Vegetation History and Human Impact on the Environs of Tel Megiddo in the Bronze and Iron Ages: A Dendroarchaeological Analysis

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A substantial amount of macro-botanical remains has been recorded at Tel Megiddo since the initiation of the renewed excavations in 1992. We constructed a database with 1,162 identified samples and analysed them diachronically. This dataset enables us to trace environmental trends and human impact on the vegetation in the vicinity of the site during the Bronze and Iron Ages (~3,500–500 BCE). The earlier periods in the studied sequence are characterised by a higher availability of common natural arboreal elements (oak, conifers and terebinth) and the later periods by a dramatically reduced presence of these elements, with a much stronger occurrence of anthropogenically dependent species (olive), foreign species (cedar of Lebanon, sycamore fig), and less prevalent forest/maquis elements. Our investigation also provides some context for the appearance of both horticultural and rare/special species in the assemblage (almond, walnut, myrtle, laurel, sage). The appearance of prestigious species such as the imported cedar in one sector of the site (Area H) provides botanical support to other finds which rendered this area an elite neighbourhood.

Keywords Archaeobotany, Bronze Age, Iron Age, Tel Megiddo, Charcoal analysis, Paleo-vegetation

Tel Megiddo, situated on the western margins of the Jezreel Valley, served as a Canaanite city-state during the Bronze Age and as a royal city in the Kingdom of Israel during parts of the Iron Age. Its prestige was due mainly to its strategic location, guarding and serving the ancient trade route that connected Egypt with Mesopotamia. The tell stretches over approximately 11 ha and features an almost 15 m accumulation, representing over
30 settlements. Occupation began in the Pre-Pottery Neolithic period (in the seventh millennium BCE), and continued until the Persian period (4th century BCE; for general background on the site, see Ussishkin 2018).

Continuous habitation in antiquity and over a century of intensive excavations by four missions have made the site ideal for studies of diachronic processes. Its meticulous stratigraphic sequence and intensive ceramic record facilitated the development of a reliable relative chronology scheme (see, e.g., Arie 2013; Martin 2013) and its rigorous radiocarbon dating program provides a secure absolute chronology system (Regev et al. 2014; Toffolo et al. 2014).

Due to its relatively well-preserved charred remains, Megiddo has provided a detailed archaeobotanical record (e.g., Liphschitz 2000, 2006, 2013). Yet, so far there has been no attempt to draw a full picture of the vegetational history of the site and its environs. We therefore compiled an extensive dendroarchaeological dataset based on all of Megiddo’s archaeological reports, which includes all of the wood-charred remains identified and published thus far (Liphschitz 2000, 2006, 2013; Benzaquen and Langgut in press). Based on the assumption that most of the plants for domestic use were brought to the site from the vicinity (e.g., Lev-Yadun 2007; Liphschitz 2007: 11), the dendroarchaeological dataset enables the execution of diachronic comparisons, including observations of the history of human impact on the region. Additionally, the dataset is useful in synchronic investigations, attempting to shed light on questions such as social status within contemporaneous strata at the site.

Geographical settings
Tel Megiddo is located in the Jezreel Valley in the Mediterranean phytogeographic zone (Fig. 1), where the climate is characterised by mild, rainy winters with average temperatures of 17–9 °C and dry summers with average temperatures between 24–31 °C (Zohary 1973: 130; Srebro and Soffer 2011). The valley, with its plane topography, deep soil, mild climate and rainfall that averages upwards of 550 mm per year, has been traditionally regarded as prime agricultural land (ibid.: 42; Fig. 1). Hilly areas near Megiddo are characterised by a variety of light rendzina soils (ibid.).

The natural woody vegetation of the Jezreel Valley near Megiddo disappeared long ago (e.g., Lev-Yadun and Weinstein-Evron 2002: 333), though remnants of the forest/maquis, dominated by Quercus calliprinos (kermes oak) still exist in the hilly areas west and south of the site (Zohary 1962). The forest that presently exists in the area is primarily composed of Pinus halepensis (Aleppo pine), the favoured species in the afforestation policies of the State of Israel (Zohary 1962: 217; Lev-Yadun 2007: 151). Other common elements in the forest/maquis include Quercus ithaburensis (Mt. Tabor oak), Pistacia palaestina (terebinth), Pistacia lentiscus (mastic), Ceratonia siliqua (carob), Arbutus andrachne (Greek strawberry), Phyllirea media (mock privet), Styrax officinalis (storax), Rhamnus spp. (buckthorn), Cercis siliquastrum (Judas tree), Crataegus azarolous (azarole) and Crataegus aronia (azarole/hawthorn) (Zohary 1973: 135; Danin 2004). The forest/maquis on nearby Mount Carmel is primarily dominated today by kermes oak. Pines and cypresses, both feral and cultivated, contribute to the woody vegetation covering the mountain (Lev-Yadun and Weinstein-Evron 2002: 333). In the past, Mount Carmel probably featured a
typical, dense Mediterranean forest/maquis (e.g., Lev-Yadun and Weinstein-Evron 1994; Kadosh et al. 2004), with a highly concentrated and localized presence of Aleppo pine (Lev-Yadun and Weinstein-Evron 2002).

Until the 1950s, seasonal marshes were common in the vicinity of Megiddo, hindering exploitation of its full agricultural potential. This changed with modern drainage projects which permitted maximized agricultural exploitation of the valley (Fig. 2; Singer 2007: 147–149). A study, which compared the Palestine Exploration Fund map of 1881 to GIS layers from 2011, determined that the Jezreel Valley was the largest eco-region in Israel affected by modern development. The comparison also showed that the valley changed almost entirely from a ‘natural vegetation/bare area’
in 1881 to ‘managed’ agricultural land since the second half of the 20th century CE (Schaffer and Levin 2014: 126).

Recent high-resolution, well-dated south Levantine paleoclimate records which cover the Bronze and Iron Ages (palynological studies of the Dead Sea and the Sea of Galilee – Langgut, Finkelstein and Lit 2013; Finkelstein and Langgut 2014; Langgut et al. 2014, 2015a; Soreq Cave isotope analysis – Bar-Matthews and Ayalon 2011, Laugomer 2017; the reconstruction of the Dead Sea levels – Migowski et al. 2006; Kagan et al. 2015) demonstrate that during most of the period, the region was characterised by typical Mediterranean climate conditions. These records show that the wettest period occurred during the Early Bronze Age (~3,500–2,500 BCE). Two dry events were documented: The first lasted about 200–300 years, at the transition from the Intermediate Bronze Age to the Middle Bronze Age I (somewhere between

![Figure 2](image-url)  
**Figure 2** Occurrence of seasonal swamps in the vicinity of Tel Megiddo prior to the 1950s (after Ganor 1967).
~2,200–1,800 BCE); the second took place in the later phase of the Late Bronze Age (~1,250–1,100 BCE).

Material and methods

Sampling and identification

Throughout the excavations at Megiddo, the recovery of charred wood remains has been scrupulously executed. Samples larger than 0.5 × 1 cm have been collected by hand and dry sieved from secure, long-lived stratigraphic contexts that reflect scattered secondary deposits (sensu Asouti and Austin 2005). Charcoal finds were separated and tagged individually, as opposed to being combined and mixed as a group with all the charcoals from its locus, a common practice in many excavations. This method helps minimize statistical biases which may arise from the fragmentation of the finds. Flotation was not employed, as it was considered that the minute samples it is likely to produce are either: a) unidentifiable, or b) the by-products of gross fragmentation which can cause statistical biases. All in all, every sample collected in the field was analysed for its anatomical wood structure.

Charred wood remains collected from the Megiddo excavation during the 2010, 2012 and 2014 seasons were microscopically analysed in order to determine their taxonomic identification at the most specific systematic level. Diameter analysis of charcoal fragments was considered as it may provide valuable insight into woodland exploitation and management (Lev-Yadun 2007; Dufraisse and Martínez 2011; Deckers 2016). Unfortunately, in the case of Megiddo, measurements of charcoal diameters (e.g., Paradis-Grenouillet, Dufraisse and Allée 2013) or annual ring width (e.g., Marguerie and Hunot 2007) were impossible due to the small size of the samples. In total, 232 samples from secure stratigraphic contexts in Areas H, J, K and Q (Fig. 3) were taxonomically identified (seasons of 2010, 2012 and 2014).

Taxonomic determinations of the charcoal samples were made on the basis of anatomical tissue structure following the parameters of Lev-Yadun (2007: 143–145) and Pearsall (2010: 144–153). The specimens were cut and examined along three observational axes (transverse, tangential and radial) using a stereoscopic Carl Zeiss SteREO Discovery V20 microscope with magnifications of up to 360× under oblique, angled top-lighting. When determinations were ambiguous, a Hitachi TM3030 Tabletop scanning electron microscope was used. Determinations were based on the identification of wood anatomical features (e.g., vessels and their arrangements, size and arrangement of rays and profusion and nature of parenchyma and fibers), primarily through a comparison with the wood and charcoal reference collection of the southern Levant (Steinhardt Museum of Natural History, Tel Aviv University). Wood anatomy atlases (Fahn, Werker and Baas 1986; Wheeler, Baas and Gasson 1989; Schweingruber 1990; Akkemik and Yaman 2012; Crivellaro and Schweingruber 2013) were also used in the identification process.

1 Differences are due to dissimilarities in sampling resolution and chronology of the paleoclimate records.
Database compilation

Samples collected at Megiddo between 1992 and 2008 were previously identified and published in the respective Megiddo excavation reports (Liphschitz 2000, 2006 and 2013). Altogether, these studies presented a total of 930 wood charcoal samples that were identified at the most specific systematic level and chronological timeframe. These results were incorporated into one general dataset with the recently identified samples from the 2010–2014 seasons. In addition, we fine-tuned and updated the stratigraphic provenance of the samples published in the previous reports so that the chronological framework was in agreement with the most recent stratigraphic data from Megiddo (Boaretto in press; Finkelstein and Martin in press). We then grouped the data according to ceramic periods, with their division to sub-periods (e.g., Iron IIA, Iron IIB). The absolute dating of these periods follows the updated $^{14}$C results for Levantine sites (Finkelstein and Piasetzky 2010 for the Iron Age; Regev et al. 2012 for the Early and Intermediate Bronze Ages; Toffolo et al. 2014 for the Late Bronze and Iron Ages); for the Middle Bronze Age, yet to be fully radiocarbon-dated, we follow the traditional dating of the mid-19th to the mid-16th centuries BCE (Mazar 1992; Bietak 2002).

Results

The entire Megiddo dendroarchaeological assemblage is composed of a total of 1,162 identified samples and 30 different taxonomic categories (Table 1). In general, the Megiddo assemblage is dominated by Mediterranean arboreal taxa, especially by three species that
appear ubiquitously in every period. The most dominant of the three is *Olea europaea* (olive), which first appears during the EB I at 48.9% of the assemblage and reaches its pinnacle during the Iron I, when it accounts for 80.8% of the finds. *Quercus calliprinos*, the local evergreen kermes oak, is the second most abundant species in the assemblage, exhibiting its highest values during the EB I (16.3%) and lowest during the Iron I (4.1%). The third most widespread species is *Pistacia palaestina* (terebinth), the highest values of which are in the EB III (13.6%) and the lowest during the Iron I (1.5%). The assemblage also includes two local coniferous tree species, namely *Cupressus sempervirens* (Italian cypress) and *Pinus halepensis* (Aleppo pine), which exhibit a strong presence during both the EB I and EB III, when their combined ratios account for 9.8% and 11.1%, respectively. However, their ratios either drop dramatically or are altogether absent in subsequent periods. The assemblage likewise yielded several species of fruit trees and herbal plants, including: *Amygdalus communis* (almond), *Ceratonia siliqua* (carob), *Laurus nobilis* (laurel), *Myrtus communis* (myrtle), *Salvia fruticosa* (three-leaved sage), and *Vitis vinifera* (grape). Additionally, the assemblage included species which are not native to Israeli flora, namely *Cedrus libani* (cedar of Lebanon) in the Iron II, *Ficus sycomorus* (sycamore fig) in the Iron I and *Juglans regia* (Persian walnut), which appears steadily from the Middle Bronze Age onwards. Although native to the region, because of its very limited distribution, the appearance of *Platanus orientalis* (oriental plane) during the Iron II is unique. Lastly, *Tamarix* spp. (tamarisk), a ubiquitous genus in all the phytogeographic regions of Israel but especially common in arid environments, saline soils and wetlands, was encountered in every period except for the Late Bronze Age.

**Discussion**

**Reconstruction of the natural environment**

When considering the botanical data according to period, it is possible to trace the environmental trends that characterised the Megiddo area (Fig. 4). Overall, the ratios of common wild arboreal species (kermes oak, Mt. Tabor oak, boissier oak, oak species, terebinth, *Pistacia* species and azarole) decline gradually over time, while the local conifers (Italian cypress and Aleppo pine) drop dramatically from their relatively high values in the Early Bronze Age. In this regard, the data relate that the environs of Megiddo during the Early Bronze Age were characterized by an almost intact Mediterranean forest/maquis vegetation that became gradually degraded in later periods. Particularly, the data demonstrate strong fluctuations in the presence of local conifer species from ~10% in the Early Bronze Age to <1.5% during subsequent periods, indicating over-exploitation of these items, most of which were probably utilized for construction purposes.

The elevated number of conifer charcoals in the Early Bronze Age might at first glance be partially attributed to the monumental cultic structures that characterise the beginning of the period (EB I; Adams 2013). Yet, the conifer ratios are likewise high during the EB III, which does not feature monumental cultic architectural endeavors (*ibid*.). Local conifer species must have been highly coveted timbers for construction, monumental or otherwise, throughout the Early Bronze Age to the point where a
marked scarcity was created thereafter. It took a long time for the forest/maquis to regenerate these conifers; still, the forest would never regain the abundance of the trees it possessed in the Early Bronze Age. In addition, the pollen data from the Sea of Galilee demonstrate a continuous curve of *Pinus* pollen throughout the Early Bronze Age but an intermittent one during the subsequent periods (Langgut et al. 2015: Fig. 3), a fact which indicates a wider distribution of conifers during the foremost period. *Quercus* and *Pistacia* species likewise declined over time (though not as severely), illustrating the ongoing gradual deforestation in the Megiddo environs. By the same token, an increase in taxonomic diversity of the assemblage is seen in the later periods (Iron I-II) through the inclusion and noticeably higher ratios of species such as *A. syriacum* (Syrian maple), *C. siliquastra*um (Judas tree), *P. euphratica* (Euphrates poplar), *R. palaestinus* (Palestine buckthorn) and *Tamarix* spp. This suggests that the inhabitants of Megiddo, when faced with a shortage of the previously common and preferred timber species, were forced to use less suitable trees for construction and carpentry crafts (e.g., Zohary 1972: 31; 1966: 29; Gale and Cutler 2000: 219, 251).

Comparison to other Early Bronze sites in the vicinity is impossible, as their dendroarchaeological results are either meagre or virtually nonexistent (e.g., Liphschitz 2007).
## TABLE 1

The Megiddo aggregate assemblage: charcoal results from the 1992–2014 seasons in absolute numbers and percentages, presented in declining order of the overall ratios

<table>
<thead>
<tr>
<th>Taxa</th>
<th>EB I ~3600-3000 BCE</th>
<th>EB III ~2900-2500 BCE*</th>
<th>MBA ~1950-1550 BCE</th>
<th>LB I ~1550-1390 BCE</th>
<th>LB II ~1390-1180 BCE</th>
<th>LB III ~1180-1130 BCE</th>
<th>IA I ~1130-950 BCE</th>
<th>IA II ~950-586 BCE</th>
<th>Total per species</th>
<th>Overall %</th>
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<td>395</td>
<td>246</td>
<td>1162</td>
<td>100%</td>
</tr>
</tbody>
</table>

*There was an occupational gap at Megiddo during the EB II.*
In correlation to the degradation of the natural environment, the data show that later periods such as the Iron Age were characterised by a strong presence of, and reliance on, fruit trees, mainly *Olea europaea* (olive). Olive was the most prominent tree in the Megiddo area throughout the Bronze and Iron Ages (45–80% of the relevant assemblages). There is a direct correlation, then, between the increase in the levels of olive and the decrease of common wild timber species. Olive wood would have been readily available from orchards in the vicinity of Megiddo.

Our findings, regarding the gradual decline of the natural forest/maquis following centuries of impact of human activity are corroborated by regional palynological studies for the Bronze and Iron Ages (Baruch 1986; Langgut et al. 2014; Finkelstein and Langgut 2018).

**Horticulture**

The olive (Fig. 5a, b) is an essential Mediterranean diet staple (Gale and Cutler 2000; Zohary, Hopf and Weiss 2012: 116; Weiss 2015), and the tree is indeed considered as one of the most important fruit trees of the Mediterranean basin. Although domestication of the olive took place no later than the Chalcolithic period (Zohary and Spiegel-Roy 1975; Langgut et al. 2019), evidence suggests that it had already been exploited for its oil during the Late Neolithic-Chalcolithic interface (the Wadi Rabah horizon, 8th millennium BP or 6th millennium BCE) (Galili et al. 1997; Namdar et al. 2015). The high ratios of olive wood charcoals in the assemblage indicate that considerable cultivation efforts were expended in the environs of Megiddo, particularly during the Iron I, when olive horticultural activities are seen to augment dramatically in the entire southern Levant (Finkelstein and Langgut 2018). Based on the palynological evidence, it seems that during the Iron II some reduction in olive cultivation in northern Israel took place (Baruch 1986; Neumann et al. 2007; Van Zeist, Baruch and Bottema 2009; Finkelstein and Langgut 2018).

Horticultural trends are also attested by the presence of species such as almond (*Amygdalus communis*) and Persian walnut (*Juglans regia*), both of which increased from the Middle Bronze Age onwards. Although almond is considered one of the earliest fruit trees to be cultivated in the eastern Mediterranean (~6,300–5,300 years BP; Zohary, Hopf and Weiss 2012: 149), its first appearance at Megiddo occurs at a much later date. It is likely that the knowledge and technology to cultivate almond was not widespread in the southern Levant before the Middle Bronze Age. Similarly, despite the fact that palynological investigations have proven that *Juglans regia* has been present in the southern Levant since the late-Pleistocene, the same records relate that it was nonetheless rare (Langgut 2015). Pollen diagrams from Turkey and Greece demonstrate an increase of *J. regia* pollen percentages at the beginning of the second millennium BCE, suggesting that its increased presence was most likely related to its

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3 It is not clear whether wild or domesticated olive trees were used to produce this pioneering oil.

4 This resilient evergreen tree was originally only a minor component of the Mediterranean *Q. calliprino–P. palaestina* association, a fact evidenced by Late Pleistocene–Early Holocene regional palynological diagrams (Horowitz 1979; Weinstein-Evron 1983; Kadosh et al. 2004; Langgut et al. 2011; Litt et al. 2012).
Figure 5  Scanning Electron Microscope (SEM) imaging of selected samples: (a) *Olea europaea* (olive) transverse section, 14/H/072/LB05; (b) *Olea europaea* tangential section, 14/H/072/LB05; (c) *Ulmus canecens* (Mediterranean elm) transverse section, 14/H/076/LB04; (d) *Ulmus canescens* tangential section, 14/H/076/LB04; (e) *Myrtus communis* (myrtle) transverse section, 10/H/003b/LB07; (f) *Myrtus communis* tangential section, 10/H/003b/LB07; (g) *Vitis vinifera* (grape) tangential section, 10/K/002/LB23a; (h) *Platanus orientalis* (oriental plane) transverse section, 12/Q/099/LB04.
cultivation (Van Zeist, Worldring and Stapert 1975; Bottema 1980, 2000; Bottema and Woldring 1984, 1990; Eastwood et al. 1999). Indeed, based on an earlier appearance of *J. regia* in the pollen curve of Syria’s Ghab Valley, the beginning of large-scale Persian walnut cultivation for economic reasons can be dated to the early second millennium BCE (Bottema and Worldring 1990). Given that the above evidence precedes the record in Israel by a couple of hundred years, it can be argued that the knowledge, and probably also the selection, of superior genetic types for successfully cultivating Persian walnut trickled down into the southern Levant from elsewhere in the Near East. The simultaneous appearance of these two nut species at Megiddo was the result of better acquired knowledge, improved horticulture technology and the rise of a commercial industry that was catalyzed by the renewed urbanism in the area in the Middle Bronze Age (Finkelstein et al. 2006: 760–762). Exactly at the same time, walnut pollen grains begin to appear in higher frequencies at the Sea of Galilee (Langgut 2015).

*Vitis vinifera* (grape) (Fig. 5g) made its first appearance at Megiddo in the LB II. Grape is characteristically a deciduous climber species native to humid habitats in the southern Levant, as well as in southeastern Europe and all the way to western India (Fahn, Werker and Baas 1986: 175). As one of the first fruit species to be domesticated, significant viticulture has existed in the southern Levant since the Early Bronze Age (Weiss 2015), enabling generations to enjoy the sugar-rich fruit of the grape as well as its easily-stored dried raisins, juices and especially wine (Zohary and Speigel-Roy 1975: 321; Zohary 1982: 55; Zohary, Hopf and Weiss 2012). Despite the status of grape and its by-products in eastern Mediterranean tradition and lore (e.g., Postgate 1987), its presence in the archaeological record of Megiddo is meagre, demonstrating only one wood charcoal sample and a few identified grape pips (Borojevic 2006). The scarcity of the grape vine might be primarily caused by issues of preservation based on the species’ biological qualities. Given that grape wood possesses a feeble density of 0.40 g/cu cm (Crivellaro and Schweingruber 2013: 569), it would stand to reason that the frail constitution of its lianas would deteriorate easily, especially when compared to some of the denser wood species such as olive and oak. Moreover, its timber is unsuitable for use in construction and for manufacturing of wooden artefacts; lastly, it is considered a poor quality fuel material due to its low density. The palynological evidence for viticulture in northern Israel during the Bronze and Iron Ages is also limited (Baruch 1986; Neumann et al. 2007; Van-Zeist, Baruch and Bottema 2009; Langgut et al. 2015; Schiebel and Litt 2018), since *Vitis* pollen is underrepresented in the palynological spectrum (characterised by low pollen dispersal efficiency). The charcoal sample encountered at Megiddo for the LB II is therefore significant as evidence of an otherwise under-represented species.

**Rare and special species**

The following section addresses rare and special species based on three criteria: their geobotanical characteristics, low frequency in Bronze and Iron Age wood assemblages of the southern Levant, and special botanical peculiarities.
Two rare/special species appear for the first time in the Iron I. The first is myrtle (*Myrtus communis*) (Fig. 5e–f), which was encountered in Area H. Although myrtle does occur in the wild, there is evidence that in antiquity it was cultivated in the Levant (Langgut *et al.* 2013) for its aromatic qualities, edible fruit, fragrant white flowers, evergreen leaves, uses in cuisine and properties as a medicinal remedy (Zohary 1972: 371; Zilkah and Golschmidt 2014; Dafni 2016). The appearance of myrtle at Iron I Megiddo could reflect garden horticulture. Area H is located in the northwestern part of the city, an advantageous location given its proximity to the palace and gate (Arie 2006; 2013). The population there most likely belonged to the more affluent sector of society (Arie 2006, 2013; Langgut *et al.* 2016; Sapir-Hen *et al.* 2016), suggesting a penchant for garden horticulture. It is noteworthy that pollen of this species was encountered in the same area of the site slightly earlier, in the 14th century BCE (Langgut *et al.* 2016), furthering the possibility that the presence of *M. communis* at Megiddo was associated with domestic gardening endeavours related to the palace.

The same Iron I layer in Area H produced the earliest sample of *Ficus sycomorus* (sycamore fig) found at Megiddo. While the sycamore fig is indigenous to tropical northeast Africa (Zohary 1966: 38), cultivation for its fruit and timber started in Egypt, ca. 6,000 years BP (Zohary, Hopf and Weiss 2012: 130). Although it is not clear when the species was introduced into the southern Levant, it is reasonable to place this event at the end of the Late Bronze Age. Given that the sycamore fig did not occur in the land of Canaan naturally, its presence at Megiddo might be associated with horticultural activities (*ibid.*). In addition to the edible fruit and durable timber of the sycamore fig, the tree is aesthetically pleasing and hence could have formed part of a garden in this affluent sector of town; the trees are known to attain heights of 8–20 m (Crivellaro and Schweingruber 2013: 412) and cast significant shade for which they are often utilized in gardens and public spaces. Incorporation of sycamore fig wood in construction became widespread in Canaan starting in the Late Bronze Age (Liphschitz 2007: 114 and references therein). Its cultivation in this region is also alluded to in several biblical verses (e.g., Amos 7:14; 1 Kgs 10:27; 1 Chron 2:16; Isa 9:10).

*Laurus nobilis* (laurel) is recorded at Megiddo in both the LB II and Iron II. The species is used throughout the Mediterranean region for its aromatic and culinary properties (Zohary 1966: 190; Dias *et al.* 2014), and has been commonly employed since ancient times as a remedy for gastrointestinal problems (Palevitch *et al.* 1986; Said *et al.* 2002; Mabberley 2008: 471; Dias *et al.* 2014). In later periods the plant was considered sacred, most notably by the Greeks and Romans, who adorned their heroes and emperors with crowns made from laurel wreaths (Zohary 1982: 120). At Megiddo, laurel could have been grown in a garden and used for medicinal purposes. Perhaps laurel branches were brought to the site from nearby Mount Carmel, where the species thrives naturally (Danim 2004: 72).

Remains of *Salvia fruticosa* (three-leaved sage), an aromatic sage shrub, were found in a Middle Bronze Age layer in Area K. This particular sage plant has a longstanding tradition of numerous symbolic and medicinal uses (e.g., Feinbrun-Dothan 1978: 135; Yaniv, Dafni and Palevitch 1982; Rivera, Obón and Cano 1994; Ali-Shatyeh *et al.* 2008).
The appearance of the three-leaved sage may reflect domestic horticulture in or around the site. While its cultivation does not necessarily require a high degree of technical skill, understanding its many uses would require a certain degree of ethnobotanical knowledge. Palynological evidence derived from a cess pit in Area H suggests the consumption of sage at the site in the 14th century BCE (Langgut et al. 2016). It is also possible that sage was cultivated for ornamental purposes at this time, as it was in the Early Roman period in Herod the Great’s royal gardens in Caesarea (Langgut, Gleason and Burrell 2015). Of course, it is entirely feasible that the plant was also procured from the wild and brought into the city.

The appearance in the Iron II of the prestigious cedar of Lebanon (Cedrus libani) and the Mediterranean elm (Ulmus canescens) (Fig. 5c–d) is again exclusive to Area H, while the rare and robust oriental plane (Platanus orientalis) (Fig. 5h) appears solely in Area Q. The presence of relatively rare species (though native to the region), such as the plane and the elm, in the south Levantine charcoal assemblages could indicate intentional inclusion in the city for recreational/aesthetic purposes (e.g., Zohary 1973: 377; Meiggs 1982: 272–277; Gale and Cutler 2000: 180). Indeed, during the Roman period, there is evidence from one of Herod the Great’s royal gardens that plane trees were planted for ornamental purposes; they were shade trees that could provide much greenery to elite gardens (Jashemski, Meyer and Ricciardi 2002: 145–146). The presence of the three aforementioned species could likewise reflect the existence of crafted items, as their timber was of value in antiquity (Meiggs 1982: 426, 445; Liphschitz and Biger 1991; Gale and Cutler 2000: 264).

Given C. libani’s high quality, pleasant aroma and durability, it was one of the most coveted and expensive timbers of the Ancient Near East (Lev-Yadun, Liphschitz and Waisel 1983; Liphschitz and Biger 1991; Lev-Yadun 1992). Although not native to Israel, the species is common in many assemblages of the Bronze and Iron Ages (Liphschitz 2007). Generally, the presence of C. libani in ancient times is related to monumental architecture, a fact evidenced by its occurrence in the Late Bronze Age palace and temple of Lachish (Liphschitz 2004: 2240) and within the recycled beams of the al-Aqsa Mosque in Jerusalem (Lev-Yadun, Liphschitz and Waisel 1983; Lev-Yadun 1992). Commerce of cedar during the Iron Age is alluded to in the biblical accounts of 1 Kings 5:15–25, 6:18 and 9:11, in which Hiram, King of Tyre is said to have traded cedars with King Solomon.

Possible uses for the species encountered at Megiddo

Construction

Some of the most important timber species used for construction in the eastern Mediterranean include the oak species, Italian cypress, Aleppo pine and cedar of Lebanon (Meiggs 1982; Liphschitz and Biger 1991; Gale and Cutler 2000; Liphschitz 2007: 122–129). Because of their relatively long and resilient logs, they would have been the most practical material for large scale construction, specifically for roofing, beams, posts

5 Ulmus canescens was also identified in LB I and LB III layers in Area H.
and frames (Gale and Cutler 2000). Particularly, Italian cypress and Aleppo pine would have been the most appropriate of the local timber sources in the area around Megiddo; these native trees could provide both the straightest and longest logs. It is evident from the Megiddo assemblage that the aforementioned conifers were so coveted for uses in construction that as early as the Early Bronze Age there was already partial deforestation of the natural environment in the vicinity of the site.

When it comes to lesser construction endeavours and crafts, the above-mentioned species alongside wood from *O. europaea* (olive), *P. palaestina* (terebinth), *C. siliquastrum* (Judas tree), *Tamarix* spp. (tamarisk), *U. canescens* (Mediterranean elm), *P. orientalis* (oriental plane) and *P. euphratica* (Euphrates poplar) would have likewise provided excellent raw materials (Zohary 1972; Liphschitz and Biger 1991; Gale and Cutler 2000; Musselman 2007).

**Fuel**

While it is certain that eventually most wood, regardless of its original intended use, would have been burned, there are species whose biological qualities would have made them preferred fuel sources. At the very top of the list is olive wood. Given the high frequency at the site, it was likely one of the most important fuel sources for the inhabitants. The use of olive wood as a fuel source most probably derived from olive orchard waste, primarily from regular maintenance activities such as branch pruning, which was and still is commonplace in olive orchards (Zinger 1985; Langgut et al. 2019; Roth, Gadot and Langgut in press). Since olive trees typically produce fruit solely on young branches about one year of age, pruning of old branches is an important and standard practice (Zinger 1985). It stands to reason that after pruning, the branch trimmings would have been removed from the orchard in order to prevent the spreading of pests and fungi onto the healthy trees. The refuse would have served as an ideal fuel source since olive wood possesses a high density (0.75–0.96 cu cm), which makes it one of the higher-quality fuel sources in the Levant (Engel and Frey 1996: 191; Crivellaro and Schweingruber 2013: 434). In addition to olive, deteriorated or otherwise unsuitable oak wood for handiwork (e.g., dead branches, decommissioned wood, craft refuse, trimmings) would have provided excellent firewood, given the *Quercus* genus wood’s characteristic high density and high calorific values (Meiggs 1982: 206; Gale and Cutler 2000: 205). The wood of *Tamarix* spp. could have provided an additional practical fuel material, albeit of a much lower quality (Gale and Cutler 2000: 25; Cavanagh 2016).

**Consumption**

This category can be sub-divided into the edible and medicinal groups, with many species forming part of both. Beginning with the edible category, obvious fruit producing species which could have been consumed by the inhabitants of Megiddo during the Bronze and Iron Ages include olive, azarole, Persian walnut, almond, jujube, carob, myrtle, terebinth, grape and sycamore fig. Additionally, although typically not used for their fruit, various other parts from species such as laurel and sage are often employed in culinary endeavours (Rivera, Obón and Cano 1994; Dias et al. 2014).
Regarding medicinal uses, ethnobotanical studies have demonstrated that the natural pharmacopeia of the southern Levant is so extensive that nearly every species encountered in the Megiddo assemblage has some form of attested use in local folk healing traditions (Palevitch et al. 1986; Ali-Shatyeh, Yaniv and Mahajna 2000; Said et al. 2002; Yaniv and Dudai 2014). In this regard, some of the more utilitarian examples of wild species being used as folk remedies include sage, laurel, azarole, myrtle, storax, jujube, mastic, Aleppo pine, kermes oak and Mt. Tabor oak (e.g., Vardar and Oflas 1973; Palevitch et al. 1986; Ali-Shatyeh, Yaniv and Mahajna 2000; Özkan and Güray 2009; Yaniv and Dudai 2014). While we cannot assume that folk healing traditions today are comparable to those of the Bronze and Iron Ages, it is possible that some of the therapeutic benefits from a number of the species discussed would have been well-known to the ancient people.

Summary

Looking at the finds diachronically, we were able to determine certain trends regarding the site and its environment. The Early Bronze Age, with its high ratios of both conifers (Italian cypress and Aleppo pine) and common arboreal broad-leaf species (kermes oak, Mt. Tabor oak and terebinth), portrays a situation prior to the main impact of humans on the landscape. With time, the proportion of these arboreal species falls notably, indicating a lesser availability in the environs of the site. In parallel, the assemblage is gradually supplemented by higher ratios of olive trees which could serve in part the same purposes. By the Iron II, the proportion of the common wild tree species appears at nearly half of the values of what they showed during the Early Bronze Age. These data illustrate the gradual decline of the natural forest/maquis following the impact of centuries of human activity, likely resulting in a stronger reliance on anthropogenic species.

The olive—the most ubiquitous of the species in the assemblage—appears in high values (almost half of the assemblage) as early as the Early Bronze Age; its ratios progressively increase to reach a zenith in the Iron I, when the species accounts for more than three-quarters of the identified wood charcoals. This indicates the rising importance of the olive and its products in the economy of the inhabitants, possibly reflecting growing organization and development of intensive trade relations over time. The high proportion of olive wood shows that the immediate vicinity of the site must have been characterised by a significant distribution of olive orchards as early as the late fourth millennium BCE (EB I). Archaeology (especially in the Samaria highland; see Finkelstein and Gophna 1993) and pollen investigation in the Sea of Galilee (Baruch 1986; Langgut, Adams and Finkelstein 2016) demonstrate the same trend.

Noteworthy is the synchronous appearance of the two nut species. Both A. communis (almond) and the rarer J. regia (Persian walnut) appear for the first time during the Middle Bronze Age, suggesting dissemination of knowledge from elsewhere in the Near East and indicating the beginnings of significant nut horticulture in the southern Levant; from this period onward both species appear almost consistently.
The dendroarchaeological material point to certain socio-cultural peculiarities at the site. Most notably the presence of prestigious and special species such as *C. libani* (cedar of Lebanon), *M. communis* (myrtle) and *Ulmus canescens* (Mediterranean elm) in Area H reflect the elite status of the inhabitants near the palace.

Lastly, the presence of *M. communis*, *S. fruticosa* and *L. nobilis* (myrtle, sage and laurel, respectively) in the assemblage, although in relatively low ratios, is indicative of the probability that all three were cultivated inside the town. The cultivation served primarily as a means of procuring immediate access for the medicinal and culinary uses of the plants, as well as for their ornamental qualities and pleasant aromas.

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