were recorded, as well as olives, apples, and other fruit trees (Heimpel n.d.). Together with others such as box, these trees must have been introduced from the surrounding mountains or more temperate regions, much as the later Neo-Assyrian kings introduced foreign plants to their parks and gardens.

Cultivated food crops reflect the prevailing environment and give us an idea of how societies coped with climatic fluctuations. Land use and crop yields are influenced by rainfall, fallowing practices, and soil quality, and if the last two factors remain constant in a given region, changes in drought-tolerant crops can be compared to climate proxy records. In order to determine relationships between crop plants and Late Holocene aridity, Riehl (2008) used carbonized plant remains to infer how the proportion of crop types changed according to rainfall as indicated by climate proxy curves. Stable carbon isotopes extracted from barley from seven Bronze Age sites provided a proxy for ancient moisture, with low $\Delta^{13}C$ (in semi-arid environments) indicative of moisture stress and high $\Delta^{13}C$ of moisture availability or irrigation (Riehl 2008: S45). Middle and Late Bronze Age grains exhibited lower $\Delta^{13}C$ values, which is in line with proxy records from Soreq Cave and Lake Van which also indicated less moisture in the 2nd millennium. In addition, drought-susceptible plants such as flax, garden pea, grapes, lentils, and free-threshing wheat were less evident or absent during the Middle as opposed to the Early Bronze Age. Moreover, the replacement of garden pea (*Pisum sativum*), present in the Early Bronze Age, by vetch (*Vicia ervila*) during the Middle Bronze Age may relate to drier conditions (Riehl 2008: S49).

These analyses provide insights into how human communities may have responded to a drier climate in the late 3rd and early 2nd millennium BC, but they do not supply evidence of dramatic societal collapse. This is because we do not know about farming practices during phases of non-occupation, which are unaccounted for in these data. The changing crop types probably reflect coping strategies that were adopted by the population, which apparently included the adoption of more drought-tolerant plants during the 2nd millennium BC, as well as increased use of barley as fodder. As a result of these changes and a shift toward animal husbandry, parts of the population could continue to farm, whereas others adopted increasingly pastoral lifestyles (Wilkinson, Christiansen, Ur et al. 2007: 66).

## 6 Sea-Level Rise

One of the most dramatic changes in the ancient Near Eastern environment was the rise in sea-level caused by the melting of polar ice caps after 18,000 BP, which flooded the fringing continental shelf. Because the Middle Eastern seas form part of the global ocean system, the rise in sea-level was roughly synchronous throughout the region. However, being partly cut off from the oceans, the Caspian and Black Seas were independent and rose and fell to the tune of local river-flow, rainfall, and evaporation. The Caspian continues to rise and fall dramatically and over the last millennium has swept inland more than 12 kilometers to obscure the Sasanian Gorgan Wall (Nokandeh et al. 2006; Omrani Rekavandi et al. 2007, 2008; Sauer et al. 2009). In contrast, the dramatic flooding of the Black Sea basin by the rising Mediterranean c.7150 BP has resulted in its own flood myth (Ryan et al. 1997; but see Aksu et al. 2002).

Another possible origin for the flood myth derives from the flooding of what is now the Persian Gulf between Arabia and Iran. During the Late Glacial Maximum (21,000–18,000 BP), when sea-level was c.120–130 meters below the present level, the entire floor of the Gulf was dry. The plain formed by the extension of the Tigris and Euphrates rivers was dotted with occasional lakes and marshes, together with widespread desert extending some 1,000 kilometers from southern Mesopotamia to the Straits of Hormuz (Vita Finzi 1978: 258; Wilkinson 2003a: 22–3; Kennett and Kennett 2007). The river draining the present floor of the Gulf, dubbed by some the "Ur-Schatt River" (Kennett and Kennett 2007: 233–5), received tributaries from the Zagros to the north and the Arabian interior to the south to form a vast extended Tigris–Euphrates basin that incorporated much of the present Middle East (Wilkinson 2003a: Fig. 2.3). This flooded gulf is important to the settlement history of the region because not only would it have been the locus of long-term human activity during the Late Pleistocene, but any inhabitants would have been rudely evicted by the rapid transgression that swept northwards up the Gulf in the Early Holocene into neighboring parts of Iran, Arabia, and Mesopotamia, perhaps contributing to founder populations there.

The Holocene transgression was at times rapid, especially in areas where the terrain was very gentle. In such locations it translated into horizontal shoreline movements of up to 1 kilometer per year (c.10,000 BP) with a long-term average of 140 meters per year (Teller et al. 2000: 303; Kennett and Kennett 2007: 235–6). To deal with the challenges of rapidly shifting marine and land-based resources, coastal communities would have needed to be mobile and adaptable. Needless to say, the dramatic pace of the transgression in the Gulf has encouraged claims for this being the original Noah's flood (Teller et al. 2000; Kennett and Kennett 2007).

Of particular significance in the development of early states is the location of the head of the Persian Gulf. Investigations of de Morgan (1900b), Larsen and Evans (1978), Sanlaville (1989) and Aqrawi (2001) suggested that during the 5th–4th millennia BC this was located near modern Nasiriyah. Since then, a Belgian group has shown that in the lower Khuzestan plains of Iran the coastline transgressed rapidly across the shelf beneath during the initial Early Holocene rise of sea-level, forming a low-energy, tidal embayment by the Early and Middle Holocene (Baeteman et al. 2004; Gasche 2005). Following the stabilization of sea-level after c. 5500 BP and under more arid conditions, alluvial and coastal *sabkhas* (salt flats) started to extend and aggrade. When the sea-level rise decelerated, riverine alluviation extended the coast to the south from c. 2500 BP to its current position (Heyvaert and Baeteman 2007). Because Heyvaert and Baeteman found no evidence to support a sea-level as high as 1–2 meters above present levels, as suggested by Sanlaville (1989), it appears that the sea did not create a large marine gulf extending inland from Nasiriyah. Rather, the various borehole and geomorphological records suggest that when marine conditions penetrated c.200 milometers inland toward Nasiriyah and Amarah in southern Iraq (or 80 kilometers in Khuzestan) around 4000 BC, lower Mesopotamia probably formed a complex mosaic of narrow estuaries, marsh, lagoons, and intertidal flats (both brackish and fresh), as suggested by Adams (1981: 16; cf. Sanlaville 1989; Aqrawi 2001; Heyvaert and Baeteman 2007; for further discussion of how this ill-defined limit actually related to the economies of the cities of Ur, Telloh, and al-Hiba, cf. Potts 1997a and Pournelle 2007).

In the Red Sea, the Early Holocene transgression flooded old land surfaces and associated shell middens, whereas off the coasts of Israel/Palestine and Lebanon numerous Neolithic sites were submerged. Recent off-shore investigations have demonstrated the extraordinary potential of these submerged landscapes (Galili et al. 1993; Bailey et al. 2007).

Not only was the Early Holocene flooding of the continental shelf a significant event for the inhabitants of the time, it has been argued that, combined with increased aridity, sea-level fluctuations contributed to a complex range of human responses which themselves led to early state development (Kennett and Kennett 2007: 248). Although it is difficult to separate cause and response mechanisms in such complex cases, it is clear that sea-level rise was a major factor in the development of prehistoric communities.

## 7 The Significance of Wetlands

In contrast to the present landscape, the prehistoric Near East appears to have included many enclaves of remarkably verdancy, including wetlands. Despite the lack of preservation of true wetland sites, sites with some degree of organic preservation or in the proximity of marshy areas are being increasingly recognized. In addition to the remarkable submarine Neolithic sites off the coast of Israel (Galili et al. 1993), Çatal Höyük, Tell Oueli, and prehistoric sites in the Amuq plain (southern Turkey) all developed in proximity to marshes. To what degree wetlands were a significant factor in the formation of prehistoric communities and early states is unclear, but they were probably particularly significant in areas around the head of the Gulf near the zone inundated by the Early Holocene sea-level rise (Pournelle 2007).

Wetlands appear to have played a significant role in the development of urban and later societies in Sumer (southern Iraq). This was not simply by contributing to economic sustenance, but also through the relationship of wetlands and river channels to belief systems and religious practice. Marshlands and the network of anastomosing channels were often associated with specific deities, while the Euphrates itself was worshipped, with particular devotion to the river gods attested between Mari and Hit, e.g. around Sippar, west of Baghdad, where the ancient course of the Euphrates bifurcated and was prone to abrupt channel changes or avulsions (Woods 2005; Heyvaert and Baeteman 2008). However, Late Holocene desiccation has not only reduced the evidence of wetlands, it has made it easier to diminish their significance in the development of early communities.

Wetlands continued to be of significance as late as Sasanian and Islamic times and in Mesopotamia marshes were formed as a result of the activities of Babylonian kings as well as the discharge of excess water from canals or their ultimate breakdown (Cole 1994; Adams 1981; Eger 2008).

## 8 Geoarchaeology, Erosion, and Settlement

Although there is a long history of investigations that have contextualized Middle Eastern societies within their geological environment, it was not until the 1950s and 1960s that Butzer (1958), Vita-Finzi (1969), and others developed models for the genesis of alluvial fills. Late Quaternary cycles of stream aggradation and incision not only provide the context for many communities in the rain-fed zone, they also reflect the combined effect of humans and climate. However, region-wide chronologies are rare (Cordova 2008: 443). Whereas Butzer saw a fine-grained temporal record and more complex interrelations between humans and the environment, Vita-Finzi focused on region-wide climatic change as a driving factor behind fill development. Rosen (1986), Brückner (1986), Goldberg (1998), and Cordova (2000) have taken an approach similar to that of Butzer, and in recent studies have focused upon the complexity of the relationship between humans and the environment as well as the role of humans in mediating some of the affects of climatic change (Rosen 2007). Not only are geoarchaeological studies important for understanding the history of soil erosion, land degradation also provides the context for understanding the sustainability of ancient settlements (Cordova 2007).

Alluvial (of rivers and *wadis*) and colluvial (slope) fills are complex and spatially variable. Broad lowland basins do not accumulate sediments uniformly; rather, the rate of accumulation varies from place to place so that areas around the basin perimeter may accumulate deep sediments, whereas those distant from sediment sources may receive little deposition. Hence, pessimistic statements about the depth of alluvial accumulation in areas such as the Marv Dasht plain of Iran should not be extrapolated across the entire region (Brookes et al 1982). Rather, as in the case of the Amuq plain (southern Turkey), sediments accumulated as a patchwork of alluvial fans, lacustrine deposits, alluvial fills, and anthropogenic sediments, all accumulating at different rates, or, in some cases, not at all (Casana and Wilkinson 2005). In addition, basins such as that of the Kur River (Iran) have received significant input in the form of aeolian loess in addition to alluvial and lacustrine deposits, with the result that prehistoric sites are not deeply buried (Kehl et al. 2009). The message again is that local sequences are extremely important.

Although the notion that "alluvial sequences are environmentally driven but culturally blurred" (Macklin and Lewin 1993) also holds for many parts of the Middle East, it is often difficult to tell whether it was humans or environmental events that were the primary contributor to alluvial fills. Many geoarchaeological studies, understandably, emphasize the geomorphological evidence and under-represent the settlement record. Moreover, a focus on valley floor records at the expense of the valley slopes that supplied the sediments for alluvial fills means that such studies supply only a partial record of the sediment contribution area (Beach and Luzzadder-Beach 2008). However, the analysis of geoarchaeological records in tandem with quantitative studies of the amount and distribution of settlement provides a clearer idea of cause and effect relationships between human settlement and associated physical responses at the local level. Thus, in the Levant and northern Syria the significant dispersal of settlements across the landscape, onto slopes and some uplands, that occurred during the 1st millennium BC, and especially during the Hellenistic to Early Islamic periods, was associated with a loss of stabilizing vegetation, increased soil erosion, and more flashy flow conditions, which themselves contributed to alluvial fills (Wilkinson 2003a: 146–50; Hill, J.B. 2004; Casana 2008). Nevertheless, vegetation loss and human disturbance associated with such settlement phases simply provide the preconditions for soil erosion and mass movements. If the number and intensity of storms increase, soil erosion will exceed the capacity of the flow to remove the sediment, thereby resulting in an accumulation of alluvial fills.

Clearly, both human factors and climate are contributory factors to the development of alluvial fills, but their relative contribution depends on local circumstances. For example, in northern Jordan the history of soil development and climate are important for understanding long-term landscape degradation (Lucke et al. 2005: 65), whereas in the highlands of southwest Arabia, increased human settlement during a relatively dry climate initiated phases of soil erosion that followed long-term, stable soil development in a relatively moist climate (Wilkinson 2005). Both human agency and climatic events are increasingly viewed as the combined force that led to the present, degraded landscape of the Near East.

## 9 Humans and Environmental Change

A perennial question of history and geography is: how are humans influenced by the environment, or alternatively, to what degree have humans had a significant impact on the environment? The Near East has become one focus of this debate, particularly with reference to societal collapse resulting from drought that led to famine and ultimately political or demographic collapse. In addition to cycles of dynastic rise and fall, certain periods, including the collapse of Akkadian settlement in northern Syria and collapse in the eastern Mediterranean c.1200 BC, continue to be seen, by some, as driven essentially by climatic fluctuations (Weiss et al. 1993; deMenocal 2001).

Although it is clear that the environment provides opportunities and constraints for agricultural productivity, equally, changes in settlement do not necessarily fall in lockstep with environmental proxy records. One well-known fluctuation, the 8200 BP event, which triggered a cooler, more arid climate, illustrates this conundrum. One group argues that this event caused major disruptions of Neolithic cultures in the Levant, northern Syria, and the eastern Mediterranean, and perhaps triggered the spread of early farmers out of the Near East into Greece and Bulgaria (Weninger et al. 2006). On the other hand, a Dutch team infers a number of cultural responses to the stresses imposed by a phase of cooler, arid climate. At Neolithic Tell Sabi Abyad in northern Syria, which was occupied throughout the 8200 BP event (dated to c.6225 BC), Neolithic life continued despite the fact that the site was in a climatically marginal location (Akkermans et al. 2010). Although cultural continuity was manifest at the site throughout the Neolithic, during the 8200 event several cultural changes occurred, including the replacement of pig husbandry by cattle, increased use of spindle whorls indicative of textile production, and a decline in the circulation of stone axes. The Dutch team argues that not only were such changes synchronous with the cool, dry event, but the climate had an indirect rather than a direct effect on material culture change (Akkermans et al. 2010). The implication of this study, supported by more than 100 radiocarbon determinations, is that stresses imposed by climatic events impelled communities to make changes to their way of life, but that these communities were resilient and successfully made appropriate adjustments.

Nevertheless, in some cases the buffering mechanisms that enabled communities to cope with shortfalls in food may have been removed as a result of climatic change, thereby making communities more vulnerable to such events. For example, in Palestine at the end of the 3rd millennium BC the environmental crisis took the form of river incision that left flood plains high and dry. The resultant loss of potential for floodwater farming removed a buffering mechanism that had enabled previous communities to survive particularly dry years (Rosen 2007: 177; Cordova 2008).

Alternatively, in a similar environment in northern Syria, rain-fed farming was sustainable through most dry years if biennial fallow was practiced. However, if fallow was violated and cropping was annual (perhaps to sustain increasing populations or growing towns), soil moisture was reduced, thereby jeopardizing the annual cereal crops (Wilkinson 1994). In addition, the drier environment of the late 3rd and early 2nd millennia BC may have encouraged a shift from wheat to barley, increased pastoral nomadism or, in parts of southern Syria, irrigation (Riehl 2008; Braemer et al. 2009). In addition, during the early 2nd millennium BC, Mari letters indicate competition over water between upstream and downstream settlements in the Balikh Valley (Dossin 1974).

By the use of multiple proxy records, together with measurements of carbon isotope analysis of grains from the sites of Ebla and Qatna in Syria, Roberts et al. (2011) have developed a climatic record that can be related to cultural sequences. Their record suggests that the earlier Holocene moist period was followed by a three-millennium-long climatic transition punctuated by three drier stages: at the end of the 4th millennium BC, the end of the 3rd millennium BC, and between 1200 and 850 BC (Roberts et al. 2011: 151). Although these appear to relate to phases of settlement decline, the authors also point out that the consequences of climatic change varied from region to region depending upon the sensitivities of those communities to drought (Roberts et al. 2011: 152). Such local variation is evident archaeologically at climatically marginal sites like, for example, Tell es-Sweyhat and Tell Mozan in northern Syria, both of which continued as significant settlements through the later part of the 3rd millennium BC (Danti and Zettler 2007; Pfälzner 2010).

Over the last 3,000 years, when much of the Near East was incorporated into extensive territorial empires, the developing infrastructures were capable of providing a buffer of support in times of need (Rosen 2007: 171). This is illustrated by the colonization by Middle and Neo-Assyrian kings of the Syrian steppe, which, although mainly sustained by rain-fed cultivation, was associated with the spread of irrigation systems which became more common during the 1st millennium BC and AD (Wilkinson 2003a). Although the adoption of irrigation could be seen as an adaptation to a drier climate, in this case it was a result of imperial policy, either to make the desert bloom or to garner greater tax revenues.

A compelling example of the advantages of expanded infrastructure comes from Antioch (Syria) where, in 362 AD, a poor grain harvest coincided with a huge build-up of troops to fight the Sasanian army. The resultant increase in grain prices and famine was eventually mitigated by the Roman emperor Julian (360–363 AD), who ordered grain imports from Chalcis and Hierapolis near Aleppo. If these towns had been under different kings, such a solution would have required negotiation or may have been impossible. Significantly, the grain was imported from the arid Membij region to verdant Antioch, an expedient made possible by the construction of numerous water-supply systems by previous Hellenistic and Roman administrations (Wilkinson et al. 2007).

It should be emphasized that disruptions in human sustenance do not result simply from runs of dry years. Other factors include rainfall fluctuation, cold years (that kill livestock), dust storms, locust plagues, mega-floods, and river avulsions (Widell 2007). Not only did coping strategies vary from polity to polity, some – such as the huge irrigation systems of the Sasanians – may have been vulnerable to erosion, floods, and lack of maintenance, so that if they were severed, the construction required may have been too much for later communities to manage.

## 10 Conclusions

By the Roman/Arsacid period much of the landscape of the Near East was a product of human action. This was not simply a result of the destruction of forests and associated soil erosion. Marshes were formed by the discharge of excess canal flow into flood basins and river flow was depleted by the withdrawal of water for irrigation (Wilkinson 1998a). Not only do pollen records identify a spike in orchard development from the Levant to western Iran during the late 1st millennium BC and early 1st millennium AD, Sumerian texts describe the range of trees introduced into southern Mesopotamia. These texts demonstrate that human management not only intensified the production of trees native to the area, it also brought about changes in species composition as well.

Although the history of the Near East was one of resource depletion, pollen sequences demonstrate that vegetation denudation varied geographically depending upon population levels and the scale of fuel-intensive industries such as mining (Barker 2000). It is now evident that increased social complexity, larger cities, and increased populations developed in the face of a drier, Late Holocene climate. Although, in general, technological and organizational developments enabled Near Eastern civilizations to outpace such environmental challenges, populations did adapt, move, and even change their lifestyle, sometimes under or sometimes despite the human agents or kings who led them.

## GUIDE TO FURTHER READING

For the physical geography of the Near East, see Fisher (1978) and Sanlaville (2000). A more specialized, but archaeologically relevant, work on Syria is Wirth (1971). A broad account of the archaeological landscape and environments of the Near East is provided by Wilkinson (2003a). Although none of the following books is dedicated to the environment in its entirety, Adams (1981), Potts (1997a), and Algaze (2008) describe and discuss the significance of the environment for Mesopotamian civilization. Van Zeist and Bottema (1991) remains a fundamental work on the vegetation history of the region. Different approaches to the eastern Mediterranean environments are provided by Bottema et al. (1990) and Grove and Rackham (2001). The debate concerning Early Bronze Age collapse is particularly well captured in Kuzucuoğlu and Marro (2007) as well as Rosen (2007). An earlier collection of essays on the subject is Dalfes et al. (1997). See also Zettler (2003). For the Quaternary period in Saudi Arabia, see Al-Sayari and Zötl (1978) and some useful insights on the environment of the Arabian peninsula can be found in Petraglia and Rose (2009). Finally, among the large number of papers on Quaternary and environmental topics, the following provide useful reviews of broader interest: Miller (1998), Roberts et al. (2001), Brooks (2006), Robinson et al. (2006), Kennett and Kennett (2007), Kuzucuoğlu (2007), and the papers in the special edition of the journal *The Holocene* 21/1 (2011).