

*Landscape transformations at the dawn of agriculture in southern Syria (10.7–9.9 ka cal. BP): plant-specific responses to the impact of human activities and climate change*

Article

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1 **Landscape transformations at the dawn of agriculture in southern Syria (10.7-9.9 ka**  
2 **cal. BP): Plant-specific responses to the impact of human activities and climate**  
3 **change**

4  
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35 **Abstract**

36 In southwest Asia, the accelerated impact of human activities on the landscape has often  
37 been linked to the development of fully agricultural societies during the middle and late  
38 Pre-Pottery Neolithic B (PPNB) period (around 10.2-7.9 ka cal. BP). This work  
39 contributes to the debate on the environmental impact of the so-called Neolitisation  
40 process by identifying the climatic and anthropogenic factors that contributed to change  
41 local and regional vegetation at the time when domesticated plants appear and developed  
42 in southern Syria (around 10.7-9.9 ka cal. BP). In this work an inter-disciplinary analyses  
43 of botanical microremains (pollen and phytoliths) and macroremains (wood charcoal) is  
44 carried out along with stable carbon isotope discrimination of wood charcoals in an early  
45 PPNB site (Tell Qarassa North, west of the Jabal al-Arab area). Prior to 10.5 ka cal. BP,  
46 the results indicate a dynamic equilibrium in the local and regional vegetation, which  
47 comprised woodland-steppe, Mediterranean evergreen oak-woodlands, wetland vegetation  
48 and coniferous forests. Around 10.5-9.9 ka cal. BP, the elements that regulated the  
49 vegetation system changed, resulting in reduced proportions of arboreal cover and the  
50 spread of cold-tolerant and wetlands species. Our data show that a reinforcing interactions  
51 between the elements of the anthropogenic (e.g. herding, fire-related activities) and  
52 climatic systems (e.g. temperature, rainfall) contributed to the transformation of early  
53 Holocene vegetation during the emergence of fully agricultural societies in southern Syria.

54

55 **Keywords**

56 Palaeovegetation; Early Holocene; Climate change; Southwest Asia; Domestication;  
57 Archaeobotany; Anthropogenic impact

58

59 **Highlights**

- 60
- 61 • Multi-proxy analyses reveal diverse vegetation around 10.7-9.9 ka cal. BP.
  - 62 • Cereals were domesticated in wetter conditions than at present in southern Syria.
  - 63 • Dynamic equilibrium around 10.7-10.5 ka cal. BP, changes around 10.5-9.9 ka cal.  
64 BP.
  - 65 • RCCs as trigger for the expansion of cold-tolerant and wetland vegetation.
  - 66 • Increased anthropogenic impacts and RCCs coincided with decreased arboreal  
67 cover.

68 **1. Introduction**

69 The Pre-Pottery Neolithic (PPN) represents a key time period to understand the  
70 emergence of agriculture in southwest Asia. During the Pre-Pottery Neolithic A (PPNA,  
71 11.6-10.7 ka cal. BP), there is evidence for the development of plant food production  
72 activities involving morphologically wild plant species (Willcox et al., 2008), along with  
73 the evidence of early control or management of wild animal populations (Ervynck et al.,  
74 2001; Vigne, 2013). Subsequently, during the early Pre-Pottery Neolithic B (EPPNB, 10.7-  
75 10.2 ka cal. BP), the first morphologically domesticated plants (Tanno and Willcox, 2012)  
76 and animal species (Helmer et al., 2005; Peters et al. 2005; Zeder, 2011) appear in the  
77 archaeological record, yet the exploitation of morphologically wild species predominated  
78 during this time. Agriculture, defined as a subsistence system largely relying on  
79 domesticated resources (Zeder, 2015), evolved only around 10.2-9 ka cal. BP, during the  
80 middle and late PPNB (Asouti and Fuller, 2012, 2013; Zeder, 2011).

81 The environmental settings of the PPN period, exception made for the Khiamian period  
82 that developed within the last years of the Younger Dryas, were primarily those of the Pre-  
83 boreal climatic oscillations (Maher et al., 2011). This period was characterised by rapid  
84 warming, with increased mean yearly temperatures of about 7°C (Alley, 2000), combined  
85 with minimum rainfall rates in excess of 350 mm/yr, making it one of the wettest periods  
86 in Southwest Asia in the last 25,000 years (Robinson et al., 2006; Weninger et al., 2009).  
87 However, early Holocene climate was not stable, and several Rapid Climatic Changes  
88 (RCCs) occurred in the eastern Mediterranean at the time when agriculture developed in  
89 southwest Asia, c. 10.2 ka cal. BP (Mayewski et al., 2004; Weninger et al., 2009). Such  
90 RCCs comprised cold/dry (e.g. 10.2 and 8.2 ka cal. BP) and wet/warm (Levantine Moist  
91 Period and Sapropel S1, 10.1-8.6 ka cal. BP) spells. Some of these events seem to have  
92 caused considerable changes in the vegetation. For example, maximum *Pistacia*  
93 percentages (the so-called “*Pistacia* Phase”) were recorded during the Sapropel  
94 depositions (around 9-6 ka cal. BP) in several pollen diagrams from the Adriatic and  
95 Ionian Sea, Lake Ioannina and Lake Xiniias (Greece), Tenaghi Phillippon (Greece), and  
96 Ghab (Syria) indicating relatively warm winters and mild summers (Rossignol-Strick  
97 1995; 1999). Reductions in the proportions of evergreen *Quercus* were recorded shortly  
98 after the dry 8.2 ka cal. BP event at Tenaghi Phillippon Greece (Pross et al., 2009). During  
99 the same time period in the Eastern Mediterranean (close to the Israel coast) pollen records  
100 from deep-sea cores indicate maximum values for dry-tolerant *Artemisia* (Laggunt et al.,  
101 2011). Yet, the understanding of the effects that early Holocene RCCs caused in the

102 vegetation, and by extension, in the subsistence of the early agricultural groups during the  
103 Pre-Pottery Neolithic is still limited (Weninger et al., 2009; Flh r et al., 2016; Berger et  
104 al., 2016).

105 Despite the diverse bioclimatic regions and vegetation zones in southwest Asia (see a  
106 short summary in Asouti et al., 2015), the available pollen records indicate a consistent  
107 reduction in non-arboreal pollen (NAP) during the early Holocene, and an overall increase  
108 in arboreal pollen (AP), characterised, in particular, by the spread of woodland-steppe taxa  
109 (*Pistacia* and *Amygdalus*, pistachio and almond) and *Quercus* (oak) woodlands (van Zeist  
110 and Bottema, 1977; van Zeist and Woldring, 1978; Rossignol-Strick, 1993, 1995, 1997,  
111 1999; Stevens et al., 2001, 2006; Wright and Thorpe, 2003; Wick et al., 2003; Rosen,  
112 2007; Hajar et al., 2010; Rambeau, 2010). However, the time at which oak-woodlands  
113 developed across southwest Asia varied from one region to the other. In the Mediterranean  
114 area of the western Levant the spread of deciduous *Quercus* occurred 10.3-8.4 ka cal. BP  
115 (Wright and Thorpe, 2003; Rosen, 2007; van Zeist et al., 2009), whereas pollen records  
116 from the Irano-Anatolian region including southwest Iran (Zagros area) and central and  
117 eastern Anatolia point to a later expansion, around 7.5-4.5 ka cal. BP (Bottema and  
118 Woldring, 1984; van Zeist and Bottema, 1977; Stevens et al., 2001; Wick et al., 2003;  
119 Djamali et al., 2008; Litt et al., 2009).

120 Some argued that climatic conditions that would have allowed oak-woodland expansion  
121 did not develop in these areas until later (van Zeist and Bottema, 1991; Roberts and  
122 Wright, 1993; Rossignol-Strick, 1997). Yet, others have attributed this delay to  
123 anthropogenic factors. Several researchers proposed that increased wildfires at the  
124 beginning of the Holocene could have contributed to the development of grasslands in  
125 central and eastern Anatolia (considered as competitors for oak-seedlings), which would  
126 have hindered oak growth and expansion (Wick et al., 2003; Turner et al., 2010). Roberts  
127 (2002) suggested that the human activities that developed with the establishment of  
128 agriculture in southwest Asia (e.g. land clearance for crop cultivation, burning, animal  
129 grazing/browsing, and wood cutting for fuel and lime-plaster manufacture), besides a more  
130 marked seasonality and the intensified occurrence of wild fires during the early Holocene,  
131 were overall responsible for the late establishment of oak-woodlands in central-eastern  
132 Anatolia and the Zagros (see also Turner et al., 2010). Based on wood charcoal analyses,  
133 pollen records and observations on modern vegetation in central Anatolia, Asouti and  
134 Kabukcu (2014) suggested that semi-arid deciduous oak woodlands in this particular  
135 region evolved progressively, for around 3000 years, enhanced by several anthropogenic

136 activities (i.e. selective exploitation of Rosaceae-Maloideae, light-moderate grazing by  
137 ruminants and managements of *Quercus* stands) carried out by M/LPPNB groups starting  
138 around 9-8 ka cal. BP. They argued that early Neolithic anthropogenic activities  
139 contributed to, rather than hampered, the spread of oak-woodland vegetation in the Irano-  
140 Anatolian region, and they considered these low-diversity oak-dominated woodlands as  
141 one of the earliest anthropogenic vegetation types in southwest Asia.

142 Nevertheless, the type and scale of the impacts caused by human groups around 10.0 ka  
143 cal. BP in southwest Asia was regionally diverse, probably as a consequence of the  
144 different environmental conditions and economic activities carried out by local human  
145 populations. In the Zagros area, increased proportions of *Plantago lanceolata* (English  
146 plantain) in the pollen records has been interpreted as evidence of highly disturbed habitats  
147 caused by fires set by local hunters and herders (van Zeist and Bottema, 1977; see also  
148 Wasylikowa et al., 2006). In the northern Levant (Ghab area, northwest Syria), Yasuda et  
149 al. (2000) recorded an increase of micro-charcoals and the decline of *Quercus* pollen  
150 around 10.1-9.5 ka cal. BP, interpreting it as the oldest evidence of large-scale  
151 anthropogenic forest clearance or deforestation (see Roberts, 2002 and Meadows, 2005,  
152 for an alternative interpretation of the data). In the southern Levant, several authors  
153 claimed that agricultural and lime production activities by PPNB groups in areas that  
154 nowadays receive low average rainfall for dry-farming (i.e. marginal areas) completely  
155 modified the pre-existing landscape and could have led to deforestation (Köhler-Rollefson  
156 1988, Bar-Yosef, 1995; Rollefson 1990, Köhler-Rollefson and Rollefson, 1989, 1990).  
157 Yet, authors such as Blumler (2007) have put into questions that deforestation occurred  
158 during the early Holocene in Southwest Asia, since the re-examination of 13 primary  
159 pollen datasets from Greece, Turkey, Syria and Israel do not show strong reduction in  
160 arboreal cover during this time (e.g. from 90% to 30%). This view is reinforced by pollen  
161 records in north-western Turkey and Northern Israel (Golan Heights), where  
162 anthropogenic activities (e.g. herding) were identified only during the Early Bronze Age  
163 (ca. 4.8 ka cal. BP) (Miebach et al. 2015; Schwab et al. 2004), and slightly later, around  
164 3.8 ka cal. BP, in the Lake Van (eastern Anatolia) (Wick et al., 2003). Asouti et al. (2015)  
165 proposed that far from causing degradation, anthropogenic activities could have enhanced  
166 woodland-expansion not only in the Irano-Anatolian region but also in the arid area of the  
167 southern Levant (e.g. Jordan Rift Valley). High proportions of *Pistacia* wood charcoal and  
168 nutshells found at Pre-Pottery Neolithic Wadi el-Hemmeh were interpreted as evidence for  
169 the intensive management of these trees as a source of food, fuel and fodder, and along

170 with early Holocene climatic improvements, they would have contributed to the gradual  
171 expansion of *Pistacia* woodlands in the area (Asouti et al., 2015).

172 All perspectives considered, the degree to which early Holocene climate and Neolithic  
173 activities shaped local and regional vegetation in southwest Asia remains still an open  
174 question. There are as yet no enough data to address the effects of early Holocene RCC in  
175 the vegetation across southwest Asia, and depending on the author and the region under  
176 study, there are multiple views regarding the impact of Neolithic activities in the landscape  
177 (e.g. severe impacts in the form of deforestation, contribution to woodland expansion, no  
178 impact in the landscape until later periods). In addition to this, most of the studies so far  
179 have focused on the anthropogenic impacts of fully-fledged agricultural societies in  
180 southwest Asia (i.e. 10.2 ka cal. BP onwards), and as a result, there is a significant lack of  
181 evidence to characterise the environmental setting and anthropogenic impacts that concern  
182 the period immediately preceding the emergence of agriculture (e.g. the PPNA and  
183 EPPNB, around 11.6-10.2 ka cal. BP), despite animal and plant management activities  
184 were already common practice during this time.

185

## 186 **2. Aims and scope**

187 In this study we focus on the local and regional setting of Tell Qarassa North, an  
188 EPPNB site located in southern Syria (west of the Jabal al-Arab area). The site was  
189 occupied around 10.7-9.9 ka cal. BP (Ibañez et al., 2010), the time at which  
190 morphologically domesticated plants first appear in southwest Asia (Tanno and Willcox,  
191 2012; Arranz-Otaegui et al., 2016a). Tell Qarassa provides direct evidence from plant  
192 micro and macroremains found in archaeological context, correlated by micro and  
193 macrostratigraphic studies and radiocarbon dating (Ibañez et al., 2010b; Balbo et al., 2012;  
194 Santana et al., 2012, 2015; Arranz-Otaegui et al., 2016a). The aim of this work is twofold:  
195 (i) to use the high-resolution datasets from Tell Qarassa North to reconstruct the complex  
196 dynamics of the local and regional vegetation and environmental conditions around 10.7-  
197 9.9 ka cal. BP, tracing the evolution of different plant formations at the time when  
198 morphologically domesticated cereals appeared and developed in southern Syria; and (ii)  
199 to explore the factors that regulate the evolution of plant formations over time considering  
200 that changes in the vegetation occur as a result of the complex interaction patterns between  
201 the vegetation system and others systems (e.g. climate). To address these issues we carry  
202 out, for the first time, an inter-disciplinary study combining pollen, opal phytoliths, wood  
203 charcoal remains and stable carbon isotope signature of wood charcoals from



204 archaeological contexts. This work constitutes a substantial contribution to the  
205 understanding of environmental conditions at the time of cereal domestication in southern  
206 Syria and the climatic and anthropogenic factors that shaped past vegetation prior and  
207 during the development of agriculture in southwest Asia.

208

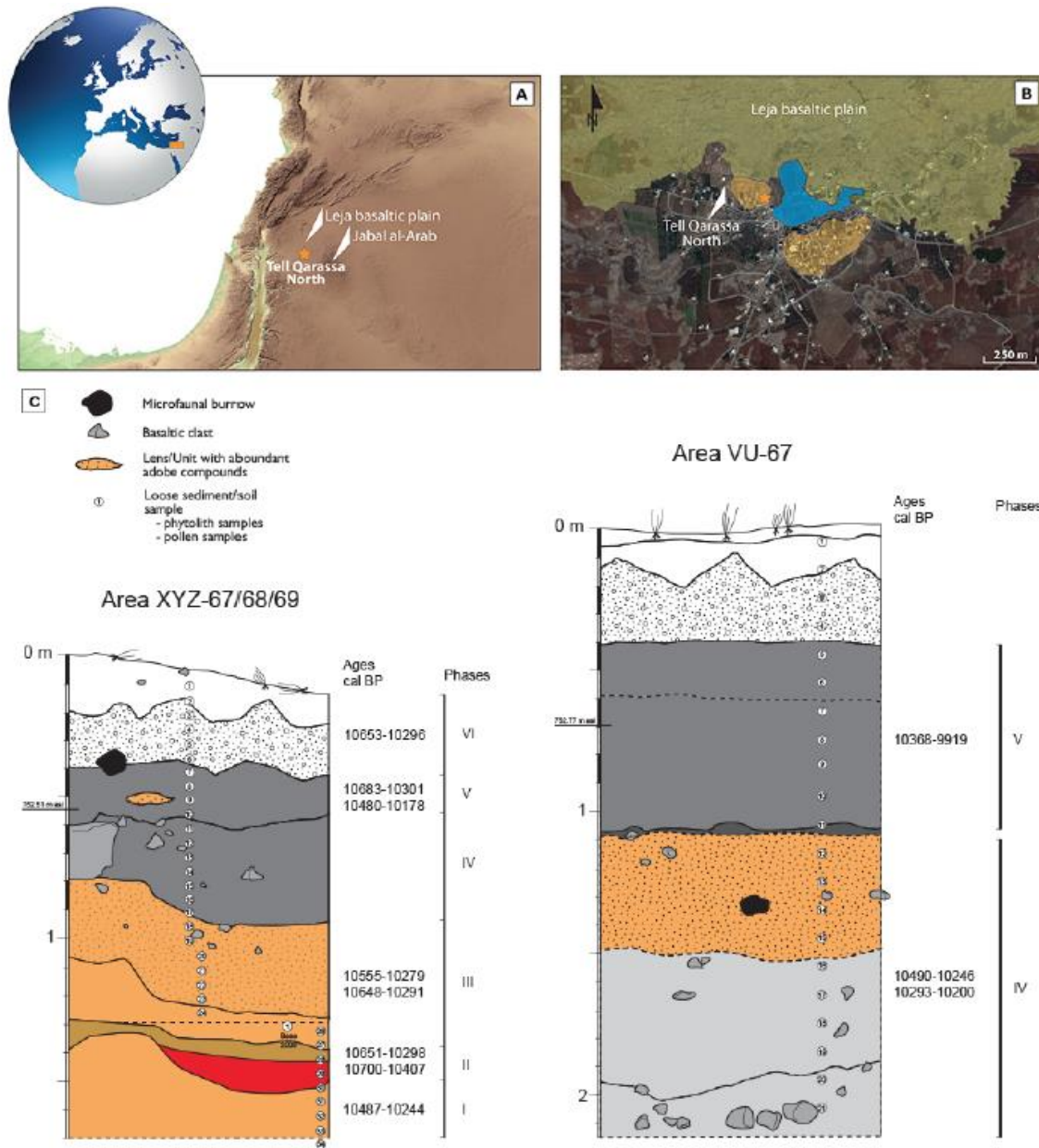
### 209 **3. Tell Qarassa North and its current environmental context**

210 The site of Tell Qarassa North was excavated in 2009 and 2010 by a Spanish team  
211 (Ibáñez et al., 2009, 2010a, 2010b) as part of the Syrian-French-Spanish archaeological  
212 research project around the palaeo-lake of Qarassa (Braemer et al., 2007, 2011). The site is  
213 located 25 km to the west of the Jabal al-Arab mountain range (36°49'54''N-41°27'40''E,  
214 750 m a.s.l.) and 20 km from the city of Sweida, south Syria (Figure 1a). The early PPNB  
215 levels of Tell Qarassa North comprise square shaped wood-made and stone-made  
216 architecture (Ibáñez et al., 2009; Balbo et al., 2012), ground stone tools such as saddle  
217 querns and mortars, imported materials such as obsidian (Ibáñez et al., 2009), diverse  
218 funerary customs (Santana et al., 2012, 2015), anthropogenic figurines (Ibáñez et al.,  
219 2014), as well as faunal remains including primarily goat (L. Gourichon in Ibáñez et al.,  
220 2010a). Tell Qarassa North is one of the two sites in the southern-central Levant (along  
221 with Tell Aswad, Tanno and Willcox, 2012) that has provided evidence for the presence of  
222 morphologically domesticated-type cereals (Arranz-Otaegui et al., 2016a).

223 Present-day climate in the Jabal al-Arab comprise cold winters (average temperature of  
224 -2 °C, and snow accumulations in some areas) and hot summers (mean temperatures of  
225 around 29 °C). The area where Tell Qarassa North is located receives a mean annual  
226 precipitation of around 350 mm (Chikhali and Amri, 2000; Traboulsi, 2013), and it is  
227 characterized by a large basaltic field with many locally interconnected multilayer aquifers  
228 that act as water conduits at different depths, allowing the formation of numerous springs,  
229 water ponds and lakes (Braemer et al., 2009; E. Iriarte and A. Balbo in Ibáñez et al.,  
230 2010a). Tell Qarassa is located in the southern border of a Pleistocene lava field, which is  
231 characterised by very scarce soil cover (Figure 1b). To the south of the tell Pliocene  
232 basaltic materials are found, which provide rich soils to carry out agricultural activities. To  
233 the east of the site, there is evidence of an ancient lake (dated broadly from the late  
234 Pleistocene to the mid-Holocene) and towards the south a temporary river is found  
235 (Braemer et al., 2009; E. Iriarte and A. Balbo in Ibáñez et al., 2009, 2010a).

236

237 **Figure 1.** A) Location of Tell Qarassa North in southwest Asia and B) detail of the  
 238 surrounding area, including the paleolake (in blue) and the Leja Basaltic plain to the north  
 239 (in yellow). B) Stratigraphy profiles of excavation areas XYZ and VU at Tell Qarassa  
 240 North showing site phases and chronology. (For interpretation of the references to colour  
 241 in this figure legend, the reader is referred to the web version of this article)



242

243

244 The Jabal al-Arab is considered a Mediterranean island within the Irano-Turanian  
 245 region (Chikhali and Amri, 2000). The current vegetation in the area is rich and diverse  
 246 with at least 900 species and various endemic taxa. Three main plant communities  
 247 characterize the study area (Mouterde, 1953): a) to the north (Leja area), a degraded  
 248 woodland-steppe community of *Pistacia atlantica* (Persian turpentine tree) and *Amygdalus*

249 *korschinskii* (wild almond) is dominant; b) in the central area of the Jabal al-Arab, with  
250 altitudes reaching 1000-1500 m a.s.l., an open-woodland community of *Quercus*  
251 *calliprinos* (Palestine oak) and *Crataegus azarolus* (hawthorn) grows, along with *Pyrus*  
252 *syrriaca* (Syrian pear), *Pistacia atlantica*, *Acer microphyllum* (small leaf maple) and  
253 *Crataegus sinaica* (Sinai hawthorn), the latter indicating the influence of altitude and  
254 dryness; in addition, *Quercus ithaburensis* (Mount Thabor's oak) has also been attested in  
255 this area (Willcox, 1999); and, c) to the east of the uplands, at an altitude around 700 m  
256 a.s.l., with a mean annual rainfall of 80-100 mm, dry-steppe vegetation dominated by  
257 *Artemisia* (wormwood) and some Chenopodiaceae (goosefoot) extends.

258

#### 259 **4. Materials and Methods**

260 The plant macro-remains and micro-remains analysed in this work come from Tell  
261 Qarassa North, Zone 1, which comprises two excavation areas: XYZ-67/68/69 (hereafter  
262 referred to as area XYZ) and VU-67 (hereafter referred to as area VU) (Figure 1c) (see  
263 Balbo et al., 2012; Santana et al., 2015 for micromorphological description of the  
264 stratigraphic units). In Table S1 the available C14 dates from Tell Qarassa North are  
265 summarised. Area XYZ is dated to 10.7-10.2 ka cal. BP, which is consistent with the  
266 EPPNB period in the Levant (Kuijt and Goring-Morris, 2002). In this area, a square-  
267 shaped stone structure (space A) and an open patio area (space B) were found. The  
268 stratigraphy consists of six phases (Figure 1c; see detailed description in Santana et al.,  
269 2015). Phase I corresponds to an occupation phase characterised by beaten earth floors  
270 within the stone structures. In phase II a fire event was documented, which enabled the *in*  
271 *situ* preservation of a collapsed roof structure in space A (Balbo et al., 2012). After this  
272 fire event, a new phase of occupation was identified which included the construction of a  
273 new beaten earth floor (phase III). Area XYZ was abandoned after phase III, leading to the  
274 accumulation of a first layer of architectural and colluvial debris (phase IV). A second  
275 layer of debris dated to 10.7-10.3 ka cal. BP, including large blocks from the sidewalls,  
276 was deposited inside the perimeter both in space A and B (unit 21, phase V). During this  
277 time (around 10.5-10.2 ka cal. BP), the abandoned structures were re-used as a funerary  
278 area (Santana et al., 2015). Phase VI in area XYZ corresponds to surface layers slightly  
279 affected by agricultural activities.

280 In the VU area, two main occupation phases were attested. A lower phase dated to 10.5-  
281 10.2 ka cal. BP, which was characterised by a thin layer of wood charcoal remains, similar  
282 to that attested in phase IV of the XYZ area; and an upper phase where a stone-made wall

283 was found associated to human remains. The upper phase was dated to 10.4-9.9 ka cal. BP  
284 and it is, probably, contemporary to the funerary phase V in area XYZ (see Santana et al.,  
285 2015).

286

#### 287 *4.1. Pollen analysis*

288 Thirty-four pollen samples were taken from the south-facing profile of square E2 in  
289 area XYZ (space A) and twenty-one from the south-facing profile of the excavation area  
290 VU. The profiles were sampled from bottom to top at 10 cm intervals, avoiding the  
291 mixture of macroscopic visible layers or structures (Figure 1c). The sedimentary  
292 accumulation is interpreted as a sequence of aggradational soils (or surfaces) with very  
293 low edaphization imprint. The origin of the sediment is interpreted as aeolian and also  
294 derived from the reworking of nearby building materials (see detailed descriptions in  
295 Santana et al., 2015). Samples from the top of each profile correspond to levels affected by  
296 current agricultural activities (samples 1 to 6 from phase VI in area XYZ; samples 1 to 4  
297 from VU, Figure 1c) and they were not included in the analyses. An average of 10 g of  
298 sediment was chemically treated to remove the mineral fractions. The method followed for  
299 pollen and non-pollen palynomorphs (NPPs) extraction is that described by Burjachs et al.  
300 (2003), where palynomorphs were concentrated using Thoulet liquor (Goeury and de  
301 Beaulieu, 1979). The final residue was suspended in glycerine and counted until a pollen  
302 sum of 250 grains was reached, excluding NPPs and anthropogenic taxa such  
303 Cichorioideae and Cardueae (Bottema, 1975; López-Sáez et al., 2003). Slides were  
304 examined with a light microscope using a magnification of 400× or 1000×. Pollen types  
305 were identified with pollen keys (Moore et al., 1991), pollen atlases (Reille, 1999), and the  
306 reference collection of the Archaeobotany Laboratory (CSIC, Madrid, Spain). Cerealia  
307 type was defined as Poaceae exceeding 45 µm with a minimum annulus diameter of 8–10  
308 µm (Beug, 2004; López-Sáez and López-Merino, 2005). The majority of NPPs present on  
309 the pollen slides were identified and their nomenclature conforms to van Geel (2001).  
310 Pollen diagrams were drawn using TGView (Grimm, 2004). To establish the zonation of  
311 the pollen sequences, we tested several divisive and agglomerative methods with the  
312 program IBM SPSS Statistics 21. Based on the ecological meaning of the obtained zones,  
313 five and two local pollen assemblage zones (LPAZs) were constructed respectively for  
314 area XYZ and VU on the basis of agglomerative constrained cluster analysis of  
315 incremental sum of squares (Coniss) with square root transformed percentage data

316 (Grimm, 1987). The number of statistically significant zones was determined using the  
317 broken-stick model (Bennett, 1996).

318

#### 319 4.2. Wood charcoal analysis

320 The wood charcoal remains analysed in this study were collected from 64 sediment  
321 samples processed with machine-assisted flotation (59 from spaces A and B in area XYZ,  
322 and five from area VU) (see Arranz-Otaegui, 2016 and Arranz-Otaegui et al., 2016a for  
323 details about the sampling and sample processing). The remains corresponded to dispersed  
324 wood charcoal fragments found in contexts such as infill of structures, open areas,  
325 processing areas, pits, refuse and burial contexts. Wood charcoal was identified using  
326 descriptions from several atlases (Fahn et al., 1986; Neumann et al., 2001; Schweingruber,  
327 1990; Vernet, 2001) and the modern wood reference collections housed at the  
328 Palaeobotany Laboratory Lydia Zapata (University of the Basque Country, UPV-EHU,  
329 Vitoria-Gasteiz), Institute of Archaeology (University College London) and Department of  
330 Archaeology, Classics and Egyptology (University of Liverpool). Identifications were  
331 carried out with the aid of an incident light microscope (Olympus BX50) with different  
332 magnifications (10× to 50×). The majority of the wood fragments analysed at Tell Qarassa  
333 North was sized between 2-4 mm. In accordance with Chabal (1989, 1991), rare taxa were  
334 always smaller than 4 mm, whilst the most common taxa were found both within 2-4 mm  
335 and >4 mm size ranges. Saturation curves were used to establish the minimum number of  
336 charcoal fragments to be analysed per sample. These curves are exponential, the higher the  
337 number of species represented in a given sample, the higher the number of charcoal  
338 fragments that need to be analysed to grant their statistical representativeness. At Tell  
339 Qarassa North, saturation curves were used in all samples containing more than 100 wood  
340 charcoal fragments and indicated that the identification of 100 wood charcoal fragments  
341 was sufficient to ensure taxa representation.

342

#### 343 4.3. Stable carbon isotope analysis

344 Stable carbon isotope analysis was carried out in wood charcoal remains of *Pistacia* sp.  
345 (*pistachio*) and *Amygdalus* sp. (*almond*) to characterize the water availability conditions of  
346 this site (Araus et al., 2014; Fiorentino et al., 2015). The assemblage includes dispersed  
347 wood charcoal remains from different contexts processed with flotation (as described  
348 above), as well as charcoal remains from a primary deposit, a burnt roof structure,  
349 recovered *in situ* (Balbo et al., 2012). The growth-ring curvature of the wood charcoal

350 fragments was evaluated following Marguerie and Hunot (2007). This method provides  
351 information to characterise what part of the tree was used (e.g. trunks or branches) and  
352 assess whether biases exist in the isotopic content of biologically old (i.e. trunk) or young  
353 (i.e. branch) specimens.

354 Carbonate crusts in charcoals were removed by soaking each charcoal sample  
355 separately in 6M HCl for 24 h at room temperature and then rinsing the grain repeatedly  
356 with distilled water (DeNiro and Hastorf, 1985; Ferrio et al., 2004). All samples were  
357 oven-dried at 60°C for 24 h before milling to a fine powder for isotope analyses. The stable  
358 isotope composition of carbon ( $\delta^{13}\text{C}$ , referred to the VPDB standard) was determined by  
359 elemental analysis and isotope ratio mass spectrometry (EA/IRMS) at the Isotope Services  
360 of the University of Barcelona (Barcelona, Spain). The overall analytical precision was  
361 about 0.1%. Carbon isotope discrimination ( $\Delta^{13}\text{C}$ ) of archaeobotanical samples was  
362 calculated from grain  $\delta^{13}\text{C}$  and from the  $\delta^{13}\text{C}$  of atmospheric  $\text{CO}_2$ , as follows:

363

$$364 \Delta^{13}\text{C}(\text{‰}) = (\delta^{13}\text{C}_{\text{air}} - \delta^{13}\text{C}_{\text{plant}}) / [1 + (\delta^{13}\text{C}_{\text{plant}} / 1000)]$$

365

366 where  $\delta^{13}\text{C}_{\text{air}}$  and  $\delta^{13}\text{C}_{\text{plant}}$  denote air and plant  $\delta^{13}\text{C}$ , respectively (Farquhar et al., 1989).  
367 The  $\delta^{13}\text{C}_{\text{air}}$  was inferred by interpolating a range of data from Antarctic ice-core records  
368 together with modern data from two Antarctic stations (Halley Bay and Palmer Station) of  
369 the CU-INSTAAR/NOAA-CMDL network for atmospheric  $\text{CO}_2$   
370 (<ftp://ftp.cmdl.noaa.gov/ccg/co2c13/flask/readme.html>), as described elsewhere (Ferrio et  
371 al., 2005). The whole  $\delta^{13}\text{C}_{\text{air}}$  dataset thus obtained covered the period from 16,100 BCE to  
372 2003 CE (data available at [http://web.udl.es/usuarios/x3845331/AIRCO2\\_LOESS.xls](http://web.udl.es/usuarios/x3845331/AIRCO2_LOESS.xls)). The  
373 provenance, dating as well as the  $\delta^{13}\text{C}$  and  $\Delta^{13}\text{C}$  of each sample used in this study and the  
374 corresponding  $\delta^{13}\text{C}_{\text{air}}$  are detailed in the Supplemental Information Table S2.

375

#### 376 4.4. Phytolith analysis

377 Seven samples from area XYZ (square E2, south-facing profile) and eleven from area  
378 VU (south profile) were selected for phytolith analysis. Samples were obtained from  
379 different contexts described in the field as filling deposits, open spaces and funerary areas.  
380 The methods used are similar to those developed by Katz et al. (2010). A weighed aliquot  
381 of between 30–40 mg of dried sediment was treated with 50  $\mu\text{l}$  of a volume solution of 6N  
382 HCl. The mineral components of the samples were then separated according to their

383 densities in order to concentrate the phytoliths using 450 µl 2.4 g/ml sodium polytungstate  
384 solution [Na<sub>6</sub>(H<sub>2</sub>W<sub>12</sub>O<sub>40</sub>)]. Microscope slides were mounted with 50 µl of material. A  
385 minimum of 200 phytoliths with recognizable morphologies was examined at 200× and  
386 400× using an Olympus BX41 optical microscope at the Department of Prehistory,  
387 Ancient History and Archaeology from the University of Barcelona. The estimated  
388 phytolith numbers per gram of sediment are related to the initial sample weight and allow  
389 quantitative comparisons between the samples and excavation areas. Phytoliths that were  
390 unidentifiable because of dissolution are listed as weathered morphotypes. Multicellular  
391 structures (multi-celled or interconnected phytoliths) were also recorded. These latter data  
392 may provide information regarding the extent of silification of plant cells, as well as of  
393 preservation conditions (Albert and Weiner, 2001; Albert et al., 2008, 2011; Portillo et al.,  
394 2014, 2016). Morphological identification was based on modern plant reference  
395 collections from the Mediterranean region (Albert and Weiner, 2001; Albert et al., 2008,  
396 2011; Portillo et al., 2014; Tsartsidou et al., 2007) and standard literature (Brown, 1984;  
397 Mulholland and Rapp, 1992; Piperno, 1988, 2006; Rosen, 1992; Twiss, 1992; Twiss et al.,  
398 1969). The terms used follow the International Code for Phytolith Nomenclature (Madella  
399 et al., 2005).

400

## 401 **5. Results**

### 402 *5.1. Pollen analysis*

403 An overall good state of preservation of pollen grains and NPPs was found at Tell  
404 Qarassa North. A total of 38 pollen and non-pollen palynomorph types were identified.  
405 Total pollen and NPP percentages from area XYZ and VU are given in Figures 2 and 3.  
406 The percentage pollen diagrams can be divided into five LPAZ zones in area XYZ and two  
407 in area VU, which correspond to phases I-V in area XYZ (LPAZs XYZ-I to XYZ-V) and  
408 the lower and upper phases in area VU (LPAZs VU-Lower and VU-Upper).

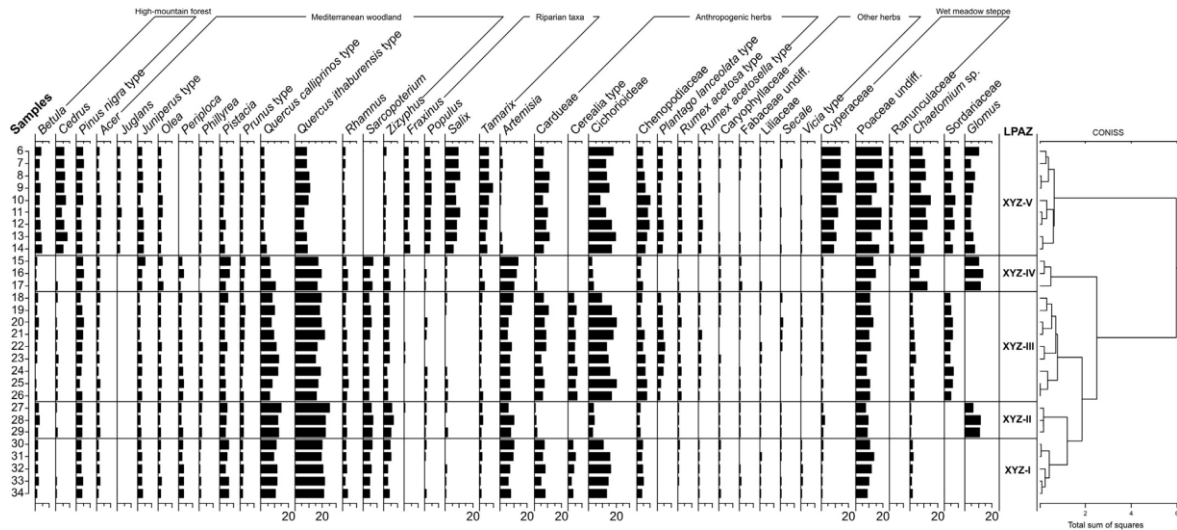
409 In area XYZ the oldest phases I to IV show overall high values for *Quercus calliprinos*  
410 (7-15%) and *Q. ithaburensis* (15-25%), along with anthropogenic herbs such as Cardueae  
411 (5-10%), Cichorioideae (10-20%) and Poaceae (8-13%) (Figure 2). Anthropozoogenous  
412 taxa such as *Plantago lanceolata* (2-6%), *Rumex acetosa* (~2%), *R. acetosella* (~2%) and  
413 Chenopodiaceae (3-7%) are mainly attested in phase III, associated with maximum values  
414 of coprophilous fungi (Sordariaceae 4-6%; *Chaetomium* 4%). Increasing proportions of  
415 Cerealia are attested from phase I (around 2.2-5.4%) to phase III (around 3.7-6.5%). Most  
416 herbs show continuous presence during phases I to IV, but during destruction phases II and

417 IV, anthropogenic and zoogenous taxa (Cardueae, Cichorioideae, Chenopodiaceae, *Rumex*  
 418 *acetosa*) sharply decrease, and Cerealia, *Plantago lanceolata* and *Rumex acetosella*  
 419 disappear. In addition, the highest concentration of *Glomus* is recorded during these two  
 420 destruction phases, whilst Sordariaceae disappear. The only difference between the two  
 421 destruction phases (II and IV) is the high percentages of *Chaetomium* (6-12%) in the latter.  
 422 Apart from these, phases I-IV are overall characterized by noticeable percentages of  
 423 *Juniperus* (1-3%), *Pistacia* (4-7%), *Periploca* (2-4%), *Phillyrea* (1-2%), *Prunus* (2-4%),  
 424 *Olea* (1-2%), *Rhamnus* (2-4%), *Sarcopoterium* (4-6%) and *Zizyphus* (3-5%) among the  
 425 shrubs (note that *Pistacia* and *Amygdalus* are commonly under-represented in  
 426 palynological analyses, e.g. Rossignol-Strick, 1993; Roberts, 2002). Wet meadow steppe  
 427 taxa (Cyperaceae) show very low values (<2%), whilst *Artemisia* shows its highest  
 428 percentages during phase IV (6-10%). Values for the rest of taxa, such as *Acer* (1-2%) and  
 429 *Pinus nigra* (3-5%) remain stable during phases I-IV, whilst *Betula*, *Cedrus*, *Corylus*,  
 430 *Tamarix*, *Fraxinus*, *Populus* and *Salix* types are rare (<2%) and sporadic.

431

432 **Figure 2.** Pollen and NPP diagram from Tell Qarassa North XYZ.

433



434

435

436 During phase V (LPAZ XYZ-5), which corresponds to the abandonment and later re-  
 437 use of the area for funerary purposes, important changes occur in terms of vegetation  
 438 composition (Figure 2). On the one hand, taxa such as *Olea*, *Pistacia* (2-4%), *Quercus*  
 439 *calliprinos* (2-4%), *Q. ithaburensis* (6-11%), *Rhamnus* and *Zizyphus* steadily decline and  
 440 *Periploca* and *Sarcopoterium* disappear. On the other hand, *Betula* (maximum 4%),  
 441 *Cedrus* (7%), *Fraxinus* (4%), *Populus* (5%), *Salix* (10%) and *Tamarix* (10%) notably

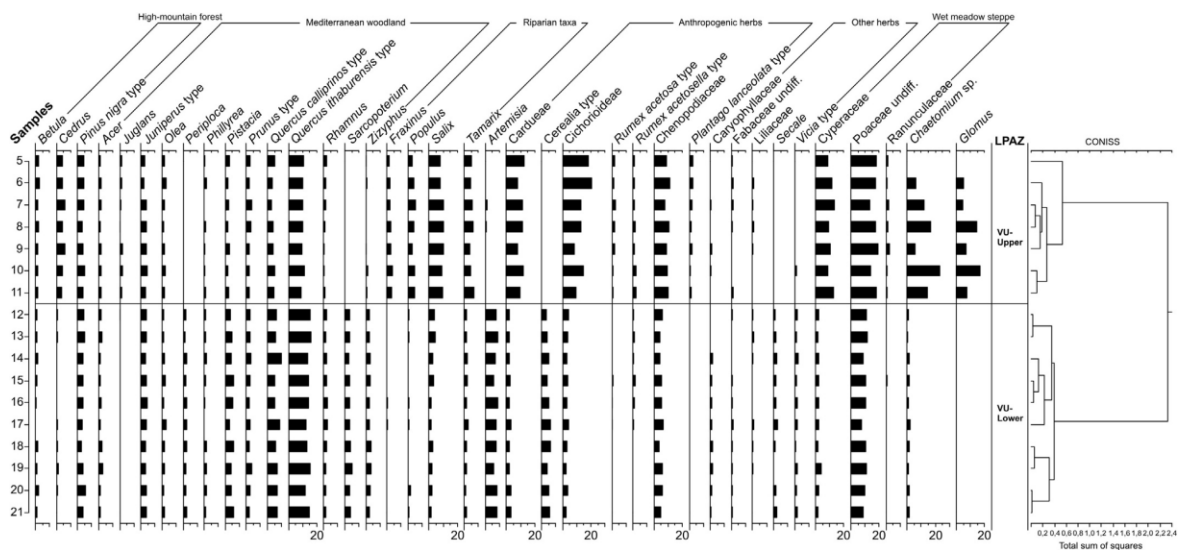


442 increase, as well as *Juglans*, which is recorded for the first time. Anthropogenic  
 443 (Cardueae, Cichorioideae) and anthropozoogenic (Chenopodiaceae, *Plantago lanceolata*,  
 444 *Rumex acetosa*, *R. acetosella*) herbs increase slightly, although Cerealia are absent.  
 445 Sordariaceae are documented again (4-6%), whereas *Chaetomium* and *Glomus* maintain a  
 446 continuous presence. Also, wet meadow steppe taxa (Cyperaceae 13-15%; Ranunculaceae  
 447 2-3%) show highest values during this time, whilst *Artemisia* drops sharply (<2%).

448

449 **Figure 3.** Pollen and NPP diagram from Tell Qarassa North VU.

450



451

452

453 In area VU (Figure 3), results for the lower phase (LPAZ VU-Lower) indicate relatively  
 454 high percentages of arboreal pollen mainly comprising *Quercus ithaburensis* (12-16%), *Q.*  
 455 *calliprinos* (5-10%) and *Pistacia* (10-14%), and to lesser extent *Acer*, *Betula*, *Salix* (<4%)  
 456 and *Pinus nigra* (3-6%). Other trees such as *Tamarix*, *Populus* and *Fraxinus* as well as  
 457 *Cedrus* are present, but show low percentages (<2%). Shrubs are abundant, with *Prunus*  
 458 (~3%), *Olea* (~2%), *Periploca* (~2%), *Phillyrea* (1-2%), *Rhamnus* (2-3%), *Sarcopoterium*  
 459 (3-5%) and *Zizyphus* (3-4%) being the most important taxa. Poaceae (5-12%) are the main  
 460 herbaceous component. Anthropogenic taxa (Cardueae, Cichorioideae), and  
 461 anthropozoogenic nitrophilous herbs (*Rumex acetosella*) are also present although with  
 462 low percentages, similar to those attested during destruction phases II and IV in area XYZ.  
 463 Hygrophytic taxa (Cyperaceae, Ranunculaceae) are represented by low percentages (~2%),  
 464 while dry steppe taxa such as *Artemisia* show high values (6-11%), very similar to the  
 465 evidence attested in phase IV in area XYZ. However, the lower phase of VU show high

466 values of Cerealia (3.3-6.6%), which are similar to those identified during occupation  
467 phase III in area XYZ.

468 During the upper phase of area VU (Figure 3, LPAZ VU-Upper), the results indicate a  
469 synchronous decrease of *Pistacia* (4-8%), *Quercus calliprinos* (3-5%) and *Q. ithaburensis*  
470 (9-11%), comparable to the decrease observed during phase V in area XYZ. *Acer*, *Pinus*  
471 *nigra* and *Juniperus* maintain similar percentages as those attested during the previous  
472 period. *Betula*, *Cedrus* (4-6%), *Fraxinus*, *Populus*, *Salix* (8-11%) and *Tamarix* (4-7%)  
473 increase significantly, and *Juglans* (1-2%) appears for the first time. Most of the shrubs  
474 (*Prunus*, *Olea*, *Phillyrea*) maintain a continuous and significant presence throughout the  
475 zone, although other shrub taxa percentages (*Rhamnus*, *Zizyphus*) display a decreasing  
476 trend, and *Sarcopoterium* and *Periploca* disappear. In comparison to the previous phase,  
477 anthropogenic and anthropozoogenic taxa such as Cardueae (8-12%), Cichorioideae (9-  
478 21%), *Rumex acetosa*, *R. acetosella* and *Plantago lanceolata* (~2%) show an increasing  
479 trend, as well as Chenopodiaceae (8-11%), while Cerealia disappear. This is also observed  
480 in phase V from area XYZ. *Artemisia* decreases (<1%) whereas Poaceae (13-19%),  
481 Ranunculaceae and Cyperaceae (9-13%) significantly increase their values. NPPs  
482 indicative of erosion and fire events, as well as pastoral activities (*Chaetomium*, *Glomus*)  
483 are at their maximum values in this pollen sequence (23 and 17%, respectively), following  
484 synchronous trends.

485

## 486 5.2. Wood charcoal analysis

487 A total of 5274 wood charcoal fragments were analysed and 14 taxa were identified in  
488 areas XYZ and VU (see the main taxa found in Figure 4). It must be noted that there were  
489 no significant differences in terms of species representation by phase (i.e. XYZ-I-V) and  
490 by type of context (i.e. infill of structure, open areas etc.). Thus, in Table 1 a summary of  
491 the ubiquity and absolute counts for area XYZ and VU is given. The results show that  
492 *Pistacia* and *Amygdalus* were the most common taxa in all analysed samples, both in terms  
493 of ubiquity (between 96.9-98.4% of samples) and absolute counts (between c. 30-50%)  
494 (Note that these two taxa might be over-represented in the wood charcoal assemblage,  
495 Arranz-Otaegui, 2016). In general, the percentages of Anacardiaceae (including *Pistacia*)  
496 slightly decreased from 58.7% in area XYZ to 54.4% in area VU, whereas Rosaceae  
497 maintained similar proportions (from 34.2 to 35.5%). The rest of taxa were rare both in  
498 terms of ubiquity (<35% of samples) and absolute counts (percentage counts <1%).  
499 Salicaceae (comprising cf. *Salix*, *Salix*, and cf. *Populus*) was only present in area XYZ

500 (phases I-IV), along with *Tamarix*, *Cedrus libani* and *Fraxinus*, which were also present  
501 but in slightly lower proportions (percentage counts <1%). *Quercus* was only identified in  
502 area VU (upper phase) and comprised 1.8% of the assemblage. At least one fragment  
503 corresponded to evergreen-type *Quercus* (Fig. 4F), although the presence of deciduous  
504 *Quercus* cannot be excluded. Other taxa were rare and only found in specific contexts of  
505 the excavation area XYZ, such as *Acer* in a pit sample, Chenopodiaceae in the infill of  
506 structure and cf. *Rhamnus* associated to a burial.

507

### 508 5.3. Isotope analysis on wood charcoal

509 Carbon isotope discrimination ( $\Delta^{13}\text{C}$ ) values for a total of 74 *Pistacia* and 28  
510 *Amygdalus* wood charcoal samples were analysed (Table S2). Curvature was positively  
511 assessed in 57 wood charcoal fragments corresponding to scattered remains and 29  
512 samples from the rood structure (Table S2). The results showed the predominance of low  
513 curvature fragments (80.7% and 65.5% respectively), followed by medium curvature  
514 (12.3% and 10.3% respectively) and strong curvature (7% and 10.3% respectively). There  
515 were no significant differences in terms of  $\Delta^{13}\text{C}$  between biologically older (e.g. weak  
516 curvature) and younger (moderate or strong curvature) specimens from the same phase  
517 (Table S3). In fact, in some cases wood charcoal fragments with strong curvature tended to  
518 exhibit lower (phase IV) or higher (phase V) values than the fragments with weak  
519 curvature. Considering this we cannot conclude that in our study the age of the wood  
520 sampled may bias the  $\Delta^{13}\text{C}$  of the samples analysed. Mean values were plotted for the six  
521 phases studied in the XYZ area and the upper and lower phases of the VU area (Fig. 5). In  
522 the case of *Amygdalus*, values were near 19‰ through all the period studied, whereas for  
523 *Pistacia* values were in general slightly lower (but above 18‰). Both species tended to  
524 show lower values in phase IV compared with the other five phases. The mean  $\Delta^{13}\text{C}$   
525 values of the samples of the two species recovered from the roof and corresponding to  
526 phase II in XYZ area were clearly lower (nearly 18‰ for *Pistacia* and slightly above 17‰  
527 for *Amygdalus*).

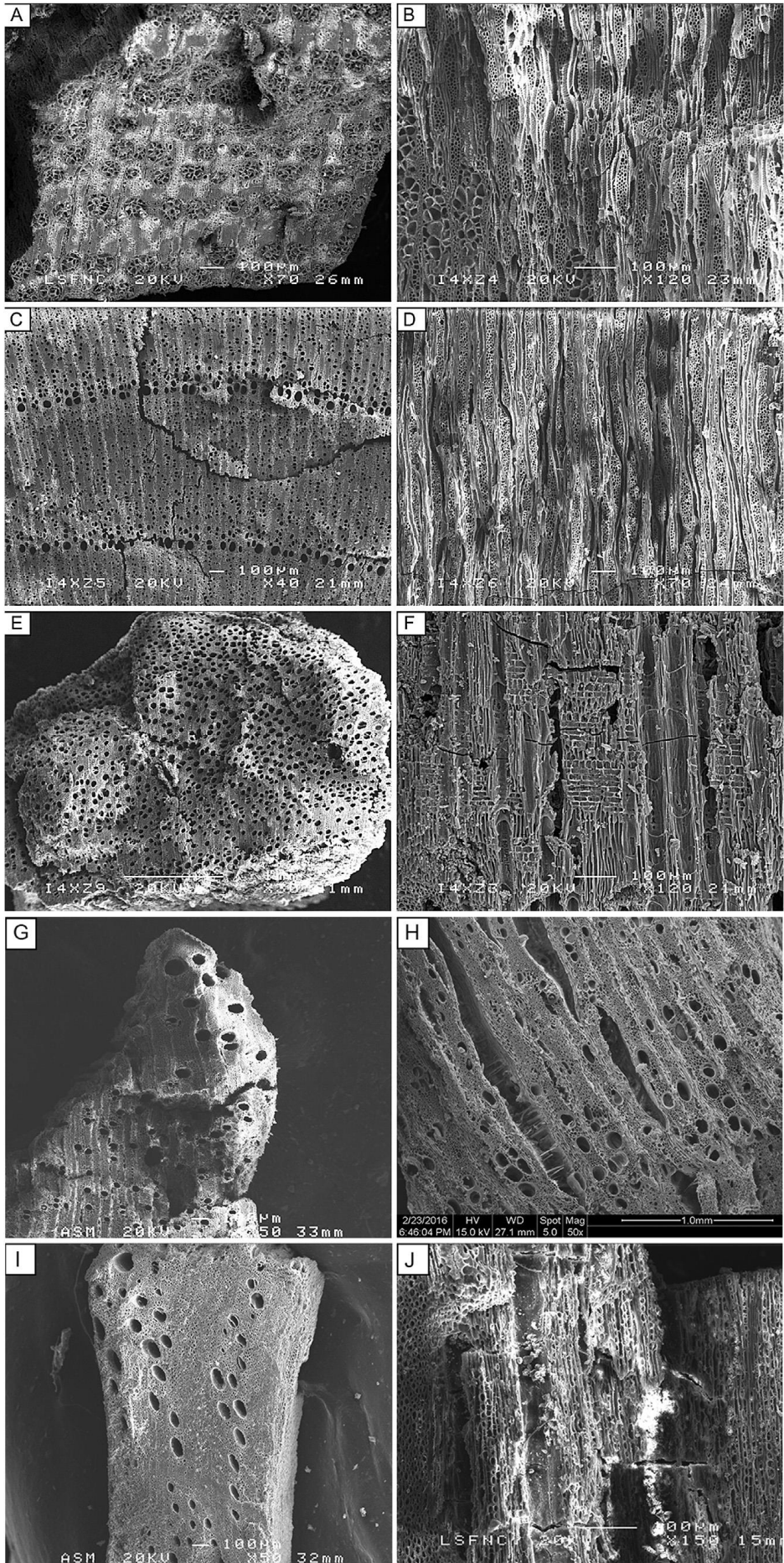
528 **Table 1.** Results of the taxonomic analyses of the wood charcoal remains from excavation areas XYZ and VU at Tell Qarassa North.

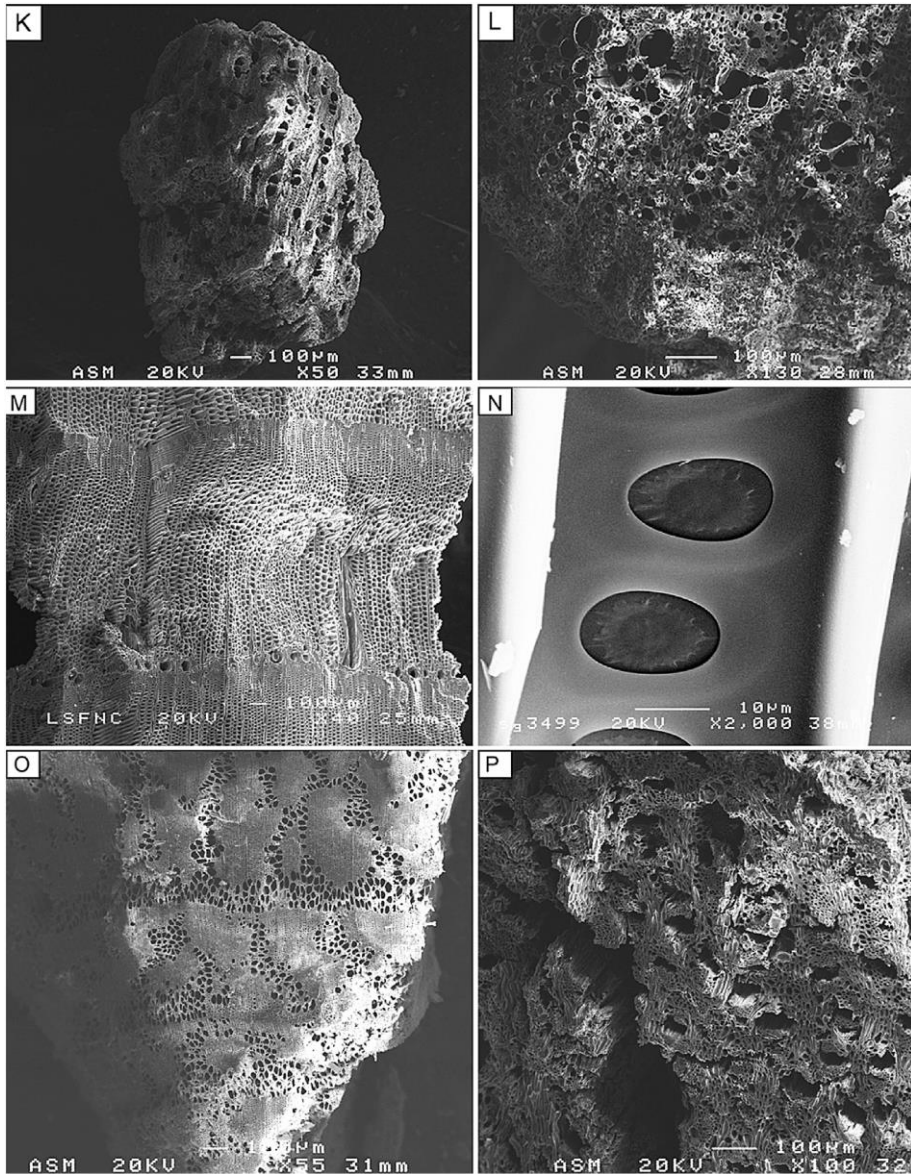
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Taxonomic analysis Scattered remains		XYZ-67/68/69 (number of samples: 59)				VU-67 (number of samples: 5)				Total fragments by taxa			
		counts	% frag. counts	presence	ubiquity (%)	counts	% frag. counts	presence	ubiquity (%)	counts	% frag. counts	presence	ubiquity (%)
woodland-steppe	<i>Pistacia</i> sp.	2556	56.3	57	96.6	238	52.8	5	100.0	<b>2794</b>	<b>56.4</b>	<b>62</b>	<b>96.9</b>
	Anacardiaceae	108	2.4	33	55.9	7	1.6	3	60.0	<b>115</b>	<b>2.3</b>	<b>36</b>	<b>56.3</b>
	<i>Amygdalus</i> sp.	1376	30.3	58	98.3	147	32.6	5	100.0	<b>1523</b>	<b>30.8</b>	<b>63</b>	<b>98.4</b>
	Rosaceae	179	3.9	41	69.5	13	2.9	4	80.0	<b>192</b>	<b>3.9</b>	<b>45</b>	<b>70.3</b>
oak-woodland	<i>Acer</i> sp.	4	0.1	1	1.7	0	0.0	0	0.0	<b>4</b>	<b>0.1</b>	<b>1</b>	<b>1.6</b>
	<i>Quercus</i> sp.	0	0.0	0	0.0	8	1.8	2	40.0	<b>8</b>	<b>0.2</b>	<b>2</b>	<b>3.1</b>
coniferous for.	<i>Cedrus libani</i>	37	0.8	14	23.7	0	0.0	0	0.0	<b>37</b>	<b>0.7</b>	<b>14</b>	<b>21.9</b>
wetland and salt marsh	Salicaceae	192	4.2	26	44.1	0	0.0	0	0.0	<b>192</b>	<b>3.9</b>	<b>11</b>	<b>17.2</b>
	<i>Fraxinus</i> sp.	27	0.5	12	20.3	0	0.0	0	0.0	<b>24</b>	<b>0.5</b>	<b>12</b>	<b>18.8</b>
	<i>Tamarix</i> sp.	43	0.9	20	33.9	1	0.2	1	20.0	<b>44</b>	<b>0.9</b>	<b>21</b>	<b>32.8</b>
	Tamaricaceae	13	0.3	8	13.6	0	0.0	0	0.0	<b>13</b>	<b>0.3</b>	<b>8</b>	<b>12.5</b>
steppe	Chenopodiaceae	2	0.0	2	3.4	0	0.0	0	0.0	<b>2</b>	<b>0.0</b>	<b>1</b>	<b>1.6</b>
	cf. <i>Rhamnus</i>	1	0.0	1	1.7	0	0.0	0	0.0	<b>1</b>	<b>0.0</b>	<b>1</b>	<b>1.6</b>
	cf. Fabaceae	1	0.0	1	1.7	0	0.0	0	0.0	<b>1</b>	<b>0.0</b>	<b>1</b>	<b>1.6</b>
Indeterminate		283		49	83.1	37	8.2	4	80.0	<b>320</b>		<b>53</b>	<b>82.8</b>
other (pith, bark)		1		1	1.7	0	0.0	0	0.0	<b>1</b>		<b>1</b>	<b>1.6</b>
<b>Total</b>		<b>4823</b>	<b>100.0</b>	<b>59</b>	<b>100.0</b>	<b>451</b>	<b>100.0</b>	<b>5</b>	<b>100.0</b>	<b>5274</b>	<b>100.0</b>	<b>64</b>	<b>100.0</b>

530

531 **Figure 4.** The wood charcoal taxa found at Tell Qarassa North: A and B) transverse and  
532 longitudinal tangential sections of *Pistacia* sp.; C and D) transverse and longitudinal  
533 tangential sections of *Amygdalus* sp.; E and F) transverse and longitudinal radial section of  
534 Salicaceae cf. *Salix*; G) transverse section of *Fraxinus*; H) transverse section of *Tamarix*; I  
535 and J) transverse and longitudinal tangential sections of *Quercus* (evergreen-type); K)  
536 transverse section of *Acer*; L) transverse section of cf. Fabaceae; M and N) transverse and  
537 radial sections (showing scalloped tori) of *Cedrus libani*; O) transverse section of  
538 *Rhamnus*; P) transverse section of *Chenopodiaceae*.



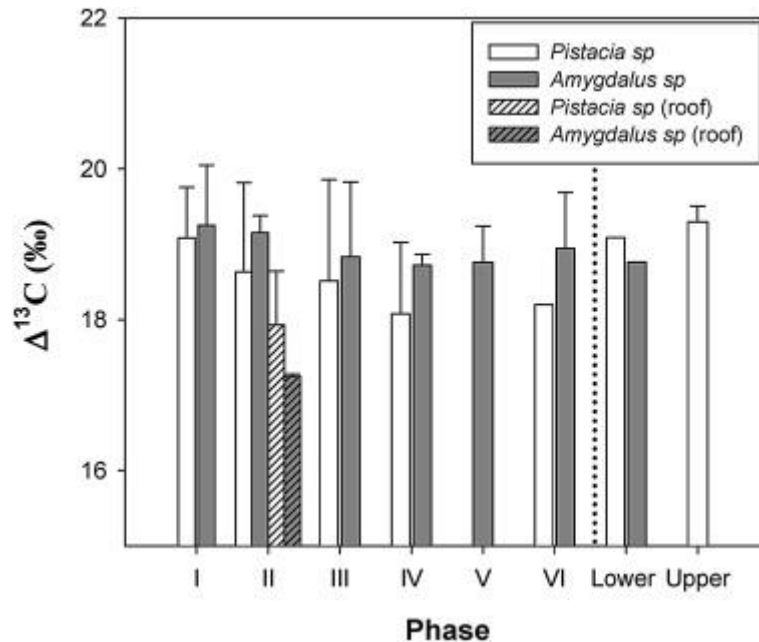


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**Fig. 4.** (continued).

552 **Figure 5.** Evolution through time of the carbon isotope discrimination ( $\Delta^{13}\text{C}$ ) of  
 553 *Amygdalus* and *Pistacia*. Phases I to VI correspond to the XYZ area, whereas the lower  
 554 and upper phases refer to the VU area. Values plotted are means  $\pm$  SE. Details about the  
 555 individual samples analysed can be found in Table S2.

556



557

#### 558 5.4. Phytolith analysis

559 Phytoliths were abundant in all the samples examined (ranging from 1 to 2.6 million  
 560 phytoliths per gram of sediment in XYZ samples and 0.7 to 1.7 in area VU; Table S4).  
 561 Overall, the low proportions of weathered phytoliths, together with the presence of  
 562 multicellular or anatomically or connected phytoliths in most of the samples, are indicative  
 563 of a good state of preservation of the assemblages. The morphological results indicated  
 564 that grasses dominated the phytolith record, with around 80% or more of all the counted  
 565 morphotypes (Figure 6). In addition to dicotyledonous morphotypes, diagnostic phytoliths  
 566 from the Cyperaceae family (sedges), which are common in wet environments, were noted  
 567 in both profiles, although to a lesser extent. Grass phytoliths were divided into the different  
 568 anatomical plant parts in which they were formed (Figure 6). Epidermal cells from grass  
 569 leaves and stems, including prickles, bulliform cells and stomata, were observed in all the  
 570 samples in different amounts (between c. 30-65%). The results show that multi-celled  
 571 concentrations of these plant parts were high in samples related to mud building materials,  
 572 such as sun-dried adobe compounds (up to 42% in sample 29, in phase II, area XYZ; Table  
 573 S4 and Figure 7a). Additionally, grass phytoliths derived from their floral parts were  
 574 abundantly noted in most of the samples (~30% or more of all grass morphotypes).

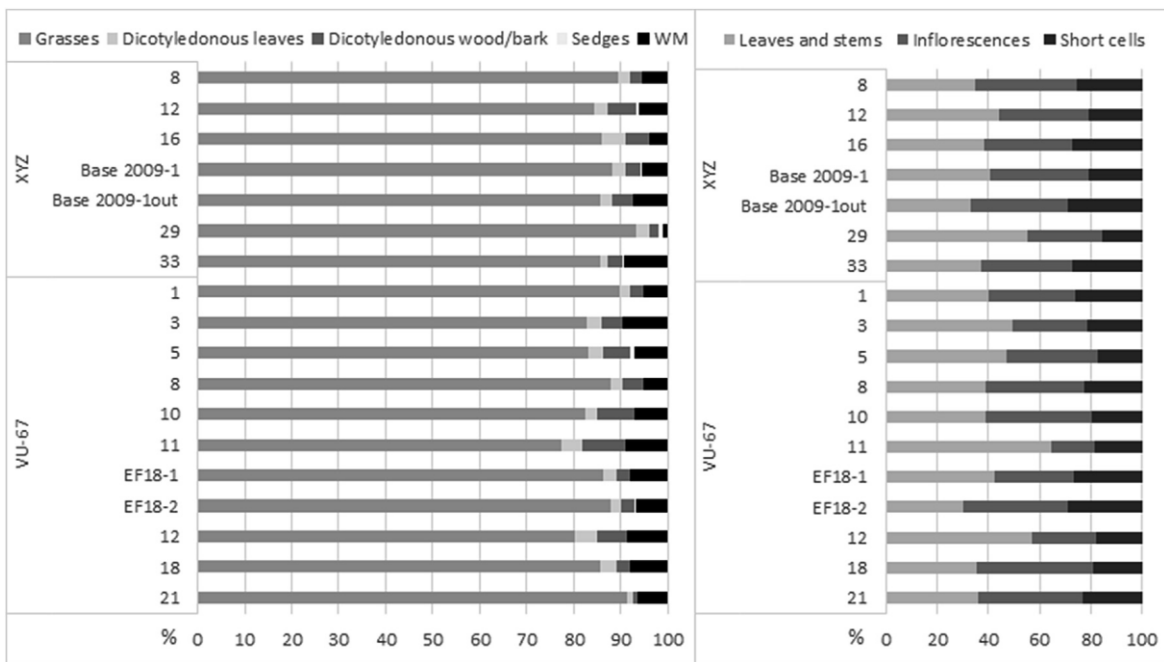


575 Inflorescences were characterized mainly by decorated dendritic and echinate long cells in  
 576 addition to epidermal papillae cells (Figure 7b). Grasses belonged to the Pooideae  
 577 subfamily which are common in well-watered woodlands and include major cereals.  
 578 Multi-celled phytoliths from the husks and culms of Pooids, including *Triticum* sp. and  
 579 *Hordeum* sp. were identified in both profiles (Figure 7c).

580

581 **Fig. 6.** Left: Relative abundances of phytoliths obtained from XYZ and VU samples;  
 582 Right: anatomical origin of grass phytoliths.

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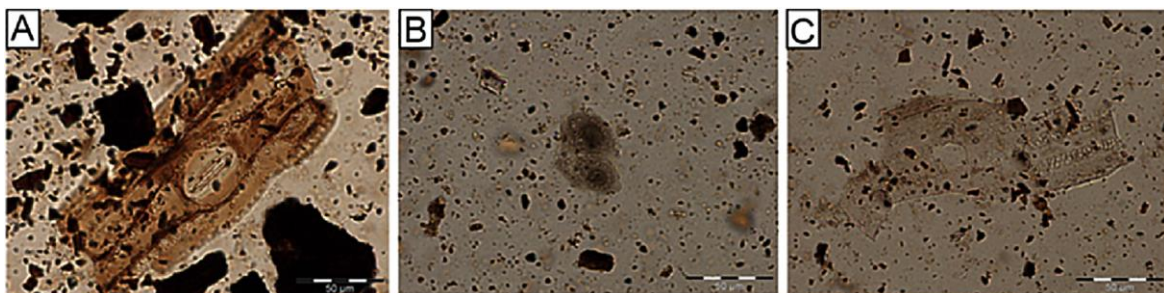


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586 **Figure 7.** Photomicrographs of phytoliths identified in XYZ samples (scale 400×): A)  
 587 multicellular structure of long cells with stomata from grass stems (sample 29, phase II);  
 588 B) epidermal appendage papillae cells (sample 8, phase V); C) multicellular structure of  
 589 dendritic long cells with short cell rondels from Pooid husk (sample 29, phase II).

590



591

592

## 593 6. Discussion

594 We follow Meadow's approach of system thinking (2008) to characterise past  
595 vegetation at Tell Qarassa North and assess its evolution through time. We consider that  
596 vegetation represents a system, and it is defined as an interconnected set of elements (e.g.  
597 trees, herbs) that are coherently organised to achieve a particular purpose (e.g. to  
598 reproduce and survive through time), and that are regulated by different inflows and  
599 outflows. In the following lines we describe the elements that define the vegetation system  
600 at Tell Qarassa North (section 6.1.), as well as characterise the environmental conditions at  
601 the time of cereal domestication (section 6.2.). Following this, we explore the complex  
602 patterns of interaction between the local and regional vegetation around Tell Qarassa  
603 North and other systems (e.g. climate and human) from 10.7 to 9.9 ka cal. BP (section  
604 6.3.).

605

### 606 6.1. *The elements of the vegetation system*

607 According to pollen, wood charcoal and phytolith evidence, from 10.7 to 9.9 ka cal. BP,  
608 four main plant formations grew in the area around Tell Qarassa North. These comprised  
609 *Pistacia* and *Amygdalus* woodland-steppe, wetland vegetation, Mediterranean open oak-  
610 woodlands, and high-mountain coniferous forests (Figure 8).

611 Wood charcoal remains from archaeological sites represent the remains of local and  
612 easily collected wood resources (Smart and Hoffman, 1988). The anthracological  
613 assemblage showed that *Pistacia* and *Amygdalus* were the preferred source of fuel during  
614 the whole occupation period (10.7–9.9 ka cal. BP) (Table 1). Considering the  
615 morphological characteristics of the nutshells found at the site (Arranz-Otaegui et al.,  
616 2016a), the remains probably represent *Amygdalus korshinskyi* and *Pistacia*  
617 *palaestina/atlantica*. These species are nowadays leading elements of Irano-Turanian  
618 woodland-steppe formations, and grow along with an understory of Poaceae,  
619 Chenopodiaceae and other steppic plants (Zohary, 1973). In addition to these, *Q.*  
620 *ithaburensis* is also common in *Pistacia-Amygdalus* woodland and woodland-steppe  
621 formations in the Mediterranean and Irano-Turanian borderlands (Zohary, 1973). This  
622 association was attested in Bronze Age and Roman sites located in the plains and  
623 mountainous areas of Jabal al-Arab, less than 10 km from Tell Qarassa North (Willcox,  
624 1999). In modern pollen rain studies conducted in the eastern Mediterranean and the  
625 Middle East values of *Quercus* pollen higher than 20% indicate the local presence of oak  
626 forests or maquis, while percentages of the order of 6–8% reflect the regional nature of

627 their origin (e.g. Bottema, 1977; Davies and Fall, 2001; Kaniewski et al., 2011 ; Fall,  
628 2012). At Tell Qarassa North percentages of *Quercus ithaburensis* pollen were up to 25%  
629 (Fig. 2), suggesting that this species could have grown in the vicinity. However, the  
630 proportions of *Pistacia* pollen found at the site (between 4 and 7% in area XYZ and 4–  
631 14% in area VU, Fig. 2; Fig. 3) are indicative of *Pistacia* tree dominance over *Quercus*,  
632 especially in *Amygdalus*-closed forest vegetation (Rossignol-Strick, 1995). Considering  
633 the remarkable percentages of grasses and steppic plants in the pollen records ( Fig. 2 ;  
634 Fig. 3) and the non-woody plant macroremains of the site (Arranz-Otaegui et al., 2016a), it  
635 is likely that the immediate areas around Tell Qarassa North were characterised by vast  
636 open areas with broadly spaced *Pistacia* and *Amygdalus* trees alternating with *Quercus*  
637 *ithaburensis*, shrubby Rosaceae, *Rhamnus* and *Acer*, and extensive patches of grasses and  
638 steppe vegetation such as *Capparis*, *Camelina*, *Stipa*, *Trigonella astroites* growing within  
639 the scattered trees ( Mouterde, 1953 ; Zohary, 1973). This type of vegetation would have  
640 been primarily located to the south of the tell, where rich soils that allow agricultural  
641 activities were found (Fig. 8A), as well as to the north of the site, in the Leja area. The  
642 limited tolerance to water-saturated soils of *Pistacia* and *Amygdalus* (Zohary, 1973) would  
643 have made them less common at the eastern foot of the tell due to the existence of a lake  
644 (Ibañez et al., 2010a). The prevalence of *Pistacia* and *Amygdalus* woodland-steppe  
645 vegetation is found during the early Holocene in inland areas of southwest Asia (Fig. S1,  
646 Table S5), from southern-central Syria ( Pessin, 2004 ; Deckers et al., 2009) up to the  
647 Euphrates area (Roitel, 1997), the Anatolian Plateau ( Willcox, 1991; Asouti, 2003 ;  
648 Emery-Barbier and Thiébaud, 2005), southeast Turkey (Neef, 2003) and the Zagros ( van  
649 Zeist et al., 1984 ; Riehl et al., 2015); that is, in areas that nowadays correspond to the  
650 Irano-Turanian phytogeographical region (Zohary, 1973). An open landscape comprising  
651 *Pistacia* forests and steppe vegetation has also been recorded in early Holocene pollen  
652 records from Anatolia ( Bottema and Woldring, 1984 ; Roberts et al., 2001), southeast  
653 Turkey ( van Zeist and Bottema, 1977; Wick et al., 2003 ; Litt et al., 2014) and Iran ( van  
654 Zeist and Bottema, 1977; Bottema, 1986 ; Djamali et al., 2008b) (Fig. S1).

655 Apart from Irano-Turanian elements, the wood charcoal, pollen and phytolith results  
656 reveal that riparian vegetation constituted an important component of the local vegetation  
657 at Tell Qarassa North (Table 1, Figures 2 and 3, Table S4). These included hygrophilous  
658 taxa such as Salicaceae (*Populus*, *Salix*), *Fraxinus* and *Tamarix*, along with *Ficus* and  
659 *Vitex agnus-castus* that were documented within the non-woody plant macroremains  
660 (Arranz-Otaegui et al., 2016a), and annual and perennial plants of the Cyperaceae (e.g.

661 *Bolboschoenus glaucus*, *Eleocharis* and *Carex*) and Ranunculaceae families. Despite their  
662 overall low absolute counts in the wood charcoal assemblage of Tell Qarassa North (Table  
663 1) it is likely they were used as importance source of fuel (Arranz-Otaegui, 2016) and  
664 building material (Balbo et al., 2012). Wetland vegetation would have been established  
665 around the shores of the ancient lake that was located at the foot of Tell Qarassa North  
666 (Figure 8B), as well as in the many water springs and the river fed by the volcanic uplands  
667 of the Jabal al-Arab (Ibañez et al., 2010b; Braemer et al., 2009). Riparian trees were  
668 commonly used as firewood and were an important element of the vegetation at  
669 contemporary sites across southwest Asia (Western, 1971; Lipshschitz and Noy, 1991;  
670 Roitel, 1997; Pessin, 2004; Austin, 2007).

671 The pollen records from Tell Qarassa North show the presence in the area of *Quercus*  
672 *calliprinos* along with a wide range of Mediterranean taxa such as *Olea*, *Rhamnus*,  
673 *Periploca*, *Phillyrea*, *Sarcopoterium*, *Ziziphus* and *Acer* (Figures 2 and 3). *Q. calliprinos* is  
674 the most important element of the maquis in the south-eastern part of the Mediterranean  
675 area (Zohary, 1973), and it is commonly associated with *Pistacia palaestina* at altitudes  
676 below 900 m, as attested nowadays in the Hermon area (Aharnovich et al., 2014). Bobek  
677 (1963) notes that *Quercus* woodland and woodland-steppe formations commonly replace  
678 *Pistacia-Amygdalus* steppe forests in areas where annual precipitation exceed an average  
679 of 500 mm. This pattern is observed in the Jabal al-Arab nowadays. Here, the plains (c.  
680 700-900 m a.s.l) with average annual precipitation of around 250-350 mm are  
681 characterised by degraded woodland-steppe components, whilst Mediterranean forest  
682 vegetation composed primarily of *Q. calliprinos* are restricted to an attitude between 1000  
683 and 1500 m a.s.l. and precipitation above 500 mm (Willcox, 1999). This would indicate  
684 that evergreen *Quercus* woodlands probably existed, at least, in what is known today as the  
685 “Mediterranean island” of the Jabal al-Arab (Figure 8C). However, the presence of several  
686 Mediterranean species such as *Echinaria capitata*, *Poa bulbosa*, *Psilurus incurvus*,  
687 *Taeniatherum caput-medusae* and *Tolpis virgata* within the non-woody plant  
688 macroremains of the site (Arranz-Otaegui et al., 2016a) and the identification of  
689 evergreen-type *Quercus* in the wood charcoal assemblage (Figure 4F) indicates  
690 infiltrations of Mediterranean vegetation close to the site. This is possible considering that  
691 moister condition than at present prevailed during the EPPNB in the area (see Balbo et al.  
692 2012, see section 6.2), which would enable these plants to grow at lower altitudes than  
693 those nowadays (e.g. 1000 m). The regional evidence shows that typically Mediterranean  
694 vegetation was predominant during the early Holocene in the southern Levant. Pollen

695 records from Hula (van Zeist et al., 2009), Dead Sea (Litt et al., 2012), Birkat Ram crate  
696 (Schiebel, 2013) and Ammiq wetland (Hajar et al., 2008) point out the prevalence of  
697 deciduous *Quercus* forests in the mountain areas of the Golan and the Beqaa (Figure S1).  
698 In the coastal areas of modern-day Israel, the wood charcoal evidence around 10.2 ka cal.  
699 BP suggests the presence of Mediterranean evergreen *Quercus* forests (Caracuta et al.,  
700 2014) and *Pistacia-Q. calliprinos* associations (Liphschitz, 1997), similar to the vegetation  
701 found nowadays in the same area. In the northern part of the Dead Sea, *Pistacia* forests  
702 and halophytic communities (e.g. *Tamarix*) grew at low elevations (i.e. around 250 m  
703 b.s.l., Liphschitz, 2010; Western, 1971), whilst in the east, at altitudes around 700 m a.s.l.,  
704 extensive deciduous *Quercus* woodlands along with some evergreen *Quercus* components  
705 were found (Neef, 2004). In the Jordan Valley, *Pistacia* trees (Asouti et al., 2015), and  
706 *Juniperus* woodlands (Neef, 2004; Austin, 2007) predominated along with some  
707 components of evergreen *Quercus*, indicating that arid areas nowadays characterised as  
708 treeless Irano-Turanian steppe and dwarf shrub were moister and more forested than at  
709 present.

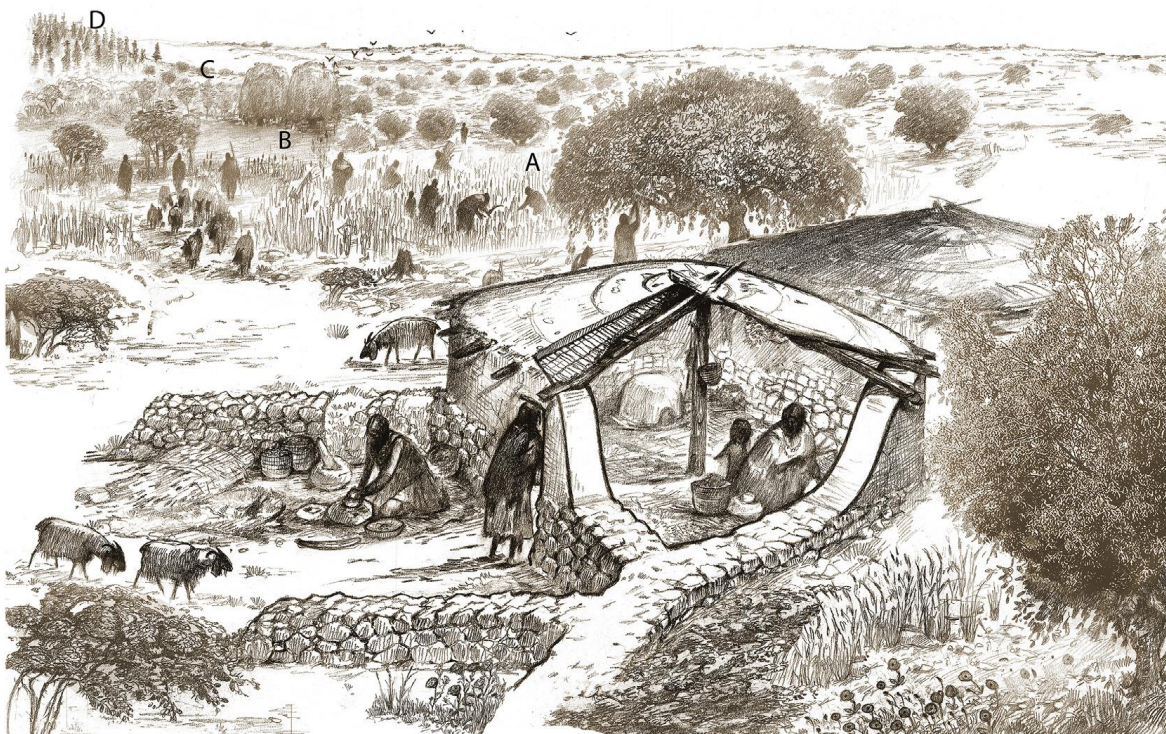
710 Mountain vegetation is represented at Tell Qarassa North by the presence of *Cedrus*  
711 *libani*, *Betula* and *Pinus nigra* type, as noted in the wood charcoal and pollen records  
712 (Figures 2 and 3, Table 1). These taxa are likely to correspond to the ‘regional’ distance  
713 transport of pollen grains from the nearby highland areas (Jabal al-Arab mountain range),  
714 or even from more distant regions (e.g. *Betula*), as suggested in the pollen records from  
715 Hula (van Zeist et al. 2009). Mixed deciduous and coniferous forests, which grow in the  
716 oromediterranean bioclimatic zone of the Syrian and Lebanese mountains, include  
717 deciduous oaks, *Pinus nigra*, *Juniperus excelsa* and *J. oxycedrus* reaching up to 1900 m  
718 a.s.l (Zohary, 1973). At higher elevations coniferous forests mainly comprise *Pinus nigra*,  
719 *Abies cilicica* and *Cedrus libani*, along with various juniper species (*Juniperus excelsa*, *J.*  
720 *drupacea*, *J. phoenicea*) (Zohary, 1973). *Cedrus libani* is now found primarily in the  
721 mountainous areas of Lebanon, northern Syria and Turkey (Hajar et al., 2010), although it  
722 has also been observed in the Mount Hermon and the northern Golan (Neumann et al.,  
723 2007), around 60 km from Tell Qarassa North. Pollen records from Ammiq wetland in  
724 Lebanon (Hajar et al., 2008) suggest that coniferous forests with species such as *Cedrus*  
725 could have been found during the early Holocene in the Barouk Mountains (Figure S1).  
726 The presence of *Cedrus* wood charcoal at the PPNB site of Tell Aswad, in the Damascus  
727 Basin, was interpreted as evidence of long-distance transportation of exotic materials  
728 (Willcox, 2005). However, *Cedrus libani* can adapt to a wide range of soil types and

729 moisture contents, including semi-arid regions with precipitation between 300 and 600 mm  
730 per year (Semerci, 2005), and altitudes above 900 m a.s.l., often between 1500-1800 m  
731 a.s.l. (Liphschitz and Biger, 1992; Hajar et al., 2010). At 25 km to the east of Tell Qarassa  
732 North the uplands of the Jabal al-Arab rise to 1800 m a.s.l., and they could have  
733 constituted a suitable area for the growth of these conifer forests during the early Holocene  
734 (Figure 8D).

735

736 **Figure 8.** Reconstruction of the local vegetation around Tell Qarassa North, view towards  
737 the south of the site (Author: C. Carlson). A) Woodland-steppe components such as  
738 *Pistacia* and *Amygdalus* growing close to the site; B) riparian vegetation growing along  
739 the shore of the lake and nearby water ponds; C) evergreen oak stands growing in more  
740 distant areas; D) coniferous forests growing in the mountain areas of the Jabal al-Arab  
741 (around 25 km from the site).

742



743

744

745 Overall, the evidence from Tell Qarassa North adds to the mosaic of plant  
746 formations attested in southwest Asia during the early Holocene (Fig. S1). The regional  
747 wood charcoal and pollen datasets highlighted east-west and north-south gradients in  
748 woodland composition not only in the southern Levant (Asouti et al., 2015), but also  
749 across southwest Asia. The evidence shows that coastal areas were dominated by

750 Mediterranean deciduous and evergreen *Quercus* in the lowlands, and conifer forests at  
751 higher altitudes, whilst inland areas were more arid and *Pistacia* and *Rosaceae* stands  
752 predominated in woodland and woodland-steppe formations (Fig. S1, Table S5). The  
753 absence of particular taxa such as deciduous *Quercus* south of the Dead Sea (Fig. S1)  
754 indicates that moisture conditions were not sufficient for this tree to grow in these regions  
755 (Asouti et al., 2015), highlighting north-south gradients in the distribution of certain plant  
756 communities. This may also apply to *Amygdalus*, a cold-tolerant species that was rarely  
757 attested in the southern Levant during the early Holocene, but predominated along with  
758 *Pistacia* in inland areas starting from southern Syria up to the northern Levant, Anatolia  
759 and the Zagros (Fig. S1, Table S5). Early Holocene records show that areas that nowadays  
760 receive low precipitation (e.g. Jordan Valley) were considerably moister than at present,  
761 and allowed the development of more extensive forests. This pattern is also evidenced at  
762 Tell Qarassa North by the presence of evergreen and deciduous *Quercus*. Notwithstanding  
763 that early Holocene vegetation was not stable and changed in relation to centennial-scale  
764 climatic fluctuations and anthropogenic impacts (among other factors), the type of plant  
765 formations found during this time broadly match the limits of modern-day  
766 phytogeographical regions in southwest Asia.

767

## 768 6.2. *The palaeoenvironmental conditions at the time of cereal domestication*

769 The analyses of the non-woody plant macroremains (Arranz-Otaegui et al., 2016a) and  
770 microremains (Figure 2, 3 6, and 7) from Tell Qarassa North indicate that cereal  
771 cultivation was common practice since the earliest occupation phases of the site (i.e.. area  
772 XYZ phase I-IV, 10.7-10.5 ka cal. BP). The presence of cereal pollen at Tell Qarassa  
773 North suggests cultivation took place in the vicinity, probably in the lands located towards  
774 the south of the site (Arranz-Otaegui et al., 2016a; López-Sáez and López-Merino, 2005).  
775 The fact that around 30% of the cereal crops bear characteristics of domesticated species  
776 (i.e. tough-rachis) indicates that since 10.7 ka cal. BP inhabitants cultivated both wild and  
777 domesticated emmer (*T. dicoccoides/dicoccum*), einkorn (*T.*  
778 *boeoticum/urartu/monococcum*), and to a lesser extent barley (*Hordeum*  
779 *spontaneum/vulgare*) (Arranz-Otaegui et al., 2016a). This evidence contrasts with that  
780 observed at contemporary sites in the southern-central Levant, where barley is the most  
781 common species exploited (see summary in Arranz-Otaegui et al., 2016b).

782 It is likely that the environmental conditions around Tell Qarassa North were more  
783 humid than in the rest of the sites in the southern Levant and allowed the exploitation of

784 wheat over barley. The minimum rainfall requirements for these cereals present at Tell  
785 Qarassa North is approximately 200 mm for *Hordeum spontaneum*, 250 mm for *T. urartu*,  
786 300 mm for *T. boeoticum* and 400 mm for *T. dicoccoides* (Willcox, 2005; Heun et al.,  
787 2008). The widespread presence of emmer in the assemblage indicates that the minimum  
788 annual precipitation around 10.7-9.9 ka cal. BP must have been of around 400 mm. This  
789 estimate is confirmed by the habitat requirements of the tree species found at the site. *Q.*  
790 *ithaburensis* is largely dependent on the amount of precipitation and it commonly needs  
791 annual average rainfall above 400 mm (Bobek, 1963; Zohary, 1973). *Pistacia atlantica*  
792 and *Amygdalus korschinskii* commonly grow in areas with average rainfall 300-400 mm  
793 per year (Bobek, 1963). The high  $\Delta^{13}\text{C}$  values recorded in the charcoal of *Pistacia* and  
794 *Amygdalus* from Tell Qarassa North indicate that these trees were growing in relatively  
795 wet conditions, prevalent at other early agricultural sites (Araus et al., 2014). In the case of  
796 *Pistacia*, the  $\Delta^{13}\text{C}$  values were similar to those recorded at Epipaleolithic and Neolithic  
797 sites in the northern Syria and southeastern Turkey (Araus et al., 2014), including those  
798 recorded in the second half of the Holocene (Deckers, 2016). Yet, the values found at Tell  
799 Qarassa North were slightly higher than present-day values in the region (Masi et al.,  
800 2013; Araus et al., 2014), indicating that cereal domestication took place at a time of  
801 moister environmental conditions (i.e. >350 mm, Traboulsi, 2013). It is also noteworthy  
802 that *Pistacia* and *Amygdalus* charcoals from the roof structure exhibited lower values in  
803 contrast to dispersed wood charcoal remains derived from fuel waste (Figure 5). These  
804 results cannot be explained by the biological age of the wood charcoal fragments analysed  
805 (i.e. deriving either from trunks or from branches) (Table S3). Moreover the available  
806 literature does not conclusively support the effect of age on the  $\Delta^{13}\text{C}$  of the wood charcoal  
807 (Tans and Mook, 1980; Leavitt and Long, 1986; Schleser, 1992; Nguyen-Queyrens et al.,  
808 1998 ; Fotelli et al., 2009). Instead, it could be that the building materials were gathered in  
809 a different location in comparison to fuel resources, probably beyond the agricultural  
810 surroundings of the site, in less fertile locations such as those found towards the north, in  
811 the Leja area.

812

### 813 6.3. *The dynamics of past vegetation around 10.5-9.9 ka cal. BP*

814 For around 200-300 years, plant formation around Tell Qarassa North did not suffer  
815 major changes indicating that the whole vegetation system worked in dynamic  
816 equilibrium. This means that from 10.7 to 10.5 ka cal. BP the inflows and outflows that  
817 regulated the amount and the type of trees present in the area were balanced. The sum of



818 all outflows (e.g. natural death of trees, wood gathering and fire-related activities) equalled  
819 the sum of all inflows (e.g. natural reproduction of trees, tree management activities), and  
820 therefore, allowed the different plant formation growing around Tell Qarassa North (i.e.  
821 woodlands-steppe, oak-woodlands, riparian vegetation and mountain vegetation) to  
822 maintain relatively unchanged. However, between c. 10.5 and 9.9 ka cal. BP (phase V in  
823 area XYZ, and the upper phase in area VU), several changes occur in some of the outflows  
824 and inflows that regulate the vegetation system, in particular in those related to the climate  
825 system and the human system, leading to substantial transformations in the local and  
826 regional vegetation.

827

### 828 6.3.1. *Changes in the climate system*

829 The latest occupation phases of Tell Qarassa North dated to between 10.5 and 9.9 k cal.  
830 BP (phase V in area XYZ and upper phase in area VU), highlight changes in the  
831 proportions of trees that are sensitive to temperature fluctuations. The pollen records show  
832 a marked decrease in thermophilous taxa such as *Pistacia*, *Periploca*, *Sarcopoterium* and  
833 *Zizyphus* and *Quercus calliprinos* (Figures 2 and 3). This trend is synchronous with the  
834 increase in the pollen of mesophilous trees such as *Betula* and *Cedrus*, and the first  
835 appearance in the assemblage of typically mesophilous *Junglans* (Figures 2 and 3). The  
836 shifts observed suggest that between 10.5 and 9.9 ka cal. BP, cold environmental  
837 conditions established around Tell Qarassa North. Regional datasets show that centennial-  
838 scale rapid climatic changes occurred during the Holocene in the Mediterranean region,  
839 and comprised changes in temperature and rainfall conditions (Mayewski et al., 2004).  
840 Based on the Glacial GISP2 non sea-salt (nss) potassium [K<sup>+</sup>] concentration record,  
841 Weninger et al. (2009) suggested that one of the coldest events during the last 50,000 years  
842 occurred at around 10.2 ka cal. BP in the eastern Mediterranean. The 10.2 ka cal. BP event  
843 was previously identified in other regions of the Northern Hemisphere (Bond et al., 1997;  
844 Rasmussen et al., 2007; Cai et al., 2008), however, so far, it has not been identified in  
845 Mediterranean pollen records. This rapid climatic change has been associated to a major  
846 interruption in the sequence of settlements in the northern Levant and it has been referred  
847 to as possible trigger for the abandonment of several Pre-Pottery Neolithic sites (Borrell et  
848 al., 2015). At Tell Qarassa North, the reduction of thermophilous species opposed to  
849 mesophilous species is a possible signal of a climatic change contemporary with the 10.2  
850 ka cal. BP event. Most of the mesophilous and thermophilous species that show changes  
851 during this time were probably growing at a considerable distance from the site (see

852 section 6.1.), and therefore, human factors can be excluded as possible explanations for  
853 their diminution/increase. Furthermore, during other cold rapid climatic changes such as  
854 the 8.2 ka cal. BP, a decrease in thermophilous species such as *Quercus calliprinos* has  
855 been recorded in several pollen records in the Mediterranean area (Rossignol-Strick, 1999;  
856 Pross et al., 2009). Besides, most of the mesophilous and thermophilous species that  
857 showed changes during this time were probably growing at a considerable distance from  
858 the site (see Section 6.1.), and therefore, human factors can be excluded as possible  
859 explanations. Considering this, it is likely that the establishment of colder environmental  
860 conditions between 10.5 and 9.9 ka cal. BP acted as an outflow on the flora of the Jabal al-  
861 Arab region reducing the extension of thermophilous taxa.

862 Besides this, temperature fluctuations could have acted as a reinforcing feedback loop,  
863 and enhanced further transformations in the local and regional vegetation. Decrease  
864 temperatures commonly result in higher snow accumulations and ice melt water, which  
865 condition the growth of alluvial fans in valley bottoms, and the rise in the water table of  
866 rivers, lakes and water ponds. In Europe, several studies have identified hydrological  
867 changes (e.g. floods) as a consequence of the 8.2 ka cal. BP cooling episode (Alley and  
868 Agustsfottir, 2005; Hughes et al. 2000; Magny et al., 2003). In the Anatolian Plateau, the  
869 expansion of alluvial fans around 9.5 ka cal. BP (Boyer et al. 2006) were referred to as a  
870 possible signal of a climatic change contemporary with the cold 9.2 ka cal BP event  
871 (Berger et al., 2016). In Cyprus, flood episodes that caused strong upstream erosion  
872 (Devillers, 2005), as well as surface erosion and torrential discharges were attested around  
873 8.5 ka cal. BP and 8.1 ka cal. BP (Berger et al., 2016), which could be linked to 8.2 ka cal.  
874 BP event. In the Lake Van, high water tables associated to increased sedimentation and  
875 mineral content were recorded also around 8.4-8.2 ka cal. BP (Lemcke and Sturm, 1997).  
876 Considering that hygrophilous plants represent edaphic communities that depend on  
877 ground moisture and water availability (Zohary, 1973), changes in the water table of the  
878 nearby water ponds and springs caused by the establishment of colder environmental  
879 conditions could have also altered the extent to which this plant formations grew in the  
880 vicinity. This hypothesis would explain the synchronous spread of mesophilous species  
881 and the development of hygrophilous and meadow steppe attested taxa between 10.5 and  
882 9.9 ka cal. BP at Tell Qarassa North (Figures 2 and 3).

883 An additional factor that could have contributed to the spread of hygrophilous plants  
884 has to do with the other main element that regulates plant growth in the climate system that  
885 is rainfall. The isotope record from Tell Qarassa North indicated centurial changes in the

886 isotopic content of the wood charcoal samples studied. In area XYZ, *Pistacia* and  
887 *Amygdalus*  $\Delta^{13}\text{C}$  values decreased from phase I to phase IV, indicating that the second  
888 destruction of the site (phase IV) occurred at the time of dry environmental conditions in  
889 comparison to earlier occupation phases, and which coincide with maximum values for  
890 dry-tolerant *Artemisia* in the pollen samples from phase IV (Figure 2). This period was  
891 followed by increased values during the last phases of the site (phase V and VI in XYZ  
892 and upper and lower phase in VU), indicating the re-establishment of wet conditions. At  
893 Tell Qarassa North, the spread of wetland taxa in phase V of area XYZ and upper phase of  
894 area VU is coincidental with the disappearance of *Artemisia* (Figures 2 and 3), a common  
895 indicator of dryness in the pollen records (Rossignol-Strick, 1995) and increase in Poaceae  
896 (e.g., from 5-12% to 13-19% in area VU, Figures 2 and 3). The increase in Poaceae pollen  
897 at the expense of *Artemisia* is suggestive of reduced summer drought or increase summer  
898 precipitation. In previous studies, high percentage of Poaceae pollen in deep-core pollen  
899 records from the Arabo-Persian Gulf were interpreted as evidence of reduced extreme  
900 summer drought around 8.0 ka cal. BP (el-Moslimany, 1983). The evidence would thus  
901 indicate that between 10.5 and 9.9 ka cal. BP environmental conditions around Tell  
902 Qarassa North not only turned colder, but also moister. This is in accordance with the  
903 regional datasets from the Mediterranean area, which indicate that after the 10.2 ka cal.  
904 BP, around 10-8.6 ka cal. BP, extremely wet conditions prevailed, referred to as the  
905 Levantine Moist Period (LMP). These conditions have been best documented in the Dead  
906 Sea (Weninger et al., 2009; Arz et al., 2003b; Migowski et al., 2006), located around 150  
907 km to the west of Tell Qarassa North. The stable carbon isotopes from Soreq Cave (Israel)  
908 indicate that during this time regional rainfall could have been twice higher than the  
909 present-day average (Bar-Matthews et al., 2000). Recent stable carbon isotope analyses of  
910 archaeological plant remains from Neolithic sites in the Middle Euphrates confirm a peak  
911 in humid conditions between 10.0 and 8.0 ka cal. BP (Araus et al., 2014). It is thus  
912 possible that increased rainfall conditions in the Jabal al-Arab produced changes in the  
913 water tables of water ponds and lakes located in the plain, and this could have contributed  
914 to the development of wetland vegetation around Tell Qarassa North.

915

#### 916 6.3.1. Changes in the human system

917 The pollen records from Tell Qarassa North show a remarkable decrease in arboreal  
918 pollen between 10.5 and 9.9 ka cal. BP (Figures 2 and 3). In area XYZ, *Quercus*  
919 *ithaburensis*, *Quercus calliprinos* and *Pistacia* pollen values decreased from 15-25%

920 (phases I-IV) to 6-11% (phase V), from 7-15% (phases I-IV) to 2-4% (phase V) and from  
921 4-7% (phases I-IV) to 2-4% (phase V) respectively, and this decrease is also attested in  
922 area VU (Figures 2 and 3). Whilst the evidence does not suggest massive deforestation, it  
923 does indicate a shift towards an open landscape and overall lower tree cover than in  
924 previous periods. The decrease in Mediterranean vegetation comprising thermophilous  
925 species such as *Q. calliprinos* could have been triggered by changes in the climate system  
926 (section 6.3.1). However, the evidence shows that changes in the arboreal cover occurred  
927 at the time of increased evidence for anthropogenic pressures (Figures 2 and 3). This  
928 means that plant formation that grew in the immediate vicinity of the site (e.g. *Pistacia*, *Q.*  
929 *ithaburensis*) would have been regulated by additional inflows and outflows associated to  
930 the anthropogenic system.

931 The pollen records for the latest occupation phases of the site (phase V in area XYZ,  
932 and upper phase in area VU) indicate a sudden rise in anthropozoogenic taxa  
933 (Chenopodiaceae, *Plantago lanceolata*, *Rumex acetosa*, *R. acetosella*), which refer to  
934 plants related to grazed pastures (Behre, 1981); coprophilous fungi (Sordariaceae,  
935 *Chaetomium*), which commonly develop on dung (van Geel, 2001). This indicates that  
936 between 10.5 and 9.9 ka cal BP, coinciding with the development of agropastoral societies  
937 in southwest Asia (Asouti and Fuller, 2012, 2013; Zeder, 2011), herding activities  
938 intensified in the area around Tell Qarassa North. The preliminary analyses of the faunal  
939 remains from Tell Qarassa North revealed the primary exploitation of goat (*Capra* format  
940 *aegagrus*) during all the occupations (L. Gourichon in Ibáñez et al., 2010), along with a  
941 large spectrum of animal taxa comprising other ungulates like the gazelle, the aurochs, the  
942 wild boar and the Mesopotamian fallow deer, and the hare and various species of  
943 carnivores and birds as small game (see Table S6). Sheep bones have not been clearly  
944 identified and the goat remains show the same size range (though slightly larger in  
945 average) that the goat populations from the late Early and Middle PPNB levels of Tell  
946 Aswad where evidence of herding was attested (Helmer and Gourichon 2008, 2016). If the  
947 domestic status of the goats from Tell Qarassa cannot be asserted from metrical or  
948 morphological criteria or kill-off profiles, due to the lack of data, the results provided by  
949 the study of NPPs shed new light on this question. The regular occurrence of coprophilous  
950 fungi (Sordariaceae) throughout the sequence indicates the prevalence of ungulate dung  
951 around and within the habitat that cannot be explained solely by incidental deposits from  
952 the intestinal contents of wild animals butchered in the surroundings. In this sense, these  
953 data strongly suggest that at least part of the goats were herded near Tell Qarassa North, at

954 a time where early domestication of the bezoar goat was demonstrated in Northern  
955 Mesopotamia (Peters et al., 2005). It must be considered that compared to sheep, goats are  
956 preferentially browsers and can remove tree seedlings, reducing the rates of natural  
957 woodland regeneration (Janis, 2008; Skarpe and Hester 2008). Several researchers  
958 suggested that overgrazing was partially responsible for the reduction in plant cover in  
959 regions associated to the emergence of sheep/goat pastoralism, resulting in changes in  
960 settlement patterns as early as the PPNB (Falconer and Fall, 1995; Grigson, 1995; Köhler-  
961 Rollefson, 1988; Köhler-Rollefson and Rollefson, 1990; Simmons, 2000; Tchernov and  
962 Horwitz, 1990). Despite it is difficult to test, it is possible that increased herding activities  
963 between 10.5 and 9.9 ka cal. BP acted as an outflow and reduced the chances for local  
964 trees such as *Pistacia* or deciduous *Quercus* to reproduce. This change, coupled with the  
965 shift to colder environmental conditions (section 6.3.1), would have hindered the  
966 maintenance of the arboreal cover in proportions similar to those attested in previous  
967 phases (i.e. I-IV in area XYZ, and lower-phase in area VU).

968 Additionally, the evidence between 10.5 and 9.9 ka cal. BP shows a marked increase  
969 carbonicolous fungi such as *Chaetomium*, a common indicator of anthropogenic fires  
970 (López-Sáez et al., 1998; van Geel et al., 2003; López-Sáez and López-Merino 2007); as  
971 well as increased *Glomus* values, which have been associated to erosive processes related  
972 to the anthropic dynamics in the immediate environment of archaeological sites (López-  
973 Sáez et al., 2000). The evidence thus indicates increased firing activities in the area. The  
974 purpose of these fires is difficult to assess, but fire management is in general associated  
975 with hunter-gatherers, pastoralists and cultivators that aim to maintain open savannah-type  
976 landscapes with grasslands and trees suitable for agropastoral activities (Roberts, 2002),  
977 and Tell Qarassa North the evidence coincided with the time when herding activities  
978 intensified and arboreal cover reduced. Regional datasets indicate that grasslands reached  
979 maximum values during the early Holocene and dry-season burning was one of the main  
980 factors regulating these grass-land ecosystems (Turner et al., 2010). Grasses represent  
981 competitors for the development of *Quercus* seedlings and they can hamper the expansion  
982 of oak-woodlands (see recent review by Asouti and Kabukcu, 2014). In the Mediterranean  
983 region, low-intensity ground fires are common in the summer dry season, and favour the  
984 development of wild cereal grasses (Zohary and Hopf, 2000; Grove and Rackham 2001). It  
985 is thus likely that increased fire-related and herding activities, as well as additional  
986 changes in the climate system, all contributed as direct or indirect factors to the decline of  
987 the local arboreal cover between 10.5 and 9.9 ka cal. BP.

988

## 989 **7. Conclusions**

990

991 The analyses carried out at Tell Qarassa North show the importance of considering  
992 multiple datasets (e.g. plant macro and microremains) to reconstruct past vegetation and  
993 environmental conditions in southwest Asia. The multi-proxy analyses at the site have  
994 provided high-resolution data to characterise the local and regional vegetation and its  
995 evolution at the time when morphologically domesticated cereals appear and developed in  
996 southern Syria (10.7-9.9 ka cal. BP). The combination of wood charcoal and pollen  
997 evidence indicates that Tell Qarassa North was located within the Irano-Turanian and  
998 Mediterranean phytogeographical regions. The local vegetation comprised woodland-  
999 steppe components and riparian taxa, whilst Mediterranean oak-woodlands and coniferous  
1000 forests could have grown at further distance, in the mountain areas of the Jabal al-Arab  
1001 located to the east of the site. The results overall indicate that considerably moister  
1002 conditions than at present prevailed around Tell Qarassa North and the Jabal al-Arab,  
1003 which is consistent with climatic and environmental conditions during the early Holocene  
1004 (Robinson et al., 2006; Weninger et al., 2009). Furthermore, the evidence shows that the  
1005 site was located also in amore humid area in comparison to coeval sites in the southern  
1006 Levant, and could explain why the inhabitants of site exploited predominantly wheat  
1007 species opposed to barley. Cereal domestication in southern Syria occurred at a time when  
1008 vegetation, climate and human groups interacted in dynamic equilibrium and the  
1009 environment was characterised by mild winters (probably frost-free) and hot summers, and  
1010 an average rainfall of around 400 mm per year.

1011 Slightly later, between 10.5 and 9.9 ka cal. BP, the inflows and outflows that regulated  
1012 vegetation and that were dependant upon climate and human activities were altered, and  
1013 resulted in substantial transformations in the local and regional vegetation. Our results  
1014 provide evidence for the spread of mesophilous and hygrophilous taxa during this time,  
1015 and suggest the establishment of colder and wetter environmental conditions than today.  
1016 These fluctuations occurred during a broad time frame (from 10.5 to 9.9 ka cal. BP) and  
1017 while they cannot be directly correlated with specific RCCs (e.g. the 10.2 ka cal. BP), it is  
1018 likely that they were triggered by shifts in the inflows and outflows associated to the  
1019 climate system (e.g. rainfall, temperature). Considering that climatic anomalies vary in  
1020 time, space, intensity and type of signal, further investigations are needed to compare the  
1021 shifts observed in this study with records from other regions across southwest Asia. Apart

1022 from this, pollen records from Tell Qarassa North showed increased fire-related and  
1023 herding activities from 10.5 to 9.9 ka cal. BP, which along with changes in the climatic  
1024 conditions, could have enhanced the spread of grasses and the shift to an open landscape  
1025 with less arboreal cover. At this regard, more studies are necessary not only to identify the  
1026 presence of anthropogenic impacts in the wood charcoal and pollen records, but also to  
1027 fully evaluate how human activities altered local plant formations beyond linear models  
1028 that link human activities to the decrease of the arboreal cover and deforestation.

1029 Overall, in this work we show that changes in the past vegetation were complex in that  
1030 they involved elements of different systems acting synergistically, and causing plant-  
1031 specific responses. This means that single factor explanations (i.e., climatic or  
1032 anthropogenic) of plant change during the Holocene will fail to recognize the diversity and  
1033 complexity of the interactions that commonly regulate plant ecosystems.

1034

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1052

1053

1054 **Supplementary data**

**Table S1.** Available radiocarbon dates for Tell Qarassa North, area XYZ and VU. Radiocarbon determinations were performed in charcoal samples at Beta Analytic Inc. (Miami, Florida, USA) and Centro Nacional de Aceleradores (Sevilla, Spain). Radiocarbon ages were calibrated with OxCalv4.2.2 (Bronk-Ramsey, 2009) using the IntCal09 calibration curve (Reimer et al., 2009).

Area	Phase/ Group	Space	Unit	Phase Interpretation	Reference	14C BP	cal BP	cal BC	Dated material
XYZ- 67/68/69	I	B	52C	1° Occupation	CNA - 1355	9185±40	10487-10244	8538-8295	<i>T. dicoccoides/dicoccum</i>
	II	A	57	1° Destruction	CNA - 1065	9300±45	10651-10298	8702-8349	<i>Pistacia</i> sp. (Branch BB48)
		A	74		Beta - 290929	9340±50	10700-10407	8751-8458	<i>T. boeoticum/monococcum</i>
		B	52B		-	-	-	-	-
	III	A	24b;25	2° Occupation	CNA - 1353	9252±38	10555-10279	8606-8330	<i>T. boeoticum/monococcum</i>
		B	52		CNA - 1354	9292±48	10648-10291	8699-8342	<i>T. boeoticum/monococcum</i>
	IV	A	24;36;37	2° Destruction	-	-	-	-	-
		B	14		-	-	-	-	-
	V	A	21	Abandonment	Beta - 272103	9320±50	10683-10301	8734-8352	Large-seeded Poaceae
		A	34;18;5;6	Cemetery	Beta - 262213	9100±60	10480-10178	8531-8229	<i>T. dicoccoides/dicoccum</i>
VI	A	15;3;4	Surface layers	Beta - 277177	9300±50	10653-10296	8704-8347	<i>Triticum</i> spp.	
VU-67	Lower	14;15;10	Lower phase	CNA-3129	9192±40	10490-10246	8541-8297	Leguminosae seed	
				Beta - 402487	9100±30	10493-10200	8344-8251	Wood charcoal	
	Upper	4;3	Upper phase	Beta - 274098	9030±60	10368-9919	8419-7970	Leguminosae seed	



**Table S2.** Carbon isotope discrimination ( $\Delta^{13}\text{C}$ ) values of the *Pistacia* and *Amygdalus* wood charcoal remains from Tell Qarassa North. Sample reference and location as well as dating, growth-ring curvature and carbon isotope composition ( $\delta^{13}\text{C}_{\text{sample}}$ ) values are listed for each sample. Spaces A and B belong to the XYZ area, whereas the upper and lower phases refer to the VU area.

Sample N°	Sample ID	Layer	Growth-ring Curvature	<i>Pistacia</i> sp.	<i>Amygdalus</i> sp.	Reference	Data BP	%C	$\delta^{13}\text{C}_{\text{sample}}$ (‰)	$\delta^{13}\text{C}_{\text{air}}$ (‰)	$\Delta^{13}\text{C}$ (‰)
1	Z67 Y67	Space A, phase IV	weak	X				64.71	-24.67	-6.73	18.40
2	Z67D/E 5	Space A, phase IV	weak	X				65.19	-24.88	-6.73	18.61
8	Y68	Space A, phase IV	moderate		X			62.98	-25.08	-6.73	18.82
12	Y67	Space A, phase IV	strong	X				64.81	-23.37	-6.73	17.04
14	Y67 C2	Space A, phase IV	-	X				65.57	-22.79	-6.73	16.44
15	Y67 D2	Space A, phase IV	moderate		X			64.17	-24.88	-6.73	18.62
17	Y68	Space A, phase IV	weak	X				65.53	-25.11	-6.73	18.85
51	Y67 C/D1	Space A, phase IV	strong	X				67.63	-25.07	-6.73	18.82
24	Y67 E2	Space A, phase IV	weak	X				62.06	-24.64	-6.73	18.37
3	Y67	Space A, phase VI	moderate		X	Beta - 277177	9300 ± 50	61.96	-25.59	-6.73	19.35
11	Y67	Space A, phase VI	weak		X	Beta - 277177	9300 ± 50	65.46	-24.86	-6.73	18.58
20	Y67 E2	Space A, phase VI	-		X	Beta - 277177	9300 ± 50	63.43	-25.45	-6.73	19.21
5	Y68	Space A, phase VI	-	X		Beta - 277177	9300 ± 50	63.95	-24.49	-6.73	18.20
6	Y67	Space A, phase VI	weak		X	Beta - 277177	9300 ± 50	63.33	-24.15	-6.73	17.84
10	Y67	Space A, phase VI	moderate		X	Beta - 277177	9300 ± 50	62.98	-25.96	-6.73	19.74
23	Y67 E2	Space A, phase V (cemetery)	strong		X	Beta - 262213	9100 ± 60	64.20	-24.97	-6.72	18.71
13	Y67 C3	Space A, phase V (cemetery)	strong		X	Beta - 262213	9100 ± 60	65.83	-25.66	-6.72	19.43

Sample N°	Sample ID	Layer	Growth-ring Curvature	<i>Pistacia</i> sp.	<i>Amygdalus</i> sp.	Reference	Data BP	%C	$\delta^{13}\text{C}_{\text{sample}}$ (‰)	$\delta^{13}\text{C}_{\text{air}}$ (‰)	$\Delta^{13}\text{C}$ (‰)
18	Y67 E2	Space A, phase V (abandonment)	weak		X	Beta - 272103	9320 ± 50	62.56	-24.87	-6.74	18.60
9	Y67 D3	Space A, phase V (abandonment)	weak		X	Beta - 272103	9320 ± 50	95.05	-24.58	-6.74	18.29
4	V67	Upper phase	weak	X		Beta - 274098	9030 ± 60	64.74	-25.29	-6.70	19.07
7	V67	weaker phase	weak	X		Beta - 402487	9100 ± 30	63.28	-25.30	-6.70	19.09
16	V67	Upper phase	moderate	X		Beta - 274098	9030 ± 60	64.95	-25.53	-6.70	19.32
22	V67	Upper phase	weak	X		Beta - 274098	9030 ± 60	65.22	-25.69	-6.70	19.49
25	V67	weaker phase	weak		X	CNA-3129	9192 ± 40	62.70	-25.00	-6.70	18.76
50	Y67 E3	Space A, phase III	weak	X		CNA1353	9252 ± 38	55.78	-22.57	-6.73	16.21
52	Y67 E4	Space A, phase III	weak		X	CNA1353	9252 ± 38	64.84	-23.61	-6.73	17.29
55	Y67 E1	Space A, phase III	weak		X	CNA1353	9252 ± 38	64.34	-25.78	-6.73	19.56
56	Y68 A4	Space A, phase III	-		X	CNA1353	9252 ± 38	61.79	-25.31	-6.73	19.07
57	Y68 A1	Space A, phase III	weak	X		CNA1353	9252 ± 38	68.08	-24.44	-6.73	18.16
58	Y67 D1	Space A, phase III	weak		X	CNA1353	9252 ± 38	63.20	-25.16	-6.73	18.91
59	Y67 D2	Space A, phase III	weak	X		CNA1353	9252 ± 38	65.53	-25.18	-6.73	18.93
60	Y68 A2	Space A, phase III	weak	X		CNA1353	9252 ± 38	64.87	-24.61	-6.73	18.33
61	Y68 A2	Space A, phase III	weak	X		CNA1353	9252 ± 38	66.20	-24.86	-6.73	18.60
62	Y67 E3	Space A, phase III	weak		X	CNA1353	9252 ± 38	56.57	-23.86	-6.73	17.56
65	Y67 E3	Space A, phase II	-		X	Beta - 290929	9340 ± 50	64.44	-25.18	-6.74	18.91
66	Y67 C3	Space A, phase III	weak	X		CNA1353	9252 ± 38	65.49	-25.34	-6.73	19.10
79	Y67 D3	Space A, phase III	weak		X	CNA1353	9252 ± 38	62.62	-25.28	-6.73	19.04
81	Y67 D2	Space A, phase III	weak	X		CNA1353	9252 ± 38	61.88	-26.50	-6.73	20.31
82	Y67 D3	Space A, phase III	-	X		CNA1353	9252 ± 38	58.14	-22.21	-6.73	15.83

Sample N°	Sample ID	Layer	Growth-ring Curvature	<i>Pistacia</i> sp.	<i>Amygdalus</i> sp.	Reference	Data BP	%C	$\delta^{13}\text{C}_{\text{sample}}$ (‰)	$\delta^{13}\text{C}_{\text{air}}$ (‰)	$\Delta^{13}\text{C}$ (‰)
84	Y67 C/D1	Space A, phase III	weak	X		CNA1353	9252 ± 38	64.62	-24.16	-6.73	17.87
86	Y67 C1	Space A, phase III	weak	X		CNA1353	9252 ± 38	58.06	-22.73	-6.73	16.38
87	Y67 D2	Space A, phase III	weak	X		CNA1353	9252 ± 38	52.43	-24.18	-6.73	17.89
89	Y67 E3	Space A, phase III	-	X		CNA1353	9252 ± 38	57.85	-23.37	-6.73	17.04
90	Y67 E1	Space A, phase III	-	X		CNA1353	9252 ± 38	57.16	-25.12	-6.73	18.87
91	Y67 E3	Space A, phase II, roof	-	X		Beta - 290929	9340 ± 50	61.46	-23.40	-6.74	17.06
94	Y67 E2	Space A, phase II, roof	weak	X		Beta - 290929	9340 ± 50	53.32	-24.37	-6.74	18.07
95	Y67 E2	Space A, phase II, roof	weak	X		Beta - 290929	9340 ± 50	59.98	-24.38	-6.74	18.08
96	Y67 D2	Space A, phase II, roof (post)	weak	X		Beta - 290929	9340 ± 50	55.45	-25.89	-6.74	19.66
75	Y67 E/D1	Space A, phase III (pit)	weak	X		CNA1353	9252 ± 38	64.66	-24.80	-6.73	18.54
76	Y67 E/D1	Space A, phase III (pit)	weak	X		CNA1353	9252 ± 38	60.52	-25.01	-6.73	18.76
54	X68 B1	Space B, phase III	weak	X		CNA1354	9292 ± 48	63.99	-25.85	-6.73	19.63
63	Y68 D5	Space B, phase III	weak	X		CNA1354	9292 ± 48	61.72	-26.85	-6.73	20.67
64	Y68 C5	Space B, phase III	moderate	X		CNA1354	9292 ± 48	64.92	-24.95	-6.73	18.68
77	X69 A1	Space B, phase III	weak	X		CNA1354	9292 ± 48	62.76	-25.46	-6.73	19.22
92	Y68 C4	Space B, phase III	weak	X		CNA1354	9292 ± 48	64.14	-25.75	-6.73	19.52
93	Y68 E4	Space B, phase III	weak		X	CNA1354	9292 ± 48	62.70	-26.52	-6.73	20.33
68	Y68 B5	Space B, phase III	weak	X		CNA1354	9292 ± 48	61.49	-25.66	-6.73	19.42

Sample N°	Sample ID	Layer	Growth-ring Curvature	<i>Pistacia</i> sp.	<i>Amygdalus</i> sp.	Reference	Data BP	%C	$\delta^{13}\text{C}_{\text{sample}}$ (‰)	$\delta^{13}\text{C}_{\text{air}}$ (‰)	$\Delta^{13}\text{C}$ (‰)
69	Y68 C5	Space B, phase III	weak	X		CNA1354	9292 ± 48	62.94	-24.51	-6.73	18.22
71	X68 C1	Space B, phase III	weak		X	CNA1354	9292 ± 48	61.63	-25.55	-6.73	19.31
73	X68 E1	Space B, phase III	weak	X		CNA1354	9292 ± 48	62.65	-26.57	-6.73	20.37
83	Y68 B4	Space B, phase III	weak		X	CNA1354	9292 ± 48	62.73	-25.25	-6.73	18.99
67	Y68 C5	Space B, phase I	weak	X		CNA1355	9185 ± 40	63.25	-25.68	-6.72	19.45
70	Y68 E5	Space B, phase I	weak		X	CNA1355	9185 ± 40	63.11	-25.96	-6.72	19.75
72	Y68 D5	Space B, phase I	weak	X		CNA1355	9185 ± 40	63.09	-24.66	-6.72	18.39
74	X68 E1	Space B, phase I	-		X	CNA1355	9185 ± 40	63.95	-25.88	-6.72	19.67
78	X69 A1	Space B, phase I	-	X		CNA1355	9185 ± 40	59.09	-26.25	-6.72	20.05
80	X68 D1	Space B, phase I	moderate		X	CNA1355	9185 ± 40	61.63	-24.61	-6.72	18.34
88	Y68 B4	Space B, phase I	weak	X		CNA1355	9185 ± 40	59.81	-24.86	-6.72	18.60
85	Y68 B4/5	Space B, phase III (pit)	-	X		CNA1354	9292 ± 48	64.36	-25.18	-6.73	18.92
11245	BB29	Space A, phase II, roof	-		X	CNA1065	9300 ± 50	54.65	-23.55	-6.73	17.23
11244	BB28	Space A, phase II, roof	strong		X	CNA1065	9300 ± 50	63.54	-23.61	-6.73	17.28
11212	BB10	Space A, phase II, roof	moderate		X	CNA1065	9300 ± 50	60.57	-23.55	-6.73	17.22
11246	BB30	Space A, phase II, roof	-	X		CNA1065	9300 ± 50	56.08	-24.25	-6.73	17.95
11238	BB24	Space A, phase II, roof	-	X		CNA1065	9300 ± 50	60.97	-23.93	-6.73	17.62
11247	BB31	Space A, phase II, roof	-	X		CNA1065	9300 ± 50	60.17	-24.98	-6.73	18.71

Sample N°	Sample ID	Layer	Growth-ring Curvature	<i>Pistacia</i> sp.	<i>Amygdalus</i> sp.	Reference	Data BP	%C	$\delta^{13}\text{C}_{\text{sample}}$ (‰)	$\delta^{13}\text{C}_{\text{air}}$ (‰)	$\Delta^{13}\text{C}$ (‰)
11248	BB32	Space A, phase II, roof	weak	X		CNA1065	9300 ± 50	59.22	-25.13	-6.73	18.87
11254	BB36	Space A, phase II, roof	moderate	X		CNA1065	9300 ± 50	59.74	-23.61	-6.73	17.28
11266	BB43	Space A, phase II, roof	moderate	X		CNA1065	9300 ± 50	61.04	-25.37	-6.73	19.12
11274	BB48	Space A, phase II, roof	moderate	X		CNA1065	9300 ± 50	62.75	-25.16	-6.73	18.90
11232/3	BB22	Space A, phase II, roof	moderate	X		CNA1065	9300 ± 50	60.16	-24.79	-6.73	18.51
11218	BB12	Space A, phase II, roof	moderate	X		CNA1065	9300 ± 50	61.50	-23.48	-6.73	17.14
11242	BB27	Space A, phase II, roof	weak	X		CNA1065	9300 ± 50	59.02	-23.86	-6.73	17.55
11249	BB33	Space A, phase II, roof	weak	X		CNA1065	9300 ± 50	62.76	-25.27	-6.73	19.02
11263	BB40	Space A, phase II, roof	weak	X		CNA1065	9300 ± 50	57.47	-23.65	-6.73	17.32
11267	BB44	Space A, phase II, roof	strong	X		CNA1065	9300 ± 50	63.78	-23.22	-6.73	16.87
11250	BB34	Space A, phase II, roof	weak	X		CNA1065	9300 ± 50	57.71	-24.12	-6.73	17.82
11221	BB15	Space A, phase II, roof	weak	X		CNA1065	9300 ± 50	60.63	-24.46	-6.73	18.17
11253	BB35	Space A, phase II, roof	weak	X		CNA1065	9300 ± 50	64.27	-24.06	-6.73	17.75

Sample N°	Sample ID	Layer	Growth-ring Curvature	<i>Pistacia</i> sp.	<i>Amygdalus</i> sp.	Reference	Data BP	%C	$\delta^{13}\text{C}_{\text{sample}}$ (‰)	$\delta^{13}\text{C}_{\text{air}}$ (‰)	$\Delta^{13}\text{C}$ (‰)
11228	BB18	Space A, phase II, roof	weak	X		CNA1065	9300 ± 50	63.45	-23.31	-6.73	16.97
11234	BB23	Space A, phase II, roof	weak	X		CNA1065	9300 ± 50	60.88	-24.35	-6.73	18.05
11193	BB4	Space A, phase II, roof	weak	X		CNA1065	9300 ± 50	64.34	-24.08	-6.73	17.77
11277	BB51	Space A, phase II, roof	weak	X		CNA1065	9300 ± 50	56.46	-24.00	-6.73	17.69
11265	BB42	Space A, phase II, roof	weak	X		CNA1065	9300 ± 50	61.24	-23.01	-6.73	16.65
11279	BB53	Space A, phase II, roof	weak	X		CNA1065	9300 ± 50	57.18	-23.86	-6.73	17.55
11260	BB39	Space A, phase II, roof	weak	X		CNA1065	9300 ± 50	57.41	-24.42	-6.73	18.12
11214	BB11	Space A, phase II, roof	weak	X		CNA1065	9300 ± 50	61.20	-24.22	-6.73	17.92
11278	BB52	Space A, phase II, roof	weak	X		CNA1065	9300 ± 50	58.98	-23.55	-6.73	17.22
11256	BB38	Space A, phase II, roof	weak	X		CNA1065	9300 ± 50	61.93	-25.02	-6.73	18.76
11273	BB47	Space A, phase II, roof	weak	X		CNA1065	9300 ± 50	57.67	-23.97	-6.73	17.65
11275	BB49	Space A, phase II, roof	weak	X		CNA1065	9300 ± 50	56.97	-24.22	-6.73	17.92
	BB54	Space A, phase II, roof	strong	X		CNA1065	9300 ± 50	56.30	-24.79	-6.73	18.52
	BB55	Space A, phase II, roof	moderate	X		CNA1065	9300 ± 50	57.32	-23.64	-6.73	17.32

**Table S3.** Carbon isotope discrimination ( $\Delta^{13}\text{C}$ , ‰) of the charcoal remains recovered in different phases of the Space A (area XYZ) and classified attending their degree of growth-ring curvature. Values presented are means  $\pm$  SD. Comparisons were performed only for those phases where charcoals from the same genus and different curvatures were recovered as detailed in Table S2. Samples from phases II (Roof) and IV belong to *Pistacia* sp., whereas samples from phases V and VI are of *Amygdalus* sp. Differences across categories of charcoals were tested with ANOVA.

<b>Growth-ring Curvature</b>	<b>Phase II (Roof)</b>	<b>Phase IV</b>	<b>Phase V</b>	<b>Phase VI</b>
<b>Weak</b>	17.74 $\pm$ 0.60	18.61 $\pm$ 0.24	18.44 $\pm$ 0.21	18.21 $\pm$ 0.52
<b>Moderate</b>	18.05 $\pm$ 0.91	/	/	19.54 $\pm$ 0.27
<b>Strong</b>	17.69 $\pm$ 1.16	17.93 $\pm$ 1.25	19.07 $\pm$ 0.50	/
<b>Level of significance</b>	0.654 <sup>ns</sup>	0.395 <sup>ns</sup>	0.252 <sup>ns</sup>	0.086 <sup>ns</sup>

**Table S4.** Provenance, description of samples and main phytolith results obtained from excavation areas XYZ and VU at Tell Qarassa North.

<b>Area</b>	<b>Sample number</b>	<b>Phase</b>	<b>Phytoliths 1 g of sediment (million)</b>	<b>Phytoliths weathering (%)</b>	<b>Multicelled phytoliths (%)</b>	<b>Description</b>
<b>XYZ-67/68/69</b>	8	V	1.19	5.6	2.3	Dark very fine ashy powdery clayey silt without clasts, including flint, bone and pottery.
	12	IV	1.3	6.2	1.6	Dark very fine ashy powdery clayey silt. The matrix is similar to unit 3, with few scattered small rounded basalt clasts and randomly scattered larger stones. The dominant colour is dark greyish brown.
	16	IV	1.3	3.9	6.6	Dark very fine ashy powdery clayey silt, small rounded basalt clasts and abundance of randomly scattered larger stones.
	Base 2009, 1	III	2	5.4	10.9	Almost exclusively reddish yellow adobe compounds, embedded in a fine matrix of similar colour.
	Base 2009, 1 out	III	1.3	7.5	0.9	Reddish yellow adobe compounds.
	29	II	2.6	1.2	42.3	Ashy with large fragments of charcoal, including carbonized wooden elements, heavily burned adobe and non-wooden plant remains.



	33	I	1	9.1	6.9	Massive homogeneous pulverised reddish yellow adobe including decimetric angular basalt clasts and small basalt clasts.
<b>VU-67</b>	1		1.7	5.2	2.4	Compact clay sediment.
	3		1.2	9.6	2	Clayey silt with small basalt clasts, greyish brown colour.
	5	V	0.84	7.1	0.9	Powdery clayey silt, brown colour.
	8	V	1.4	5.1	4.1	Powdery clayey silt, similar to US 3 but darker.
	10	V	0.72	7.2	0	Powdery clayey silt, similar to US 3 but darker.
	11	V	1.3	9.1	7.3	Dark gray ashy sediments, including adobe compounds.
	12	IV	0.88	8.6	9.1	Yellowish brown sediments, including adobe fragments, ashes, charcoal, bone and lithic artefacts.
	18	IV	0.97	7.9	3	Yellowish brown sediments, including adobe fragments, ashes, charcoal, bone and lithic artefacts.
	EF18-1	IV	1.1	7.9	1.8	Burial EF18, close to cranial remains.
	EF18-2	IV	0.74	6.7	1.2	Burial EF18, under the pit base.
	21	IV	0.95	6.6	2.4	Clayey matrix sediments and basalt clasts, with abundant ashes charcoal fragments, bone and lithic artifacts.

**Table S5.** Summary of the early Holocene wood charcoal records in southwest Asia. Numbers represent percentage fragment counts by taxa. In some cases the raw datasets were not available, and the presence of taxa was recorded with an X. “Small shrubs” comprise steppic taxa such as *Artemisia*, *Acacia*, *Atriplex*, *Paliurus* etc. “Others” represent rare taxa (e.g., *Vitis*, Leguminosae), as well as cf. identifications of taxa not included in the table (e.g. cf. Labiatae). *Quercus* (E, D) means *Quercus* evergreen and deciduous respectively. Total fragments were calculated excluding indeterminate wood charcoal fragments.

Site		Wadi			Körti	
		Faynan 16 12.6- 10.2	Gilgal I (PPNA) 11.5-11.1	Öküzini (Ia) 11.6-9.3	Tepe 11.7- 11.4	Jerf el Ahmar 11.4-10.7
Salicaceae		15.5	22.8		x	26.0
<i>Ficus</i>		6.3				
<i>Platanus</i>	Wetland					0.7
<i>Fraxinus</i>				x	x	12.1
<i>Vitex</i>						
<i>Tamarix</i>		7.1	50.9	cf.	x	9.5
Chenopodiaceae		4.0	8.8			3.7
<i>Ephedra</i>	Steppe and halophytes	0.1				
Small shrubs						0.7
<i>Capparis</i>		1.4				
<i>Pistacia</i>		3.2	7.0	x	x	14.3
<i>Amygdalus</i>	Woodland /steppe			cf.	x	19.0
Rosaceae						1.8
<i>Rhamnus</i>				x	x	4.4
Maloideae						
<i>Juniperus</i>		57.5				
<i>Celtis/Ulmus</i>					x	0.4
<i>Olea</i>	Oak/juniper er woodland					
<i>Quercus</i> (E/D)						
<i>Quercus</i> (E)		2.2		x		
<i>Quercus</i> (D)				x	x	5.5
<i>Acer</i>				x	x	
<i>Pinus</i>	Coniferous woodland	0.1				
<i>Cedrus</i>	Others					
		2.7	10.5			1.8
Total fragments		2539	57	204	1487	273
		Austin, 2007	Liphschitz, 2010	Emery- Barbier and Thiébaud, 2005	Riehl et al., 2012	Roitel, 1997 (see also Pessin, 2004)

Site		Mureybet (phase III- IV)	Göbekli Tepe 11.2- 10.6	Baaz (II- III)	el- Hemmeh PPNA	Jericho (I) 11.1- 10.3	
Date ka cal. BP		11.3-10.5	10.6	11.1-10.2	11.1-10.7	10.3	
Salicaceae	Wetland	<i>x</i>		91.0	7.5	15.2	
<i>Ficus</i>					3.9	20.9	
<i>Platanus</i>							
<i>Fraxinus</i>			<i>x</i>			1.6	
<i>Vitex</i>							0.4
<i>Tamarix</i>			<i>x</i>			0.6	49.4
Chenopodiaceae	Steppe and halophytes				7.2		
<i>Ephedra</i>							
Small shrubs						1.7	9.5
<i>Capparis</i>						cf. 0.2	0.4
<i>Pistacia</i>				63.4		70.6	
<i>Amygdalus</i>				cf. 36	6.1	2.0	
Rosaceae	Woodland/steppe				0.8		
<i>Rhamnus</i>					0.6		
Maloideae					0.2		
<i>Juniperus</i>					3.0		
<i>Celtis/Ulmus</i>							
<i>Olea</i>							0.4
<i>Quercus</i> (E/D)	Oak/juniper woodland					2.7	
<i>Quercus</i> (E)					3.0		
<i>Quercus</i> (D)		<i>x</i>	0.6				
<i>Acer</i>	Coniferous woodland						
<i>Pinus</i>							
<i>Cedrus</i>							
	Others					1.1	
Total fragments		-	164	907	636	c. 263	

Table 7 in  
Roitel,  
1997 (after  
Willcox)

Neef,  
2003

Deckers  
et al.,  
2009

Asouti et  
al., 2015

Western,  
1983

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Site		Chogha Golan (XI-VII)	Pinarba şı (A) 10.7- 10.5	Dja'de 10.7-10.3	Horvat Galil 10.7-9.9	Mureybet (phase IV) 10.7- 9.9
Date ka cal. BP		11.9-10.7				
Salicaceae		33.5		37.3		
<i>Ficus</i>						
<i>Platanus</i>	Wetland			2.0		
<i>Fraxinus</i>				9.7		
<i>Vitex</i>		0.3				
<i>Tamarix</i>		23.5		33.3		
Chenopodiaceae		2.0	1.6	4.6		
<i>Ephedra</i>	Steppe and halophytes					
Small shrubs		0.3	4.9	0.7		
<i>Capparis</i>						
<i>Pistacia</i>		34.3	1.6	6.8	66.6	
<i>Amygdalus</i>	Woodland/s teppe	2.8	32.8	0.6		
Rosaceae			55.7	0.5		
<i>Rhamnus</i>				0.5		
Maloideae						
<i>Juniperus</i>						
<i>Celtis/Ulmus</i>						
<i>Olea</i>					16.7	
<i>Quercus</i> (E/D)	Oak/juniper woodland					
<i>Quercus</i> (E)					16.7	
<i>Quercus</i> (D)				3.0		x
<i>Acer</i>		0.3		0.4		
<i>Pinus</i>	Coniferous woodland					
<i>Cedrus</i>						
	Others	3.1	3.3	0.4		
Total fragments		391	61	1116	6	-
		Riehl et al., 2015	Asouti, 2003	Roitel, 1997	Liphschitz, 1997	Table 7 in Roitel 1997, after Willcox

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Site		Tepe Abdul Hosein	Cafer Höyük	Nahal Zippori 3	ʿAin Ghaza 1	Çatalhöy ük (South G)
Date ka cal. BP		10.3-9.8	10.3-9.4	10.2-9.9	10.3- 8.6	c. 10.3- 8.4
Salicaceae		<i>x</i>	<i>x</i>		<i>x</i>	29.7
<i>Ficus</i>				3.7		
<i>Platanus</i>	Wetland		<i>x</i>			
<i>Fraxinus</i>			<i>x</i>			0.2
<i>Vitex</i>						0.2
<i>Tamarix</i>		<i>x</i>			<i>x</i>	0.3
Chenopodiaceae		<i>x</i>				0.5
<i>Ephedra</i>	Steppe and halophytes					
Small shrubs						
<i>Capparis</i>						
<i>Pistacia</i>		<i>x</i>	<i>x</i>	3.3	<i>x</i>	2.9
<i>Amygdalus</i>	Woodland/steppe					2.1
Rosaceae		<i>x</i>	<i>x</i>			0.4
<i>Rhamnus</i>			<i>x</i>			
Maloideae						1.8
<i>Juniperus</i>						0.7
<i>Celtis/Ulmus</i>			<i>x</i>			56.8
<i>Olea</i>						
<i>Quercus</i> (E/D)	Oak/juniper woodland			18.9		
<i>Quercus</i> (E)				74.1	<i>x</i>	
<i>Quercus</i> (D)			<i>x</i>		<i>x</i>	2.4
<i>Acer</i>			<i>x</i>			
<i>Pinus</i>	Coniferous woodland					
<i>Cedrus</i>						
	Others					2.1
Total fragments		-	-	615	-	1311

Willcox , 1990    Willcox , 1991    Caracuta et al., 2014    Neef, 2004a    Asouti, 2013

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Site		Ganj Dareh	el-Hemmeh PPNB	Jericho (II)	Tell Aswad II	Chogha Golan (VI-I)	
Date ka cal. BP		10.2-9.8	c. 10-9	10.2-9.5	10.2-9.5	10-9.6	
Salicaceae	Wetland	x	20.5	7.9	11.7	33.3	
<i>Ficus</i>			9.0	4.9			
<i>Platanus</i>					0.5		
<i>Fraxinus</i>				34.7	7.4	29.7	
<i>Vitex</i>					0.5		
<i>Tamarix</i>				14.7	53.2	44.4	20.8
Chenopodiaceae	Steppe and halophytes		6.3		2.1	1.5	
<i>Ephedra</i>							
Small shrubs				1.3	2.0		0.7
<i>Capparis</i>					3.4		
<i>Pistacia</i>	Woodland/steppe	x	6.3		1.3	39.1	
<i>Amygdalus</i>				1.1	1.0		2.3
Rosaceae		x	0.8				0.1
<i>Rhamnus</i>		x			0.5	0.4	
Maloideae			0.5			cf. 0.1	
<i>Juniperus</i>							
<i>Celtis/Ulmus</i>		?					
<i>Olea</i>	Oak/juniper woodland						
<i>Quercus</i> (E/D)				0.5			
<i>Quercus</i> (E)				0.6			
<i>Quercus</i> (D)							
<i>Acer</i>	Coniferous woodland						
<i>Pinus</i>							
<i>Cedrus</i>						0.4	
Others			4.0	18.2	10.0	2.1	
Total fragments		-	619	c. 203	478	809	
		van Zeist et al., 1984	Asouti et al., 2015	Western, 1983	Pessin, 2004	Riehl et al., 2016	

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Site		Can Hassan III	Tell Halula (M/L PPNB)	Basta
Date ka cal. BP		9.7-9.4	9.8-9.3	9.5-9.0
Salicaceae	Wetland	x	23.9	x
<i>Ficus</i>				
<i>Platanus</i>			1.2	
<i>Fraxinus</i>			14.2	x
<i>Vitex</i>				
<i>Tamarix</i>	Steppe and halophytes		30.6	x
Chenopodiaceae			2.6	
<i>Ephedra</i>				
Small shrubs			0.7	
<i>Capparis</i>				
<i>Pistacia</i>	Woodland/steppe	x	11.0	x
<i>Amygdalus</i>		x	1.9	x
Rosaceae			0.2	
<i>Rhamnus</i>				
Maloideae				
<i>Juniperus</i>	Oak/juniper woodland	x		x
<i>Celtis/Ulmus</i>		x	2.2	
<i>Olea</i>				
<i>Quercus</i> (E/D)				
<i>Quercus</i> (E)				x
<i>Quercus</i> (D)	Coniferous woodland	x	8.1	
<i>Acer</i>			0.6	
<i>Pinus</i>		x		
<i>Cedrus</i>				
Others				0.6
Total fragments		-	2322	-

Willcox,  
1991,  
Figure 2, p.  
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Roitel,  
1997

Neef,  
2004b

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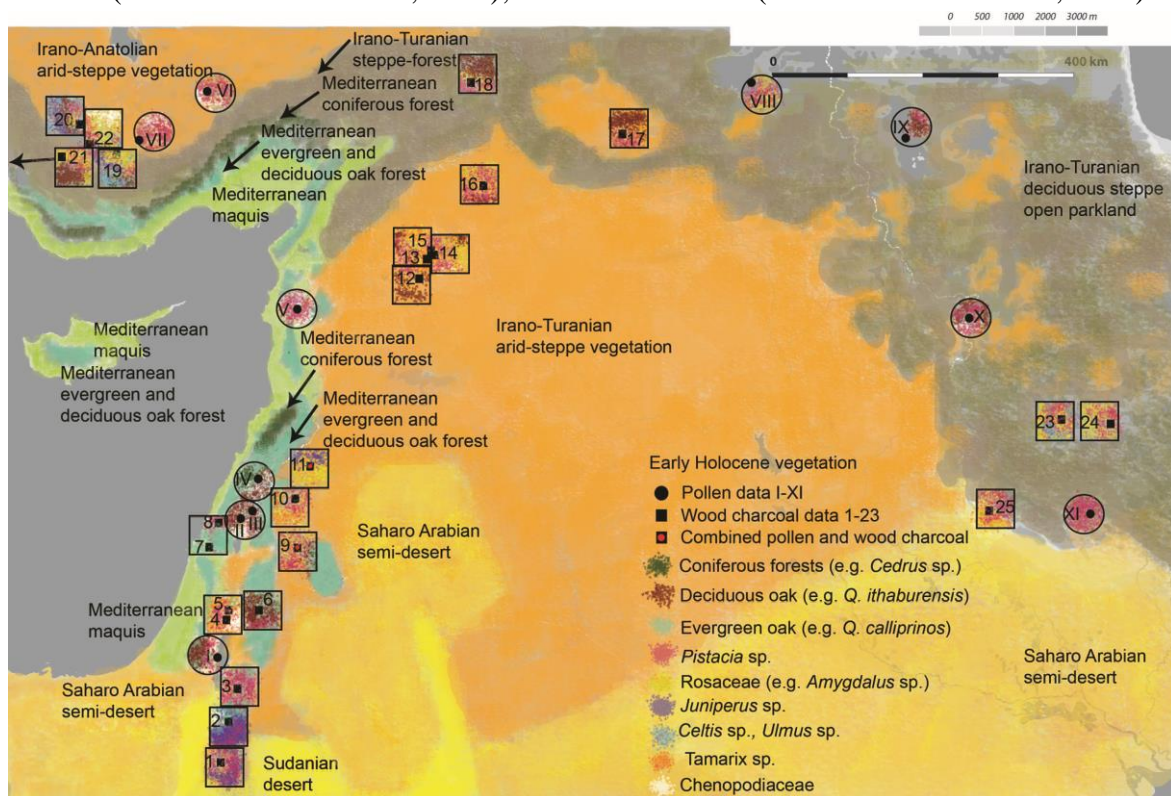
41 **Table S6.** Faunal remains from excavations areas XYZ at Tell Qarassa North (NISP:  
 42 number of identified specimens). Bone tools were excluded from the counts.

Taxa	Area XYZ						Area VU			Total
	I	II	III	IV	V	VI	Lower	Upper	Surface layers	
<i>Vulpes</i> sp.	5	11	38	18	12	3	26	1	2	62
<i>Meles meles</i>			6	1	3					4
<i>Felis silvestris</i>		2	5		1		3			4
<i>Canis familiaris</i>			8	1	2	1				4
Carnivore unidentified	5	2	27	6	11		13	1	2	33
<i>Sus</i> f. <i>scrofa</i>			5	1	1	1	13		2	18
<i>Dama mesopotamica</i>			1	1	2				1	4
<i>Bos</i> f. <i>primigenius</i>	2	2	22	16	7	24	5	8	2	62
Large ungulate	1	1	1	16	37	7	3	5	9	77
<i>Gazella</i> ssp.	15	8	89	38	61	23	67	21	12	222
<i>Capra</i> f. <i>aegagrus</i>	15	1	7	27	49	1	38	12	2	129
<i>Capra/Ovis</i>	18	15	15	46	74	18	59	9	14	220
Small ungulate	3	34	232	75	181	21	14	16	18	325
<i>Lepus capensis</i>	2	3	25	6	12	2	8	4		32
<i>Erinaceus concolor</i>			1							0
<i>Anas acuta</i>	1									0
<i>Anas platyrhynchos</i>	1		3		5	1		1	2	9
<i>Anas crecca</i>			1		1					1
A. <i>crecca/querquedula</i>					1			1		2
Anatinae unidentified			4		2		1			3
<i>Aquila</i> f. <i>chrysaetos</i>							1			1
Accipitridae		1								0
<i>Alectoris chukar</i>		1	11	1	3	1	5			10
Rallidae			1							0
<i>Otis tarda</i>				1						1
<i>Corvus corone</i>			1		1					1
Birds unidentified	2	1	9	5	4		4			13
Total NISP	101	94	706	264	558	113	409	82	102	1528

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48 **Figure S1.** Summary of early Holocene pollen (black circles) and wood charcoal (black  
 49 squares) records (based on Table S5, excluding riparian taxa) in relationship to modern-  
 50 day phytogeographical regions in southwest Asia (schematic representation based on  
 51 vegetation maps by Frey and Kürschner, 1989). Dark orange: Irano-Turanian arid steppe;  
 52 Grey: Irano-Turanian deciduous steppe and open parkland. Light orange: Saharo-Arabian  
 53 semi-desert vegetation. Yellow: Sudanian desert. Light green: Mediterranean maquis;  
 54 Turquoise: Mediterranean evergreen and deciduous oak forests; Dark green: coniferous  
 55 forests. 1. Basta; 2. Wadi Faynan 16; 3. El-Hemmeh; 4. Jericho; 5. Gilgal I; 6. Ain Ghazal;  
 56 7. Nahal Zippori 3; 8. Horvat Galil; 9. Tell Qarassa North; 10. Tell Aswad; 11. Baaz  
 57 Rockshelter; 12. Mureybet; 13. Dja'de; 14. Jerf el Ahmar; 15. Tell Halula; 16. Göbekli  
 58 Tepe; 17. Körtik Tepe; 18. Cafer Höyük; 19. Can Hassan III; 20. Çatalhöyük; 21. Öküzini  
 59 Cave; 22. Pinarbaşı; 23. Ganj Dareh; 24. Tepe Abdul Hosein; 25. Chogha Golan. I. Ein  
 60 Gedi (Litt *et al.*, 2012); II. Hula pollen core (van Zeist *et al.*, 2009); III. Birkat Ram Crate  
 61 (Schiebel, 2013); IV. Aamiq wetland (Hajar *et al.*, 2008); V. Ghab (Wright and Thorpe,  
 62 2003); VI. Eski Acigöl (Roberts *et al.*, 2001); VII. Akgöl (Bottema and Woldring, 1984);  
 63 VIII. Lake Van (Wick *et al.*, 2003); IX. Lake Urmia (Djamali *et al.*, 2008b); X. Lake  
 64 Zeribar (van Zeist and Bottema, 1977); XI. Lake Mirabad (van Zeist and Bottema, 1977).



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72 **References**

73

74 Aharonovich, S., Sharon, G., Weinstein-Evron, M., 2014. Palynological investigations at  
75 the middle palaeolithic site of Nahal Mahanayem outlet, Israel. *Quatern. Int.* 33, 149–166.

76

77 Albert, R.M., Weiner, S. 2001. Study of phytoliths in prehistoric ash layers using a  
78 quantitative approach. In: Meunier J.D., Colin, F. (Eds.), *Phytoliths, Applications in Earth  
79 Sciences and Human History*, AA Balkema Publishers, 251–266.

80

81 Albert, R.M., Shahack-Gross, R., Cabanes, D., Gilboa, A., Lev-Yadun, S, Portillo, M.,  
82 Sharon, I., Boaretto, E., Weiner, S. 2008. Phytolith-rich Layers from the Late Bronze and  
83 Iron Ages at Tel Dor (Israel): Mode of Formation and Archaeological Significance. *J  
84 Archaeol Sci* 35, 57–75.

85

86 Albert, R.M., Esteve, X., Portillo, M., Rodríguez-Cintas, A., Cabanes, D., Esteban, I.,  
87 Hernández, F. 2011. Phytolith CoRe, Phytolith Reference Collection.  
88 <http://phytcore.org/phytolith/index>. Accessed 21 November, 2015

89

90 Alley, R.B. 2000. The Younger Dryas cold interval as viewed from central Greenland.  
91 *Quat Scie Rev* 19, 213–226.

92

93 Araus, J.L., Ferrio, J.P., Voltas, J., Aguilera, M., Buxó R. 2014. Agronomic conditions and  
94 crop evolution in ancient Near East agriculture. *Nature Commun.*, Article number: 3953.  
95 Doi:10.1038/ncomms4953.

96

97 Arranz-Otaegui, A. 2016. Evaluating the impact of water flotation and the state of the  
98 wood in archaeological wood charcoal remains: implications for the reconstruction of past  
99 vegetation and identification of firewood gathering strategies at Tell Qarassa North (South  
100 Syria). *Quat Int*, Doi:10.1016/j.quaint.2016.06.030

101

102 Arranz-Otaegui, A., Colledge, S., Ibañez, J.J., Zapata, L. 2016a. Crop husbandry activities  
103 and wild plant gathering, use and consumption at the EPPNB Tell Qarassa North (south  
104 Syria). *Veg Hist Archaeobot*, doi:10.1007/s00334-016-0564-0

105

106 Arranz-Otaegui, A., Ibañez, J.J., Zapata, L. 2016b: Hunter-gatherer plant use in southwest  
107 Asia: the path to agriculture. In: Hardy, K., Kubiak-Martens, L. (Eds.), *Wild*  
108 *Harvest: Plants in the Hominin and Pre-Agrarian Human Worlds*, Oxbow Books, 91–110.  
109

110 Arz, H.W., Lamy, F., Patzold, J., Müller, P.J., Prins, M., 2003. Mediterranean moisture  
111 source for an early-holocene humid period in the northern red sea. *Science* 300, 118.  
112 <http://dx.doi.org/10.1126/science.1080325>.  
113

114 Asouti, E. 2003. Woodland vegetation and fuel exploitation at the prehistoric campsite of  
115 Pinarbaşı, south-central Anatolia, Turkey: the evidence from the wood charcoal macro-  
116 remains. *J Archaeol Sci* 30(9), 1185–1201.  
117

118 Asouti, E., Fuller, D.Q. 2012. From foraging to farming in the southern Levant: the  
119 development of Epipalaeolithic and Pre-Pottery Neolithic plant management strategies.  
120 *Veg Hist Archaeobot* 21, 149–162.  
121

122 Asouti, E., Fuller, D.Q. 2013. A contextual approach to the emergence of agriculture in  
123 Southwest Asia. Reconstructing Early Neolithic plant-food production. *Curr Anthropol*  
124 54(3), 299–345.  
125

126 Asouti, E., Kabukcu, C. 2014. Holocene semi-arid oak-woodlands in the Irano-Anatolian  
127 region of Southwest Asia: natural or anthropogenic?. *Quat Sci Rev* 90, 158–182.  
128

129 Asouti, E., Kabukcu, C., White, C. E., Kuijt, I., Finlayson, B., & Makarewicz, C. 2015.  
130 Early Holocene woodland vegetation and human impacts in the arid zone of the southern  
131 Levant. *The Holocene* 25(10), 1565–1580.  
132

133 Austin, P., 2007. The wood charcoal macroremains. In: Finlayson, B., Mithen, S. (Eds.),  
134 *The Early Prehistory of Wadi Faynan, Southern Jordan (Levant Supplementary Series 4)*.  
135 Oxbow, Oxford, pp. 408–419.  
136

137 Balbo A.L., Iriarte E., Arranz A., Zapata L., Lancelotti C., Madella, M., Teira, L., Jiménez,  
138 M., Braemer, F., Ibañez, J.J. 2012. Squaring the Circle. *Social and Environmental*

139 Implications of Pre-Pottery Neolithic Building Technology at Tell Qarassa (South Syria).  
140 *PLoS ONE* 7(7): e42109. doi:10.1371/journal.pone.0042109  
141

142 Bar-Matthews, M., Ayalon, A., Kaufman, A. 2000. Timing and hydrological conditions of  
143 Sapropel events in the Eastern Mediterranean, as evident from speleothems, Soreq cave,  
144 Israel. *Chem Geol* 169, 145–156.  
145

146 Behre, K.E., 1981. The interpretation of anthropogenic indicators in pollen diagrams.  
147 *Pollen Spores* 23, 225–245.  
148

149 Bennett, K.D. 1996. Determination of the number of zones in a biostratigraphical  
150 sequence. *New Phytol* 132, 155–170.  
151

152 Berger, J.F., Lespez, L., Kuzucuoglu, C., Glais, A., Hourani, F., Barra, A., Guilaine, J.,  
153 2016. Interactions between climate change and human activities during the early to mid-  
154 Holocene in the eastern Mediterranean basins. *Clim. Past.* 12, 1847–1877.  
155

156 Berger, J.F., Guilaine, J., 2009. The 8200 cal BP abrupt environmental change and the  
157 Neolithic transition: a Mediterranean perspective. *Quat. Int.* 200, 31–49.  
158

159 Beug, H.J., 2004. *Leitfaden der Pollenbestimmung für Mitteleuropa und angrenzende*  
160 *Gebiete*, Gustav Fisher Verlag.  
161

162 Blumler, M.A., 2007. Near Eastern pollen diagrams and “deforestation”. *Middle States*  
163 *Geogr.* 40, 150–157.  
164

165 Bobek, H., 1963. Nature and Implications of Quaternary Climatic Changes in Iran.  
166 *Changes of Climate*. UNESCO, pp. 403–413.  
167

168 Bond G, Showers W, Cheseby M, Lotti R, Almasi P, deMenocal P, et al. (1997) A  
169 pervasive millennial-scale cycle in North Atlantic Holocene and glacial climates. *Science*  
170 278(5341): 1257–1266.  
171

172 Borrell, F., Junno, A., Barcelo, J.A., 2015. Synchronous environmental and cultural  
173 change in the emergence of agricultural economies 10,000 Years ago in the levant. *PLoS*  
174 *One* 10 (8), e0134810. <http://dx.doi.org/10.1371/journal.pone.0134810>.  
175

- 176 Bottema, S. 1975. The interpretation of pollen spectra from prehistoric settlements (with  
177 special attention to liguliflorae). *Palaeohistoria* 17, 17–35.
- 178
- 179 Bottema, S., 1977. A pollen diagram from the Syrian anti Lebanon. *Paleorient* 3, 259–268.
- 180
- 181 Bottema, S., 1986. A late quaternary pollen diagram from lake urmia (northwestern Iran).  
182 *Rev. Palaeobot. Palynology* 47, 241–261.
- 183
- 184 Bottema, S., Woldring, H. 1984. Late Quaternary vegetation and climate of southwestern  
185 Turkey, Part II. *Palaeohistoria* 26, 123–149.
- 186
- 187 Boyer, P., Roberts, N., Baird, D., 2006. Holocene environment and settlement on the  
188 Carsamba alluvial fan, south-central Turkey: integrating geoarchaeology and  
189 archaeological field survey. *Geoarchaeology* 21, 675–698.
- 190
- 191 Braemer, F., Nicolle, C., Steimer-Herbet, T., Broutin, P., Flambeaux, A., Abdo, K. 2007.  
192 Atlas archeologique des sites pre- et protohistoriques de Syrie du Sud. Étude préliminaire  
193 du site de Qarassa (Mohafazat de Suweida). *Chron Archeola Syrie* 3, 88–101.
- 194
- 195 Braemer, F., Genequand, D., Dumond Maridat, C., Blanc, P.M., Dentzer, J.-M., Gazagne,  
196 D., Wech, P. 2009. Long-term management of water in the Central Levant: the Hawran  
197 case (Syria). *World Archaeol* 41(1), 36–57.
- 198
- 199 Braemer, F., Ibanez, J.J., Shaarani, W., 2011. Qarassa (Mohafazat de Suweida): campagne  
200 2009. *Chron Archeol Syrie* 5, 31–42.
- 201
- 202 Brown, D.A. 1984. Prospects and limits of a phytolith key for grasses in the central United  
203 States. *J Archaeol Sci* 11, 345–368.
- 204
- 205 Burjachs, F., López-Sáez, J.A., Iriarte, M.J. 2003. Metodología Arqueopalinológica. In:  
206 Buxó, R. and Piqué, R. (Eds.), *La recogida de muestras en Arqueobotánica: objetivos y*  
207 *propuestas metodológicas. La gestión de los recursos vegetales y la transformación del*  
208 *paleopaisaje en el Mediterráneo occidental*, Museu d'Arqueologia de Catalunya, 11–18.
- 209

210 Chabal, L. 1989. Perspectives anthracologiques sur le site de Lattes (Hérault), Lattara, vol.  
211 2, 53–72.  
212

213 Cai, B., Edwards, R.L., Cheng, H., Tan, M., Wang, X., Liu, T., 2008. A dry episode during  
214 the Younger Dryas and centennial-scale weak monsoon events during the early Holocene:  
215 a high-resolution stalagmite record from southeast of the Loess Plateau, China. *Geophys.*  
216 *Res. Lett.* 35 (2), L02705. <http://dx.doi.org/10.1029/2007GL030986>.  
217

218 Caracuta, V., Weiss, E., van den Brink, E.C.M., Liran, R., Vardi, J., Barzilai, O., 2014.  
219 From natural environment to human landscape: new archaeobotanical data from the  
220 neolithic site of nahal zippori 3, lower galilee. *Neo-lithics* 1/14, 33–41.  
221

222 Chabal, L., 1989. Perspectives anthracologiques sur le site de Lattes (Hérault). Lattara  
223 2, 53–72.  
224

225 Chabal, L. 1991. L'Homme et l'évolution de la végétation méditerranéenne, des âges des  
226 métaux à la période romaine: recherches anthracologiques théoriques, appliquées  
227 principalement à des sites du Bas-Languedoc. PhD thesis, Université de Montpellier II.  
228

229 Chikahli, M., Amri, A. 2000. Jabal El- Arab: A Mediterranean Island. *Dryland Agrobio* 3,  
230 8.  
231

232 Davies, C.P., Fall, P.L., 2001. Modern pollen precipitation from an elevational transect  
233 in central Jordan and its relationship to vegetation. *J. Biogeogr.* 28, 1195–1210.  
234

235 Deckers, K. 2016. Oak charcoal from northeastern Syria as proxy for vegetation, land use  
236 and climate in the second half of the Holocene. *Rev Palaeobot Palynol* 230, 22–36.  
237

238 Deckers, K., Riehl, S., Jenkins, E., Rosen, A., Dodonov, A., Simakova, A.N., Conard,  
239 N.J., 2009. Vegetation development and human occupation in the Damascus region of  
240 southwestern Syria from the Late Pleistocene to Holocene. *Veg. Hist. Archaeobot.* 18,  
241 329–340.

242 DeNiro, M. J., Hastorf, C. A. 1985. Alteration of  $^{15}\text{N}/^{14}\text{N}$  and  $^{13}\text{C}/^{12}\text{C}$  ratios of plant  
243 matter during the initial stages of diagenesis: Studies utilizing archaeological specimens  
244 from Peru. *Geochim Cosmochim Acta* 49, 97–115.  
245

246 Djamali, M., de Beaulieu, J.L., Miller, N.F., Andrieu-Ponel, V., Lak, R., Sadeddin, M.,  
247 Akhani, H., Fazeli, H. 2008a. Vegetation history of the SE section of Zagros Mountains  
248 during the last five millennia; a pollen record from the Maharlou Lake, Fars Province,  
249 Iran. *Veg Hist Archaeobot* 18, 123–136.  
250

251 Djamali, M., de Beaulieu, J.L., Shah-Hosseini, M., Andrieu-Ponel, V., Ponel, P., Amini,  
252 A., Akhani, H., Leroy, A.S., Stevens, L., Alizadeh, H., Brewer, S., 2008b. A late  
253 Pleistocene long pollen record from Lake Urmia, NW Iran. *Quat. Res.* 69, 413–420.  
254

255 Devillers, B., 2005. Morphogenese et anthropisation holocenes d'un bassin versant semi-  
256 aride: le Gialias, Chypre. These de doctorat de geographie physique. Universite Aix-  
257 Marseille I.  
258

259 El-Moslimany, A., 1983. History of Climate and Vegetation in the Eastern Mediterranean  
260 and Middle East from the Pleniglacial to the Mid-holocene. Ph.D. Dissertation. University  
261 of Washington.  
262

263 El-Moslimany, A., 1986. Ecology and late-Quaternary history of the Kurdo-Zagrosian oak  
264 forest near Lake Zeribar, western Iran. *Vegetation* 68, 55–63.  
265

266 Emery-Barbier, A., Thiebault, S., 2005. Preliminary conclusions on the Late Glacial  
267 vegetation in south-west Anatolia (Turkey): the complementary nature of palynological  
268 and anthracological approaches. *J. Archaeol. Sci.* 32, 1232–1251.  
269

270 Ervynck, A., Dobney, K.M., Hongo, H., Meadow, R.H. 2001. Born Free ? New Evidence  
271 for the Status of *Sus scrofa* at Neolithic Çayönü Tepesi (Southeastern Anatolia, Turkey).  
272 *Paléorient* 27, 47–73.  
273

274 Fahn, A., Werker, E., Baas, P. 1986. *Wood anatomy and identification of trees and shrubs*  
275 *from Israel and adjacent regions*, The Israel Academy of Sciences and Humanities.

276

277 Falconer, S.E., Fall, P.L. 1995. Human impacts on the environment during the rise and  
278 collapse of civilization in the eastern Mediterranean. In: Steadman, D.W., Mead, J.I.  
279 (Eds.), *Late Quaternary Environments and Deep History: A Tribute to Paul S. Martin.*  
280 *Hot Springs, South Dakota: The Mammoth Site of Hot Springs*, Scientific Papers 3, 84–  
281 101.

282

283 Fall, P.L., 2012. Modern vegetation, pollen and climate relationships on the Mediterranean  
284 island of Cyprus. *Rev. Palaeobot. Palynol.* 185, 79–92.

285

286 Farquhar, G.D., Ehleringer, J.R., Hubick, K.T. 1989. Carbon isotope discrimination and  
287 photosynthesis. *Ann Rev Plant Physiol Plant Mol Biol* 40, 503–537.

288

289 Ferrio, J.P., Alonso, N., Voltas, J., Araus, J.L. 2004. Estimating grain weight in  
290 archaeological cereal crops: a quantitative approach for comparison with current  
291 conditions. *J Archaeol Sci* 31, 1635–1642.

292

293 Ferrio, J.P., Araus, J.L., Buxó, R., Voltas, J., Bort, J. 2005. Water management practices  
294 and climate in ancient agriculture: inference from the stable isotope composition of  
295 archaeobotanical remains. *Veget Hist Archaeobot* 14, 510–517.

296

297 Fiorentino, G., Ferrio, J.P., Bogaard, A., Araus, J.L., Riehl, S. 2015. Stable isotopes in  
298 archaeological research. *Veget Hist Archaeobot* 24, 215–227.

299

300 Flohr, P., Fleitmann, D., Matthews, R., Matthews, W., Black, S., 2016. Evidence of  
301 resilience to past climate change in Southwest Asia: early farming communities and the  
302 9.2 and 8.2 ka events. *Quat. Sci. Rev.* 136, 23–39.

303

304 Fotelli, M.N., Nahm, M., Radoglou, K., Rennenberg, H., Halyvopoulos, G., Matzarakis,  
305 A., 2009. Seasonal and interannual ecophysiological responses of beech (*Fagus sylvatica*)  
306 at its south-eastern distribution limit in Europe. *For. Ecol. Manag.* 257, 1157–1164.

307

308 Goeury, C., de Beaulieu, J.L. 1979. À propos de la concentration du pollen à l'aide de la  
309 liqueur de Thoulet dans les sédiments minéraux. *Pollen Spores* 21, 239–251



310

311 Grimm, E.C. 1987. Coniss: a Fortran 77 program for stratigraphically constrained cluster  
312 analysis by the method of incremental sum of squares. *Comput Geosci* 13, 13–35.

313

314 Grimm, E.D. 2004. TGView. Illinois State Museum, Research and Collection Center,  
315 Springfield.

316

317 Grigson, C. 1995. Plough and pasture in the early economy of the southern Levant. In:  
318 Levy, T.E. (Ed.), *The Archaeology of Society in the Holy Land*, Leicester University Press,  
319 245–268.

320

321 Grove, A.T., Rackham, O., 2001. *The Nature of Mediterranean Europe: an Ecological*  
322 *History*. Yale University Press, London.

323

324 Hajar, L., Khater, C., Cheddadi, R., 2008. Vegetation changes during the late Pleistocene  
325 and Holocene in Lebanon: a pollen record from the Bekaa valley. *Holocene* 18 (7), 1089–  
326 1099.

327

328 Hajar, L., Haïdar-Boustani, M., Khater, C., Cheddadi, R. 2010. Environmental changes in  
329 Lebanon during the Holocene: Man vs. climate impacts. *Journal of Arid Environments*  
330 74(7), 746–755.

331

332 Helmer, D., Gourichon, L., Monchot, H., Peters, J., Saña Seguí, M. 2005. Identifying early  
333 domestic cattle from Pre-Pottery Neolithic sites on the Middle Euphrates using sexual  
334 dimorphism. In: Vigne, J.-D., Peters, J., Helmer, D. (Eds.), *The First Steps of Animal*  
335 *Domestication: New Archaeozoological Approaches*. Oxbow Books, Oxford, 86–95.

336

337 Helmer, D., Gourichon, L. 2008. Premières données sur les modalités de subsistance à Tell  
338 Aswad (Syrie, PPNB moyen et récent, Néolithique céramique ancien) – fouilles 2001-  
339 2005. In: Vila, E., Gourichon, L., Choyke, A.M., Buitenhuis, H. (Eds.), *Archaeozoology of*  
340 *the Southwest Asia and Adjacent Areas VIII*. Travaux de la Maison de l’Orient 49, Maison  
341 de l’Orient et de la Méditerranée, Lyon, 119–151.

342

343 Helmer, D., Gourichon, L. 2016. The fauna of Tell Aswad (Damascus, Syria), early

344 Neolithic levels. Comparison with the northern and southern Levant sites. In: Mashkour,  
345 M., Beech, M. (Eds.), *Archaeozoology of the Southwest Asia and Adjacent Areas IX*.  
346 Oxbow Books, Oxford, 23–40.

347

348 Heun, M., Haldorsen, S., Vollan, K., 2008. Reassessing domestication events in the near  
349 east: einkorn and *Triticum urartu*. *Genome* 51, 444–451.

350

351 Hughes, P.D.M., Mauquoy, D., Barber, K.E., Langdon, P.G., 2000. Mire development  
352 pathways and paleoclimatic records from a full Holocene peat archive at Walton Moss,  
353 Cumbria, England. *Holocene* 10 (4), 465–479.

354

355 Ibáñez, J.J., Abdo, K., Balbo, A., Boix, J., Darwish, A., Himi, M., Iriarte, E., Lagüera, M.,  
356 Nuñez, M.A., Regalado, E., Sabreen, E., Santana, J., Teira, L., Terradas, X., Zapata, L.  
357 2009. *Rapport Qarassa 2009. Mission syro-française de la léja, travaux de l'équipe*  
358 *espagnole*, Damasc, Siria.

359

360 Ibañez, J.J., Abdo, A., Arranz, A., Balbo, A., Boix, J., Bshesh, M., Gourichon, L., Iriarte,  
361 E., Lagüera, M., Nuñez, M.A., Ortega, D., Regalado, E., Santana, J., Teira, L., Terradas,  
362 X., Zapata, L. 2010a: *Rapport Qarassa 2010. Mission syro-Française de la Léja. Travaux*  
363 *de l'équipe espagnole*, Damasc, Siria.

364

365 Ibañez, J.J., Balbo, A., Braemer, F., Gourichon, L., Iriarte, E., Santana, J., Zapata, L.  
366 2010b. The early PPNB levels of Tell Qarassa North (Sweida, southern Syria). *Antiquity*  
367 84, issue 325.

368

369 Ibáñez, J.J., González-Urquijo, J.E., Braemer, F. 2014. The human face and the origins of  
370 the Neolithic: the carved bone wand from Tell Qarassa North, Syria. *Antiquity* 88, issue  
371 81.

372

373 Janis, C. 2008. An evolutionary history of browsing and grazing ungulates. In: Szaro, R.,  
374 Johnston, D.W. (Eds.), *Biodiversity in Managed Landscapes: Theory and Practice*.  
375 Springer, 21–43.

376

377 Kaniewski, D., Van Campo, E., Paulissen, E., Weiss, H., Bakker, J., Rossignol, I., Van  
378 Lerberghe, K., 2011. The medieval climate anomaly and the little Ice Age in coastal Syria  
379 inferred from pollen-derived palaeoclimatic patterns. *Glob. Planet. Change* 78, 178–187.  
380

381 Katz, O., Cabanes, D., Weiner, S., Maeir, A.M., Boaretto, E., Shahack-Gross, R. 2010.  
382 Rapid phytolith extraction for analysis of phytolith concentrations and assemblages during  
383 an excavation: an application at Tell es-Safi/Gath, Israel. *J Archaeol Sci* 37, 1557–1563.  
384

385 Köhler-Rollefson, I. 1988. The aftermath of the Levantine Neolithic Revolution in the  
386 light of ecological and ethnographic evidence. *Paléorient* 14, 87–93.  
387

388 Köhler-Rollefson, I., Rollefson, G. 1990. The impact of Neo- lithic subsistence strategies  
389 on the environment: The case of ‘Ain Ghazal, Jordan. In: Bottema S., Entjes-Nieborg, G.,  
390 Van Zeist, W. (Eds.), *Man’s Role in the Shaping of the Eastern Mediterranean Landscape*.  
391 Balkema, 3–14.  
392

393 Kuijt, I., Goring-Morris, N.A. 2002. Foraging, Farming, and Social Complexity in the  
394 Pre-Pottery Neolithic of the Southern Levant: A Review and Synthesis. *World*  
395 *Archaeol* 164, 361–440.  
396

397 Laggunt, D., Almogi-Labin, A., Bar-Matthews, M., Weistein-Evron, M., 2011. Vegetation  
398 and climate changes in the south eastern Mediterranean during the Last Glacial Interglacial  
399 cycle (86 ka): new marine pollen record. *Quat. Sci. Rev.* 30, 3960–3972.  
400

401 Leavitt, S.W., Long, A., 1986. Stable-carbon isotope variability in tree foliage and wood.  
402 *Ecology* 67, 1002–1010.  
403

404 Lemcke, G., Sturm, M., 1997.  $\delta^{18}O$  and trace element measurements as proxy for the  
405 reconstruction of climate changes at Lake Van (Turkey): preliminary results. In: Nüzher  
406 Dalfes, H., Kukla, G., Weiss, H. (Eds.), *Third Millenium BC Climate Change and Old*  
407 *World Collapse*, NATO ASI Series, vol. I (49). Springer, Berlin, Heidelberg, pp. 653–678.  
408

409 Liphshitz, N., Noy, T., 1991. Vegetational landscape and the macroclimate of the gilgal  
410 region during the natufian and pre-pottery neolithic a. *J. Israel Prehist. Soc.* 24, 59–63.  
411

412 Liphshitz, N., 1997. Wood remains from two PPNB sites: horvat galil and Nahal Beset.  
413 *Tel Aviv* 24, 237–239.  
414

415 Liphshitz, N., 2010. Wood remains from the gilgal sites. In: Bar-Yosef, O., Goring-  
416 Morris, A.N., Gopher, A. (Eds.), *Gilgal: Early Neolithic Occupation in the Lower Jordan*  
417 *Valley, the Excavations of Tamar Noy.* Oxbow Books, Oxford and Oakville, pp. 259–262.  
418

419 Liphshitz, N., Biger, G., 1992. Israel: historical timber trade in the Levant: the use of  
420 *Cedrus libani* in construction of buildings in Israel from ancient times to the early  
421 twentieth century. In: Bartholin, T.S., Berglund, B.E., Eckstein, D., Schweingruber, F.H.  
422 (Eds.), *Tree Rings and Environment. Proceedings of the International*  
423 *Dendrochronological Symposium, Ystad, South Sweden 3-9 September 1990.* Lundqua  
424 *Report, Lund, vol. 34, pp. 202–206.*  
425

426 Litt, T., Krastel, S., Sturm, M., Kipfer, R., Örcen, S., Heumann, G., Franz, S.O., Ülgen,  
427 U.B., Niessen, F. 2009. Lake Van Drilling Project ‘PALEOVAN’, Interna- tional  
428 Continental Scientific Drilling Program (ICDP): results of a recent pre-site survey and  
429 perspectives. *Quat Sci Rev* 28, 1555–1567.  
430

431 Litt, T., Anselmetti, F.S., Baumgarten, H., Beer, J., Çagatay, N., Cukur, D., Damci, E.,  
432 Glombitza, C., Haug, G., Heumann, G., Kallmeyer, J., Kipfer, R., Krastel, S., Kwiecien,  
433 O., Meydan, A.F., Orcen, S., Pickarski, N., Randlett, M.-E., Schmincke, H.-U., Schubert,  
434 C.J., Strum, M., Sumita, M., Stockhecke, M., Tomonaga, Y., Vigliotti, L., Wonik, T., The  
435 PALEOVAN Scientific Team, 2012. 500,000 years of environmental history in Eastern  
436 Anatolia: the PALEOVAN drilling project. *Sci. Drill. J.* 14, 18–29.  
437

438 Litt, T., Pickarski, N., Heumann, G., Stockhecke, M., Tzedakis, P.C., 2014. A 600,000  
439 year long continental pollen record from Lake Van, eastern Anatolia (Turkey). *Quat. Sci.*  
440 *Rev.* 104, 30–41.  
441

442 López-Sáez, J.A., López-Merino, L. 2005. Precisiones metodológicas acerca de los  
443 indicios paleopalinológicos de agricultura en la Prehistoria de la Península Ibérica.  
444 *Portugalia* 26, 53–64.  
445

446 López-Sáez, J.A., López-Merino, L. 2007. Coprophilous fungi as a source of information  
447 of anthropic activities during the Prehistory in the Amblés Valley (Ávila, Spain): the  
448 archaeopalynological record. *Rev Esp Micropal* 39, 103–116.  
449

450 López-Sáez, J.A., van Geel, B., Martín-Sánchez, M., 2000. Aplicacion de los microfósiles  
451 no polínicos en Palinología Arqueológica. In: Oliveira Jorge, V., Coord. (Eds.),  
452 Contributos das Ciências e das Tecnologias para a Arqueologia da Península Ibérica.  
453 Actas do 3 Congresso de Arqueologia Peninsular, vol. IX, Vila-Real, Portugal, setembro  
454 de 1999, ADECAP, Porto, pp. 11–20.  
455

456 López-Sáez, J.A., López-García, P., Burjachs, F. 2003. Arqueopalinología: Síntesis crítica.  
457 *Pollen* 12, 5–35.  
458

459 López-Sáez, J.A., van Geel, B., Farbos-Texier, S., Diot, M.F. 1998. Remarques  
460 paléoécologiques à propos de quelques palynomorphes non-polliniques provenant de  
461 sédiments quaternaires en France. *Rev Paléobiol* 17, 445–459.  
462

463 Madella, M., Alexandre, A., Ball, T.B., ICPN Working Group 2005. International Code  
464 for Phytolith Nomenclature 1.0. *Ann Bot* 96, 253–260.  
465

466 Magny, M., Begeot, C., Guiot, J., Peyron, O., 2003. Contrasting patterns of hydrological  
467 changes in Europe in response to Holocene climate cooling phases. *Quat. Sci. Rev.* 22,  
468 1589–1596.  
469

470 Maher, L., Banning, E.B., Chazan, M. 2011. Oasis or Mirage? Assessing the Role of  
471 Abrupt Climate Change in the Prehistory of the Southern Levant. *Cam Archaeol J* 21(1),  
472 1–29.  
473

474 Marguerie, D., Hunot, J.Y., 2007. Charcoal analysis and dendrology: data from  
475 archaeological sites in north-western France. *J. Archaeol. Sci.* 34, 1417–1433.  
476

477 Masi, A., Sadori, L., Banechi, I., Siani, A.M., Zanchetta, G. 2013. Stable isotope analysis  
478 of archaeological oak charcoal from eastern Anatolia as a marker of mid-Holocene climate  
479 change. *Plant Biol* 15, 83–92.  
480

481 Mayewski, P., Rohling, E.E., Stager, J.C., Karl e, W., Maasch, K., Meeker, L.D.,  
482 Meyerson, E.A., Gasse, F., van Kreveld, S., Holmgren, K., Lee-Thorp, J., Rosqvist, G.,  
483 Rack, F., Staubwasser, M., Schneider, R., Steig, E.J., 2004. Holocene climate variability.  
484 *Quat. Res.* 62, 243–255.  
485

486 Meadows, J. 2005. The Younger Dryas episode and the radiocarbon chronologies of the  
487 Lake Huleh and Ghab Valley pollen diagrams, Israel and Syria. *The Holocene* 15(4), 631–  
488 636.  
489

490 Meadows, D.H., 2009. *Thinking in Systems*. Earthscan, London. Miebach, A., Niestrath,  
491 P., Roeser, P., Litt, T., 2015. Impacts of climate and humans on the vegetation in NW  
492 Turkey: palynological insights from Lake Iznik since the Last Glacial. *Clim. Past. Discuss.*  
493 11, 5157–5201.  
494

495 Migowski, C., Stein, M., Prasad, S., Negendank, J.F.W., Agnon, A., 2006. Holocene  
496 climate variability and cultural evolution in the Near East from the Dead Sea sedimentary  
497 record. *Quat. Res.* 66, 421–431.  
498

499 Moore, P.D., Webb, J.A., Collinson, M.E. 1991. *Pollen analysis*. Blackwell.  
500

501 Mouterde, P. 1953. *La flore du Djebel Druze*. Université Saint Joseph de Beyrouth.  
502

503 Mulholland, S.C., Rapp, J.r.G. 1992. A morphological classification of grass silica-bodies.  
504 In: Rapp, Jr.G., Mulholland, S.C. (Eds.), *Phytolith Systematics: Emerging Issues*,  
505 *Advances in Archaeological and Museum Science*. Plenum Press, 65–89.  
506

507 Neef, R. 2003. Overlooking the steppe forest: preliminary report on the botanical remains

508 from early Neolithic Göbekli Tepe (southern Turkey). *Neo-Lithics* 2, 13–15.  
509

510 Neef, R., 2004a. PPNB settlements: vegetation and climate. A comparison between PPNB  
511 ‘ain ghazal and Basta. In: Bienert, H.D., Gebel, H.G.K., Neef, R. (Eds.), *Central*  
512 *Settlements in Neolithic Jordan. ex Oriente, Berlin*, pp. 289–299.  
513

514 Neef, R., 2004b. Vegetation and plant husbandry. In: Nissen, H.J., Muheisen, M., Gebel,  
515 H.G.K. (Eds.), *Basta I: the Human Ecology. ex Oriente, Berlin*, pp. 187–218.  
516

517 Neumann, K., Schoch, W., Détienne, P., Schweingruber, F.H. 2001. *Woods of the Sahara*  
518 *and the Sahel*. Paul Haupt.  
519

520 Neumann, F.H., Schölzel, C., Litt, T., Hense, A., Stein, M. 2007. Holocene vegetation and  
521 climate history of the northern Golan heights (Near East). *Veg Hist Archaeobot* 16(4),  
522 329–346.  
523

524 Nguyen-Queyrens, A., Ferhi, A., Loustau, D., Guehl, J.M., 1998. Within-ring delta C-13  
525 spatial variability and interannual variations in wood cellulose of two contrasting  
526 provenances of *Pinus pinaster*. *Can. J. For. Res. Rev. Can. de Recherche For.* 28, 766–773.  
527

528 Pessin, H. 2004. *Stratégies d’approvisionnement et utilisation du bois dans le Moyen*  
529 *Euphrate et la Damascène. Approche anthracologique comparative de sites historiques et*  
530 *préhistoriques*. Ph.D. thesis, Université de Paris.  
531

532 Peters, J., van den Driesch, A., Helmer, D. 2005. The Upper Euphrates-Tigris Basin:  
533 Cradle of agro-pastoralism? In: Vigne, J.-D., Peters, J., Helmer, D. (Eds.), *The First Steps*  
534 *of Animal Domestication: New Archaeozoological Approaches*. Oxbow Books, Oxford, 41–  
535 48.  
536

537 Piperno, D.R. 1988. *Phytolith Analysis: An Archaeological and Geological Perspective*.  
538 Academic Press.  
539

540 Piperno, D.R. 2006. *Phytoliths: A comprehensive guide for archaeologists and*  
541 *paleoecologists*. AltaMira Press.  
542

543 Portillo, M., Kadowaki, S., Nishiaki, Y., Albert, R.M. 2014. Early Neolithic household  
544 behavior at Tell Seker al-Aheimar (Upper Khabur, Syria): a comparison to  
545 ethnoarchaeological study of phytoliths and dung spherulites. *J Archaeol Sci* 42, 107–118.  
546

547 Portillo, M., Llergo, Y., Ferrer, A., Albert, R.M. 2017. Tracing microfossil residues of  
548 cereal processing in the archaeobotanical record: an experimental approach. *Veget Hist*  
549 *Archaeobot.* 26, 59–74.  
550

551 Pross, J., Kotthoff, U., Müller, U.C., Peyron, P., Dormoy, I., Schmiedl, G., Kalaitzidis, S.,  
552 Smith, A.M. 2009. Massive perturbation in terrestrial ecosystems of the Eastern  
553 Mediterranean region associated with the 8.2 kyr B.P. climatic event. *Geology* 37, 887–  
554 890.  
555

556 Rambeau, M.C. 2010. Palaeoenvironmental reconstruction in the southern Levant:  
557 Synthesis, challenges, recent developments and perspectives. *Philos T the Roy Soc A* 368,  
558 5225–5248.  
559

560 Rasmussen, S.O., Vinther, B.M., Clausen, H.B., Andersen, K.K., 2007. Early Holocene  
561 climate oscillations recorded in three Greenland ice cores. *Quat. Sci. Rev.* 26, 1907–1914.  
562

563 Reille, M. 1999. *Pollen et spores d'Europe et d'Afrique du Nord*, 2<sup>nd</sup> edn. Laboratoire de  
564 Botanique Historique et Palynologie.  
565

566 Riehl, S., Asouti, E., Karakaya, D., Starkovich, B.M., Zeidi, M., Conard, N.J., 2015.  
567 Resilience at the transition to agriculture: the long-term landscape and resource  
568 development at the aceramic neolithic tell site of chogha golan (Iran). *Biomed. Res. Int.* 1–  
569 22. Article ID 532481.  
570

571 Roberts, N. 2002. Did prehistoric landscape management retard the postglacial spread of  
572 woodlands in south-west Asia?. *Antiquity* 76, 1002–1010.  
573

574 Roberts N., Wright H.E. 1993. Vegetational, lake-level and climatic history of the Near  
575 East and Southwest Asia. In Wright, H.E., Kutzbach, J.E., Webb, T., Ruddiman, W.F.,  
576 Street-Perrott, F.A., Bartlein, P.J., editors, *Global Climates Since the Last Glacial*



577 Maximum, University of Minnesota Press, 194–220.  
578

579 Roberts, N., Reed, J., Leng, M.J., Kuzucuoglu, C., Fontugne, M., Bertaux, J., Woldring,  
580 H., Bottema, S., Black, S., Hunt, E., Karabiyikoglu, M., 2001. The tempo of Holocene  
581 climatic change in the eastern Mediterranean region: new highresolution crater-lake  
582 sediment data from central Turkey. *Holocene* 11, 719–734.  
583

584 Roberts, N., Rosen, A.M. 2009. Diversity and complexity in early farming communities of  
585 Southwest Asia: new insights into the economic and environmental basis of Neolithic  
586 Catalhöyük. *Curr Anthropol* 50, 393–402.  
587

588 Robinson, S., Black, S., Sellwood, B., Valdes, P. 2006. A review of palaeoclimates and  
589 palaeoenvironments in the Levant and Eastern Mediterranean from 25,000 to 5000 years  
590 BP: Setting the environmental background for the evolution of human civilisation, *Quat*  
591 *Sci Rev* 25, 1517–1541.  
592

593 Roitel, V. 1997. *Végétation et action de l'homme du Natoufien au Néolithique acéramique*  
594 *dans le Haut-Euphrate syrien*. Ph.D thesis, Université de Montpellier II.  
595

596 Rollefson, G.O., Köhler-Rollefson, I. 1989. The collapse of Early Neolithic settlements in  
597 the southern Levant. In: Herskovitz I. (Ed.), *People and culture in change: Proceedings*  
598 *of the Second Symposium on Upper Palaeolithic, Mesolithic and Neolithic Populations of*  
599 *Europe and the Mediterranean Basin*, British Archaeological Reports International Series  
600 508(i), Oxford, 73–89.  
601

602 Rosen, A.M. 1992. Preliminary identification of silica skeletons from Near Eastern  
603 archaeological sites: an anatomical approach. In: Rapp, Jr.G., Mulholland, S.C. (Eds.),  
604 *Phytolith Systematics: Emerging Issues, Advances in Archaeological and Museum*  
605 *Science*. Plenum Press, 129–147.  
606

607 Rosen, A.M. 2007. *Civilizing Climate: Social Responses to Climate Change in the Ancient*  
608 *Near East*. Altamira.  
609

610 Rossignol-Strick, M. 1993. Late Quaternary climate in the Eastern Mediterranean Region.

611 *Paléorient* 19(1), 135–152.

612

613 Rossignol-Strick, M. 1995. Sea-land correlation of pollen records in the Eastern  
614 Mediterranean for the Glacial-Interglacial transition: biostratigraphy versus radiometric  
615 time-scale. *Quat Sci Rev* 14, 893–915.

616

617 Rossignol-Strick, M. 1997. Paléoclimat de la Méditerranée orientale et de l'Asie du sud-  
618 ouest de 15000 à 6000 BP. *Paléorient* 23, 175–186.

619

620 Rossignol-Strick, M. 1999. The Holocene climatic optimum and pollen records of sapropel  
621 1 in the Eastern Mediterranean, 9000–6000 BP. *Quat Sci Rev* 18, 515–530.

622

623 Santana, J., Velasco, J., Ibanez, J.J., Braemer, F. 2012. Crania with mutilated facial  
624 skeletons: a new ritual treatment in an early Pre-Pottery Neolithic B cranial cache at Tell  
625 Qarassa North (South Syria). *Am J Phys Anthropol* 149 (2), 205–216.

626

627 Santana, J., Velasco, J., Balbo, A., Iriarte, E., Zapata, L., Teira, L., Nicolle, C., Braemer, F.,  
628 Ibáñez, J.J. 2015. Interpreting a ritual funerary area at the Early Neolithic site of Tell  
629 Qarassa North (South Syria, late 9th millennium BC). *J Anthropol Archaeol* 37, 112–127.

630

631 Semerci, A., 2005. Fifth year performance of morphologically graded *Cedrus libani*  
632 seedlings in the Central Anatolia Region of “Turkey”. *Turk. J. Agric. For.* 29, 483–491.

633

634 Schiebel, V., 2013. Vegetation and Climate History of the Southern Levant during the Last  
635 30,000 Years Based on Palynological Investigation. PhD Thesis. Mathematisch-  
636 Naturwissenschaftlichen Fakultät, Rheinischen Friedrich-Wilhelms-Universität. Available  
637 at: <http://hss.ulb.uni-bonn.de/2013/3270/3270.htm>.

638

639 Schleser, G.H., 1992. Delta C-13 pattern in a forest tree as an indicator of carbon transfer  
640 in trees. *Ecology* 73, 1922–1925.

641

642 Schwab, M.J., Neumann, F., Litt, T., Negendank, J.F.W., Stein, M., 2004. Holocene  
643 palaeoecology of the Golan Heights (near east): investigation of lacustrine sediments from  
644 Birkat Ram crater lake. *Quat. Sci. Rev.* 23, 1723–1731.

645

646 Schweingruber, F.H. 1990. *Anatomy of European woods. An atlas for the identification of*  
647 *European trees, shrubs and dwarf shrubs*. Paul Haupt.

648

649 Simmons, A. H. 2000. Villages on the edge: regional settlement change and the end of the  
650 Levantine Pre-Pottery Neolithic. In: Kuijt, I. (Ed.), *Life in Neolithic Farming*  
651 *Communities*, Kluwer Academic, 211–230.

652

653 Skarpe, C., Hester, A. 2008. Plant traits, browsing and grazing herbivores, and vegetation  
654 dynamics. In: Gordon, I.J., Prins, H.H.T. (Eds.), *The Ecology of Browsing and Grazing*,  
655 Springer, 217–261.

656

657 Smart, T.L., Hoffman, E. 1988. Environmental interpretation of Archaeological Charcoal.  
658 In: Hastorf, C.A., Popper, V.S. (Eds.), *Current Palaeoethnobotany Analytical Methods*  
659 *and Cultural Interpretations of Archaeological Plant remains*. University of Chicago  
660 Press, 167–205.

661

662 Stevens, L.R., Wright, H.E. Jr., Ito, E. 2001. Proposed changes in seasonality of climate  
663 during the Late-glacial and Holocene at Lake Zeribar, Iran. *The Holocene* 11, 747–756.

664

665 Stevens, L.R., Ito, E., Schwalb, A., Wright, H.E. Jr. 2006. Timing of atmospheric  
666 precipitation in the Zagros Mountains inferred from a multi-proxy record from Lake  
667 Mirabad, Iran. *Quat Res* 66, 494–500.

668

669 Tanno, K.I., Willcox, G. 2012. Distinguishing wild and domesticated wheat and barley  
670 spikelets from early Holocene sites in the Near East. *Veg Hist Archaeobot* 21, 107–115.

671

672 Tans, P.P., Mook, W.G., 1980. Past atmospheric CO<sub>2</sub> levels and the <sup>13</sup>C/<sup>12</sup>C ratios in tree  
673 rings. *Tellus* 32, 268–283.

674

675 Tchernov, E., Horwitz, L.K. 1990. Herd management in the past and its impact on the  
676 landscape of the southern Levant. In: Bottema, S., Entjes-Nieborg, G., van Zeist, W.  
677 (Eds.), *Man's Role in the Shaping of Eastern Mediterranean Landscape*. Balkema, 207–  
678 218.

679

680 Traboulsi, M. 2013. Les précipitations dans les marges arides du Proche-Orient: l'exemple  
681 du bassin versant du Yarmouk. *Hannon, revue de géographie libanaise*, 26, 7–39.

682

683 Tsartsidou, G., Lev-Yadun, S., Albert, R.M., Miller-Rosen, A., Efstratiou, N., Weiner, S.  
684 2007. The phytolith archaeological record: strengths and weaknesses based on a  
685 quantitative modern reference collection from Greece. *J Archaeol Sci* 34, 1262–1275.

686

687 Turner, R., Roberts, N., Eastwood, W.J., Jenkins, E., Rosen, A. 2010. Fire, climate and the  
688 origins of agriculture: micro-charcoal records of biomass burning during the last  
689 glacialeinterglacial transition in Southwest Asia. *J Quat Sci* 25, 371–386.

690

691 Twiss, P.C. 1992. Predicted world distribution of C<sub>3</sub> and C<sub>4</sub> grass phytoliths. In: Rapp,  
692 Jr.G., Mulholland, S.C. (Eds.), *Phytolith Systematics: Emerging Issues, Advances in*  
693 *Archaeological and Museum Science*. Plenum Press, 113–128.

694

695 Twiss, P.C., Suess, E., Smith, R.M. 1969. Morphological classification of grass phytoliths.  
696 *Soil Science Society of America Proceedings* 33, 109–115.

697

698 van Geel, B. 2001. Non-pollen palynomorphs. In: Smol, J.P., Birks, H.J.B., Last, W.M.,  
699 (Eds.), *Tracking environmental change using lake sediments, vol. 3, Terrestrial, algal, and*  
700 *siliceous indicators*. Kluwer, Dordrecht, 99–119.

701

702 van Geel, B., Buurman, J., Brinkkemper, O., Schelvis, J., Aptroot, A., van Reenen, G.,  
703 Hakbijl, T. 2003. Environmental reconstruction of a Roman Period settlement site in  
704 Uitgeest (The Netherlands), with special reference to coprophilous fungi. *J Archaeol Sci*  
705 30, 873–883.

706

707 van Zeist, W., Timmers, R.W., Bottema, S. 1970. Studies of modern and Holocene pollen  
708 precipitation in southeastern Turkey. *Palaeohistoria* 14, 19–39.

709

710 van Zeist, W., Bottema, S. 1977. Palynological investigations in western Iran.  
711 *Palaeohistoria* 24, 19–85.

712

- 713 van Zeist, W., Woldring, H. 1978. A postglacial pollen diagram from Lake Van in East  
714 Anatolia. *Rev Palaeobot Palyno* 26, 249–276.
- 715
- 716 van Zeist, W., Bottema, S. 1991. *Late Quaternary Vegetation of the Near East*. Dr Ludwig  
717 Reichert Verlag, Wiesbaden.
- 718
- 719 van Zeist, W., Baruch, U., Bottema, S. 2009. Holocene palaeoecology of the Hula area,  
720 northeastern Israel. In: Kaptijn, W., Lucas, P. (Eds.), *Archaeological and Related Essays*  
721 *on the Jordan Valley in Honor of Gerrit van der Kooij on the Occasion of his 65th*  
722 *Birthday. A Timeless Vale*. Leiden University Press, 29–64.
- 723
- 724 van Zeist, W., Smith, P.E.L., Palfenier-Vegter, R.M., Suwijn, M., Casparie, W.A., 1984.  
725 An archaeobotanical study of ganj dareh tepe, Iran. *Palaeohistoria* 26, 201–224.
- 726
- 727 Vernet, J.L. 2001. *Guide d'identification des charbons de bois préhistoriques et récents*.  
728 CNRS Editions, Paris.
- 729
- 730 Vigne, J.-D. 2013. Domestication process and domestic ungulates: new observations from  
731 Cyprus. In: Colledge, S., Dobney, K., Manning, K., Shennan, S. (Eds.), *The Origins and*  
732 *Spread of Domestic Animals in Southwest Asia and Europe*. Publications of the Institute of  
733 Archaeology, University College, London, West Coast Press, Walnut Creek (CA), 115–  
734 128.
- 735
- 736 Wasylikowa, K., Witkowski, A., Walanus, A., Hutorowicz, A., Alexandrowicz, S.W.,  
737 Langer, J.J. 2006. Palaeolimnology of Lake Zeribar, Iran, and its climatic implications.  
738 *Quat Res* 66(3), 477–493.
- 739
- 740 Weninger, B., Clare, L., Rohling, E.J., Bar-Yosef, O., Böhner, U., Budja, M., Bundschuh,  
741 M., Feurdean, A., Gebel, H.G., Jöris, O., Linstädter, J., Mayewski, P., Mühlenbruch, T.,  
742 Reingruber, A., Rollefson, G., Schyle, D., Thissen, L., Todorova, H., Zielhofer, C. 2009.  
743 The impact of rapid climate change on prehistoric societies during the Holocene in the  
744 eastern Mediterranean. *Documenta Praehistorica* 367–459.
- 745
- 746 Western, A.C., 1983. Appendix F. Catalogue of identified charcoal samples. In: Kenyon,

747 K., Holland, T.A. (Eds.), *Excavation at Jericho. Volume 5: the Pottery Phases of the Tell*  
748 *and Other Finds*. British School of Archaeology in Jerusalem, London, pp. 770–773.  
749

750 Wick, L., Lemcke, G., Sturm, M. 2003. Evidence of Lateglacial and Holocene climatic  
751 change and human impact in eastern Anatolia: High-resolution pollen, charcoal, isotopic  
752 and geochemical records from the laminated sediments of Lake Van, Turkey. *The*  
753 *Holocene* 13, 665–675.  
754

755 Willcox, G. 1990. Charcoal remains from Tepe Abdul Hosein. In: Pullar, J. (Ed.), *Tepe*  
756 *Abdul Hosein: A Neolithic site in Western Iran Excavations 1978*. British Archaeological  
757 Reports International Series 563, 233–227.  
758

759 Willcox, G. 1991. Cafer Höyük (Turquie): Les Charbons de bois Neolithiques. *Cahiers de*  
760 *l'Euphrate* (5-6), 139–150.  
761

762 Willcox, G. 1999. Charcoal analysis and Holocene vegetation history in southern Syria.  
763 *Quat Sci Rev* 18(4-5), 711–716.  
764

765 Willcox, G., 2005. The distribution, natural habitats and availability of wild cereals in  
766 relation to their domestication in the Near East: multiple events, multiple centres. *Veg.*  
767 *Hist. Archaeobo.* 14 (4), 534–541.  
768

769 Willcox, G., Fornite, S., Herveux, L., 2008. Early Holocene cultivation before  
770 domestication in northern Syria'. *Veg. Hist. Archaeobot.* 17 (3), 313–325.  
771

772 Wright, H.R. Jr., Thorpe, J.L. 2003. Climatic change and the Origins of agriculture in the  
773 Near East. In: Mackay, A., Battarbee, R., Birks, J., Oldfield, F. (Eds.), *Global Change in*  
774 *the Holocene*. Arnold, 49–62.  
775

776 Yasuda, Y., Kitagawa, H., Nakagawa, T. 2000. The earliest record of major anthropogenic  
777 deforestation in the Ghab Valley, Syria: a palynological study. *Quat Int* 73(74), 127–136.  
778

779 Zeder, M. 2011. The origins of agriculture in the Near East. *Curr Anthropol* 54(S4), S221–  
780 S235.

781

782 Zeder, M. 2015. Core questions in domestication research. *Proc Natl Acad Sci USA*  
783 112(11), 3191–3198.

784

785 Zohary, M. 1973. *Geobotanical foundations of the Middle East*. Stuttgart, G Fischer, Swet  
786 and Zeitlinger, Amsterdam.

787

788 Zohary, D., Hopf, M., Weiss, E., 2012. *Domestication of Plants in the Old World*. 4<sup>th</sup>  
789 Edition. Oxford University Press, Oxford.

790