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An Ecological Comparison of Two Abandoned Heritage Orchards in Northern Israel

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Abstract: In this study, we documented two relict traditional Palestinian orchards; one was abandoned following the 1948 war when the farmers were exiled to Lebanon and the second was tended by farmers up until the early 1970s. The orchards examined are located in two different Mediterranean phytogeographic regions, one in the hilly Upper Galilee and the other on the slopes of Mount Carmel in the hinterland of the Mediterranean coast. We found differences in the species composition and spatial layout of trees in each orchard which followed the dictates of the geographic settings, demonstrating the farmer's knowledge of their environment. We discuss the importance of these orchards as part of the heritage horticultural systems of the region and explore possible measures that can be taken to preserve this unique historical arboricultural landscape and ways to empower local, traditional knowledge in promoting awareness for the conservation and preservation of heritage horticulture.

Keywords: fruit trees; arboricultural diversity; Upper Galilee; Mount Carmel; agricultural sustainability; veteran tree; traditional knowledge

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1. Introduction

> "There are comparatively few significant inefficiencies in the allocation of factors of production in traditional agriculture". ([1], p. 37)

Millennia of anthropogenic intervention have shaped the present-day landscape of Israel [2]. This is conspicuously evident in the history of fruit–crop horticulture, with the domestication of the founder group of Mediterranean fruit trees taking place in this region: olive (*Olea europaea*), date (*Phoenix dactylifera*), grape (*Vitis vinifera*), fig (*Ficus carica*), and pomegranate (*Punica granatum*) [3–5]. In subsequent Biblical and Classical periods, a broad variety of fruit tree species, originating from diverse biogeographic areas and including many that are propagated by grafting, were introduced and adopted locally. For example, cultivators introduced walnut (*Juglans regia*) from Persia and citrus fruit such as lime (*Citrus medica*) and lemon (*Citrus* × *limon*) from Southeast Asia and the Indian subcontinent [6,7]. Cultivation of a variety of fruit trees was an integral part of the landscape of Roman/Byzantine Palestine, with over 25 recorded varieties of fruit trees [8], with many species appearing for the first time in the region, e.g., pear (*Pyrus communis*), apple (*Malus*

domestica), peach (*Prunus persica*), quince (*Cydonia oblonga*), and pistachio (*Pistacia vera*) [3]. The Islamic "Green Revolution" [9] saw the introduction of additional fruit crops such as banana (*Musa* × *paradisiaca*) and bitter orange (*Citrus* × *aurantium*). An example of a more recently introduced fruit is the prickly pear (*Opuntia ficus-indica*), a symbolic fruit of Israel/Palestine, that originated in the Americas but dispersed into the Mediterranean region, including the Levant, via historic period trade routes and conquest [10,11].

Since at least Biblical times, fruit trees in the Holy Land were cultivated in 'mixed orchards' (e.g., *Leviticus* 19: 23; *Jeremiah* 29: 5, 28; *Amos* 9: 14) [12,13]. Mixed orchards, characterized by rich biological diversity became a fixture of Palestine's cultural landscape and abounded in the rural landscape of the ancient Near East, even in marginal arid environments like the Negev Desert [14–16]. The practice of cultivating mixed orchards continued into Ottoman and British Mandate times [17–20].

Following the 1948 war, over 400 Palestinian villages within Israel were depopulated and abandoned, village buildings were destroyed (some only after the war), and their lands were appropriated by the State of Israel [17,21,22]. Although untended since 1948, remnants of traditional fruit orchards, located in the immediate environs of many of these depopulated villages, still survive today [23]. These fruit orchards are termed in Arabic *basātin* (بَسَاتِينplural; and *bustān*بستان singular). Traditionally, they comprise a mix of fruit trees, sometimes alongside vegetable cultivation, and their produce is primarily meant for domestic consumption [24]. They differ from small gardens located immediately next to, or in, the courtyard of a house where vegetables are cultivated. These are known in Arabic *as ḥāakūra* (in Arabic, singular حاكورة; plural *ḥawākīr* حواكير), which are urban garden orchards, often within a walled space [25]. As noted by Mazzawi ([26] p. 1), "the classic *hakura,* was an essential and integral part of the home; it provided food and was a source of income in times of need". These garden–orchards differ markedly from the Late Ottoman and British Mandate mono-crop citrus tree plantations on the coastal plain, which was a large-scale enterprise geared toward a specialized economy of fruit for export ([27,28], p. 1).

In this paper, we focus on the diversity and spatial layout of traditional fruit tree crops in two abandoned *busātin* located in two different Mediterranean phytogeographic regions in northern Israel. The first *bustan*, located in the hilly Upper Galilee, is associated with the Palestinian village of Qadas and was abandoned in 1948 following the war, while the second orchard is in Wādī al-'Ein on the western slopes of Mount Carmel (in the hinterland of the Mediterranean coast) and was abandoned only in the 1970s when the population was forcibly relocated (Figure 1). We examine the range of tree species cultivated in each locality, as well as their spatial layout, against the local geographic characteristics of each region. This enables us to examine the arboricultural knowledge of traditional Palestinian farmers. One of the post-study goals of this scholarly inquiry is to promote active awareness of ancient landrace fruit trees and the conventions of heritage horticulture that supported their growth.

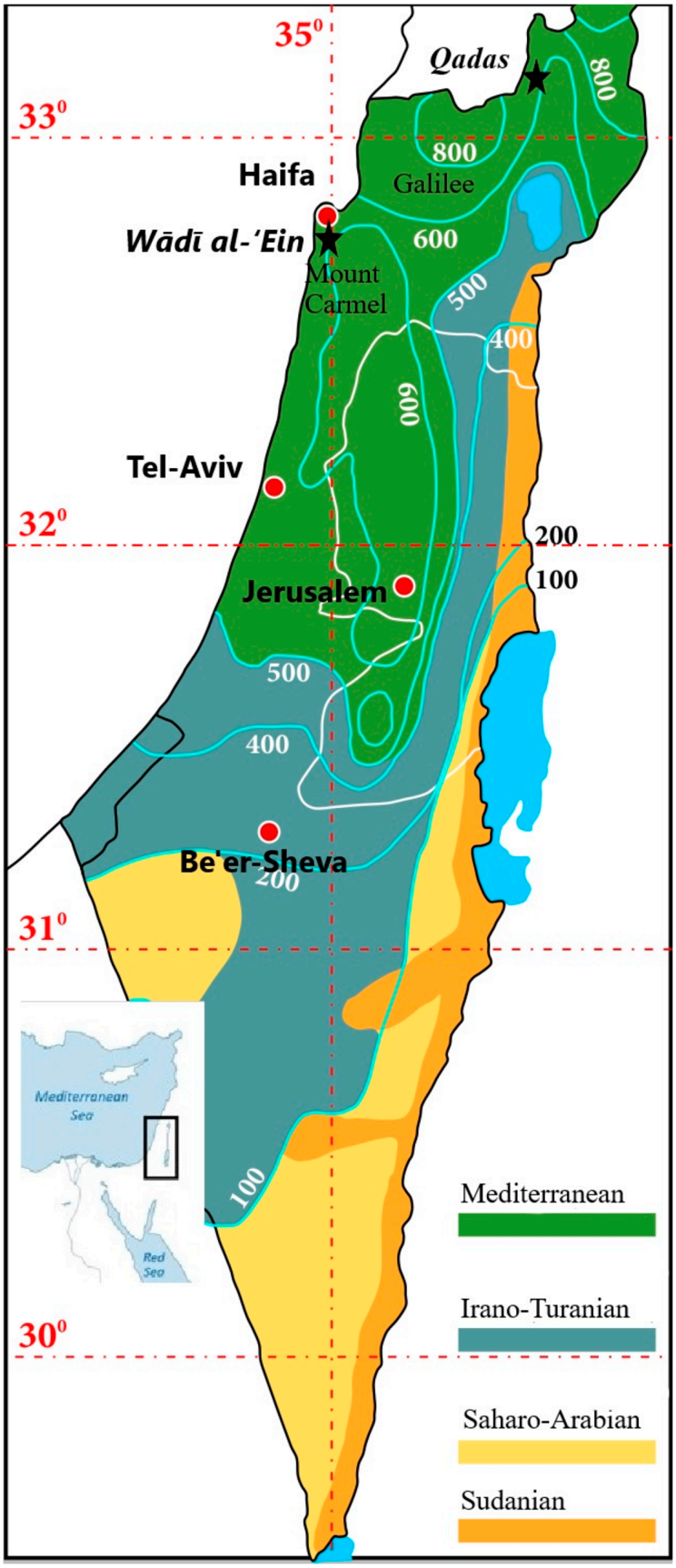


Figure 1. Location of Qadas and Wādī al-'Ein on a map showing phytogeographic regions and mean annual rainfall (mm) in Israel.

2. Survey Methods

The methodological workflow included the following steps:

1. Historical maps and aerial photos: In the initial stage, we compiled and georeferenced historical maps and aerial photos of both village orchards. These primarily consist of Cadastral and Topo-cadastral maps produced by the British Mandate authorities through the Palestine Survey (Scale 1:10,000, 1:20,000) [29]. The 1932 maps delineate each village's lands, plot names, and a general code for the main agricultural product grown on each plot (e.g., O for orchards, Ol for olive, V for vines, C for citrus, etc.).

The georeferencing process, conducted using ArcGIS Pro by Esri (version 3.2.1), aligned each map with the New Israel Grid (Israel TM Grid). This enabled us to generate work sheets for the field survey, incorporating both historical maps and recent satellite images at a scale of 1:2500 for use in the field, providing both orientation and mapping support.

2. Field survey: The field survey involved comprehensive pedestrian coverage of village lands, recording all the trees (cultivated and wild) within a 1 km radius from the center of the village. The location of each tree was precisely recorded using a portable GPS device (Garmin, with a maximum error of 4 m) and assigned a unique serial number. For each tree, we identified and registered the species. The trees were identified in the field by examining their morphological characteristics, including their bark, leaves, flowers, and fruits. Familiarity with the species played a significant role in the identification process. When there were doubts, photographs as well as leaves or fruit were taken from the field and checked against publications (such as [30,31]) as well as websites of floral databases, for example, "Flora of Israel and Adjacent Areas," created by Prof. Avinoam Danin and Dr. Ori Fragman-Sapir on behalf of The Jerusalem Botanical Gardens (https://flora.org.il/en/en/ accessed on numerous occasions November 2022 through September 2023). Terminology of Latin and common English names follow the website: https://powo.science.kew.org, accessed on 16 November 2024. Arabic names of trees were provided by Roy Marom. We measured the tree trunk circumference at breast height for a representative sample of trees of different species [32]. This provided some indication of their age, i.e., antiquity.

3. Interviews: We gathered a great deal of information about the role of plants in traditional local communities from Mahfuz El-Hatib, who oversees the olive groves, orchards, and ancient agriculture at the Ramat Hanadiv Nature Park and Garden, situated ca. 40 km south of the town of Haifa. His expertise includes traditional orchards that existed before 1948 and their significance in local culture at that time. The paper also makes indirect use of information gleaned from interviews carried out with former inhabitants of Tirat al-Karmel and Wādī al-'Ein in the context of Roy Marom's Palestinian Rural History Project (PRHP), an ongoing initiative documenting, preserving, studying, and publishing culturally and scientifically important information concerning Palestine's rural history and heritage. The interviewees, who cannot be named for ethical reasons, provided Marom with first-hand information about the development of the orchards in the Wadi and, most significantly, their continued cultivation and development post-1948 by al-Tira refugees who settled in the Wādī al-'Ein until they were displaced in the 1970s.

4. Mapping: We utilized the GPS readings of tree location and related data to construct a GIS layer, enabling the plotting of each tree's location in relation to the modern landscape. This assessment considered local topography, geology, soil type, and cultural remains. The database facilitated spatial queries, allowing us to create maps based on species and to overlay the present-day arboreal landscape with that of approximately 80 years ago, as reflected in the British Mandate mapping. Using GIS, we were also able to provide estimated measurements of tree-covered areas based on our field surveys, compared to

that shown in the Mandate period maps. We then compared all the parameters of the two orchards, assessing differences and similarities.

2.1. The Orchards

2.1.1. Qadas Village

The village of Qadas (Map Location: 33.111795/35.530080; Figure 1) is located in the humid Mediterranean phytogeographic zone of the Upper Galilee (Figure 1). The region receives an average annual precipitation of over 600 mm per year [33]. The village sits on top of a small hill at an altitude of 440 m above sea level, consisting of mainly chalk, clay, and marls from the Mishash, Ghareb, and Taqiye geological formations [34]. The soils in the region are mainly Terra Rossa, Rendzina, and Grumusols [35].

On either side of the small hill are shallow valleys with natural springs that are not active today. The area of the spring on the western side of the hill consists of chalk, clay, and marls from the Mishash, Ghareb, and Taqiye geological formations, but the location is in a flat area and only a few trees have survived in this location. In contrast, the spring on the eastern side of the hill, where the larger *bustān* we studied is found (Figure 2), sits mainly on chalk and marls from the Menuha geological formation [34].

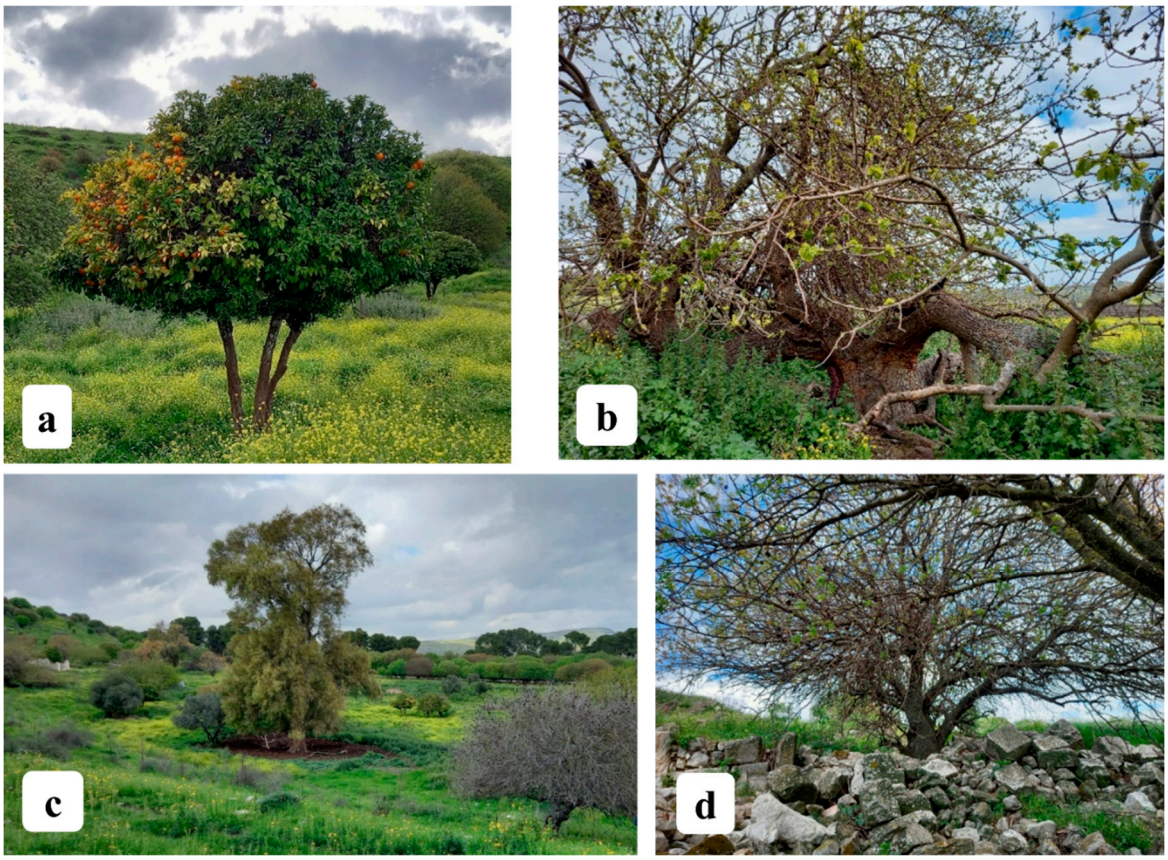


Figure 2. Qadas orchard. (**a**) A bitter orange (on the left side of the tree with fruit) that served as the rootstock for lemon (right side of the tree) as well as for other citrus species in the orchard. (**b**) A very large mulberry tree in the orchard. (**c**) Overview of the orchard showing a part of the reservoir on the upper left, a large eucalyptus tree in the center of the photograph, and relict fruit trees dotted about the landscape. (**d**) Mt. Atlas mastic tree growing amidst the ruins of the village (Photos: Liora Kolska Horwitz, April 2023).

Excavations have shown that Qadas and its environs (a locality known as Biblical Tel Kedesh) had been inhabited successively, from the Chalcolithic/Early Bronze Age (4500-2000BCE) through to the Roman period (64 BCE–135 CE) [36]. British Mandate maps

and aerial photos from 1945 show the village as having comprised a concentration of ~15–20 houses and courtyards, a cemetery, and cultivated parcels of land, some designated on maps as communal (*masha'*) and others as privately owned (*mafruz*).

In 1948, Qadas village and its land were inhabited by Shia Muslims, most of whom fled to Lebanon following the 1948 war. Subsequently, the village lands were allocated to Jewish settlements (Kibbutzim and Moshavim) that were established in the area, while the village was razed in 1966. The antiquities of Qadas—the Roman temple at the foot of the hill, the two parts of the ancient mound upon which the village was built [36], and an additional zone around them—were incorporated in 1999 in the Tel Qedesh National Park (totaling 135.2 hectares), which is managed by the Israel Nature and Parks Authority. The park is a nature reserve and is a restricted access, depopulated 'natural' zone. Aside from grazing of a cattle herd owned by the neighboring Kibbutz Malkiya, no agricultural activities, hunting, or settlement is permitted within the park. Moreover, special permission is required for antiquities-related activities within the park boundaries. Today, the ruined village on the hilltop is an undeveloped area covered by thistles and other ruderal plants, including trees that have established themselves naturally.

The main village orchard that we documented (in the eastern valley below the village) currently covers an area of ~20 dunams (2 hectares), based on mapping of surviving trees. The orchard is not walled, but in its eastern corner, a large water reservoir exists that was constructed in the past, probably by the villagers. It was fed by irrigation channels leading from a natural spring some 40 m to its north. No evidence of irrigation channels or other agrarian-related structures is visible in the orchard itself.

2.1.2. Wādī al-'Ein

The orchard of Wādī al-'Ein (Map Location: 32.7598000/34.9883080) lies in a broad valley on the western slope of Mount Carmel, ~3 km inland from the Mediterranean Sea (Figure 1). Unlike Qadas, the hamlet was settled after the 1948 war by Palestinian refugees displaced from the adjacent town of al-Tira, which was conquered by Israeli forces in 1948. The Wādī al-'Ein community existed until the early 1970s when the population was forced out by the Israeli Authorities, following the declaration of the area as part of the Mount Carmel National Park that was established in 1960. Following the inhabitants' eviction, the houses of the hamlet were not destroyed, but instead remain uninhabited to this day. It is likely that some of the trees in the mixed fruit tree orchard that surrounds the houses were planted post-1948 (Figure 3).

The Carmel mountains surrounding the hamlet consist of sedimentary rocks dated to the late Cenomanian which form cliffs above the riverbed. The orchard is located at an altitude of 70–150 m above sea level and was planted on chalk and chert from the Shamir formation and chalk from the Kureibe formation, and the soils in the region are mainly Hamra soils [35]. The small seasonal stream of Nahal Galim flows past the hamlet, and within the Wādī al-'Ein orchard, there is a water well. To the southeast is a second, small stream, Nahal Ornit, and the perennial spring of 'Ain Qedem. The karstic Ornit Cave located in this wadi (also known as 'Arak esch Sheikh or Esh Sheikh Suleiman, map ref, 199380/740196) is an archaeological site documented from as early as 1908, which has yielded remains spanning the late Lower Palaeolithic period (ca. 200,000 BP) through the Bronze Age (3300–1200 BCE) [37,38]. There is also evidence of early 19th-century cave use by shepherds, as attested to by Ottoman-period pottery and stone walling [37,39].

Figure 3. Wādī al-'Ein orchard. (**a**) A section of the depopulated hamlet and orchard showing olive, citrus, and extremely large cypress trees, with pine trees of Mount Carmel visible on the upper hill slopes. (**b**) Olive trees on both sides of the valley. (**c**) Mastic trees were planted in a row and used as a living fence in the garden. (**d**) One of the dry-stone walls supporting a terrace with cultivated trees (Photos: Eli Ashkenazi, December 2023).

The orchard currently covers some 22 dunams (2.2 hectares) based on the presence of surviving fruit trees. It sits in an open area adjacent to four abandoned houses that abut it to the north. A living hedge of mastic trees (*Pistacia lentiscus*) delineates its southern border. These trees are not recent given that the trunk circumference of a sample of five trees ranges from 41 to 71 cm. Within the orchard is a water well and remnants of at least three stepped terraces supported by dry-stone walls, which were built to support the orchard and stop the soil from eroding downslope (Figure 3d).

3. Results

3.1. The Qadas Field Survey

Within the ruins of the village of Qadas, mostly Mt. Atlas mastic trees (*Pistacia atlantica*) and almond trees (*Prunus dulcis*) grow today (Tables 1 and 2). Many of the almond trees within the village look young and have thin trunks, but their root crowns are large (sample of four trees had basal trunk circumferences of 106–117 cm), so that they may well originate from stock planted by the farmers pre-1948. Alternately, they may have been seeded naturally after the village was depopulated in 1948 [40]. The Mt. Atlas mastic trees are wild and some can be identified on the pre-1948 aerial photos and so are over 75 years old, while others appear to have grown recently as they are not visible on the historical aerial photos. Similarly, the large size of some of the Mt. Atlas mastic trees is an indication of their antiquity (a sample of six had trunk circumferences of 86–95 cm). A few Mt. Atlas mastic trees appear to bear evidence of having been shaped. For example, the boughs of a large tree abutting a wall of the village have been removed in order to preserve the wall, and the tree has grown outwards in the opposite direction (Figure 3c).

Table 1. List of tree species found in the two orchards (presence denoted by x).

Trees, Shrubs, and Woody Vines		Arabic Name Transliterated into English	Qadas	Wādī al-'Ein
Prunus dulcis	Almond	Lōz	x	x
Citrus × *aurantium*	Bitter orange	Hāmeḍ, Khushkhāsh	x	x
Ceratonia siliqua	Carob	Kharrūb		x
Melia azedarach	Chinaberry	Zanzalakht	x	
Cupressus sempervirens	Cypress	Sirū		x
Phoenix dactylifera	Date palm	Naḥle		x
Eucalyptus camaldulensis	Eucalyptus	Kīnā	x	
Ficus carica	Fig	Tīn	x	
Citrus × *limon*	Lemon	Laymūn	x	x
Pistacia atlantica	Mt. Atlas mastic	Buṭum	x	
Pistacia lentiscus	Mastic	Sarrīs		x
Morus alba	Mulberry	Tūt	x	x
Olea europaea	Olive	Zeitūn Rūmī	x	x
Punica granatum	Pomegranate	Rummān	Rare	x
Opuntia ficus-indica	Prickly pear	Ṣaber	Rare	x
Ficus sycomorus	Sycamore fig	Jummēz		x

Table 2. Comparison of geographic and botanical data between Qadas and Wādī al-'Ein.

	Geographic Area	Altitude Masl	Rocks	Average Annual Temperature in Celsius	Average Annual Precipitation	Trees in Orchards	Trees in Gardens	Trees in the Village
Qadas	Upper Galilee	440	Chalk, clay, an marls	17–18	700–750	Mostly olive. Mt. Atlas mastic, pomegranate (rare), and spiny hawthorn	Bitter orange, fig, lemon, mulberry, eucalyptus, olive, chinaberry, and Mt. Atlas mastic	Mt. Atlas Mastic and almond
Wādī al-'Ein	Mount Carmel	100	Chalk	20–21	550–600	Olive	Bitter orange, lemon, mulberry, spiny hawthorn, mastic tree, carob, pomegranate, prickly pear, sycamore fig almond, and cyress	

As illustrated in Figure 4a, the Qadas hilltop has a chalk-rich substrate; the soil's moisture content is relatively low compared to the hill slopes and riverbeds, making it advantageous for trees that require less water. Thus, the reason that mostly Mt. Atlas mastic and almond trees grow within the village is that neither need irrigation. If cultivated, other

reasons for their choice may be that both provide shade, which is particularly important during the summer months, and both bear fruits that can be consumed: Mt. Atlas mastic fruit after roasting.

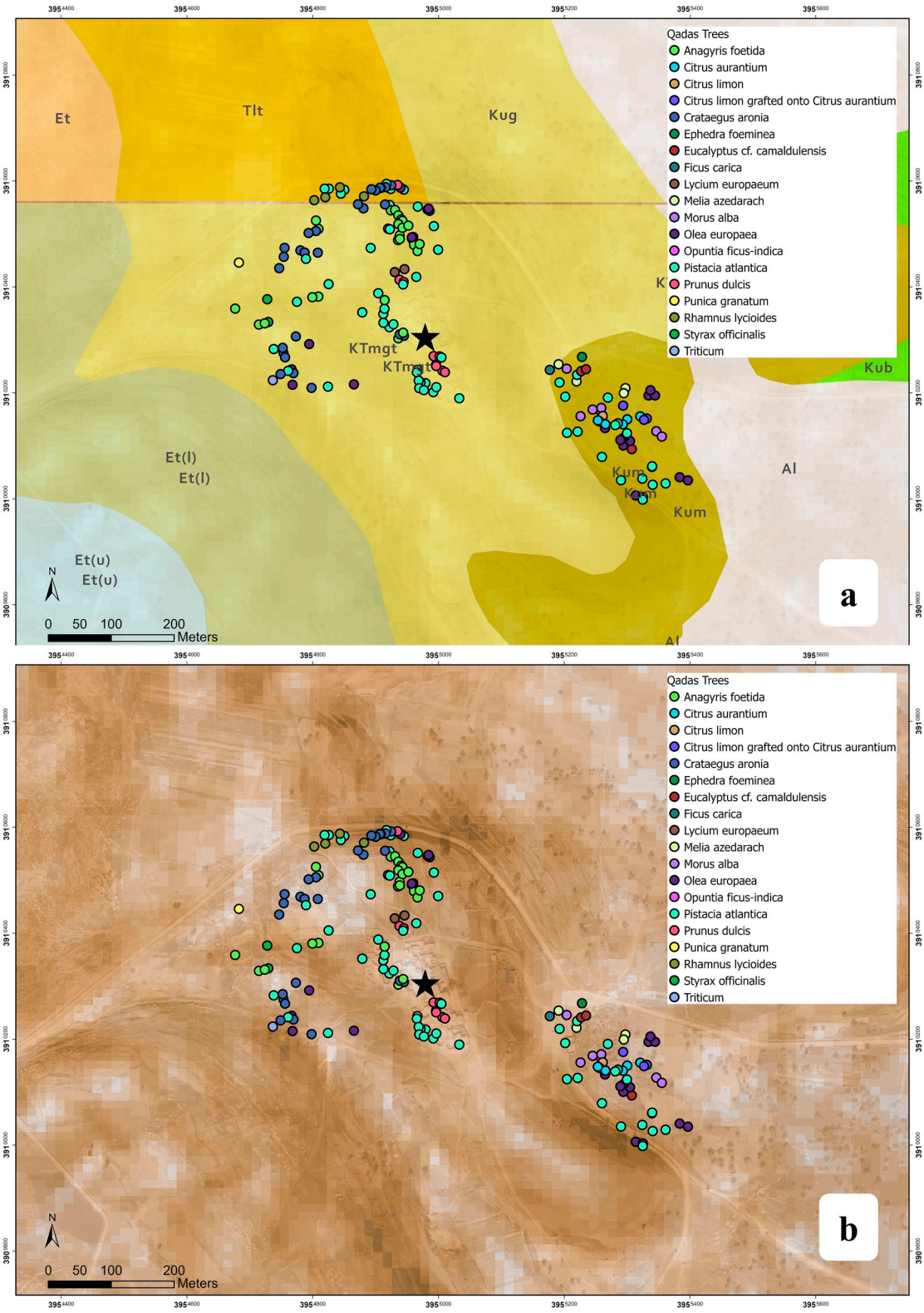


Figure 4. Spatial zonation of trees within the Qadas village (denoted by a black star in (**a**)) and in the western and eastern spring areas relative to (**a**) geology and (**b**) topography (GIS maps Ido Wachtel).

On the village hill slopes, olives (*Olea europaea*) were planted (Figure 4a). Their trunk circumference indicates that these are relatively old trees (a sample of nine had trunk neck circumferences of 100–120 cm). Even in harsh desert climates with only ~90 mm of rain per annum, olives can grow without irrigation [41], and even more so in the high-rainfall Mediterranean region of the village of Qadas. Indeed, non-irrigated cultivation of olive trees in a Mediterranean climate zone is a great advantage—high yield with relatively low labor investment. In the pre-1948 period, olives were the main source of agricultural livelihood for many villages in the north of the country, providing food security and oil—for consumption and as a medium for food preservation and for the manufacture of soap [24,42,43]. In Qadas, pomegranate trees are only found in the valley north of the village, adjacent to olive trees. Other fruit trees probably did not survive in this area as they were not irrigated, at least since 1948.

The main spring of the village is ~200 m east of the village, and here, an extensive fruit orchard has survived, established on a Senonian chalk and marl substrate. Another small spring is ~300 m west of the village (called *El Majnuna* in the Mandate period map) but has only a few surviving trees (Figure 5). In proximity to two springs located in the valley beds on the western and eastern sides of the village, the farmers had planted fruit trees that are hydrophilic and require irrigation throughout the year (a range of citrus varieties, mulberry-*Morus alba*, and fig-*Ficus carica*) as well as chinaberry (*Melia azedarach*) and eucalyptus (*Eucalyptus camaldulensis*).

On the British Mandate period map of 1932 (Figure 5a), the two springs of Qadas are noted as Ein Qadas to the east and *Al Majnuna* to the west. The orchard we documented is shown on the map as a green area around Ein Qadas, and is marked by the letter 'c' which denotes the cultivation of citrus fruit, possibly orange, lemons, or citrons. Comparison of the area containing fruit trees that survived (~20 dunams) and the area taken up by the orchard on the Mandate map (~55 dunams; 5.5 hectares) indicates that only about half of the orchard has survived. Additionally, the olive trees that grow on the hill slopes of the western valley below the village even today, and the fruit trees growing near the western spring and within the village, are not marked on the Mandate period map. This indicates that the main *bustān* was at Ein Qadas and that most trees we found growing inside the village are probably from the post-1948 period. This is borne out by a comparison of the location of trees in the environs of the village of Qadas as seen in the 1945 aerial photos. In Figure 6a, we present an aerial view of the village versus an aerial view of the same area today. Trees in the 1945 aerial photo appear as dark spots and are readily visible, while our mapped trees are marked as yellow circles.

In Figure 6b, a close-up is shown of a part of the village and the landscape located immediately to its north. It is possible that smaller trees are not visible in the 1945 image given that the aerial photo was taken from a plane at a greater altitude than our 2019 drone image. Salient features of the landscape are the presence of numerous small agricultural plots that are clearly demarcated by walls, a path running south–north, that traverses the fields north of the village and joins the main road at the base of the hill on which the village sits, and far to its right, a belt of trees alongside the main road.

We then visually compared the structure of the landscape and the location of trees to an aerial photo taken in 2019 of roughly the same area on which the georeferenced trees we surveyed have been superimposed (colored circles) (Figure 6). Bearing in mind that the recent aerial photo was taken at a lower altitude using a drone than the 1948 aerial photo, some interesting differences are apparent. Notably, the divisions between the small agricultural plots visible in the 1948 aerial photo have all but disappeared, as has the path crossing them to its north. Instead, myriad small paths are visible—these are paths made by a herd of cattle that grazes in the village and its environs. Trees are still clearly

recognizable as dark spots, and these seem to be only the larger and most mature specimens as visible in the 1948 aerial photo. Most of the colored circles (our surveyed trees) are not clearly recognizable as trees in the drone image, suggesting that they are too small and undeveloped to be registered in such an image. Without even summing their numbers, it is self-evident in Figure 6a,b, that tree cover in this part of the landscape has increased significantly in the 75-plus years that have elapsed since the village was abandoned—both within the areas that were once agricultural plots, on the slope to the west of the village and along the main road. Based on our survey, the main tree species found in this part of the landscape is the Mt. Atlas mastic.

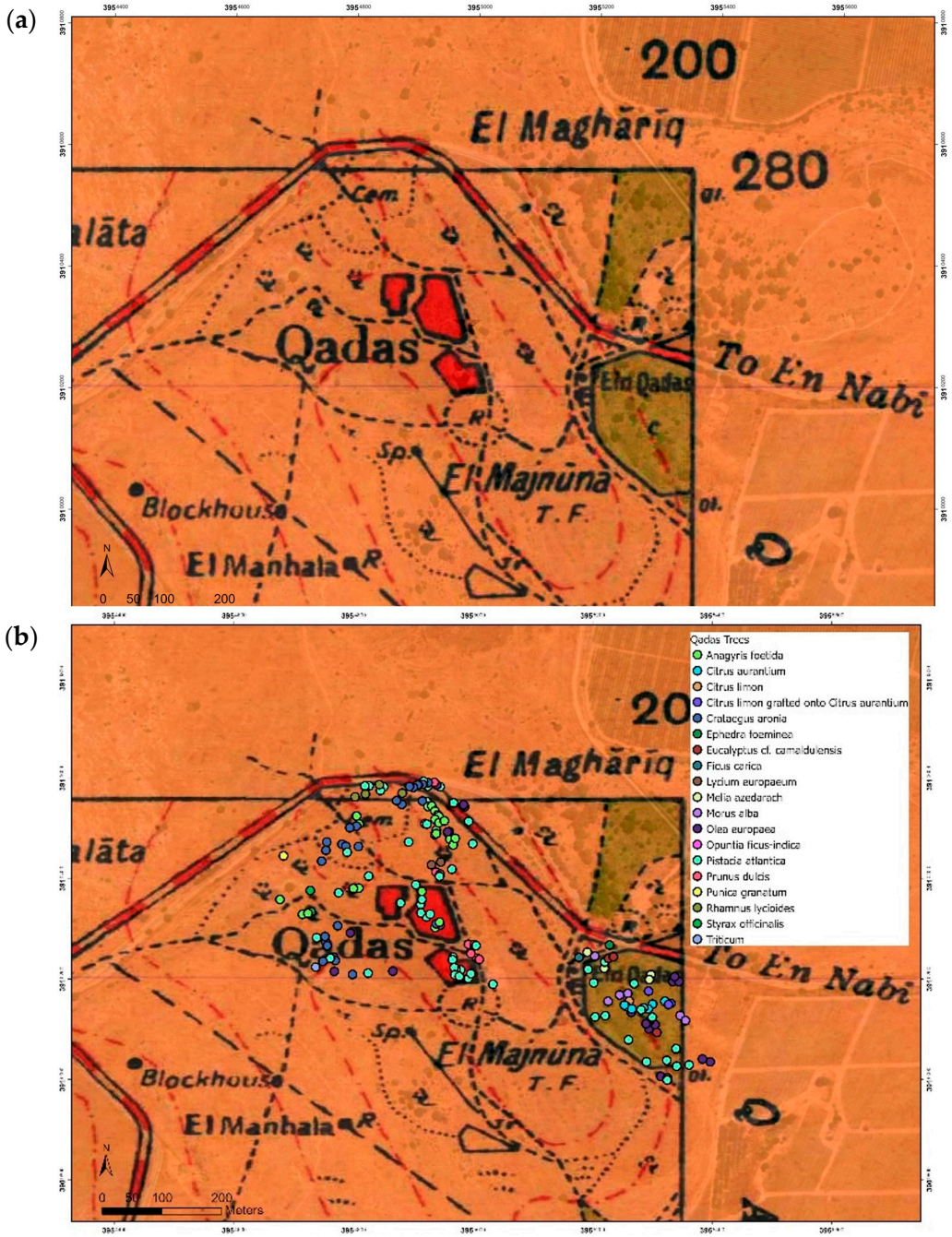
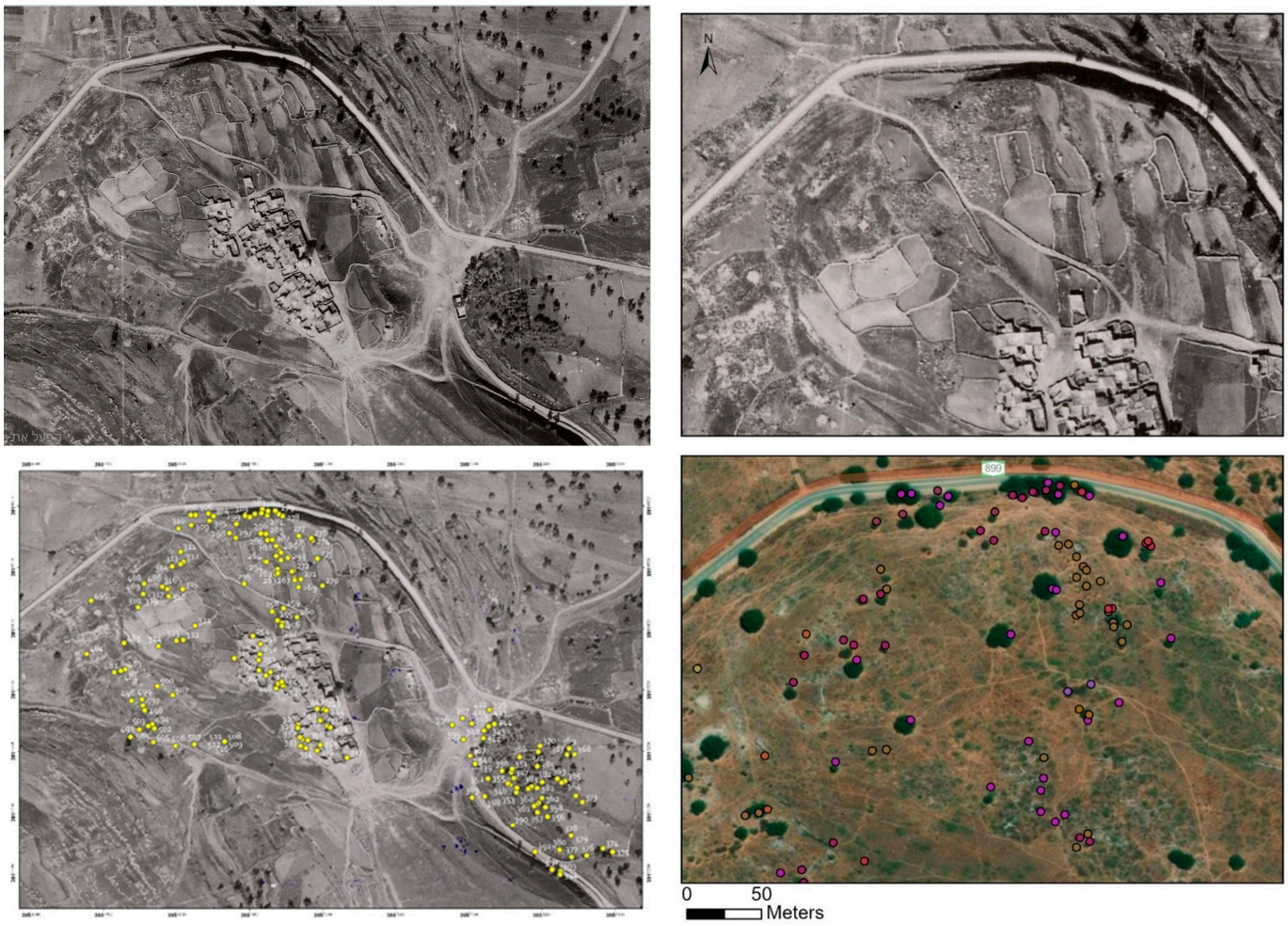


Figure 5. Qadas maps. (**a**) Mandate period (1932) map showing the location of plots with trees. (**b**) Close-up of the area where we identified relict trees in our survey.



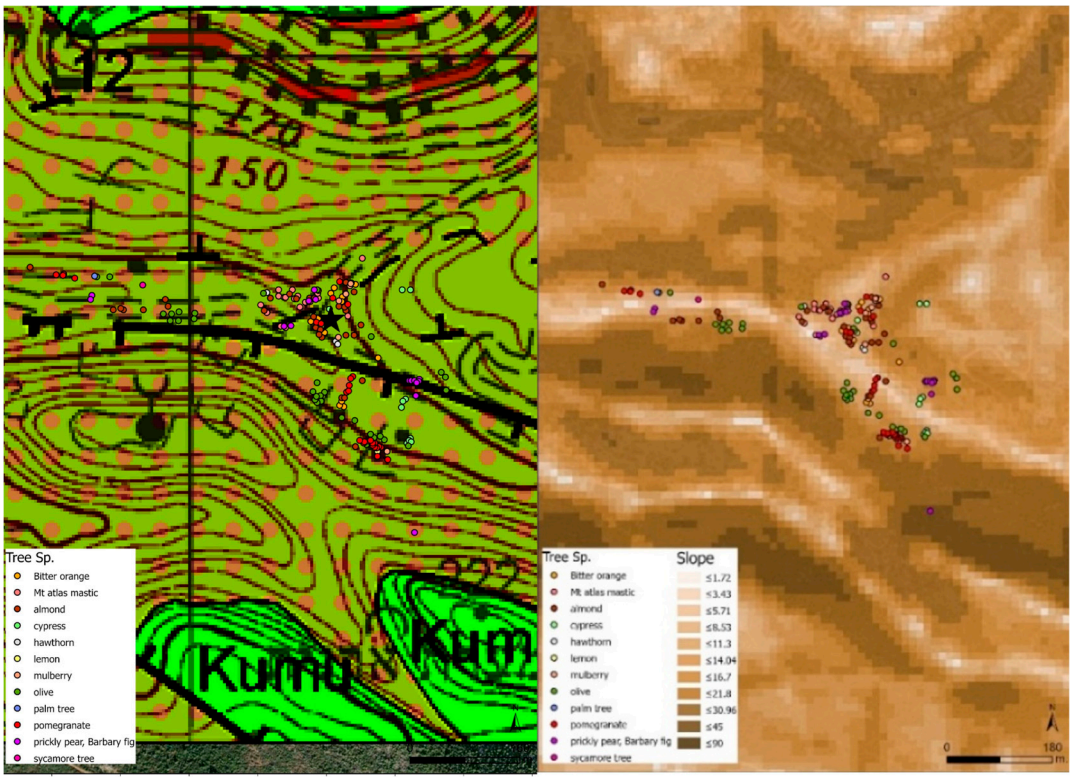
(**a**) (**b**)

Figure 6. Qadas village. (**a**) Aerial photo of the village in 1945 (**top**) and with our mapped trees shown as yellow circles (**bottom**); (**b**) a close-up of a part of Qadas village in 1945 (**top**) and an aerial photo from 2019 (**bottom**) showing our mapped trees as pink circles (GIS maps Ido Wachtel).

3.2. The Wādī al-'Ein Survey

The orchard is located in a flat area (Arabic: Māris, dhrā') adjacent to three houses on the north bank of the seasonal stream, currently covering an area of ~22 dunams (2.2 hectares) which tallies with the area we measured on the British Mandate map. This is the primary location of a diversity of fruit trees cultivated in the region due to the presence of a permanent water source, a well. Therefore, in the garden, we find trees that require year-round irrigation, especially during the summer months: bitter orange, lemon, and mulberry (and also Spiny Hawthorn). Based on the size of the olive trees (Figure 7; five with trunk neck circumferences 185–289 cm), mulberry trees (four with trunk circumferences of 125–180 cm), and almond trees (five with trunk circumferences of 106–120 cm), it is clear that planting in this fruit orchard took place, both before and after 1948, on a flat part of the valley, north of the seasonal stream, and up to the point where the mountain slopes begin to rise toward the north. Also to the south, large numbers of ancient olive trees survive on the slopes of Mount Carmel (Figure 8). Olive and pomegranate trees are the primary vegetation in the flat area south of the stream which comprised some 13 dunams (1.3 hectares) in the Mandate period map, of which we found surviving trees on about 10 dunams (1 hectare). Large cypress trees, which are not a fruit-bearing species (a sample of six with trunk circumferences of 150–286 cm and one was even 610 cm), also grow on the flat area both north and south of the stream.

Figure 7. An old and extremely large olive tree from the Wādī al-'Ein orchard (Photo: Liora Kolska Horwitz, December 2023).



(**a**) (**b**)

Figure 8. Spatial zonation of trees on both sides of the seasonal stream at Wādī al-'Ein relative to (**a**) geology and (**b**) topography.

On the British Mandate map of 1932 (Figure 9a), two strips of green divided into plots are shown on either side of the wadi. Plots marked on the map are all denoted with the letter 'o' denoting mixed-fruit orchards, with olive groves (ol) marked on the western slope above the hamlet and to the southeast of the wadi toward al-Tira, as well as around the

Sheikh's tomb (*Safḥet esh Sheikh Suleiman*) that is marked in the center of the wadi. Conifers are illustrated on the upper mountain slopes while on the eastern side of the wadi, "other plantations" are marked. When the field observations are superimposed on the Mandate map (Figure 9b), it is possible to observe that although the relict trees fall within the area denoted on the map as an orchard, only a relatively small area with cultivated trees has survived compared to their original extent.

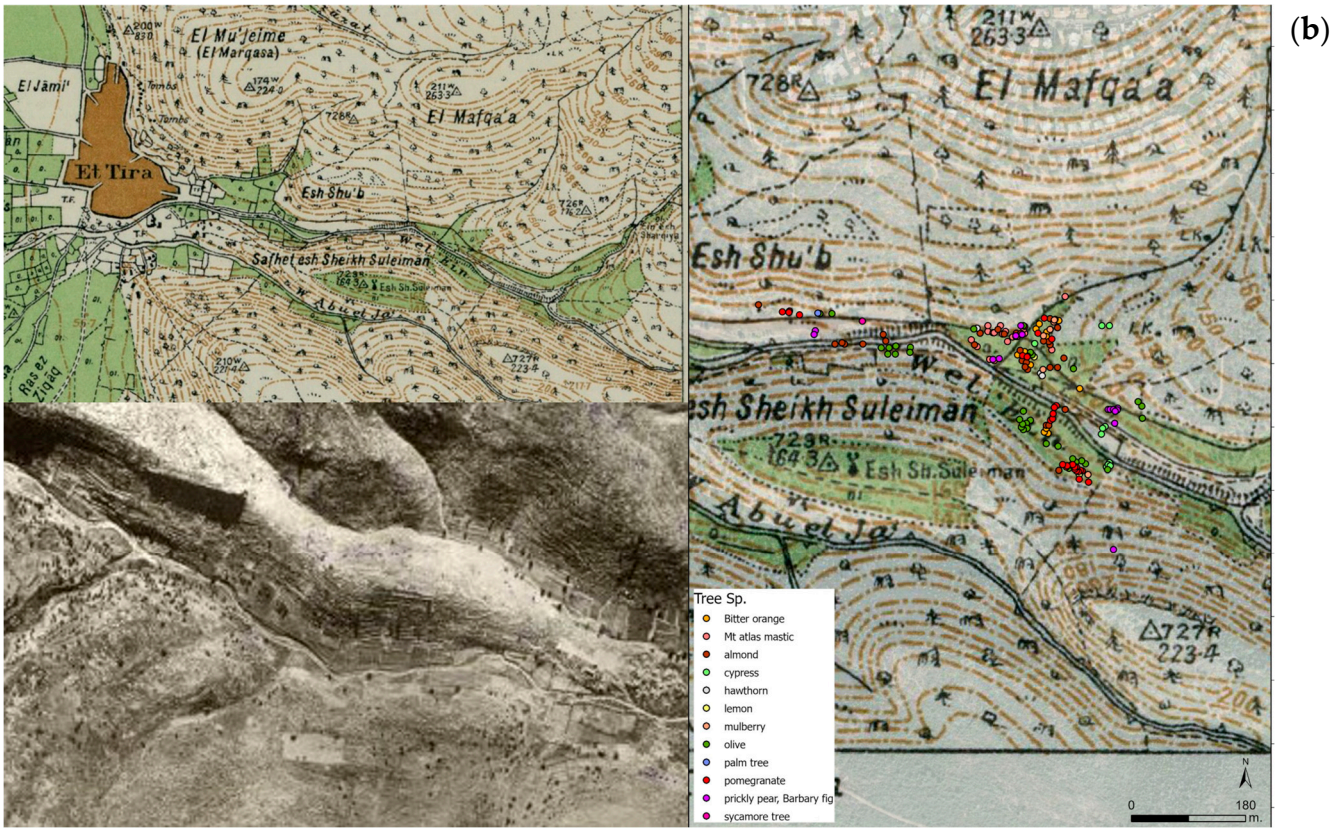


Figure 9. Wādī al-'Ein historical maps. (**a**) Mandate period (1932) map of Wādī al-'Ein showing the location of plots with trees. (**b**) Close-up of the area where we identified relict trees in our survey. (**c**) Aerial photo of Wādī al-'Ein in 1945; the dark spots are trees.

Comparison of the current landscape with a 1945 aerial photo of the area shows that relatively little has changed in the landscape of Wādī al-'Ein (Figure 9a). The plots of cultivated land going up the small valley are quite easy to make out, and the large structure in the background of Figure 9a is discernable as a white blob in the center left of the photo. Adjacent to it is the very large cypress tree–trunk circumference 610 cm (a dark spot), and the orchard appears as a small clump of dark spots to its right. The hill slopes are dotted with olive trees (dark spots), which we still see today. It is suggested that the small scale of the settlement, the fact that the buildings were abandoned and not destroyed, and that no development has taken place in this valley—probably as it is a declared nature reserve (the Mount Carmel Nature Reserve and National Park)—have helped to preserve intact many features of the 1945 landscape.

4. Discussion and Conclusions

4.1. Spatial Distribution Within Orchards

In our examination of the biodiversity and spatial arrangement of trees on the landscape of the villages of Qadas and al-Tira/Wādī al-'Ein, we were able to examine the farmers' decision-making process. By examining the position and composition of trees,

water needs, and topography, we found that despite the orchards representing an anthropogenic landscape, local environmental factors have dictated arboreal species choice and also the habitats where trees were planted.

In both Qadas and Wādī al-'Ein, we found a combination of two arboricultural practices:

1. Extensive olive orchards that were cultivated on the hill slopes surrounding the settlements. These were grown without irrigation and were watered solely by winter rains.
2. Small groves composed of a diversity of different fruit trees that were cultivated in limited areas close to permanent water sources. Notably, these sources supported the growth of water-dependent trees that require irrigation all year (e.g., especially in the summer). In Qadas, the permanent water sources were the two springs, while in Wādī al-'Ein, there is a water well and a stream that flows irregularly in winter. Indeed, Nadan ([42], p. 62) notes that in the Arab rural sector of Mandate Palestine "apart from the coastal plain and the plains of Acre and Esdraelon, irrigation took place primarily in areas adjacent to open water resources".

4.2. Geographic Distribution in the Country

We placed the two villages documented here within a broader perspective. The results of our survey of relict orchards from several other villages, showed that the variety of tree species up until 1948 varied by the geographic and topographic conditions of the villages and their biophysical surroundings.

Some tree species prefer colder climates (such as Mt. Atlas mastic trees) whereas others prefer warmer regions. Indeed, we found the prickly pear and cypress grow in the lower and hotter regions of the Mediterranean area at an altitude of 70–450 m above sea level. These findings explain why the Wādī al-'Ein farmers planted extensive numbers of these specific trees in this hamlet while the Qadas farmers did not. The wide, thick, and thorny prickly pear shrubs are used as fences for gardens and sometimes also for orchards. Their large and sweet summer fruits are edible.

Almond, fig, olive, and pomegranate trees were planted in most regions, even in the desert areas that receive 80 mm of rainfall annually [41,44], and were irrigated. This explains why we find these fruit trees both in Qadas in the Upper Galilee and in Wādī al-'Ein in Mount Carmel. Similarly, lemon and bitter orange trees grow in the Mediterranean areas, mainly near permanent water sources so that the trees can be irrigated during the summer, such as the springs in Qadas and the water well in Wādī al-'Ein.

4.3. Tree Uses

Both villages cultivated trees for consumption, but probably the economic and practical usefulness of the trees as well as their cultural value, was also considered by the farmers. The species preferred were olives—used for a range of products (oil, soap, and medicine) [45]—that were grown over extensive areas. In both villages studied, although the farmers cultivated domestic fruit trees in the orchards and gardens, they also introduced wild trees which served agricultural purposes and as sources of traditional medicine [46,47]. For example, the chinaberry we found in the Qadas orchard was traditionally a species used to protect wheat grains from insects and worms; its fruits were spread alongside the grains and would repel insects and worms (Mahfuz El-Hatib, Ramat Hanadiv, pers comm. 2.7.2024). In addition, the trunks of this tree were used for the wood industry and construction, and the bark, fruits, and leaves were used for medicinal purposes for both people and their livestock (Mahfuz El-Hatib, Ramat Hanadiv, pers comm. 2.7.2024). Cypress trees were planted in the environs of villages as they are sacred to Muslims [48], and their long straight trunks were also used for construction. In the Qadas *bustān*, which is located in a higher and colder area than Wādī al-'Ein, farmers planted eucalyptus instead of

cypress trees. This, as eucalyptus has long, straight trunks that are useful for construction and is used in traditional medicine [47]. Moreover, eucalyptus trees have a shallow root system and are suitable for the shallow soils found at Qadas, while cypress trees have a root system that reaches several meters deep and so are suited to the Hamra soils found in Wādī al-'Ein.

In both cases *Pistacia* trees were cultivated, but in Qadas, they were Mt. Atlas mastic, and in Wādī al-'Ein, it was the common mastic tree. In Qadas, the latter trees were probably planted within the village for decoration and shade, while the fruits could be roasted and eaten. Fruit trees (e.g., citrus) were grown where there was sufficient water in the small-scale orchards. While some of the fruits were probably marketed, in contrast to the olives, the economic significance of the *busātin* was small (e.g., [42] p. 170, [49] p. 23) and mostly aimed at household consumption in providing dietary variety and as an important food supplement for the farmers.

4.4. Modification of Trees

In Wādī al-'Ein, the mastic trees were planted in a row in the garden. Typically, these plants are low and wide, with many trunks similar to a large shrub. The farmers pruned the many branches, leaving only the main trunk. Along this main trunk, the shrub developed. They carried out this process for all the mastic trees, creating a fence in the northwestern part of the garden (Figure 3c). In Qadas, the Mt. Atlas mastic trees were pruned only inside the village according to the layout of the buildings and the streets.

4.5. Rootstocks

We found evidence of the use of rootstocks in traditional Palestinian arboriculture. In the eastern orchard in Qadas, the lemon trees had been grafted onto bitter orange (*Citrus* × *aurantium*) and it can be assumed that so were other citrus varieties that were cultivated here. Over time, the complex citrus varieties died off (the scions), while the bitter orange (the rootstock), being better adapted to arid conditions, survived. Rezq et al. [50] note that the bitter orange is the rootstock most suited to local conditions since it is resistant to frost and salinity. They also state, that due to their resistance to drought, bitter almond seedlings (*Amygdala amara*) are used locally as rootstock for stone fruits including sweet and sour cherry, apricot, peach, nectarine, plums, and sweet almond. Although Rezq et al. [50] note that nowadays in this region, quince seedlings (*Cydonia oblonga*) are used as rootstock for apples and pears, according to local informants (Mahfuz El-Hatib, Ramat Hanadiv, pers comm. 2.7.2024), pear and apple trees were traditionally grafted onto Spiny Hawthorn (*Crataegus* sp.). The Spiny Hawthorn is a wild tree in the Mediterranean area and we found this tree in the agricultural areas of both Qadas and Wādī al-'Ein. We suggest that it is possible that at the latter locality, the pear and apple scions had died off over time, while the Spiny Hawthorn (the rootstock), being better adapted to natural conditions, survived. Of course, pears and apples were not grown on all the wild Spiny Hawthorn trees, but at least on some of them, especially those close to the permanent water sources, because pears and apples require more water, including via irrigation, compared to wild and olive trees.

4.6. Preservation of Arboricultural Heritage

The traditional *basātin* offers habitats for a multitude of lifeforms, including vertebrates, invertebrates, fungi, lichens, mosses, and liverworts (the latter two grow on trees). Additionally, orchards are associated with a range of built features—such as walls, water sources, and hedges that in turn serve as microhabitats for a wide range of wildlife and plant species. Thus, the destruction of an orchard results in the loss of many different ecological niches. We also know that deforestation contributes to land degradation, a

decline in soil fertility, and unsustainable management of renewable natural resources, factors that are also relevant to groves of cultivated trees.

As briefly demonstrated herein, the traditional arboriculture of the Mediterranean region of Israel used to depend on adapting the growth of different types of trees to the geographic and topographic characteristics of each area. The topographic structure, such as slopes and hilltops, the location of springs, and rainfall and temperature all determined the types of trees that were planted and where they were planted. As Nadan [42] has argued, Palestinian agrarian practices (i.e., indigenous knowledge) also had an economic rationale that was in line with local conditions, namely a surplus of labor and scarce capital, a contention that follows the arguments outlined by Theodore Schultz [1] in his groundbreaking book *Transforming Traditional Agriculture* that we have quoted in the introduction to this paper.

Since the establishment of Israel in 1948, inroads have been made into the historical arboreal landscape due to urban development such that the number and extent of the pre-1948 traditional orchards have decreased due to development and/or afforestation [51,52]. Moreover, there has been replacement of some local fruit-tree species and varieties with imported ones that differ from those planted before 1948. As a consequence, local breeds (landraces) have been extirpated or become extinct [40,53]. Notably, we live in an era of cultivation of monocultures, such that natural and cultivated arboreal biodiversity is reduced on all scales [51]. Although, as detailed in the introduction, most fruit trees grown were not indigenous species, those planted before 1948 belonged to traditional cultivars and included unique varieties that are rare today [18,40,54]. These varieties should be preserved due to their resilience to local climatic conditions and diseases. Research on heritage orchards can help identify landrace cultivars that adapt well to challenging growing conditions and exhibit greater resilience to adverse climate changes. Furthermore, since many are varieties that grow in surrounding countries, these heritage fruit trees also serve as a witness to the historical links that existed between Israel and other lands. Fruit tree cultivars have evolved over thousands of years along various geographic and historical pathways, and studying their history enhances our understanding of this complexity. Further research into the socio-geographic history of Mediterranean trees can provide insights into the legacies of lost cultivars, many of which had significant commercial and cultural value in antiquity.

Preserving the old varieties of fruit trees is essential for maintaining the richness and diversity of local ecosystems and the traditional agricultural landscapes of Israel. Additionally, these heritage trees dictate the physical design of the botanical landscape of the region—on the hillslopes, in valleys, and around springs—which makes them an integral part of the natural and cultural biodiversity of the region. As Frediani [55] stated, "By embracing a holistic understanding of trees and their environments, professionals can contribute to shaping future landscapes that support both human wellbeing and biodiversity".

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