Introduction

The period from ca. 16 to 9 cal. ka BP in the Eastern Mediterranean region witnessed profound economic, social and technological changes which transformed human communities from Epipalaeolithic hunter-gatherers into settled Neolithic village farmers. This transformation coincided with climatic warming after the Last Glacial Maximum that provided new challenges and resource opportunities for human groups. Cold *Artemisia*–chenopod steppe, which had been widespread during glacial times, was replaced by grass steppe, parkland and forest after ca. 15 ka (van Zeist and Bottema, 1991). The Lateglacial climate amelioration was interrupted in many, although not all, sequences by a return to quasi-glacial conditions at approximately the same time as the circum-North Atlantic Younger Dryas event (Robinson *et al.*, 2006). This climatic deterioration halted the spread of trees from

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glacial refugia and resulted in the temporary re-expansion of the drought-tolerant steppe (Rossignol-Strick, 1995). The onset of the Holocene in Southwest Asia was marked by a rapid climatic shift to conditions warmer and generally wetter than at the present day (Bar-Matthews *et al.*, 1997; Roberts *et al.*, 2008) and a renewed expansion of woodland and grassland vegetation.

Coinciding with the last glacial–interglacial climatic transition (LGIT; 16–9 ka), there occurred the key stages in the domestication of cereals and other crop plants, and animals including sheep, goats, pigs and cattle (Zohary and Hopf, 2000; Barker, 2006). In the so-called Fertile Crescent, the wild progenitors of domestic cereals occur naturally today, having been much less widely distributed during glacial times (Hillman, 1996). The climatic warming associated with the LGIT offered greatly improved conditions for plant growth due to higher temperatures along with increased, but markedly seasonal, moisture availability (Wright, 1993). The initial expansion of open grass parklands across the region provided an enhanced resource base for local hunter-gatherer communities due to the natural occurrence of wild food plants including cereals and legumes. This supported considerable population growth and the adoption of a more sedentary way of life, as recorded in Epipalaeolithic early Natufian sites in the southern Levant (Bar-Yosef and Belfer-Cohen, 1992). The reversion to quasi-glacial conditions at the end of the Lateglacial, coinciding with the late Natufian period, saw a reduction in the availability of many wild resources as those species intolerant of the cold and arid climatic conditions became locally extinct. This climatically driven collapse in wild resources has been cited as a potential catalyst for the emergence of cultivation in the region, evidence of which has been found within archaeobotanical remains at Abu Hureyra, located in the Euphrates Valley (Moore *et al.*, 2000; Hillman *et al.*, 2001; but see Willcox, 2005). Sheep and goat domestication appears to have taken place at broadly the same time but further east, towards the Zagros mountains (Zeder and Hesse, 2000). By the time of the Pre-Pottery Neolithic B period (PPNB, ca. 10.6 ka onwards), sedentary village communities combining plant and animal domesticates became widespread across the Fertile Crescent region (Colledge *et al.*, 2004; Rosen, 2007a). From here, agriculture spread outwards from Southwest Asia, most notably westwards into Greece, the southern Balkans and Europe beyond (van Andel and Runnels, 1995).

The beginning of agriculture was not only influenced by environmental changes, but it also greatly increased the potential of newly settled human communities to modify their natural surroundings. Early human impacts on Eastern Mediterranean landscapes have not been easily identified in pollen records from lake cores (Willis and Bennett, 1994). In part, this is because many of the palynological indicators used to identify prehistoric crop husbandry in temperate Europe (e.g. *Cerealia*-type pollen) are present naturally in the Mediterranean region and so do not provide a diagnostic indicator of farming activity. However, another potential explanation is that pre-Neolithic baseline 'primaeval' vegetation may never have existed in some of Southwest Asia's landscapes. It is therefore possible that significant human impacts began even before vegetation had completed its adjustment to the shift in climate at the end of the last glacial period.

One important but relatively neglected component of landscape change during the climatic and cultural transition between 16 and 9 ka is the role of wildfire. Wildfires modify vegetation composition and structure, as well as altering the availability of natural resources for human groups. Fire frequency and intensity are determined by a range of natural factors including biomass availability, a seasonally dry climate and ignition sources, but fire is also one of our oldest tools of environmental management. Fire was a tool used by Native Americans (e.g. Clark and Royall, 1995; Keeley, 2002) and the Aboriginal populations of Australia (e.g. Kershaw *et al.*, 1997) to manage and manipulate vast tracts of landscape. We therefore hypothesise that changing burning regimes in the Eastern Mediterranean influenced, and were in turn influenced by, the transition to Neolithic agriculture in this region.

Lewis (1972) was one of the first to recognise the potential importance of fire in the process of plant domestication in Southwest Asia. He proposed, partly from ethnographic analogy with Native California, that burning was employed as a technique of landscape management during the 'broad-spectrum revolution' that formed a key part of the pathway to plant domestication in the Eastern Mediterranean region. Lewis argued that 'the judicious use of fire could increase and improve the production of herbaceous plants' (Lewis, 1972, p. 206), specifically large, hard-grained grasses, along with 'those animals most dependent on [plant] growth'. Some of the wild progenitors of domesticated plant species would have been promoted through low-intensity ground fires that are commonplace in Mediterranean-type ecosystems during the summer dry season (Zohary and Hopf, 2000; Grove and Rackham, 2001). On the other hand, fires can also have deleterious effects on large-seeded annual grasses, especially if adversely timed (Blumler, 1991; Hillman, 1996). More generally, wildfires act to maintain open grasslands, promoting their growth and retarding the encroachment of trees (Naveh and Carmel, 2003). Based on this, Roberts (2002) postulated that wildfires, at least partly of anthropogenic origin, contributed to the delay in postglacial woodland recolonisation of the drier, interior areas of Southwest Asia. In contrast to the wetter coastal mountains which were rapidly reafforested during the LGIT, in south central–eastern Anatolia and western Iran maximum arboreal pollen values were not reached until mid Holocene times (van Zeist and Bottema, 1991; Wick *et al.*, 2003). Previously accepted explanations for this delay – notably a slow inferred increase in effective moisture availability during the first half of the Holocene (e.g. Roberts and Wright, 1993) – have become increasingly difficult to sustain in the face of independent palaeoclimatic evidence that the early Holocene was wetter than at present in the Eastern Mediterranean (Bar-Matthews *et al.*, 1997; Jones *et al.*, 2007; Roberts *et al.*, 2008).

In this study, we investigate the changing climate, vegetation, wildfire and human activity in Southwest Asia – and the relationship between them – during the LGIT. In order to trace the fire history of this region, we use microscopic charcoal from lake sediment records. Micro-charcoal analysis is now well established as a means of reconstructing local, regional and even global records of biomass burning (Carcaillet *et al.*, 2002; Power *et al.*, 2008; Conedera *et al.*, 2009). Most previous research into long-term fire activity in the Eastern Mediterranean has been of low temporal resolution and carried out as an adjunct to pollen analytical studies (e.g. Yasuda *et al.*, 2000). Here we present two new micro-charcoal records which span the LGIT: one from south central Anatolia, the other from the southern Levant. Through the use of complementary multi-proxy data, these microscopic charcoal records are linked to changes in climate (based on stable oxygen isotope ratios), vegetation cover (via pollen data) and human activity (from archaeological excavations and surveys). Data derive either from the same sediment core sequence, or from locations that are geographically close by and which should have experienced the same environmental and cultural history. In this way, we attempt to relate shifts in regional fire activity to different natural and anthropogenic drivers. For example, shifts in fire history records that are 'out of phase' with $\delta^{18}O$-inferred climatic changes but associated with corroborating archaeological evidence would be consistent with direct anthropogenic causation. Finally, we present a regional synthesis of Eastern Mediterranean fire activity, comparing the two new records against other published micro-charcoal sequences from Southwest Asia in order to test for regionally coherent trends.

Study areas

South central Turkey

The key data presented in this paper derive from Akgöl at the eastern end of the Konya basin (37° 30′ N, 33° 44′ E; ~1000 m above sea level; Fig. 1). Until it was drained during the 1980s, this was the largest residual lake of Pleistocene palaeolake Konya. The Akgöl depression consisted of a central saline playa, the main lake (~50 km^2 in extent, but only 1–2 m deep), along with a Pleistocene beach ridge which separated the main lake from Adabağ marsh (Roberts *et al.*, 1999). The principal inflow entered the lake through the Zanopa River, which is in turn fed by the largest karstic water spring of the Konya Basin at Ivriz (Leng *et al.*, 1999). Minor freshwater inputs also entered Akgöl from ephemeral streams running off the limestone hills to the south of the lake basin. The primary outflow of Akgöl was a sink-hole ('düden') on the southern margin of the lake basin.

The natural vegetation of the Konya Plain was classified by Zohary (1973) as Xero-Euxinian, characterised by either broad-leaved steppe forest or grass steppe. These are transitional vegetation communities which contain dwarf shrubs, grasses and scattered trees. Deciduous oaks (e.g. *Quercus pubescens* and *Q. rober*) tend to dominate the tree flora on surrounding uplands but *Pistacia* spp., *Juniperus* spp. and some *Pinus* spp. also occur, along with wild fruit trees (e.g. Pomoideae). However, the longevity of grazing in the area has resulted in the natural vegetation been replaced by Irano-Turanian ground flora characterised by *Stipa–Brometum* (Zohary, 1973). Following the drainage of the lake and surrounding marshes during the 1980s, the area has been turned over to agriculture. Owing to the elevation and distance from the coast, the climate of central Turkey is semi-arid and semi-continental. Mean annual precipitation on the Konya plain is 250–300 mm a^{-1}, 30% of which falls in spring (Türkeş, 2003); summer rainfall is rare. Average temperatures range from −2°C in January up to 24°C in July (Türkeş, 2003). The combination of cold, moist winters and hot, dry summers results in a regional moisture deficiency. On the surrounding uplands, precipitation rises to 500 mm a^{-1}, and in winter much of this falls as snow.

Within the Konya Basin there are important early Holocene archaeological sites, several of which have been excavated. They include Neolithic–Chalcolithic settlement mounds at Çatalhöyük, Can Hasan and Boncuklu, and the Pınarbaşı rockshelter site (Figs 1 and 2); they testify that the Konya plain was the scene of settled village life and early agriculture from at least ca. 9.5 ka, along with evidence of earlier proto-agricultural communities (Baird, 2002, 2005).

The southern Levant

A fire history record is also presented from Lake Hula in Israel, which is situated ~70 m above sea level in the Levantine section of the Syro-African rift system (see Fig. 1). Lakes and swamps have occupied this area of the Jordan Rift Valley since the early Quaternary due to the presence of a basaltic block which serves to dam the basin (Horowitz, 1979; Baruch and Bottema, 1991). Prior to drainage of the shallow lake in the late 1950s, open water covered an area of 5–10 km^2, with a similar area of swampland to the north. Lake water flowed out south via

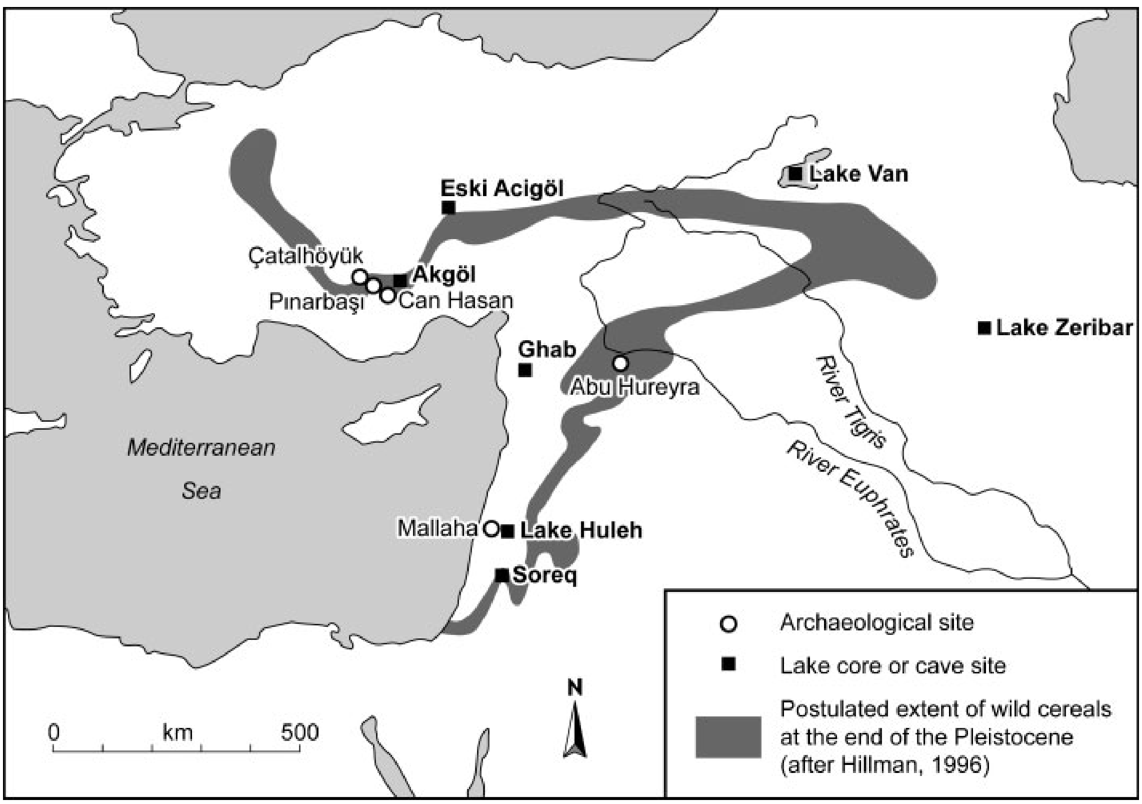

Figure 1 Location of the study sites, lake basins, cave and archaeological sites referred to in this paper

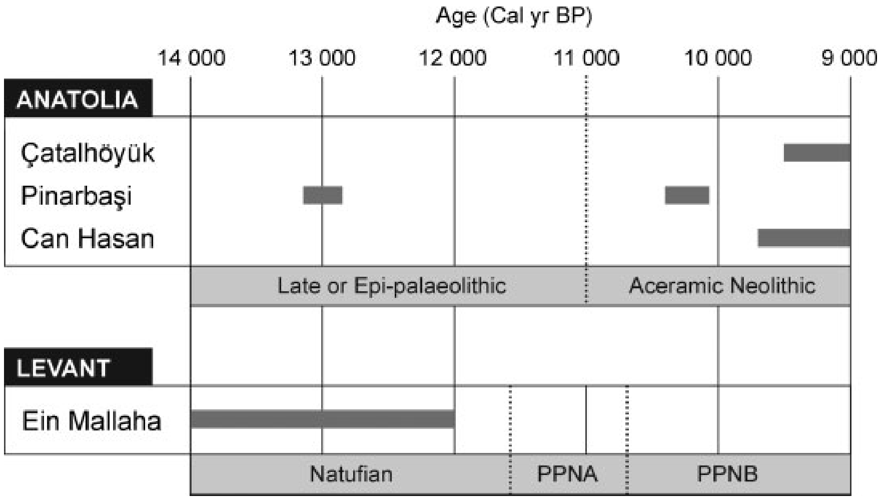

Figure 2 Archaeological periods and site occupations in the Konya and Hula basins during the LGIT

the Jordan River into the Sea of Galilee and eventually into the Dead Sea, ensuring that – like Akgöl – Hula contained fresh water.

The Levant experiences typical summer-dry, Mediterranean-type climatic conditions. However, there is a strong climatic gradient running from the subtropical climate of the northern Levant to the semi-arid areas of the south, with the severity of the summer drought varying along this gradient (Ben-Gai *et al.*, 1998). There is also considerable variation in precipitation and temperature with altitude; e.g. mean annual precipitation in the Jordan Valley measures 450–650 mm a^{-1}, whereas in the mountains it measures 500–1000 mm a^{-1} (Baruch and Bottema, 1999). As with precipitation and temperature, there are variations in vegetation associated with altitude. In the Golan Heights to the east of Lake Hula, the *Q. ithaburensis* parkland is replaced by *Quercus ilex*. The slopes of Upper Galilee are characterised by steppe forest dominated by *Pistacia atlantica* at the lower elevations, to be replaced by Mediterranean maquis at higher elevations (Baruch and Bottema, 1999). As in south central Turkey, due to the longevity of human occupation of this area, the natural vegetation has been greatly modified though grazing and cultivation; therefore the oak parkland of the Hula Valley sides only occurs sparsely in areas of protected land (Baruch and Bottema, 1999).

The area surrounding Lake Hula contains one of the most important Epipalaeolilithic archaeological sites: Ain Mallaha. This site contains evidence of a long episode of Natufian occupation which includes the transition from the Lateglacial Interstadial through the cooling of the Lateglacial Stadial (Valla *et al.*, 2007) (Fig. 2). Further south, in the Jordan Valley, other archaeological settlements record the cultural shifts that took place during the LGIT associated with the transition from hunter-gatherer communities to the emergence of sedentary agricultural settlements (Bar-Yosef and Belfer-Cohen, 1992).

Methods

Lake coring and sampling resolution

Akgöl was originally cored in 1977 (core ADA77), primarily for pollen analysis (see Bottema and Woldring, 1984, for details), and then re-cored as part of the KOPAL project in 1995 (cores AGL95A/B) using an Eijkelkamp vibro-corer. A range of geochemical and palaeoecological indicators have been analysed on the KOPAL cores, including pollen, diatoms and stable oxygen isotopes ($\delta^{18}O$) (the latter reported in Leng *et al.*, 1999). AGL95A was dated using radiocarbon, luminescence and U-series (U–Th) dating, and wider sedimentological analyses were also conducted (see Roberts *et al.*, 1999). Additional analyses of micro-charcoals and phytoliths were conducted on the AGL95A as part of the study presented in this paper. The Lake Hula core analysed here was taken by U. Baruch and S. Bottema in 1987 using a Dachnowsky corer as part of their palynological research.

Microscopic charcoal analysis

Fire events produce a pulse in charcoal that is rapidly transported away from a fire site through airborne and fluvial transport mechanisms, and thereby become incorporated into lake sediments (Patterson *et al.*, 1987). Reconstructing an accurate fire history record is dependent on identifying these pulses of charcoal within sedimentary records. Traditional approaches to sampling palaeoenvironmental proxies, whereby spot (i.e. fixed-interval) sampling strategies are employed, are not necessarily suited to reconstructing records of fire activity as they can lead to peaks in charcoal concentrations being missed. Therefore a contiguous sampling strategy was adopted for the Akgöl sequence above 440 cm, this section of the core corresponding to the time period relevant to this study (Roberts *et al.*, 1999). Contiguous 1 cm^3 sediment samples measuring $4.0 \times 1.0 \times 0.25$ cm were extracted from this section of core AGL95A using a Dremmel hand drill (model 395). A higher sampling resolution of $2.0 \times 1.0 \times 0.5$ cm was applied to the section of this core correlating to major climatic changes: e.g. onset of the Holocene. The Lake Hula core sequence was incomplete due to sampling employed during previous analyses and the loss of the top 2 m of the core and the section between 10 and 12 m. Therefore it was only possible to conduct a fixed-interval sampling strategy for microscopic charcoal analysis. 1 cm^3 sediment samples were taken every 8 cm for the lower portion of the core spanning the Lateglacial–Holocene transition, and every 32 cm for the upper portion of the core corresponding to the mid–late Holocene.

After adding *Lycopodium* tablets to enable estimation of charcoal concentrations, samples were prepared using density separation (Turner, 2007). The density separation method was found experimentally by Turner *et al.* (2008a) to have a higher recovery than other published methods for the fine charcoal fraction, and more than 10 times the recovery of standard pollen preparation method. Samples were initially treated with 10% HCl to disaggregate the sediments and then passed through a 180 μm mesh to remove (and retain) the larger, potentially more fragile charcoal particles that could fragment during the preparation and result in a potential overestimation of the charcoal concentration of a sample. Lithium hetero-polytungstate with a specific gravity of 2.5 was used to separate the <180 μm microscopic charcoal particles from the sediment matrix. These were then mounted on a standard microscope slide, and all charcoal particles within each field of view were counted using a BX100 high-power light microscope at 200× magnification, until a count of 250 *Lycopodium* spores was reached. Micro-charcoal particles were identified based on a set of diagnostic criteria, primarily that they had to be jet black in colour, with straight edges, and with the presence of a blue hue on edges (Turner *et al.*, 2008a).

Pollen analysis

Subsamples were taken at regular ~16 cm intervals throughout the length of core AGL95A and subjected to standard processing procedures (Faegri and Iversen, 1989; Moore *et al.*, 1991). This involved digestion in 10% HCl, followed by treatment with 10% NaOH. Clay-rich samples were subjected to 5% $Na_4P_2O_7$ and sieved at 5 μm and 150 μm mesh sieves. Minerogenic samples were treated with 60% HF acid before Erdtman's acetolysis. *Lycopodium* tablets were added to calculate pollen concentrations and samples were mounted in glycerine jelly.

Pollen grains and other palynomorphs were counted on a Nikon Labophot-2 microscope at 200× and 400× magnification traversing at regularly spaced intervals until the pollen sum of 350 grains was reached. Critical identifications were conducted under oil immersion at 1000× magnification together with phase contrast. Identifications were aided by the keys, descriptions and microphotographs contained within Moore *et al.* (1991), Reille (1992), van Bentham *et al.* (1984) and Punt *et al.* (1991). Reference pollen was also consulted. Plant nomenclature follows *Flora Europaea* (Tutin *et al.*, 1964). Identification of algal and fungal microfossils was aided by the descriptions and microphotographs by van Geel (1986) and van Geel *et al.* (1989). Conventions for the degree of taxonomic certainty follow Berglund and Ralska-Jasiewiczowa (1986).

Phytolith analysis

Phytoliths are silica bodies that form casts of plant epidermal tissue during the life of a plant. Following the decay of plant matter phytoliths are readily preserved in sediments and are commonly recovered in archaeological and natural deposits. They are formed most abundantly within grasses, sedges and other monocotyledons, although they also occur within the leaves, bark and wood of dicotyledonous shrubs and trees. Phytoliths were extracted from the Akgöl and Hula core sediments at intervals comparable to those examined for micro-charcoal. An aliquot of ~800 mg of fine-grained sediment (<0.25 mm) was processed for each sample. Calcium carbonates were removed by adding 10% HCl. The samples were then washed in filtered water and centrifuged at 2000 rpm for 5 min. Clays were dispersed by agitating the samples in a 20 mL solution of sodium hexametaphosphate (calgon), and removed by settling the sediment through a column of filtered water and decanting the suspended clay fraction. Colloidal organic matter was then removed by burning the sample in a muffle furnace at 500°C for 2 h. The remaining sediment was transferred to a 15 mL polypropylene centrifuge tube, and 3 mL of sodium polytungstate heavy-density solution of 2.3 specific gravity was added to the tube. The sample was agitated and centrifuged at 800 rpm for 10 min. The suspense containing the phytolith material was poured into a clean 15 mL centrifuge tube, washed in distilled water, and centrifuged to clean. The remaining pellet was dried and weighed, and then a weighed aliquot of about 2 mg was mounted on a microscope slide using Entellan as a mounting medium. The samples were counted at 400× magnification using an Olympus BH-2 optical microscope. The number of microscope fields counted were recorded and the number of phytoliths per gram sediment was calculated for absolute counts of phytolith types.

Results

Akgöl

The full AGL95A core sequence is 847 cm long and consists of peaty clays (0–120 cm), a buried soil horizon (120–128 cm) overlying pale-grey, and calcareous clay marls with increasing detritus silt below 610 cm. There is a dark organic horizon at 282–286 cm and a pebble layer at 440–446 cm (Fig. 3). Previous dating and sedimentological analyses allowed a number of hiatuses in sedimentation to be identified in the Akgöl sequence. In terms of the present study, the most important of these occurred at 440 cm and ~126 cm. The hiatus at 440 cm is marked by a desiccation layer and an abrupt change in the diatom assemblages (Roberts *et al.*, 1999; J. Reed, pers. comm.), while that at 126 cm corresponds to the buried soil horizon, when the site became terrestrialised. Between these depths, the AGL95 core sequence covers the time period between ca. 15 and 9.5 ka; sedimentation subsequently recommenced at ca. 6.5 ka . In addition, comparison of the pollen records shows a distinct, short-lived *Betula*-dominated phase present in the ADA77 core (Bottema and Woldring, 1984) that is absent in the pollen record from core AGL95A (Roberts *et al.*, 2006; W. Eastwood, pers. comm.). This implies that a third minor hiatus or other disturbance occurred in AGL95A at the very beginning of the Holocene, probably representing a few centuries and possibly linked to spatial shifts in the depo-centre within the lake during this climatic warming stage. There is no evidence of a fall in lake level at this time. These hiatuses were taken into consideration in the construction of the age model summarised in Table 1. Proxy-climate data from the AGL95A sequence exhibit changes that appear similar in timing and magnitude to those of the Lateglacial in northwestern Europe (viz. Bölling–Alleröd interstadial and Younger Dryas stadial). However, it is not yet possible to make conclusions regarding the precise synchronicity of these events and therefore they are named here the Lateglacial Interstadial and Lateglacial Stadial (following Jones *et al.*, 2007).

The Akgöl $\delta^{18}O$ record has been demonstrated to respond to changes in both the precipitation:evaporation balance of the lake as well as freshwater inputs from the Zanopa River (Leng *et al.*, 1999). Between ca. 15 and ca. 11 ka , there was a fluctuating trend towards more negative $\delta^{18}O$ values, reflecting a shift towards generally wetter conditions during the LGIT (Fig. 4). These negative $\delta^{18}O$ values persisted throughout the

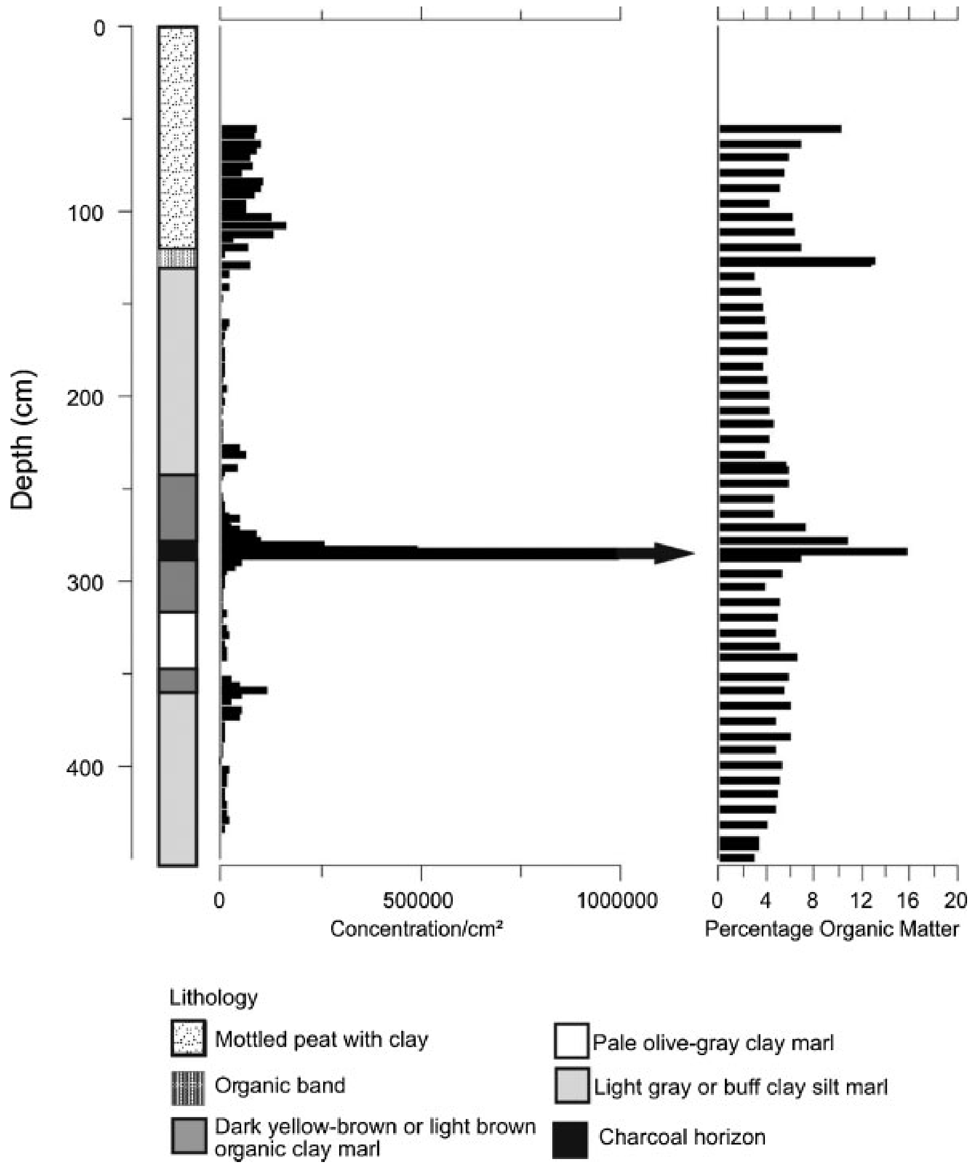

Figure 3 Akgöl core AGL95A charcoal concentration values, loss of ignition at 550°C, and lithology (upper 440 cm only)

early Holocene, reflecting a period of favourable water balance, before returning to intermediate values after 6.5 ka (Leng *et al.*, 1999). The pollen data from Akgöl (Bottema and Woldring, 1984, and the new data presented here) together with additional sites from central Turkey (e.g. Eski Acıgöl; Woldring and Bottema, 2003) demonstrate that during the Lateglacial the vegetation was dominated by largely treeless *Artemisia*–Chenopod steppe. The onset of the Holocene was marked by a reduction in *Artemisia* and Chenopods, followed by the gradual expansion of trees. The early Holocene was characterised by open grass parklands which included *Pistacia* and the continued expansion of mesic tree species (Bottema and Woldring, 1984).

As is evident in Figs 3 and 4, strongly fluctuating levels of charcoal were recorded in Akgöl through the LGIT. They include a black, charcoal-rich layer at 282–286 cm, which records a major landscape burning event at around 13.0 ka, the interpretation and significance of which are discussed further below. In contrast to the other Eastern Mediterranean records for which fire history reconstructions were made employing the same density separation technique (e.g. Eski Acıgöl and Nar Gölü; England *et al.*, 2008; Turner *et al.*, 2008b), overall charcoal concentration and influx values at Akgöl are relatively high. The shallow, open morphology of Akgöl (Fig. 5) combined with the flat, open landscape of the Konya Basin means that, in contrast to the crater–lake sequences discussed in Turner *et al.* (2008b), Akgöl probably recorded a spatially heterogeneous fire history signal. Charcoal from both local and regional fire events is likely to have reached the lake primarily through aeolian transport processes.

Interpretation

In order to interpret the Akgöl core in terms of causal agencies, the micro-charcoal record should be partitioned between primarily local and primarily regional fire events. This is particularly important for the large peak in charcoal recorded at ca. 13.0 ka. Fine resolution analysis of both AGL95A and parallel core AGL95B shows that this charcoal peak was not limited to a single sample, but included two maxima over a depth interval of >4 cm (Turner, 2007). Charcoal was also abundant in the >180 μm fraction from this layer, while pollen was very poorly preserved. Together, these facts are consistent with a fire of local origin. In order to test this further, we

Table 1 Akgöl AGL95A core chronology. For full details see Roberts *et al.* (1999)

Key ^{14}C dates

Depth (cm)	Lab no.	Age (^{14}C a BP)	Median age (cal. a BP)	Dated material
109–112	Beta 136285	5 170 ± 110	5 920	Peaty sediment[a]
126–128.5	SRR-5935	8 690 ± 50	9 602	Organic matter from buried soil
284–286	AA-23930	11 110 ± 70	13 021	Charcoal band

[a] Previously unpublished date.

Key U–Th dates

Depth (cm)	Age (a)
168–170	10 600 ± 1 300
286–288	12 000 ± 500
362–364	13 400 ± 900

Calculated age–depth relationship

Depth (cm)	Age (cal. a BP)	
<58–122	<3 109–6 381	
122–128	6 381–9 666	(Buried soil)
128–170	9 666–10 612	
170–240	10 612–11 050	(Minor break)
240–280	11 396–12 790	
280–440	12 790–15 026	

analysed phytoliths from core AGL95A (Fig. 4), which show that phytoliths in the 'burning horizon' are dominated by *Phragmites* and Cyperaceae, and that many of the phytoliths are themselves burnt, as indicated by their black appearance (Parr, 2006) (see supporting information for images). This appears to confirm that the main fuel source for the 13 ka fire(s) derived from Akgöl marsh itself, not from the surrounding dryland vegetation. Diatoms from this level are dominated by periphytic taxa, consistent with a shallow, marshy lake at this time (J. Reed, pers. comm.). The most likely explanation for the 'burning horizon' is that the marsh surface desiccated during a drought interval and that the reedbeds ignited. A possibly similar burning of the marsh surface had occurred just prior to coring in 1977 (Bottema and Woldring, 1984, p. 132). The source of ignition for the 13 ka event could have been climatic (lightning), volcanic (Late Pleistocene eruptions occurred in the vicinity (Fig. 5); see Kuzucuoğlu *et al.*, 1998), cosmic (cf. Firestone *et al.*, 2007) or anthropogenic, since there is archaeological evidence for Epipalaeolithic hunter-gatherers in the Konya plain at this time (D. Baird, pers. comm.). This burning event, although potentially only of local significance, coincides with a positive $\delta^{18}O$ trend between ca. 13.3 and ca. 12.8 ka associated with the climatic shift from the wetter interstadial to the subsequent colder, drier stadial.

Other micro-charcoal maxima in core AGL95A have phytoliths dominated not by sedges and reeds but by woody dicots of terrestrial origin (Fig. 4); nor are they burnt. The overall pollen record also contains substantial arboreal values of non-local origin. This implies that micro-charcoal influx through the rest of the core was derived primarily from terrestrial vegetation sources rather than burning of the marsh surface. Other than the 13 ka burning event, the micro-charcoal record from Akgöl is therefore interpreted in terms of regional-scale fire regimes. Comparisons between the remaining charcoal record and other proxy evidence (pollen and $\delta^{18}O$) from AGL95A do not show as clear a relationship between climate, biomass and fire as in some other fire history reconstructions from this region during the LGIT (e.g. Eski Acigol; Turner *et al.*, 2008b). Nonetheless, maximum micro-charcoal influx of regional origin occurs immediately following dry to wet climatic shifts at the start of the Lateglacial Interstadial (ca. 14 ka) and again during the early Holocene (ca. 11 ka), presumably reflecting increases in available biomass. Pollen data suggest that grasslands – including wild cereals – would have reached their greatest extent at these times, and dry season burning of grasses seems likely to have provided one of the main charcoal sources. By contrast, by mid Holocene times, woody biomass may have provided the predominant fuel source for wildfires. Burning intensities were notably low during the Lateglacial Stadial when chenopod and *Artemisia* pollen reached maximum values.

Lake Hula

The core sequence recovered by Baruch and Bottema measures 1625 cm and consists of pale grey-buff calcareous clay marls. The results of ^{14}C dating and palynological analyses are reported in Baruch and Bottema (1991, 1999). There has been considerable debate in the published literature regarding the chronology of this sequence. Cappers *et al.* (1998, 2002) identified a 'hard water' effect, but proposed relatively minor corrections to the ^{14}C dates based on $\delta^{13}C$ determinations. A more radical reassessment of the chronology by Rossignol-Strick (1995) and Meadows (2005) identified a much larger correction factor of up to 5500 ^{14}C a based on the analysis of the contemporary isotopic composition of Lake Hula's water and comparison with regional palynological records. Particularly notable in this regard is the fall in steppic herbs and start of a continuous rise in *Pistacia* between 14 and 15 m core depth; in other regional pollen records, these mark the Pleistocene–Holocene boundary. For the purposes of the present paper, micro-charcoal data are presented against a depth scale set

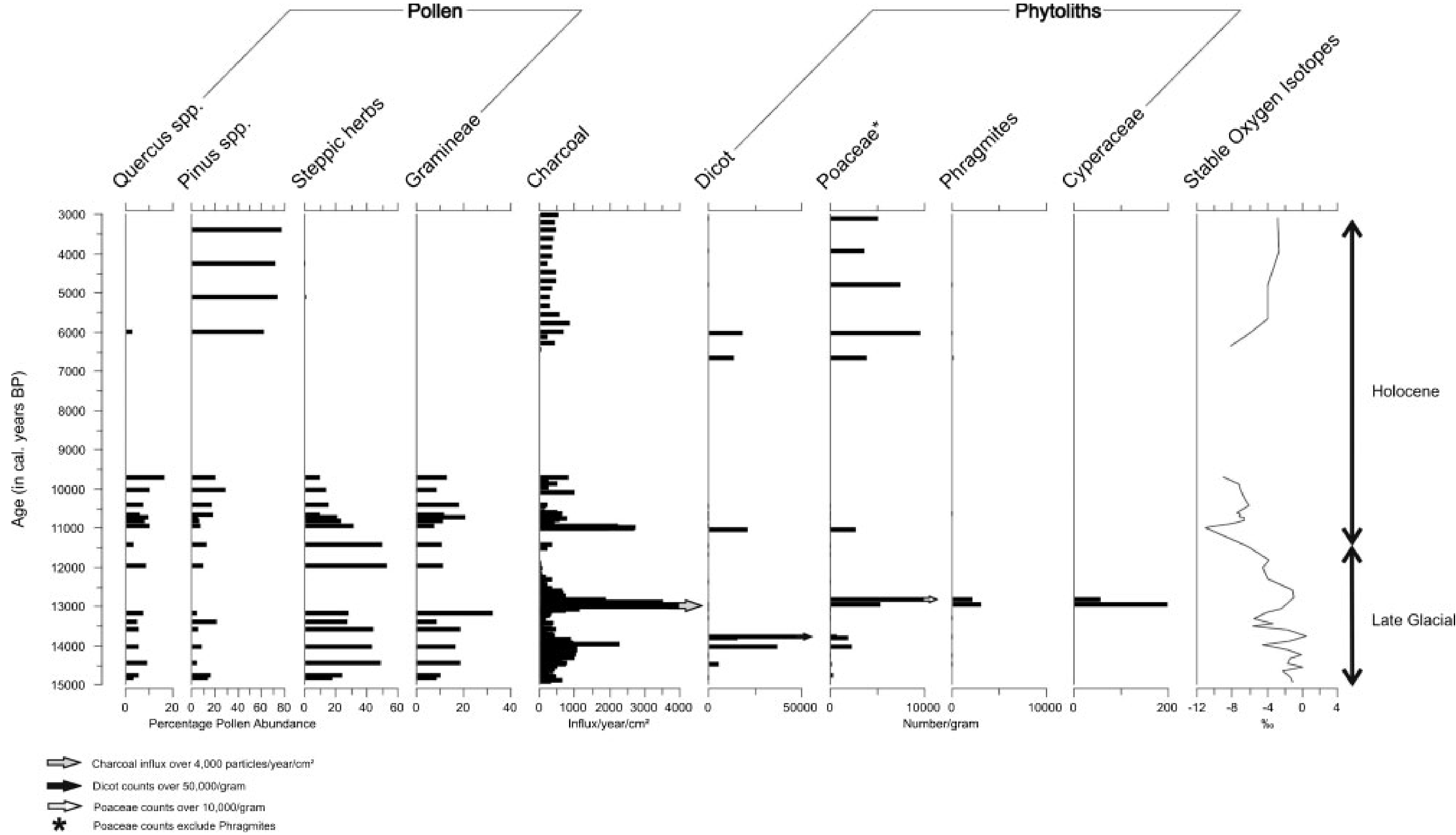

Figure 4 Micro-charcoal influx for Akgöl AGL95A compared to summary pollen, phytolith and oxygen isotope data from the same sequence, 15–3 cal. ka BP ($\delta^{18}O$ data from Leng *et al.*, 1999). The time period 9.6–6.4 ka was marked by soil formation, so no data are available

Figure 5 Akgöl prior to drainage (1980; photograph, N. Roberts). Note the extensive reed banks, the open nature of the landscape and the volcanic cone of late Quaternary age. This figure is available in colour online at www.interscience.wiley.com/journal/jqs

against the Meadows chronology, which gives the core a basal age of ca. 14 ka; however, it is recognised that this chronology may be subject to future revision, which would require some reinterpretation of the fire history record. Whatever their precise age, the micro-charcoal data can be compared directly against pollen data from this Hula core sequence to reveal past fire–vegetation relationships, as they derive from the same sedimentary sequence.

Pollen data for the basal part of the core of Late Pleistocene age (Baruch and Bottema, 1999) show that *Quercus* spp. and Gramineae were common, indicating the presence of open, oak-dominated parkland (Fig. 6). Chenopodiaceae and *Artemisia* spp. were also represented, indicating a steppic component to the parkland vegetation communities, but they were less significant than at Akgöl and other interior sites during the Lateglacial period. The onset of the Holocene (using the Meadows chronology) saw a progressive increase in arboreal pollen values as trees, particularly *Quercus itaburensis*, began to expand as climate warmed. As trees and grasses expanded there was a subsequent reduction in steppic herbs.

$\delta^{18}O$ analyses were conducted by Stiller and Hutchinson (1980) on an earlier core sequence taken from Lake Hula. In addition to the chronological uncertainty discussed above and the need for inter-core correlation, there are difficulties in interpreting this stable isotope record because of the presence of detrital carbonates in the sediments. Whether because of this, or because Hula is an open, throughflow lake, $\delta^{18}O$ values are strongly negative and show only minor downcore changes. This means that stable isotope data from Hula do not provide a record of regional changes in water balance (Roberts *et al.*, 2008). Instead, we can use the well-dated $\delta^{18}O$ record from speleothems in Soreq Cave, Israel, to provide a record of hydro-climatic changes over the Lateglacial–Holocene transition in the southern Levant (Bar-Matthews *et al.*, 1997). Climatic amelioration was recorded in the Lateglacial Interstadial at Soreq, with inferred annual precipitation of 550–750 mm and temperatures of 14.5–18.0°C, followed by a reversal to glacial $\delta^{18}O$ values during the Lateglacial Stadial as a result of a reduction an annual precipitation. By contrast, the early Holocene witnessed high precipitation values (675–950 mm a^{-1}). The expansion in oak woodland on the hills around Hula would thus have coincided with the climatic shift from cold and arid to warm and moist conditions between 12.0 and 9.5 ka.

Charcoal influx values fluctuate strongly during the basal part of the Hula core but show an initial decreasing trend (15.7–14.5 m, inferred age 13.0–11.5 ka) followed by a marked increase to reach maximum values for the whole sequence (14.5–12.0 m; 11.5 to ca. 9 ka; Fig. 6). Micro-charcoals broadly mirror the trend in deciduous oak pollen, suggesting that wildfire was limited primarily by the availability of woody biomass, which itself was limited by moisture and warmth during this transitional period. Cerealia-type pollen experiences its lowest percentage values during this interval of forest growth and greatest fire frequency/intensity. Later in the Holocene (above ~9.7 m) micro-charcoal flux gradually decreases to reach a minimum during early historic times. Climatic desiccation and landscape transformation by agro-pastoralism seem to have combined to reduce fuel availability and hence also burning activity.

Interpretation

Lake Hula has a similar morphology to Akgöl, insofar as prior to drainage it was a large, open, shallow lake with surrounding marsh. Therefore it is likely to have received a spatially heterogeneous fire history signal. However, unlike Akgöl there is no evidence that would indicate the occurrence of localised burning events on the marsh surface during the core record. There are no charcoal-rich horizons, and micro-charcoal maxima correlate with dicot rather than reed/sedge phytolith peaks (Fig. 6). This would appear to reflect a relatively minor contribution of locally derived charcoal to this sequence.

The Lateglacial Interstadial in the southern Levant was characterised by oak–grass parkland which expanded in response to the regional climatic warning. Oak–grass parkland is characterised by regular ground fires (Naveh, 1974), and the few samples that were analysed from this period do show moderate–high regional fire activity. Despite the reversion to cooler and drier conditions during the Lateglacial Stadial, the severity of the climatic deterioration was not as great here as elsewhere in the Eastern Mediterranean (Bar-Matthews *et al.*, 1997; Jones *et al.*, 2007). Although arboreal pollen values declined, trees remained present throughout the record, and Gramineae continued to dominate over steppic herbs in the non-arboreal pollen component. Despite the reduction in biomass availability there was still adequate fuel to support fire activity throughout this period, as indicated by the continued – though reduced – presence of micro-charcoal. There is also well-documented evidence of human activity around Lake Hula during Lateglacial times, in the form of the Natufian settlement at Ain Mallaha. These peoples operated a broad-spectrum economy that involved harvesting of large and small-seeded grasses including wild cereals (Rosen, 2007b). It is therefore possible that seasonal burning was used as a form of environmental management to prevent woodland encroachment at this time, and that this contributed to the fire record (Roberts, 2002). Hominin use of fire in the Hula basin is attested as long ago as 0.8 Ma (Alperson-Afil, 2008).

The climatic amelioration at the start of the Holocene promoted an increase in net primary productivity of the vegetation community surrounding the Hula basin, particularly of oak woodland, which expanded much more rapidly than it did in central Anatolia. This in turn increased the fuel load and the potential for increased fire activity, which is reflected in high charcoal influx to the lake at this time. The association with the maximum oak extension and with dicot phytoliths suggests that woody biomass rather than grasses provided the principal supply of fuel. The role of human firing setting is

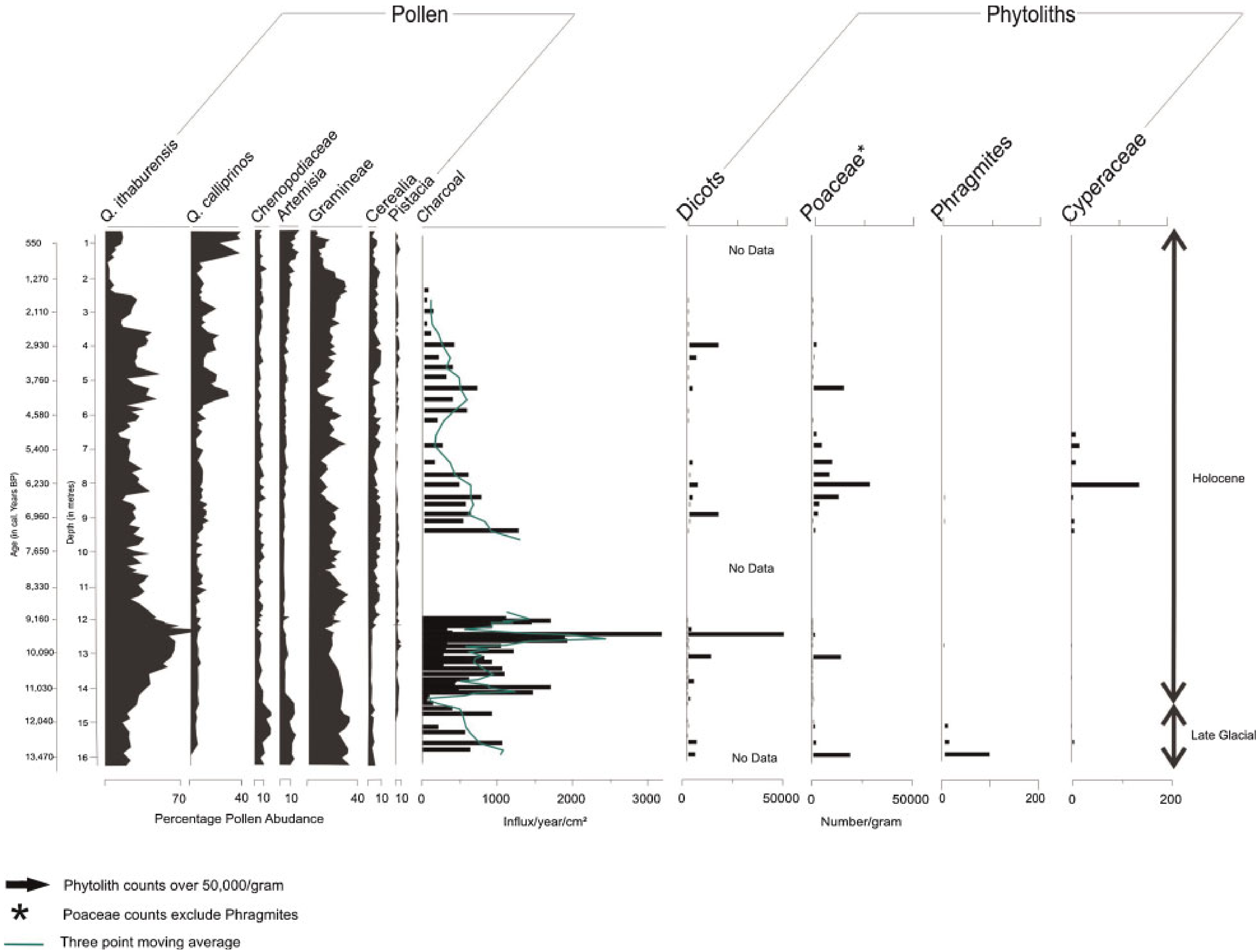

Figure 6 Micro-charcoal influx for Lake Hula compared to summary pollen and phytolith data (pollen data from Baruch and Bottema, 1999; chronology based on Meadows, 2005). Note the change in scale for different phytolith types. No core samples remained for the section between 10 and 12 m after pollen analysis and ^{14}C dating, for micro-charcoal or phytolith analysis. This figure is available in colour online at www.interscience.wiley.com/journal/jqs

Table 2 East Mediterranean micro-charcoal records during the LGIT

Site	Basal age and dating	Pollen analysis	$\delta^{18}O$ analysis	Present-day regional vegetation zone	Charcoal recruitment	References
Akgöl, C. Turkey	15.0 ka ^{14}C and U–Th	X	X	Oak grass parkland	Local and regional	This paper
Hula, Israel	13.5 ka Meadows (ca. 20 ka Cappers) ^{14}C	X	[X]	Oro-Mediterranean forest/woodland	Local and regional	This paper
Eski Acıgöl, C. Turkey	≥20 ka U-series and varve counts	X	X	Oak grass parkland	Regional	Turner *et al.* (2008b)
Van, SE Turkey	≥14 ka Varve counts	X	X	Oak grass parkland	Regional	Wick *et al.* (2003)
Ghab, Syria	ca. 18 ka ^{14}C on molluscs	X		Oro-Mediterranean forest/woodland	Local and regional	Yasuda *et al.* (2000)

harder to assess. The period from 11.5 to 9.0 ka coincided with the emergence of the first true farming communities in the southern Levant, but PPNA and PPNB sites were also common in the drier and less heavily wooded regions further south and east.

Regional synthesis of Eastern Mediterranean fire activity during the Lateglacial–Holocene transition

Under 'natural' circumstances climate would be expected to exert an overriding control on regional fire activity, via the influence it exerts on fuel load and its liability to combustion. This in turn requires moisture for plant growth alternating with drought to allow it to desiccate. People have altered this relationship since Palaeolithic times through their manipulation and management of vegetation communities and through deliberate fire-setting (Alperson-Afil, 2008). Therefore for both natural and anthropogenic factors, biomass plays a central role in determining fire frequency and intensity.

In addition to the records from Akgöl and Hula presented here, there are a number of other Southwest Asian micro-charcoal records of biomass burning available for comparison that span the LGIT, including Eski Acıgöl in central Anatolia, Ghab in northwestern Syria and Lake Van in southeastern Turkey (Fig. 1 and Table 2). Whereas Eski Acıgöl was analysed using identical analytical methods to those described in this paper, the Ghab and Van sequences used different extraction methods and sampling strategies, and some caution is therefore needed when making comparison with them. The Eski Acıgöl crater lake sediment sequence was contiguously sampled at 4 cm intervals (Turner *et al.*, 2008b), and provides a regional record of biomass burning from the LGM to the late Holocene. $\delta^{18}O$ and pollen analysis from the same sequence shows a close correspondence between hydro-climate, vegetation and burning regimes during the LGIT. The Ghab Valley forms part of the same rift valley system as the Hula basin and, like Hula, originally comprised an extensive area of marshland surrounded by wooded hills. Charcoal flux may therefore have included both local fires on the marsh surface and regional upland fires. Micro-charcoal was counted as an adjunct to pollen analysis both here (Yasuda *et al.*, 2000) and at Lake Van (Wick *et al.*, 2003). The latter study covered the period from the Lateglacial Interstadial onwards, and presented micro-charcoal influx as well as concentration data. It also included stable isotope and elemental chemistry analyses as proxies for past climate and lake water balance. Because Van is a very large and deep lake, micro-charcoal recruitment would have been regional to supra-regional in extent including the surrounding steppe parkland along with some areas of montane forest. Comparison between these different records is also hindered by issues of chronology, partly due to the different dating methods that have been utilised (Table 2). The original Van varve chronology, for example, underestimates the age for the start of the Holocene by around 1 ka (Wick *et al.*, 2003). By contrast, the Eski Acıgöl and Ghab chronologies appear to overestimate the age of the Pleistocene–Holocene climato-stratigraphic boundary by ca. 0.4 ka and 0.9 ka , respectively (^{14}C ages reported by Yasuda *et al.*, 2000, are uncorrected mollusc ages, although van Zeist and Woldring, 1980, found a 900 a 'old carbon' effect at Ghab; see Meadows, 2005, for further discussion). Notwithstanding these differences, regional pollen and isotope stratigraphies allow broad correlation between the different sequences (Fig. 7).

Micro-charcoal records of full glacial age are available only from Eski Acıgöl and Ghab, and in both cases they show low values, with charcoals often completely absent in samples older than ca. 16 ka from the central Anatolian site (Fig. 7). At this time the regional vegetation was dominated by drought-tolerant Chenopodiaceae–*Artemisia* steppe. Glacial-age pollen influx rates were low at sites such as Lake Van (e.g. Litt *et al.*, 2009), and the adverse climate and restricted vegetation cover in interior areas of Southwest Asia meant that there was limited biomass available to burn and consequently very few wildfires. Based on the low biomass availability and the paucity of archaeological evidence in central and eastern Anatolia, climate is therefore likely to have been the main factor limiting fire activity at this time in interior regions. By contrast, tree cover survived better in some coastal areas, and at sites such as Öküzini Cave in southwestern Turkey (Emery-Barbier and Thiébault, 2005) there is archaeological evidence of anthropogenic burning activity during this early Epipalaeolithic period.

The climatic warming associated with the Lateglacial Interstadial resulted in the partial replacement of cold steppe with grass steppe in south central Turkey and the expansion of open oak parkland in the Levant (van Zeist and Bottema, 1991). Micro-charcoal influx increased at the same time as a shift to greater moisture availability, as indicated by $\delta^{18}O$ analyses at sites such as Akgöl, Eski Acıgöl and Soreq cave. These climatic changes led to an expansion in grasses which in turn provided greater fuel availability for wildfire. Among them were large-seeded annual cereal grasses such as einkorn and wild barley, whose harvesting provided a key catalyst for the cultural shift from mobile bands of hunter-gatherers to the establishment of larger, sedentary settlements (Bar-Yosef and Belfer-Cohen, 1992). Although there is evidence of human activity in central Anatolia, the Zagros and other interior regions during the

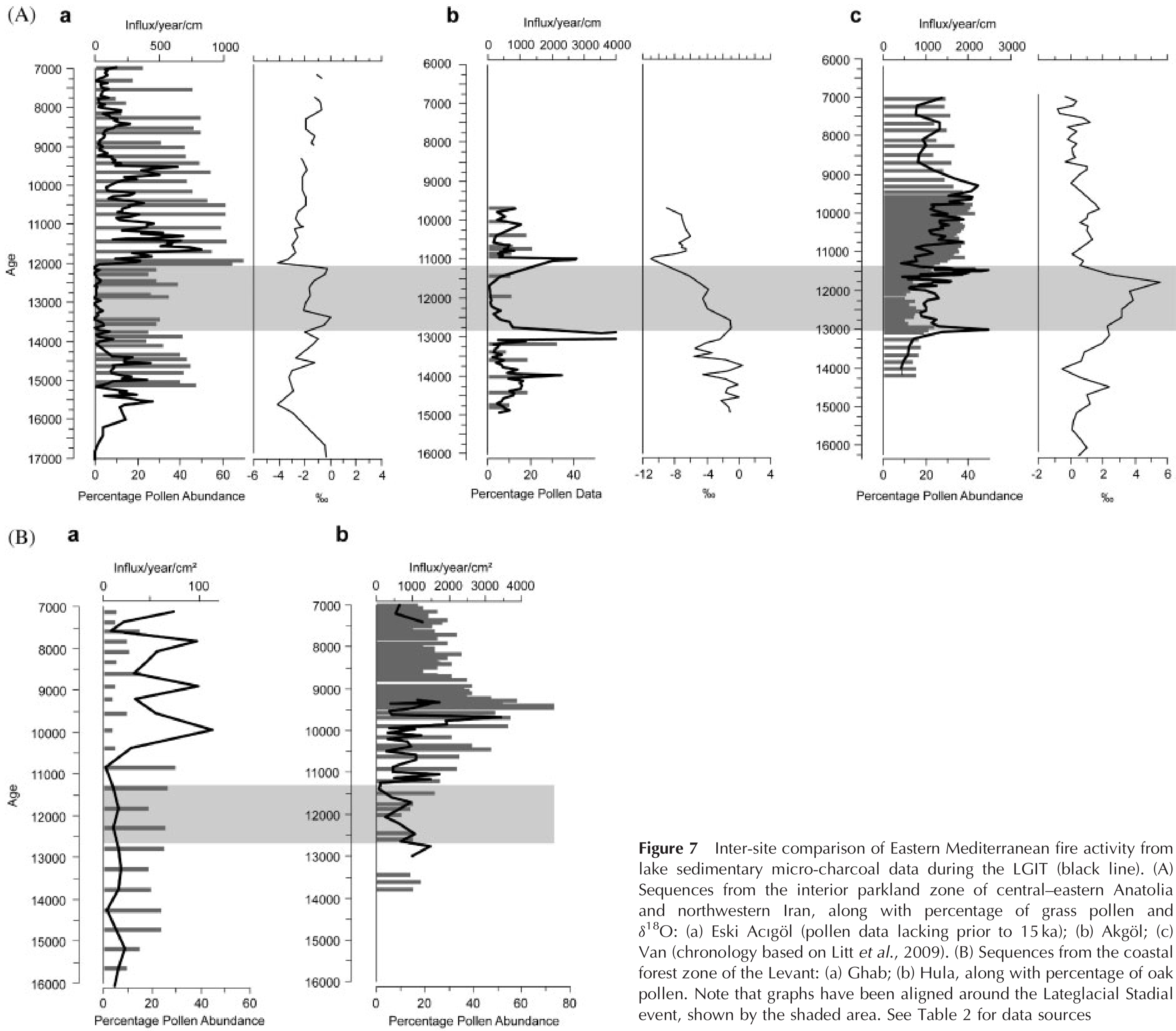

Figure 7 Inter-site comparison of Eastern Mediterranean fire activity from lake sedimentary micro-charcoal data during the LGIT (black line). (A) Sequences from the interior parkland zone of central–eastern Anatolia and northwestern Iran, along with percentage of grass pollen and $\delta^{18}O$: (a) Eski Acıgöl (pollen data lacking prior to 15 ka); (b) Akgöl; (c) Van (chronology based on Litt *et al.*, 2009). (B) Sequences from the coastal forest zone of the Levant: (a) Ghab; (b) Hula, along with percentage of oak pollen. Note that graphs have been aligned around the Lateglacial Stadial event, shown by the shaded area. See Table 2 for data sources

Lateglacial Interstadial period, the main focus of this new economy was the Levant. The Lake Hula sequence probably only covers the tail end of Lateglacial Interstadial, and it is therefore difficult to assess whether or not people were exerting an influence on fire activity, although they were certainly living around its shores at this time. Although burning of the marsh surface may have contributed to micro-charcoal influx at Ghab and Hula, it is only at Akgöl that a distinct burnt layer of local origin has been identified, in this case by comparing charcoal against phytolith data from the same record (Fig. 4). Although this ca. 13 ka event originated from localised burning of the reedbeds in the Konya basin, it may have its ultimate origin in the regional climatic drying trend at the end of the Lateglacial Interstadial which led to desiccation of the marsh surface. Micro-charcoals were not counted systematically in the Zeribar pollen record from northwestern Iran, but van Zeist (1967, p. 311) noted 'numerous charcoal particles between 4.40 and 3.80 m indicat[ing] that the vegetation on the dried lake bottom was set on fire not infrequently'. Although these particular samples date to the mid Holocene, a similar argument may apply to abundant charred macrofossils present in the Zeribar core samples of late Quaternary age (Wasylikowa, 2005, p.730).

The reversion to quasi-glacial conditions during the Lateglacial Stadial had a significant impact on regional fire activity. In south central Turkey regional fire occurrence appears to have declined rapidly following the climatic deterioration as the composition of the biomass changed from grass steppe back to drought-tolerant Chenopodiaceae–*Artemisia* steppe. This reduction implies a continuing overriding impact of climate on fire activity in this region, which is consistent with a paucity of archaeological evidence for human occupation of central Anatolia at this time. In the Levant, where the ecological and human effects of climatic cooling would have been less severe than in central Turkey, the decline in fire occurrence through the Lateglacial Stadial was less marked. Although archaeological evidence indicates significant abandonment of settlement towards the desert edge at this time (Hillman *et al.*, 2001), there was clear cultural continuity in better-watered regions nearer to the coast through the late Natufian period (ca. 13–11.7 ka; Byrd, 2005). Pollen records show that vegetation in the Levant retained a significant cover of oaks and other trees during the Lateglacial Stadial and that wild cereal stands continued to be present (Rosen, 2007a). Thus in the southern Levant both climatic and anthropogenic factors may have exerted an impact on fire regimes at this time.

The rapid climatic amelioration that marked the onset of the Holocene was associated with the replacement of cold steppe with open grass-dominated parkland in south central and eastern Turkey and expansion of oak woodlands in the Levant (van Zeist and Bottema, 1991). Micro-charcoal records imply that there was an equally rapid increase in fire occurrence throughout the region. Enhanced winter season moisture availability promoted vegetation growth, resulting in ample fuel being available, while the advent of Mediterranean-type climate regimes (Wright, 1993) meant that there was seasonal drying out of plant biomass. In all three sites from central and eastern Anatolia, there is a sharp peak in micro-charcoal influx during the first few centuries of the Holocene, suggesting a transient response as the vegetation–wildfire system adjusted to the new climate; this is consistent with an initial postglacial control over biomass burning regimes that was natural rather than cultural. The main fuel source for wildfires in this interior open parkland biome during the early Holocene appears to have been grasses and herbs rather than trees. There are strikingly similar curves for grass pollen percentages and micro-charcoal concentration at both Van and Eski Acıgöl through the LGIT (Fig. 7(A)). An association between maxima in grass pollen and charcoal during the early Holocene also applied at some other Mediterranean sites, such as Accesa in Italy (Vannière *et al.*, 2008). Micro-charcoal and grass pollen values remained high throughout the first two to three millennia of the Holocene in the parkland zone of south central and eastern Anatolia, during which time aceramic Neolithic settlements became established. A strong positive correlation between charcoal influx and $\delta^{18}O$ values in the Eski Acıgöl record implies that over decadal–centennial timescales climate continued to act as the 'pace-maker' for burning regimes until at least ca. 10 ka, with fires being more frequent during periods of wetter climate and enhanced biomass production (Turner *et al.*, 2008b). On the other hand, deliberate cultural fire-setting during the transition to full agriculture may have meant that fires occurred more frequently, hence increasing the overall magnitude of micro-charcoal flux peaks, even if not altering their timing on multi-decadal to multi-centennial timescales. It is clear from anthracological analysis of macro-charcoals that by 9 ka wood fuel for human domestic use had to be transported from a distance at sites such as Çatalhöyük in central Turkey (Asouti and Hather, 2001; Asouti, 2005). It should be borne in mind also that Anatolian woodlands include many insect-pollinated species (Woldring and Cappers, 2001) so that some key woody taxa (e.g. *Amygdalus*) are likely to be underrepresented in early Holocene pollen assemblages.

There is archaeological evidence for substantial village communities throughout the Levant during the early Holocene; for example, in the Jordan Valley, the Damascus Basin and along the middle Euphrates River (Bar-Yosef, 1998; Byrd, 2005). It has been hypothesised that the proto-agricultural practices developed during the Lateglacial Stadial continued for at least a thousand years alongside communities based on advanced hunting-foraging, before being widely adopted as fully fledged farming during the PPNB and spreading out into Anatolia and beyond (Bar-Yosef, 1998; Colledge *et al.*, 2004). In terms of Levantine fire regimes, there is a clear positive correlation between oak pollen percentages and micro-charcoal flux at Hula in Israel, whereas further north in Syria's Ghab valley the phase of oak pollen maximum shows rather low values for micro-charcoal concentration (Fig. 7(B)). Here the early Holocene wildfire peak occurs later, after deciduous oak pollen values had started to decline, but coincident instead with an increase in pollen of pine and evergreen oak. Alternative explanations are possible for these contrasting pollen–charcoal correlations (which remain valid regardless of the precise age of events in the two core records). Firstly, they could reflect the wetter climate in the Jebel Ansariyeh mountains west of the Ghab compared to the Judean hills west of Hula; at times of maximum forest development, fires in the former region may have been regulated not by fuel availability but by drought episodes. Secondly, and alternatively, differences between the two areas could have been due to contrasting histories of human burning regimes, with deliberate firing being more common in the southern Levant early in the Neolithic (PPNA, PPNB), and later in northwestern Syria (ceramic Neolithic, Chalcolithic). In addition, it should be noted that the Hula record is incomplete for the vegetation phases associated with the highest charcoal concentrations at Ghab.

Conclusion

Micro-charcoal, stable isotope and pollen data show that there is a good correspondence between biomass burning regimes, climate and vegetation throughout the Lateglacial–Holocene transition in Southwest Asia. Climatic changes appear to have acted as the primary pacemaker of regional-scale fire histories over this time period, and they highlight the importance of warmth and humidity as limiting factors in regional fire activity. Increased moisture and higher temperatures promoted the primary productivity of the vegetation community, in turn resulting in increased fuel availability. Fires were least frequent on the cold, Chenopod–*Artemisia* steppe that characterised interior uplands during full glacial times and again during the Lateglacial Stadial. This appears to have been associated with low plant biomass, but hunter-gatherer populations – and hence human fire-setting – were also rather rare in south central and eastern Turkey during these periods. Such fires as did occur therefore seem likely to have had a natural origin. In contrast, the Levant was climatically less arid, better vegetated and much more densely settled by Epipalaeolithic peoples at these times. Burning regimes, although reduced, were none the less maintained at significant levels.

Fires were more frequent and/or larger at times of warmer, wetter but seasonally dry climate, namely the Lateglacial Interstadial and the early Holocene. These climatic conditions led to an increase in biomass production throughout Southwest Asia, associated with a rapid expansion of grassland across the Anatolian plateau and woodland across the coastal hills of the Levant. In both regions, wild cereals would have formed a significant component of the ground storey vegetation. Southwest Asia's grasslands reached their greatest extent during the early Holocene, notwithstanding the fact that the climate was at least as moist (and in most areas moister) than at the present day. High micro-charcoal concentrations at this time show that dry-season burning was an integral part of these grass parkland ecosystems. This supports the hypothesis (Roberts, 2002) that fires played a key role in delaying by several millennia the spread of woodland across upland plateaux that were always climatically marginal for tree growth. Pollen and micro-charcoal records show that fire-maintained grasslands existed for between 2 and 3 ka across south central and eastern Turkey (and also, by inference, northwestern Iran), at the same time as the first aceramic Neolithic farming communities were being established. Fires also attained their maximum frequencies and/or intensities in the Levant during the early Holocene; however, pollen data imply that here wood rather than grass provided the principal fuel source.

While climatic changes appear to have acted as the principal 'pacemaker' for fire activity through the LGIT, those same shifts in climatic regime also strongly influenced human activities in Southwest Asia, both directly (e.g. severe glacial age winter cold limiting settlement on the Anatolian plateau) and indirectly (e.g. availability of wild cereal stands). Human population densities increased at those times and in those regions when conditions were warmer and wetter, and during the transition from hunting-foraging to farming there is archaeological evidence that Epipalaeolithic and Neolithic communities modified their local and – possibly – regional environments by their use of, and need for, fire (e.g. Asouti and Hather, 2001; Emery-Barbier and Thiébault, 2005). Human actions thus seem to have amplified the underlying, climatically paced shifts in fire regime during the transition to Neolithic agriculture. If correct, then fire frequencies may have been significantly higher during the Lateglacial and early Holocene than during the early parts of previous interglacial periods (cf. Djamali *et al.*, 2008; Litt *et al.*, 2009), when anatomically modern humans were absent or rare in Southwest Asia. Because fire frequencies increased at those times and in those areas where the human 'ecological footprint' was greatest, it is difficult, indeed probably futile, to try to partition burning regimes between natural and cultural drivers, since they operated synergistically. What is not in doubt is that fire regimes changed markedly during the major climatic and environmental transition between ca. 16 and ca. 9 ka BP and the parallel cultural-economic transition from hunter-foraging to agriculture and village life.

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