Vegetation and Climate of Megiddo and Its Surroundings during the Bronze and Iron Ages

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A view from Megiddo to the Jezreel Valley and Mount Tabor. Photograph by Israel Finkelstein.

This survey article presents a broad overview of the vegetational and environmental history of Tel Megiddo and its environs during the Bronze and Iron Ages (ca. 3600–600 BCE). The site was a prominent Canaanite city-state during the Bronze Age and later a royal city in the kingdom of Israel during parts of the Iron Age. Its importance was due mainly to its strategic location, guarding and serving the ancient trade route that connected Egypt and Mesopotamia. The extensive study of ceramic assemblages (e.g., Martin 2013; Arie 2013), together with the production of a robust radiocarbon dating program (e.g., Regev et al. 2014; Toffolo et al. 2014), enabled the establishment of a reliable chronological framework for the site. Historical records, including the archives of Egypt and Assyria and biblical texts, have further supported the development of a secure chronology (Ben-Dor Evian and Finkelstein 2023). A century of extensive excavations by four archaeological expeditions exposing the site's continuous habitation and the establishment of a robust chronology have made Tel Megiddo an invaluable resource for studying diachronic processes. Despite this, the archaeobotanical remains were not synthesized.[1] *Accordingly, the purpose of this review article is to reconstruct the vegetation of Tel Megiddo and its environs, focusing on the use of plants by its residents.*

The archaeobotanical assemblage of Tel Megiddo renders a large body of data from both domestic and palatial quarters, covering all phases of the Bronze and Iron Ages. The macrobotanical remains (wood, seed, and fruit remains) are characterized by a relatively good state of preservation (Liphschitz 2000, 2006, 2013; Borojevic 2006; Benzaquen, Finkelstein, and Langgut 2019; Ahola 2023). Microbotanical remains were also present at the site in some specific contexts (pollen: Langgut et al. 2016; and Weinstein-Evron, Bratenkov, and Rosenberg 2022; residue analysis: Linares et al. 2019). This article synthesizes these macro- and microbotanical remains collected over the years from excavations at Tel Megiddo to provide insights into the use of plants for construction, woodworking, fuel, medicinal, and ritual purposes. It also sheds light on horticultural practices, plant dietary habits, social status, and evidence of long-distance trade. Given the scarcity of continuous, high-resolution paleoclimate records from Tel Megiddo or its immediate surroundings, paleoclimate records from other nearby locations within the Mediterranean climate zone were used to provide a detailed reconstruction of the environmental and climatic conditions (Langgut and Finkelstein 2023, and references therein).

Geographical Settings of Tel Megiddo

Megiddo is situated in the western Jezreel Valley. The region experiences a typical eastern Mediterranean climate, receiving between five hundred and six hundred millimeters of

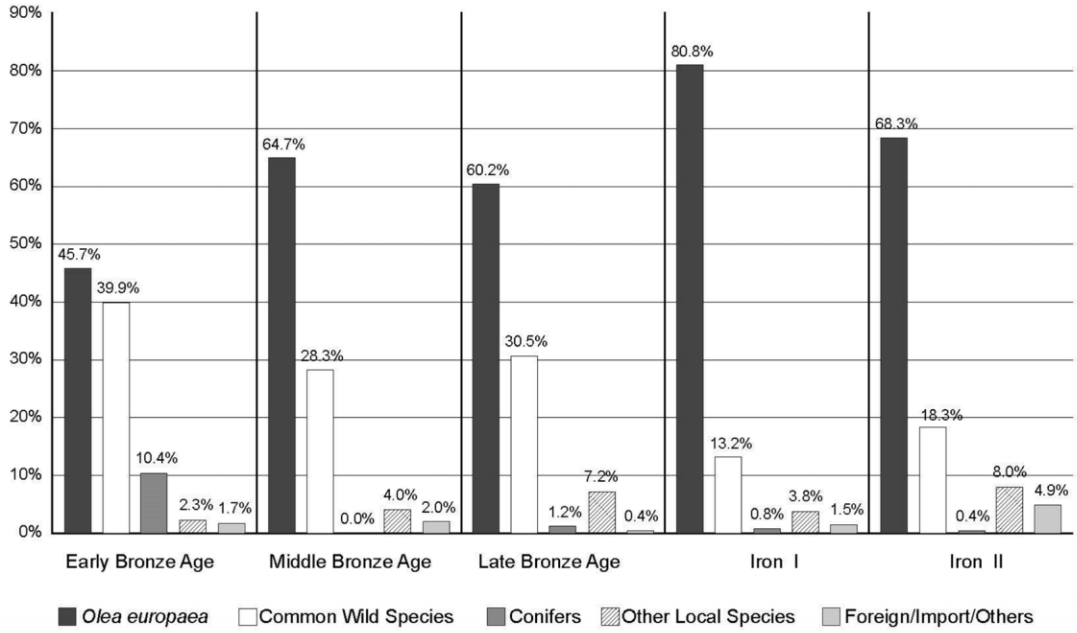

Figure 1. Relative frequencies of tree taxa categories from Tel Megiddo charcoal assemblages. "Common Wild Species" pertains to the combined percentages of kermes oak, Mt. Tabor oak, boissier oak, oak species, terebinth, Pistacia species, and azarole. "Conifers" refers to the combined percentages of the most common native conifer trees in Israel, namely Italian cypress and Aleppo pine. "Other Local Species" include the combined percentages of the remainder, less prevalent local flora in the assemblage. "Foreign/Import" presents the combined percentages of the nonnative cedar of Lebanon, the introduced sycamore fig, and the tamarisk, which most probably originated in a saline/wetland habitat. Early Bronze Age, n=173; Middle Bronze Age, n=99; Late Bronze Age, n=249; Iron Age I, n=395; Iron Age II, n=246. From Benzaquen, Finkelstein, and Langgut 2019: fig. 4

precipitation annually, mostly during winter and spring, with hot and dry summers. The hilly area to the west features light rendzina soils, which gradually mix with the heavy, clay-rich grumusols of the valley. Most of the natural Mediterranean woody vegetation in the valley has long since disappeared (Lev-Yadun and Weinstein-Evron 2002; Schaffer and Levin 2014), as was the case in other nearby regions (Lev-Yadun 1997; Marston 2015). However, remnants of forest and maquis dominated by kermes oak (*Quercus calliprinos*) still persist in the hilly region southwest of the site (Zohary 1962). If well maintained, the Jezreel Valley, with its plane topography and deep soil, makes for prime agricultural land. In periods of neglect (e.g., recent history, until the early twentieth century), seasonal marshes were common; this changed with modern drainage projects that maximized agricultural exploitation of the valley (Singer 2007: 147–49; Benzaquen, Finkelstein, and Langgut 2019).

Figure 2. An open platter with charred wood remains and animal bones found in Middle Bronze Age III Tomb 16/H/50. Photograph taken by Robert S. Homsher.

The Natural Environment and Arboriculture Surrounding Megiddo

As expected, the charcoal assemblages recovered from Tel Megiddo during the excavations of 1992–2022 indicate a natural Mediterranean woodland composed mainly of oak and pistachio species (fig. 1; Benzaquen, Finkelstein, and Langgut 2019; Ahola 2023). The olive (*Olea europaea*) dominates the assemblages; it is assumed that most olive remains came from nearby orchards since olive trees make only a minor component of the natural Mediterranean forest/maquis of the southern Levant, as documented by palynological records from the Pleistocene and Early Holocene (Langgut et al. 2019, and references therein).

It seems that, beginning in the Early Bronze Age, the arboreal natural environs of Megiddo were gradually degraded (fig. 1; Benzaquen, Finkelstein, and Langgut 2019). The data demonstrate a particularly dramatic decrease in the local conifer species, the Italian cypress (*Cupressus sempervirens*) and the Aleppo pine (*Pinus halepensis*). This decline likely resulted from overexploitation of these trees, primarily for construction purposes. The percentages of common wild arboreal species—such as kermes oak (*Quercus calliprinos*), Mt. Tabor oak (*Quercus ithaburensis*), Boissier oak (*Quercus boissieri*), pistachio (*Pistacia* spp.), and

azarole (*Crataegus* spp.)—also decrease over time, albeit more gradually (fig. 1). A noticeable increase in taxonomic diversity is seen in the later periods (Iron Age I–II), in the presence (and higher percentages) of species such as the Syrian maple (*Acer syriacum*), Judas tree (*Cercis siliquastrum*), Palestine buckthorn (*Rhamnus palaestinus*), tamarisk (*Tamarix* spp.), and Euphrates poplar (*Populus euphratica*). The inhabitants of Megiddo may have used these less suitable trees for construction and carpentry when there was a shortage of previously common and preferred timber species (Zohary 1962; Gale and Cutler 2000: 219, 251; Benzaquen, Finkelstein, and Langgut 2019). The paleogeomorphological study conducted in the Megiddo environs confirms that during the Early Bronze Age, the nearby hillslope soils were stabilized by a Mediterranean woodland that was eroded in later periods due to a combination of somewhat drier climate conditions and deforestation (Rosen 2006).

Wood remains of fruit trees recovered from archaeological sites are considered a good marker for horticulture (e.g., Lev-Yadun 2007; Weiss 2015; Deckers et al. 2024). It is clear from the charcoal assemblages of Megiddo that olive trees dominated its horticultural landscape during the Bronze and Iron Ages (45 to 80 percent; fig. 1). They reached a peak during the Iron Age I, when olive horticultural activities dramatically increased throughout the southern Levant (Langgut et al. 2015). Other fruit trees, such as carob (*Ceratonia siliqua*),[2] Persian walnut (*Juglans regia*), grape (*Vitis* spp.), and almond (*Amygdalus communis*), may also have been cultivated in orchards near Megiddo, yet to a much lesser extent than olive trees. The high frequency of olive trees is most probably related to the common practice of pruning, which is required in order to increase their fruit yield (Zinger 1985: 94–95). This pruned olive tree material was most probably the significant woody fuel source of Megiddo's inhabitants.

Figure 3. The yellowish fibrous feature uncovered in a Late Bronze layer in Area H, identified as a cess deposit. Photograph by Adam Prins.

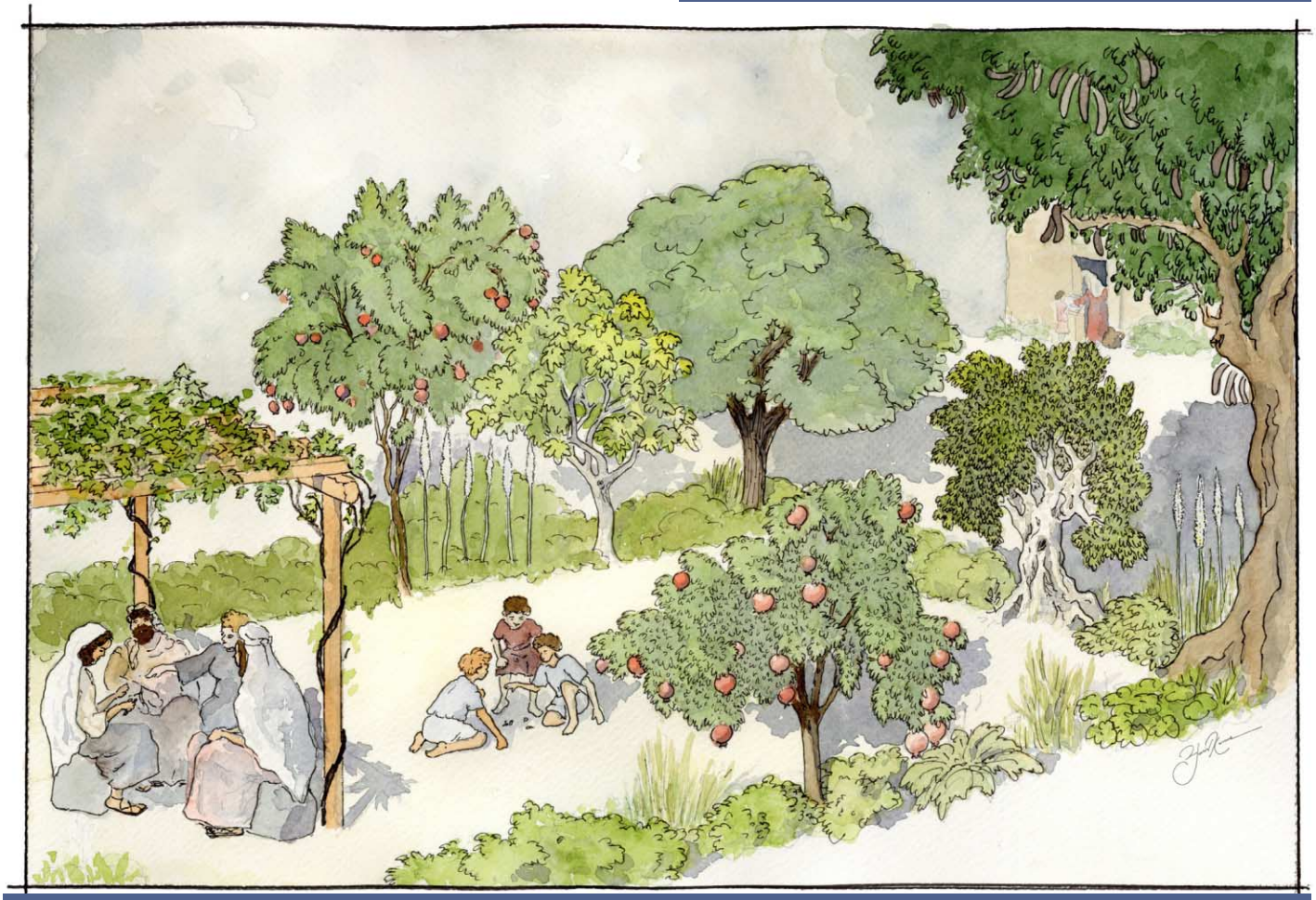

Figure 4. A suggested reconstruction of a home garden (*bustan*) based on the charred wood assemblage recovered from Area K. Drawing by Y. Korman.

Plant Use at Tel Megiddo

Construction and Carpentry Crafts

Some of the most significant timber used for construction in the eastern Mediterranean include oak species, Italian cypress, Aleppo pine, and cedar of Lebanon (*Cedrus libani*; Gale and Cutler 2000; Liphschitz 2007: 122–29). Due to their long, durable logs, these trees were ideal for large-scale construction, particularly for roofing, beams, posts, and frames (Gale and Cutler 2000). Italian cypress and Aleppo pine, in particular, were the most suitable local timber sources around Megiddo, as they provided the straightest and longest logs, were easy to work with, and were highly resistant to insects and fungi (Lev-Yadun and Weinstein-Evron 2002). The Megiddo charcoal assemblage suggests that these conifers were so highly valued for construction purposes that by the Early Bronze Age, the area's natural environment was already experiencing partial deforestation (fig. 1).

All the arboreal taxa recovered from Megiddo are native to the region with two exceptions: the sycamore fig (*Ficus sycomorus*) and the cedar of Lebanon (*Cedrus libani)*. The latter was regarded as a prestigious timber, prized for its straight beams, durability, and pleasant aroma. Consequently, it was typically reserved for monumental architecture, as demonstrated by evidence from other sites in the southern Levant (Lev-Yadun 1992; Lev-Yadun et al. 1996; Liphschitz 2007: 116–17; Roth, Gadot, and Langgut 2019). It is not surprising, therefore, that it was found only in Area H, the elite sector of Megiddo during most of the periods under discussion, given its proximity to the palace and the gate (Arie 2006, 2013; Sapir-Hen et al. 2016). Commerce of this high-quality timber during the Iron Age is alluded to in biblical accounts (1 Kgs 5:15–25; 6:18; 9:11), in which Hiram, king of Tyre, traded cedars with King Solomon. Sycamore fig was probably introduced to Canaan from Egypt, starting in the Late Bronze Age (Liphschitz 2007: 114; Jin, Lipschitz, and Langgut 2024). When it comes to lesser construction endeavors and crafts, wood from trees such as olive, pistachio, and tamarisk would likewise have provided good raw materials (Gale and Cutler 2000).

Plant Diet

The suggested plant diet of Megiddo's inhabitants is mainly based on macrobotanical remains recovered from the Bronze and Iron Age layers across the site, collected by hand picking, dry sifting, and flotation. While wood remains and pollen may indicate plants grown in the neighborhoods of the site, in the case of seed and fruit remains, the possibility of trade should also be taken into consideration. The researchers who studied the macrobotanical assemblages (Borojevic 2006; Liphschitz 2000, 2013) describe a typical Mediterranean diet composed of cereals (both wheat and barley), pulses (legumes including lens), and fruit (mainly olive, fig, grape, almonds, and dates). This information is at least partially confirmed by other archaeobotanical proxies from Tel Megiddo (pollen and charcoal remains). Similar seed assemblages were also recovered from other contemporaneous south Levantine sites (e.g., Weiss and Kislev 2004; Frumin and Weiss 2018; Nicolì et al. 2022).

Fuel

Charcoal recovered from ordinary archaeological occupation layers often represents the remnants of ancient fuel use (Miller and Marston 2012). Likewise, most wood ends up as fuel materials regardless of its primary use (Asouti and Hather 2001). The high proportion of olive wood in the charcoal assemblages of Tel Megiddo suggests that it was the major fuel source for the site's inhabitants. Olive tree waste was probably put aside for fuel during the regular maintenance of olive orchards, particularly during branch pruning, a practice that remains common today (Bati et al. 2012). When trees were young, pruning shaped them for easier harvesting. In later years, pruning improved yield and maintained tree health by enhancing sunlight penetration for better photosynthesis and increasing fruit production in well-lit areas. It also promoted air circulation, reduced humidity and pests, and encouraged new branch growth, where most flowers and fruit are formed. Additionally, pruning helped manage the phenomenon of alternate-year bearing. Pruned branches must be cleared from orchards to prevent the spread of pests and fungi (Zinger 1985: 94–95; Bati et al. 2012). This waste was most probably ideal for fuel for Megiddo's inhabitants since it was easy to access, and its high density made it one of the best fuel sources in the Levant (Benzaquen, Finkelstein, and Langgut 2019). The use of olive pruning refuse for fuel was also suggested for other Bronze and Iron Age south Levantine sites (e.g., Liphschitz 2007; Jin, Lipschits, and Langgut 2024; Mor, Greenberg, and Langgut in press).

In addition to olive wood, oak that was considered unsuitable for crafting—such as dead branches, discarded materials, or trimmings—but with a high density—would also have been excellent fuel (Gale and Cutler 2000: 205). Tamarisk wood, though of lower quality, would have been a practical alternative (Gale and Cutler 2000: 25). A microarchaeological study on Iron Age ashes from Megiddo supports the conclusion that wood was the primary fuel at the site, with dung playing only a minor role (Gur-Arieh et al. 2014).

Cultic Use

Certain archaeological contexts can also shed light on the use of plants for cultic and ritual purposes (e.g., Ramsay and Perry 2022). At Tel Megiddo, this is best represented by the detailed archaeobotanical analyses of the finds from Tomb 16/H/50 in Area H, an elite, monumental masonry-constructed chamber tomb dating to the MBA III (fig. 2; Adams, Cradic, and Finkelstein 2025: 407). While pollen was not preserved and seeds and phytolith analyses did not yield unexpected results (Adams, Cradic, and Finkelstein 2025: 413), wood charcoal remnants and residue analyses illuminate the use of plants in second-millennium BCE funerary practices. The charcoal assemblage consists of native woody plants and is characterized by a relatively high species variety. Common trees, such as olive, appear alongside rarely

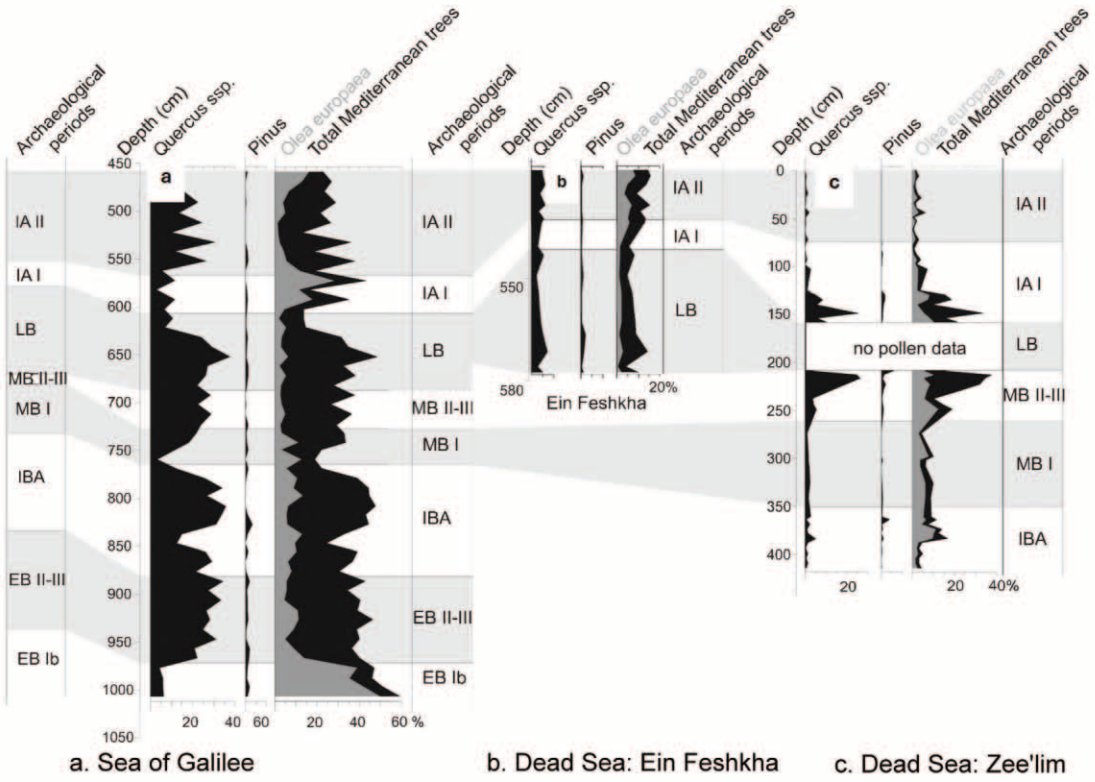

Figure 5. Main pollen curves of south Levantine palynological records covering most of the Bronze and Iron Ages (ca. 3100–500 BCE), recovered from the Sea of Galilee and the Dead Sea (Ein Feshkha and the Ze'elim Gully). Four main pollen curves are given: *Quercus* (oak), *Pinus halepensis* (pine), *Olea europaea* (olive), and total tree pollen of the Mediterranean maquis/forest. Modified after Langgut et al. 2015: fig. 4.

present woody plants, such as Syrian pear (*Pyrus syriaca*), common fig (*Ficus carica*), grapevine (*Vitis*), true myrtle (*Myrtus*), styrax (*Storax* spp.), and bay laurel (*Laurus nobilis*). The latter three have aromatic properties and may have been burned as a form of incense to cover the scents of decay or to evoke a particular sensory ritual (Benzaquen and Langgut 2025: 341–54). Interestingly, the remains of olive and true myrtle were also found at another south Levantine Middle Bronze Age tomb (Kisilevitz et al. 2017). The notion that plants were involved in funerary practices is supported by the presence of organic residue of vanilla extracted from several ceramic juglets that had been used as containers for offerings. This marks the first appearance of vanilla in the southern Levant. The vanilla was identified along with the residue of olive oil and other biomarkers (Linares et al. 2019). The vanilla compound may have been used as a rare aromatic or flavoring additive to oils, to fulfill functions such as embalming and fumigation during the funerary ritual (Linares et al. 2019). These archaeobotanical results illuminate the specific sensory environments and the resources used in mortuary settings of elite groups in Canaan during the Middle Bronze Age, indicating the involvement of both local and imported ritualized plants.

Medicinal Use of Plants

Ethnobotanical studies have shown that many plant species found in the Megiddo macro- and microbotanical assemblages may have been used in local folk medicine. A unique palynological spectrum from a cess deposit in a Late Bronze Age layer in Area H offers new insights into this complex subject (fig. 3). The pollen evidence indicates that several plants with medicinal qualities were likely used to prepare herbal teas. These include wormwood (*Artemisia* spp.), chamomile (*Matricaria chamomilla* type), Mormon tea (*Ephedra* spp.), nettle (*Urtica* spp.), mint (*Mentha* spp.), sage (*Salvia* spp.), and true myrtle (Langgut et al. 2016). Charred wood remains of true myrtle and sage were found at Megiddo across different periods (Benzaquen, Finkelstein, and Langgut 2019).

Home Gardens (*bustan*)

A unique variety of wood remains of fruit trees was recovered in MBA I–II levels in Area K (Ahola 2023). The assemblage was composed of olive, carob, grape, common fig, and pomegranate (*Punica granatum*). Wood remains from the latter three were discovered at Tel Megiddo exclusively within these contexts. Area K served as a domestic section of the settlement (Gadot and Yasur-Landau 2006), in contrast to Area H, which housed the wealthier segment of the population (Arie 2006, 2013). It is therefore possible to suggest that the above-listed fruit trees represent the remnant of a home garden (*bustan*). A *bustan* is an agricultural garden composed of mixed fruit trees and herbal spices. This form of a family garden probably originated in the Near East.[3] In addition to its economic value, it was also used for family gatherings, providing shade, color, and a calming atmosphere (fig. 4).

This garden could have been located on the eastern slope of the mound, below Area K.

The Environment and Climate History of Tel Megiddo's Surroundings

The Jezreel Valley receives most of its precipitation from a climate system that originates in the Mediterranean Sea (the Cyprus Low). There is no long consecutive paleoclimate archive for Tel Megiddo or the Jezreel Valley, therefore, paleoclimate records that were recovered from other areas in the southern Levant, which are influenced by the same Mediterranean climate system, are used here to illuminate the climate history of the site and its surrounding areas. This includes the following high-resolution consecutive profiles: palynological records from the Sea of Galilee and the Dead Sea (Langgut et al. 2015), the isotopic record of the Soreq Cave (Laugmer 2017), the Dead Sea Lake level reconstruction (Kagan et al. 2015), and geoarchaeological investigation (Rosen 2006).

The well-dated high-resolution pollen records show that the EBA IB was characterized by relatively humid climate conditions, until about 3000 BCE (fig. 5). Though a slight reduction in the arboreal pollen percentages was documented during the EBA II–III (ca. 3000–2500 BCE), the region was still typified by relatively high moisture (fig. 5). The Intermediate Bronze Age (ca. 2500–2000 BCE) was also characterized by a comparatively wet climate. Drier climate conditions prevailed starting in about 2100 BCE and through the beginning of the MBA I, while the MBA II–III and much of the Late Bronze Age once again enjoyed a wetter climate (ca. 1750–1250 BCE; fig. 5). The period of about 1250–1100 BCE was identified as the driest period during the entire Bronze and Iron Ages, and was suggested as the prime mover behind the collapse of eastern Mediterranean empires at the end of the Late Bronze Age (Langgut, Finkelstein, and Litt 2013; Kaniewski, Guiot, and Van Campo 2015). An increase in arboreal percentages was documented between about 1100–750 BCE, which covers most of the Iron Age I (ca. 1150–950 BCE) and the Iron Age IIA (ca. 950–780 BCE), representing humid climate after the severe period of dryness. During the Iron Age IIC (ca. 780–600 BCE) the region experienced moderate climate conditions (fig 5; Langgut et al. 2015).

A recent well-dated, high-resolution, isotopic analysis, which examines the oxygen ($\delta^{18}O$) and carbon ($\delta^{13}C$) values within the Soreq Cave speleothems (Laugomer 2017), reveals similar trends to those observed in the palynological studies. This is also the case with the reconstruction of the Dead Sea lake levels (Kagan et al. 2015). Slight variations may result from different dating methods and sampling resolutions of the paleoenvironmental records (detailed in Langgut and Finkelstein 2023). Based on the regional history of the alluvial deposits in the vicinity of Megiddo, it was suggested that from the beginning of the Middle Bronze Age through the Late Bronze and Early Iron Ages, climatic conditions were slightly drier in comparison to the humid climate conditions that characterized the Early Bronze Age. Rosen (2006) also proposed a more even pattern of rainy days over the rainy season during the Early Bronze Age (in comparison to the following periods) than rain falling in sudden torrents, as is the situation in the region today. A similar suggestion regarding rain distribution was raised based on the pollen evidence (Langgut and Finkelstein 2023). The paleogeomorphological study conducted in the Megiddo environs shows that during the humid climate conditions of the Early Bronze Age, the site was surrounded on three sides by small streams and backwater marshes, which would have provided a defensive advantage. During these moist climate conditions, the landscape of the valley was covered by a rich, well-watered agricultural landscape. It became eroded at some time between the second millennium BCE and the classical periods (Rosen 2006).

Special attention should be given to the economic and ecological situation toward the end of the Late Bronze Age (ca. 1250–1100 BCE): parallel to the dramatic decrease in arboreal pollen in the entire region (both natural and human-made), indicating dry climate conditions (Langgut, Finkelstein, and Litt 2013; Kaniewski, Guiot, and Van Campo 2015), the Sea of Galilee palynological evidence shows relatively high percentages of cereals (Finkelstein et al. 2017). This suggests that the Egyptian administration in Canaan may have initiated the extension of dry farming in the valleys in order to stabilize the crisis in the southern and eastern fringe areas of the Levant and supply grain to areas in the northern Near East that were badly affected by the dry climate event. The Sea of Galilee cereal pollen curve is supported by several lines of evidence from Tel Megiddo: (1) the zooarchaeological dataset that indicates an increase in cattle for the plow; (2) the rise in flint for cereal harvest; (3) ancient DNA evidence regarding the possible importation of Zebu cattle (well-adapted to dry, hot conditions) from Egypt (Finkelstein et al. 2017, and references therein).

Summary

Tel Megiddo, continuously inhabited during the Bronze and Iron Ages (ca. 3600–600 BCE), has become a rich repository of archaeological data, thanks to a century of intensive excavations conducted by four archaeological missions. Its meticulously preserved stratigraphic sequence and well-established chronology make it an ideal site for studying diachronic processes. This article presents, for the first time, the macro- and microbotanical archives recovered from Tel Megiddo over decades of excavation. A variety of environmental and archaeobotanical methods were employed, including palynology (both on-site and off-site), paleogeomorphology, dendroarchaeology, identification of seeds and fruit remains, residue analysis of ceramic vessels, and more. These proxies have provided insights into the environmental and climatic conditions during the site's occupation, while also revealing the human impact on the surrounding natural landscape. Additionally, the botanical archive shed light on the plant-based diet of Megiddo's inhabitants and their use of plants for purposes such as construction, fuel, ritual practices, and medicine.

The botanical archive from Megiddo, spanning the Bronze and Iron Ages, highlights that those economic and cultural trends (e.g., horticultural activities and long-distance trade), were shaped by a complex interplay of factors. These trends

cannot be attributed to a single cause, such as climate change or variations in sociopolitical structures, but rather to the combined influence of multiple factors, as recent studies in other parts of the region have also demonstrated (Rosenzweig and Marston 2018; Marston 2021; Finkelstein, Gadot, and Langgut 2022; Langgut and Finkelstein 2023).

Notes

1. This archaeobotanical synthesis was written for this special issue of *Near Eastern Archaeology* celebrating the one hundredth anniversary of expeditions in Megiddo.

2. The domestication history of the carob tree (*Ceratonia siliqua*) has been a subject of debate. While earlier studies suggested late domestication in Roman times due to grafting requirements (Zohary 2002), recent research challenges this view. Genetic analyses reveal multiple domestication origins across the Mediterranean, with locally selected wild genotypes and some long-distance dispersals by humans (Baumel et al. 2022).

3. The word *bustan* is originally from Persian. It probably penetrated Hebrew via Classical Arabic.

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