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MARIA NTINOU

Trees and shrubs in the sanctuary

Wood charcoal analysis at the Sanctuary of Poseidon at Kalaureia, Poros

Abstract

Wood charcoal analysis at the Sanctuary of Poseidon at Kalaureia, Poros aims to provide information on the vegetation of the area and its management and on the range of plants used in the activities taking place at the sanctuary. During the excavations of 2003–2005 in Areas D and C, systematic samples from fills and features from all the excavated strata were recovered and water flotation was used for the separation of wood charcoal from the sediment. Wood charcoal was found in two pits dated to the Early Iron Age, near the supposed altar of the Archaic period (Feature 05), in a deposit of the Hellenistic period (the "dining deposit"), in floor deposits (Early Iron Age and Late Classical/Early Hellenistic periods), and fills of different chrono-cultural periods (Archaic–Early Roman). All the taxa identified in the wood charcoal assemblages are thermophilous Mediterranean elements, most of them evergreen broadleaved. The assemblages show that the most frequent taxon is the olive, followed by the prickly oak, the Fabaceae, and the heather. In most assemblages mock privet/buckthorn, strawberry tree, the pear and Prunus family species are present, while Aleppo pine, lentisc, the fig, and the carob trees are less frequent. Olive cultivation was an important economic activity during the whole life of the sanctuary and probably olive pruning constantly provided the sanctuary with fuel. The woodland would be the additional source of firewood for the sanctuary's needs for fuel for mundane activities such as heating and cooking, for more formal ones, such as sacrifice, but also for industrial activities such as tile firing. Activities related to the reorganization of space and the expansion of the sanctuary may be reflected in charcoal of carpentry by-products as the fir, cypress, and maybe pine remains.*

Keywords: wood charcoal, vegetation, firewood, timber, tree cultivation

https://doi.org/10.30549/opathrom-12-08

Introduction

One of the main aims of the research at the Sanctuary of Poseidon at Kalaureia, Poros, has been to detect aspects of the everyday life in the sanctuary and to describe the broader environmental setting related to it. Such a purpose can be met by the study of bioarchaeological remains. These originate from a broad array of on-site activities that may reflect long-term, general characteristics of the life at the site as well as one-time specific events. To meet this goal the Kalaureia project has included a most efficient strategy for the sampling and recovery of all possible categories of bioarchaeological remains that ensures the recording of variable aspects of the natural environment and the sacred and profane life at the sanctuary. One category of such remains is wood charcoal. Its study aims to provide information on the vegetation of the area and its management and on the range of plants used in the activities taking place at the sanctuary. In this report we present the results from the analysis of the wood charcoal recovered from Areas D and C in 2003–2005.

Method

In the past and until very recently wood was the main fuel source both in domestic (heating, cooking, lighting, etc.) and industrial activities (metallurgy, pottery kiln firings, glass manufacture, etc.), while timber was widely used in construction and the manufacture of various objects. Therefore wood charcoal, a very durable material, is usually among the most abundant re-

* *Acknowledgments*: This study owes the most to the late Berit Wells who first asked me to take part in the Kalaureia project. Arto Penttinen and Dimitra Mylona have always helped in many different ways. Many thanks are due especially to Dimitra for stimulating conversations and for discussing earlier versions of this manuscript. Anaya Sarpaki and the flotation team are much thanked for painstaking retrieval of bioarchaeological remains. I am grateful to the directors of the Museum of Poros and its personnel for facilitating access to the material and accommodating the study at all times. The two anonymous reviewers have helped enormously in improving this manuscript and are especially thanked.

Editorial note

The section on the bioarchaeological remains from the Sanctuary of Poseidon at Kalaureia, published in the *OpAthRom* 12, includes seven articles: Penttinen & Mylona 2019; Mylona 2019; Serjeantson 2019; Lymberakis & Iliopoulos 2019; Syrides 2019; this contribution by Maria Ntinou; Sarpaki 2019. Summary of chronological phases (presented in Penttinen & Mylona 2019):

Abbreviation	Phase	Chronology	Area	Comment
EIA I	Early Iron Age	*c.* 750 BC	D	Fills of Features 07, 08, and 09 (three pits). Fill underneath Early Iron Age building.
EIA II	Early Iron Age	*c.* 750–700 BC	D	Floor accumulation in Early Iron Age building.
A I	Archaic	7th century BC	D	–
A II	Archaic–Hellenistic	6th century–Hellenistic	C	Construction of Wall 24.
			D	Remains from outdoor activities. Feature 05 (supposed altar).
A III	Archaic	*c.* 500 BC	C	–
			D	Construction of Stoa D and Features 03 and 04 (interconnected cisterns). Feature 10 (kiln).
A IV	Archaic	after *c.* 500 BC	D	Life span of buildings constructed during A III.
C I	Late Classical/Early Hellenistic	*c.* 325 BC	C	Construction of Building C.
			D	Construction of back part of Building D, including Feature 06 (staircase), Feature 01, and Feature 02 (unknown, altar?).
C II	Late Classical/Early Hellenistic	after *c.* 325 BC	D	Finds in the dirt floors of Building D.
H I	Hellenistic	*c.* 165 BC	D	"Dining deposit" west of Building D.
H II	Late Hellenistic/Early Roman	*c.* 50 BC–*c.* AD 100	D	Fill of Feature 03 (cistern). Finds from trench against Wall 11, which exposed Wall 33.

Other abbreviation used: WF = Water flotation.

mains found during archaeological excavations. Wood charcoal analysis focuses on those remains that are normally recovered from the archaeological contexts through dry or wet sieving and/or flotation, aiming to provide information concerning the local vegetation of the studied area in the past and most importantly how this was used by the people who lived there.[1]

The method is based on the identification of woody plant species by way of the microscopical analysis of their anatomy. All plant species show characteristic anatomical structures, which are preserved when their wood is carbonized. The specialist with the help of an incident light microscope (dark/bright field, x50–x1000 magnification lenses), a reference collection of modern carbonized wood, and plant anatomy atlases can observe the three basic wood anatomy sections—transverse, tangential longitudinal, radial longitudinal—of the archaeological wood charcoal fragments. Through this procedure, plant families, genera, and species are identified.[2]

Wood charcoal samples may be associated with burning features, with wooden structures, with furniture and implements burnt at some point in a site's history, thereby representing short-term events, instantaneous use of firewood, and specific human activities. They can also be found scattered in the sediment and in fills that accumulated over time as the result of long-lasting activities. In this case wood charcoal represents long-term collection of the plant species available in the environment and thus gives a good picture of the palaeovegetation, the plant formations to which the identified plant species correspond, and their transformation through time.[3]

At the Sanctuary of Poseidon at Kalaureia, samples from fills and features from all the excavated strata were recovered and water flotation was used for the separation of the bioarchaeological remains. The two-fold sampling strategy (fills and features, or random and targeted sampling) guarantees that all types of deposits have been checked for material that can offer information on the use of particular plants in specific events/activities and on the vegetation of the area in the past. Various deposits, related to specific man-made features or activities of different chronological periods within the life of the sanctuary, were sampled (*Fig. 1*).[4] These are

[1] Chabal *et al.* 1999, 43, 72–75.
[2] Chabal *et al.* 1999, 45–47.
[3] Badal 1992, 170, 175, 186–187; Chabal *et al.* 1999, 62–63.
[4] Locations of the samples and of the various deposits are to be found in Penttinen & Mylona 2019.

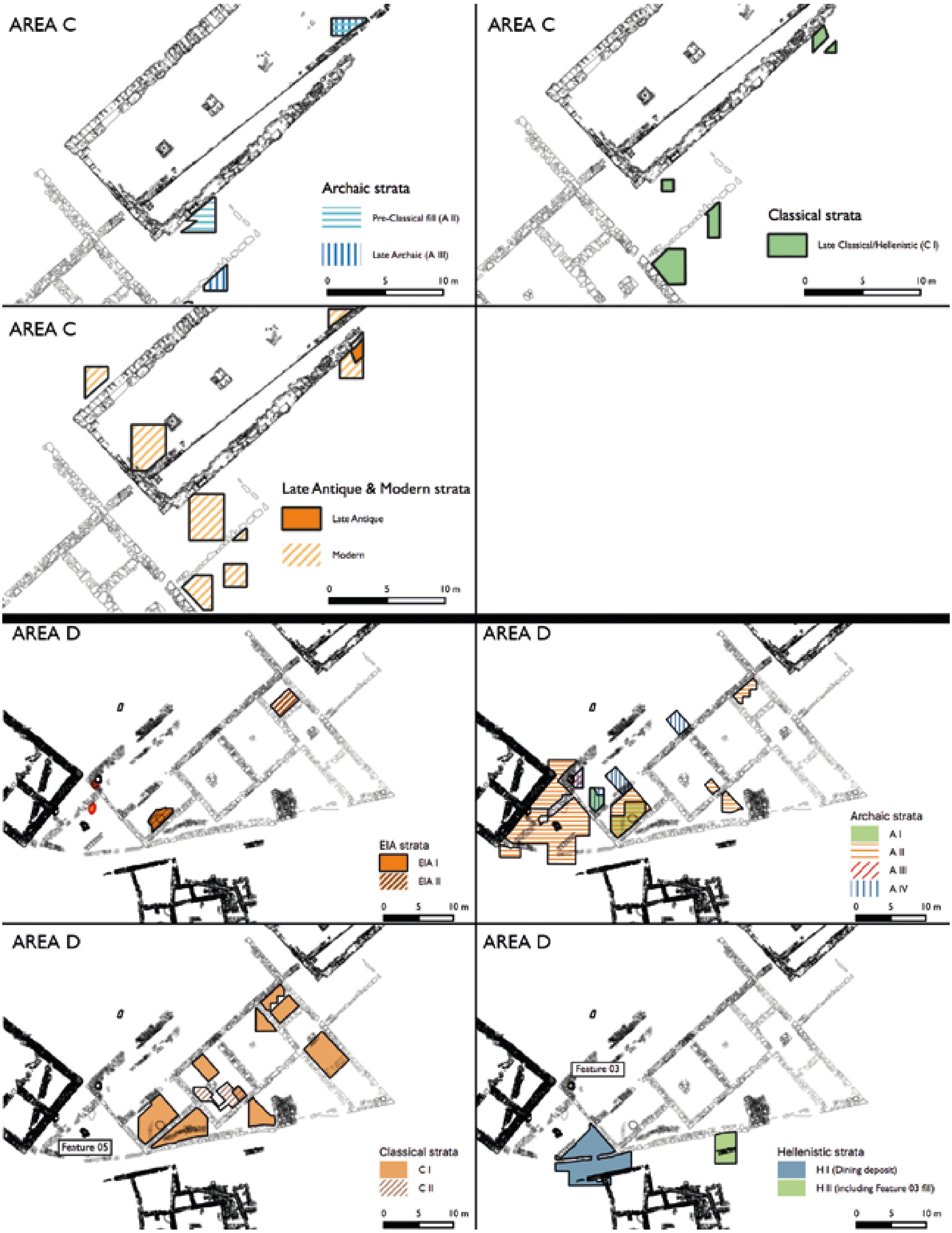


Fig. 1. Plans of the excavated areas showing the deposits from which wood charcoal was recovered. With Area C above and Area D below. By R. Rönnlund.

Table 1. The main plant taxa identified in wood charcoal samples from the Sanctuary of Poseidon.

Taxa	English name	Ancient Greek name
Arbutus unedo	strawberry tree	κόμαρος
Ceratonia siliqua	carob	κερωνία, συκῆ ἡ Αἰγυπτία
Cupressus sempervirens	cypress	κυπάριττος
Erica sp.	heather	ἐρείκη
Ficus carica	fig tree	συκῆ
Labiatae	the mint family	σφάκος, ἐλελίσφακος, ἕρπυλλος, etc.
Fabaceae	woody plants of the pulses family	Χεδροπά: ἀσπάλαθος, κολυτέα, σκορπίος, κύτισος, etc.
Maloideae	the pear family	ἀχράς, ἄπιος, ὄη, κράταιγος, μεσπίλη etc.
Olea europaea	olive	ἐλάα
Phillyrea/Rhamnus	mock privet/buckthorn	φιλυρέα, φίλυρα ἡ ἄρρην/φιλύκη, ῥάμνος
Pinus halepensis	Aleppo pine	πίτυς, πίτυς ἡ ἀγρία
Pistacia lentiscus	lentisc	σχῖνος
Prunus amygdalus	almond	ἀμυγδαλή
Quercus sp. evergreen type	prickly and holm oak	πρῖνος, ἀρία

two pits dated to the EIA I phase, the supposed altar of the A II period (Feature 05) with a long-lasting use, and a deposit of the H I period, which, appears to be an one-time deposition event (the "dining deposit").[5] All the above were found in Area D. Additionally, floor deposits (Area D) and fills of different chrono-cultural periods were sampled. These are construction and terrace fills for the reorganization of the area that date to the A I, A III, and A IV, the C I and the H II periods and floor deposits of the EIA II and C II periods. The results of the wood charcoal analysis for each context will be presented separately but also combined in chronological horizons in order to discuss both specific events and long-term trends in the plant-human relationships.

The plants (*Table 1*)

A total number of 1,043 wood charcoal fragments from 53 water-floated samples and various hand-picked ones have been analysed. At least 17 plant taxa have been identified, of which three belong to the gymnosperms, namely cf. *Abies* sp. (fir), *Cupressus sempervirens* (cypress), and *Pinus halepensis* (Aleppo pine) (*Figs. 2.7, 2.8* and *2.9*). The remaining taxa are all angiosperms and these are *Arbutus unedo* (strawberry tree), *Ceratonia siliqua* (carob), *Erica* sp. (heather) (*Fig. 2.5*), *Ficus carica* (fig tree), Labiatae (the mint family), cf. Labiatae, Fabaceae (woody plants of the pulses family) (*Fig. 2.6*), cf. Fabaceae, Maloideae (the pear family), Monocotyledon indeterminate, *Olea europaea* (olive) (*Figs. 2.3* and *2.4*), cf. *Olea*, *Phillyrea/Rhamnus* (mock privet/buckthorn), *Pistacia lentiscus* (lentisc), cf. *Pistacia*, *Prunus amygdalus* (almond), *Prunus* sp. diffuse porous type (blackthorn/plum), *Prunus* sp., *Quercus* sp. evergreen type (prickly and/or holm oak) (*Figs. 2.1* and *2.2*), and *Quercus* sp.

The identification of taxa usually reaches the species or genus level. In some cases as in the Labiatae, Fabaceae, and Maloideae only the broader family has been attributed to the wood charcoal fragments. This is mainly because the wood anatomy of particular species of these families is very similar and it is difficult to differentiate between them. Moreover, the Labiatae and Maloideae have been identified in few and/or small fragments that do not allow for detailed comparisons with the reference collection. However, many plants of the Labiatae family (*Phlomis*, *Thymus*, etc.) are very common in *maquis*[6] and *phrygana*[7] formations of all south-eastern Greece and the islands, while the Maloideae are usually represented by *Pyrus* species (the wild pear). As far as the Fabaceae family is concerned, in this taxon are included various spiny bushes and shrubs (e.g. *Calicotome*), equally characteristic of *maquis* and *phrygana*. The tree species of the Fabaceae family usually show characteristic anatomical structures which allow their identification to species level, as in the case of *Ceratonia siliqua* that has been identified in the Kalaureia samples.

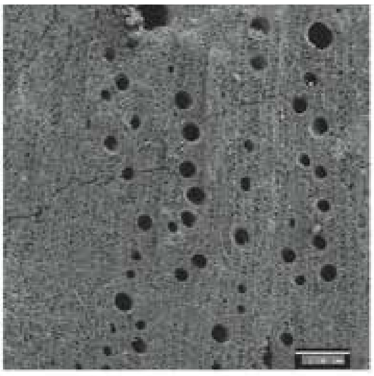
The genus *Prunus* is represented in the assemblages by three taxa. These have been identified according to the grouping of *Prunus* species proposed by Fritz H. Schweingruber[8] and in relation to the vessel distribution in the transverse section and the width of rays in the longitudinal tangential section. The indication "type" means that within Schweingruber's groups several species show similar anatomical characteristics as in the case of *Prunus* sp. diffuse porous type. However, in the case of *Prunus amygdalus* type, the species is specified because it has a

[5] Wells *et al.* 2005, 182; Mylona 2019.

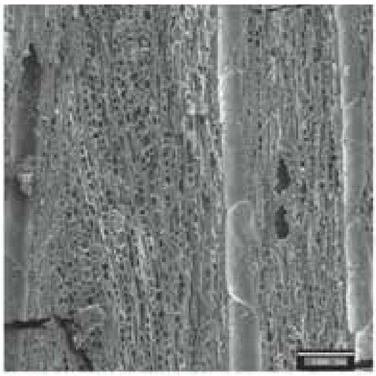
[6] *Maquis* is a tall dense scrub, 2–3 m high, largely composed of hard-leaved evergreen shrubs. *Maquis* occurs largely near the coast and in relatively damp places. The main growing period of plants is during late winter and spring while summer is a period of minimum growth activity. *Maquis* however cannot tolerate too-cold winters. It is very extensive on the Aegean islands with more humid climates such as Thassos, Samos, Sporades, etc. (Polunin 1980, 33, 36).

[7] *Phrygana* is the dwarf scrub vegetation of dry slopes, hills, and islands in the Mediterranean climatic zone. In its most characteristic form it is composed of low thickets of dense rounded shrublets, about half a metre high, with small leathery leaves, often spiny branches, commonly densely grey-hairy, and frequently aromatic. Their growth period is spring but they are very short-lived and by summer *Phrygana* vegetation becomes monotonous and unattractive. *Phrygana* is maintained in a relatively stable state by grazing, fires, and selective cutting by man (Polunin 1980, 36, 37, 42).

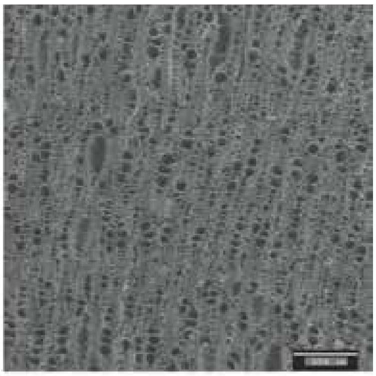
[8] Schweingruber 1990, 643.



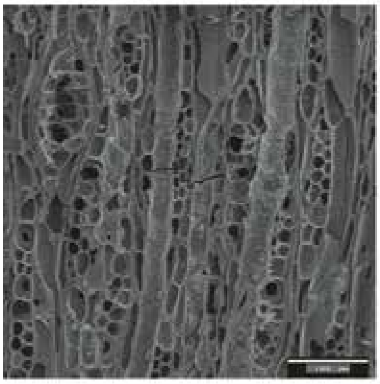
2.1. *Quercus* sp. type evergreen,
transverse section x70



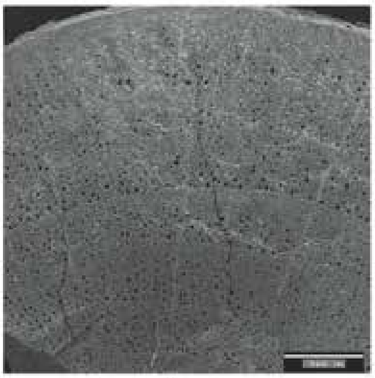
2.2. *Quercus* sp. type evergreen,
tangential longitudinal section x180



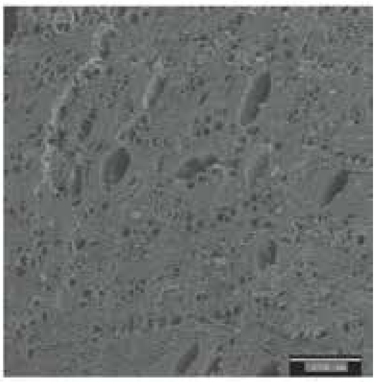
2.3. *Olea europaea*,
transverse section x80



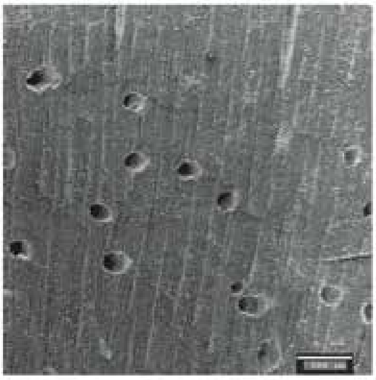
2.4. *Olea europaea*,
tangential longitudinal section x400



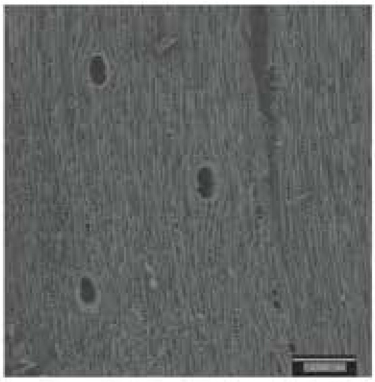
2.5. *Erica* sp.,
transverse section x50



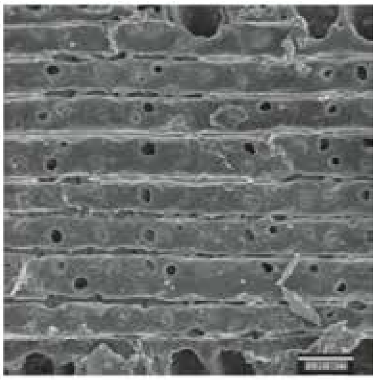
2.6. Fabaceae,
transverse section x90



2.7. *Pinus halepensis*,
transverse section x35



2.8. *Pinus halepensis*,
tangential longitudinal section x80



2.9. *Pinus halepensis*,
radial longitudinal section x700

Fig. 2. The wood anatomy of some of the identified taxa: 2.1. Quercus sp. evergreen type, transverse section x70; 2.2. Quercus sp. evergreen type, tangential longitudinal section x180; 2.3. Olea europaea, transverse section x80; 2.4. Olea europaea, tangential longitudinal section x400; 2.5. Erica sp., transverse section x50; 2.6. Leguminosae, transverse section x90; 2.7. Pinus halepensis, transverse section x35; 2.8. Pinus halepensis, tangential longitudinal section x80; 2.9. Pinus halepensis, radial longitudinal section x700. Photographs by the author.

constant presence in Greece from prehistoric times onward.[9] Other species with similar anatomy such as *Prunus armeniaca* and *P. persica* are later introductions. Nevertheless, given the chronological span of the investigated deposits it is preferable to keep such similarities under consideration, hence the indication type. The taxon *Prunus* sp. is due to insufficient information on the anatomy of the transverse section that did not preserve the determining characteristics, i.e. lack of complete annual ring and unspecified vessel distribution.

The taxon *Quercus* evergreen type includes prickly and holm oak, the two evergreen species growing in natural vegetation in Greece. Distinction of the species by their wood anatomy is not possible but they are clearly differentiated from their deciduous counterparts. Probably prickly oak is the major component of the wood charcoal assemblages given that it is the commonest in *maquis* vegetation in Greece.

The taxon *Phillyrea/Rhamnus* includes the representatives of two different plant families, the Oleaceae and Rhamnaceae respectively, which cannot be easily differentiated by their wood anatomy. Therefore both *Phillyrea* and *Rhamnus* could be present in the wood charcoal assemblages.

All the taxa identified in the wood charcoal assemblages are thermophilous Mediterranean elements, most of them evergreen broad-leaved, common in Greek islands and coastal areas. The most typical and characteristic of *maquis* vegetation are prickly oak, olive, Fabaceae, heather, strawberry tree, Aleppo pine, and the lentisc. They all grow spontaneously in Greece and/or their presence is documented since prehistoric times in natural contexts and archaeological sites by way of various lines of evidence.[10] The exception is *Ceratonia siliqua*, the carob, which is probably an introduced species in Greece. The earlier evidence for its presence comes from Late Bronze Age Crete in the form of wood charcoal and pollen grains.[11] Closer to Poros the species is recorded in pollen in the area of Megaris after 1200 cal. BC.[12] The tree was probably introduced and cultivated for its edible pods or for fodder.

Two other taxa that deserve a special mention are cf. *Abies* sp. and *Cupressus sempervirens*. There is only one wood charcoal fragment attributed possibly to the fir, which would probably correspond to imported timber and not to the natural vegetation of the island since these trees grow in high altitudes of the Mainland and in mountain forests under climatic and environmental conditions very different from those prevailing at Poros.[13] Finally, the cypress is considered native of Crete[14] and it has been identified there in wood charcoal from prehistoric contexts.[15] However, by historical times, the cypress could be grown outside Crete. There is wood charcoal evidence for its presence in Delphi from the 12th century BC and continuously afterwards.[16] Its presence at Kalaureia is rare and could be due either to its importation as timber or to the introduction and cultivation of the species on Poros and the sanctuary in particular. Sacred groves were common features of ancient Greek sanctuaries and there is archaeological evidence for cypress (or fir) planting at the Temple of Zeus in Nemea.[17]

The Early Iron Age pits[18]

Two pits, Features 07 and 09, produced wood charcoal. They date to the EIA I phase of the sanctuary. The pottery found inside the pits dates them to some time around 750 BC. It has been suggested that their fill represents the debris of activities that took place during the EIA I, which was cleared away, collected, and then deposited in the pits as a preamble for the construction of the EIA II building.[19] Part of the fill of Feature 09 however seems to have been deliberately deposited at the time of its filling, perhaps as part of a ritual.[20]

The wood charcoal results for Features 07 and 09 are presented in *Table 2* and *Fig. 3*. Although the total number of the analysed wood charcoal fragments in each pit is small, the number of the identified taxa is high. In Feature 07 at least seven taxa have been identified in a total of 55 fragments. Even more striking is the case of Feature 09 where at least eight taxa have been identified in a total of 29 fragments. The rich plant list in each one of the pits corroborates their depositional history as described above. A high number of taxa usually characterizes fills that accumulated over time, while single-event fillings usually include few plant species.[21] In cases of long-term depositions the relative abundance of species in the wood charcoal assemblage tends to reflect the relative importance of these species in the natural vegetation.[22] The quantitative results from Features 07 and 09 derive from small assemblages

[9] Ntinou 2002a; Badal & Ntinou 2013, 101, 111, 115, tables 6.2, 6.3, figs. 6.6, 6.7.

[10] Badal & Ntinou 2013, 100–101, tables 6.2, 6.3, fig. 6.7; Bottema 1994; Ntinou 2002b, 94–95, 99, figs. 2, 4; 2011, 301–304, tables 7.2, 7.3., fig. 7.8; 2012, 83–88, table 1.

[11] Bottema & Sarpaki 2003, 742, 745; Shay *et al.* 1995, 120, table 4.10; Schoch & Ntinou 2004, 133.

[12] Bottema & Sarpaki 2003, 742, 745.

[13] Polunin 1980, 47; Sfikas 1994, 46–48.

[14] Polunin 1980, 203.

[15] Badal & Ntinou 2013, 101, tables 6.2, 6.3, figs. 6.6, 6.7; Shay *et al.* 1995, 120–123, table 4.10.

[16] Renault-Miskovsky & Thiebault 1997.

[17] Darice 1992, 89–94, n. 278, 281.

[18] For a synopsis of the Early Iron Age in Area D, Penttinen & Mylona 2019.

[19] Wells *et al.* 2006–2007, 45–49.

[20] Wells *et al.* 2006–2007, 48.

[21] Chabal 1992, 215.

[22] Chabal 1992, 219–222; Chabal *et al.* 1999, 62, 79–80, 89–90; Pernaud 1992, 331–333.

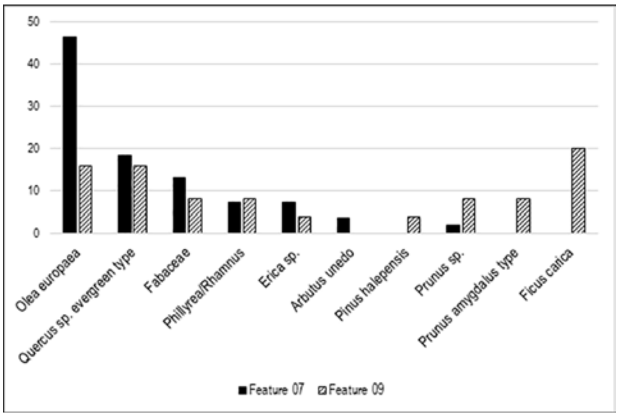


Fig. 3. Graphic representation of the presence and frequency of the taxa identified in the two EIA I pits.

(few fragments) otherwise rich in taxa that would require much more wood charcoal to be analysed in order to show the real tendency of the relative frequencies of the dominant taxa.[23] However, using these data with caution and in comparison with the summarizing results for all cultural periods at Kalaureia (*Tables* 2 and *4*, *Figs. 3* and *4*), we observe that the most frequent taxa are the same as in all successive phases, namely the olive, the evergreen oak, the Fabaceae and heather, and are present in mainly the same order of dominance. The wood charcoal characteristics of the pit assemblages seem to indicate a long-term deposition, and are in agreement with the excavators' conclusions about the provenance of the fill.

In Feature 09 there is a taxon, namely *Ficus carica* (fig tree) that is rarely present in the sanctuary. Given its high frequency in this pit we may postulate that it reflects a single depositional event intercalating in the filling of the pit. Short-term activities are usually characterized by overrepresentation of taxa in wood charcoal assemblages.[24] The presence and abundance of the fig tree in Feature 09 (*Table 2; Fig. 3*) appears to support the idea of an additional minor deposition of organic remains directly into the pit. This seems to be compatible with the zooarchaeological results for the same pit. The preservation status of the animal bones indicate that the pit contained remains of two different kinds, the eroded small bone fragments which were probably sweepings from the surrounding environment and a group of well preserved, more sizable bones which seem to represent some deliberate deposition.[25] It seems probable that the fig wood charcoal and the well-preserved bones belong to the same event.

Table 2. Absolute and relative frequency of the taxa identified in the EIA I pits, Features 07 and 09.

	EIA I pit—Feature 07		**EIA I pit—Feature 09**	
Taxa	**N**	**%**	**N**	**%**
Arbutus unedo	2	3.7		
Erica sp.	4	7.4	1	4.0
Ficus carica			5	20.0
Fabaceae	7	13.0	2	8.0
Olea europaea	25	46.3	4	16.0
Phillyrea/Rhamnus	4	7.4	2	8.0
Pinus halepensis			1	4.0
Prunus amygdalus type			2	8.0
Prunus sp.	1	1.9	2	8.0
Quercus sp. evergreen type	10	18.5	4	16.0
Quercus sp.	1	1.9		
conifer			2	8.0
Sub-total	54	100	25	100
Non-identifiable	1		4	
Total	**55**		**29**	
Total N taxa	7		**9**	

The supposed altar of the Archaic phase[26]

Wood charcoal samples were collected from the area around the A II Feature 05 dated to the first half of the 6th century BC and supposed to be an altar. The analysis of the finds indicates that the deposits accumulated over time through activities connected with the feature. The main activities in proximity to the feature were apparently related to some kind of sacrifice whereas eating and drinking seem to have taken place at some short distance from it.

Wood charcoal accumulated in the A II phase fill as a result of long-term use of this particular area and probably corresponds to the use of firewood for sacrifice and/or the preparation/cooking of food. The plant taxa identified in the A II phase fill and their frequency can be seen in *Table 3*. Olive, evergreen oak, Fabaceae, mock privet/buckthorn, fig tree, and heather firewood was mainly used, while the presence of a few other plants is sporadic. The plants used for firewood in possible ritual practices were not any different from the plants identified in other deposits (*Table 4; Fig. 4*) and it seems that the provision of fuel was carried out without any selective cri-

[23] Badal & Heinz 1991; Chabal 1992, 218.
[24] Badal 1992.
[25] Wells *et al.* 2006–2007, 47; Mylona 2019.

[26] For a synopsis of Archaic strata, Penttinen & Mylona 2019.

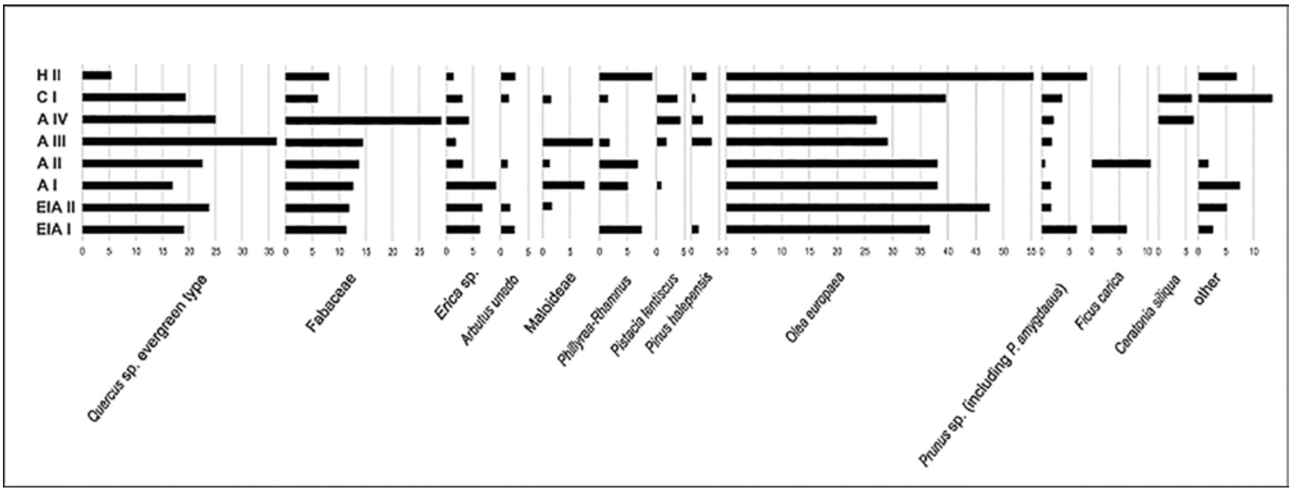


Fig. 4. The use of economic plants and the natural vegetation at the Sanctuary of Poseidon through time: frequency of the best-represented plant taxa and the woodland undergrowth in each period.

Table 3. Absolute and relative frequency of the taxa identified in specific activity deposits, the area surrounding the supposed altar belonging to the A II phase (Feature 05) and the H I "dining deposit".

	A II—around Feature 05		**H I—"dining deposit"**	
Taxa	**N**	**%**	**N**	**%**
Arbutus unedo	2	1.3	5	2.1
Cupressus sempervirens			1	0.4
Erica sp.	5	3.1	2	0.9
Ficus carica	17	10.6		
Labiatae	1	0.6		
cf. Labiatae	1	0.6		
Fabaceae	22	13.8	29	12.4
Maloideae	2	1.3		
Olea europaea	61	38.1	115	49.4
cf. *Olea*	1	0.6		
Phillyrea/Rhamnus	11	6.9	5	2.1
Pinus halepensis			18	7.7
Prunus amygdalus type	1	0.6	6	2.6
Prunus sp.			3	1.3
Quercus sp. evergreen type	36	22.5	44	18.9
Quercus sp.			2	0.9
conifer			3	1.3
Sub-total	160	100	233	100
Non-identifiable	14		24	
Total	**174**		**257**	
Total N taxa	**10**		**10**	

teria. The by-products of agricultural practices, like the pruning of olives, were recycled in fires and hearths while the evergreen oaks dominating in the *maquis* formations of the island were probably coppiced for firewood. Other woody plants were used to a lesser degree in response to their abundance in the woodland.

The only peculiarity of the A II assemblage is the abundant presence of the fig tree. The wood of the fig tree is considered bad-quality fuel because at burning it produces thick and pungent smoke and therefore it is usually avoided. Theophrastus, however, describes a complex process for drying fig tree wood in order to eventually produce good flame.[27] The wood of fig trees that are common in Mediterranean ecosystems could be used for fuel but since it is absent from almost all other fills at Kalaureia it appears that it was not systematically collected as such. It occurs in two special locations, in the Early Iron Age special deposition in Feature 09 and in proximity to the supposed Archaic altar (Feature 05). The fig tree charcoal may originate from fires associated with rituals or feasting. It can be suggested that the presence of fig tree wood in this particular assemblage is related to the consumption of the fruit in the area or to the offering of figs in the course of some ritual. Fruit still on the branches might be involved in ritual and when the fruit was consumed or offered the branches were thrown on to open-air hearths. Alternatively, we might consider the use of green fig tree wood in some kind of ritual which required the generation of smoke.

The Hellenistic "dining deposit"[28]

A H I deposit that represents dining refuse was excavated in Area D. In it domestic pottery, animal bones, sea-shells, and

[27] Theophr. *Hist. Pl.* V.IX.5–6.
[28] Penttinen & Mylona 2019.

Table 4. Absolute and relative frequency of the taxa identified in the fills of different chrono-cultural periods.

	EIA II		**A I**		**A III**		**A IV**		**C I**		**C II**		**H II**	
Taxa	**Nº**	**%**	**Nº**	**%**	**Nº**	**%**	**Nº**	**%**	**Nº**	**%**	**Nº**	**%**	**Nº**	**%**
cf. *Abies* sp.									1	0.7				
Arbutus unedo	1	1.7							2	1.5			2	2.7
Ceratonia siliqua							3	6.3	8	6.0				
Cupressus sempervirens			1	0.8										
cf. *Cupressus sempervirens*									1	0.7				
Erica sp.	4	6.8	11	9.3	1	1.8	2	4.2	4	3.0			1	1.4
Labiatae			1	0.8					2	1.5				
cf. Labiatae	1	1.7												
Fabaceae	7	11.9	15	12.7	8	14.5	14	29.2	8	6.0			6	8.1
cf. Fabaceae			2	1.7										
Maloideae	1	1.7	9	7.6	5	9.1			2	1.5				
Monocotyledon									1	0.7				
Olea europaea	28	47.5	45	38.1	16	29.1	13	27.1	53	39.6	5	62.5	41	55.4
Phillyrea/Rhamnus			6	5.1	1	1.8			2	1.5			7	9.5
Pinus halepensis					2	3.6	1	2.1	1	0.7	1	12.5	2	2.7
cf. *Pistacia*													1	1.4
Pistacia lentiscus			1	0.8	1	1.8	2	4.2	5	3.7				
Prunus amygdalus type	1	1.7	1	0.8							1	12.5	4	5.4
Prunus sp. diffuse porous type									2	1.5				
Prunus sp.			1	0.8	1	1.8	1	2.1	3	2.2	1	12.5	2	2.7
Quercus sp. evergreen type	11	18.6	13	11.0	20	36.4	10	20.8	22	16.4			4	5.4
Quercus sp.	3	5.1	7	5.9			2	4.2	4	3.0				
angiosperm	2	3.4	5	4.2					11	8.2			1	1.4
conifer									2	1.5			3	4.1
Sub-total	59	100	118	100	55	100	48	100	134	100	8	100	74	100
Non-identifiable	3		9		4				8		2		5	
Total	**62**		**128**		**59**		**48**		**142**		**10**		**79**	
Total N taxa	**8**		**11**		**9**		**8**		**16**		**4**		**10**	

wood charcoal were abundant. The fill appears to represent a single deposition event and it dates to around 165 BC.[29] The wood charcoal data of this deposit are presented in *Table 3*. Olive, evergreen oak, and Fabaceae wood was mostly used, a shared characteristic with all other wood charcoal assemblages from Kalaureia. A novelty in this assemblage is the abundant use of Aleppo pine wood that is very rare in all other contexts. Various other plant taxa are present in small numbers.

The assemblage bears the characteristics of fills that accumulated over time; many taxa are present while their relative frequency and order of dominance share analogies with natural formations, like the prickly oak dominated *maquis*. Moreover, in *Table 4* and *Fig. 4* we can observe that all fills of long-term accumulation (i.e. EIA I pits, C I construction fill) show similar characteristics which reflect a constant practice in the use of fuel that combined the remains of olive tree cultivation (pruning) and the wood of other trees and shrubs. Therefore, the wood charcoal evidence suggests that the H I "dining deposit" would best be explained as the result of repeated burning of firewood for the preparation of food. This is contrary to what the bone and pottery evidence indicates, a single deposition event rather than a repeated activity. However, an alternative interpretation that may explain the diversity of the wood charcoal assemblage despite its short-term deposition may be found in the epigraphical and literary record.[30] There, certain rules and regulations are mentioned that prevented the cutting of trees within the sanctuaries. Therefore it seems quite probable that the worshippers, especially those participating in this meal, would have to provide their own firewood that could have originated from different locations and/or differ-

[29] This argument is based on the preservation state of both bones and pottery and on the lack of signs of weathering, scavenging, and exposure to the elements (Wells *et al*. 2005, 16–68; Mylona 2019).

[30] Dillon 1997.

ent activities, coppicing of the natural woodland, pruning of orchards, etc., on the island or the Mainland opposite.[31] In this sense, the single event represented in the wood charcoal assemblage of the Hellenistic "dining deposit" is diversified due to the multiple sources of firewood reflected in it.

Floor deposits and construction fills

In the course of the excavation in Area D two floor deposits were unearthed and dated to the EIA II phase and to the C II phase respectively.[32] The EIA II floor deposit (750–700 BC) is associated with the remains of a building constructed over the EIA I fill. The C II phase floor level (post 325 BC and a couple of decades of the 3rd century BC) proved thin, and consisted of patches of earth between a paved area and a stone bedding. A hearth was located nearby. The pottery recovered suggests that the floor level did not accumulate over time but was perhaps created at one particular point in time.[33]

The results for both floor deposits, EIA II and C II, are shown in *Table 4*. Neither of the assemblages is rich in wood charcoal and the C II one is particularly poor with only ten fragments collected and analysed. The EIA II assemblage is very similar in both qualitative and quantitative terms to all other fills and/or deposits (*Table 4; Fig. 4*). The plants used are the same while the number of the identified taxa and their frequency, where no single taxon is over-represented, are characteristic of depositional episodes with a long duration and where repetitive firewood uses are reflected.[34]

The C II floor level is poor in wood charcoal and the only taxa represented are the olive, the Aleppo pine, the almond, and *Prunus* sp. (*Table 4*). The use of their wood for fuel might be supported by the presence of a hearth in the area. The absence of taxa common in other deposits, namely evergreen oak, Fabaceae, and heather could be related to the fact that one particular point in time seems to be reflected in this floor level. Thus, the wood charcoal remains could be related to the last or to a few firewood uses in the nearby hearth and for this reason the range of plant species is so restricted and different from other assemblages.[35]

In Area D various other fills that correspond to construction episodes in different chronological periods were also excavated. Three fills are attributed to the Archaic strata, A I, A III, and A IV, one to the Late Classical/Early Hellenistic stratum C I and another to the Late Hellenistic/Early Roman stratum H II.

The pottery in the A I fill dates to the 7th century BC and consists of large fragments, which indicate that the deposition may not have accumulated over time but was the result of some short-term activity.[36] The A III phase fill is associated with the building of Wall 05 while deposits of crushed purple shells and the stoking channel of a pottery kiln (Feature 10), located just to the north-west of Building D, are tentatively placed in the same phase that dates to the end of the 6th century BC. Considering the location of the kiln in the middle of a sanctuary, it is possible that this was a temporary structure and presumably associated with some of the major construction phases at Kalaureia, probably the A III phase, around 500 BC, which saw the construction of the Temple of Poseidon and other structures as well.

Deposits attributed to the A IV phase consisted mainly of a terrace fill destined to the reorganization of space.[37] A fill of the Late Classical/Early Hellenistic period (C I) is associated with a construction phase, for which the study of related finds gives a *terminus post quem* of 325 BC. Finally, a deposit and cistern fill belonging to the Late Hellenistic/Early Roman period (H II), were excavated in Area D. Pottery found in the cistern is datable to around 50 BC,[38] while the glass vessels indicate a date of around 100 AD.

The results of wood charcoal analysis from the above fills are presented in *Table 4* and *Fig. 4*. The A I and C I assemblages are the richest in wood charcoal remains and this is reflected in the plant list, especially in the C I fill in which more taxa than in any other assemblage have been identified. The wood charcoal remains in the A III and A IV and the H II assemblages are rather few but still the commonest taxa on site are present in them.

It is difficult to know the provenance of the wood charcoal in these fills. It could be the debris from burning features and/or discarded structural wood given that all the deposits are associated with some construction phase or reorganization in the area of the sanctuary. The function of the kiln during the A III period would be a possible source for the burnt wood accumulated in this fill. The majority of the plant taxa present in the construction fills have been identified in other assemblages where accumulation of firewood remains has been suggested (the "dining deposit", the cult area) and their frequency shows the same characteristics. The new elements in those fills are the possible presence of fir in the C I fill and the presence of cypress in the A I and C I fills. What is interesting about these taxa is on one hand their "exotic" provenance

31 Mylona 2019.
32 Wells *et al.* 2003, 53–54; 2006–2007, 44–45, 85.
33 Wells *et al.* 2003, 53; 2006–2007, 70–71.
34 Badal 1992.
35 Badal 1992.
36 Wells *et al.* 2006–2007, 45, 78–80.
37 Wells *et al.* 2006–2007, 45, 78–85. See also Penttinen & Mylona 2019.
38 Wells *et al.* 2006–2007, 80.

and on the other their use especially as timber in sacred areas and temples[39] or as planted trees in sacred groves.[40] The fir is not ubiquitous on the island of Poros and it could not grow there naturally given its environmental preferences especially atmospheric humidity. The cypress is very widespread in the circum-Mediterranean countries nowadays but this is a cultivated variety that if it existed in Classical times was not yet a source of timber.

In historical times the wild cypress has been confined to Crete, Rhodes, and Turkey although in most cases ancient inscriptions connect cypress with Crete from where its timber was imported.[41] Both trees, fir and cypress, produced timber that was used for the construction of temples. These were the two species used in abundance for the temple of Asclepios at Epidaurus, the former probably for roofing and the latter for the ceiling.[42] Theophrastus praises the fir as one of the most useful trees, providing the strongest timbers and the best for bearing weight.[43] According to Rackham[44] and judging by both the high price of cypress timber[45] and the special mention of a cypress tree in a 5th-century BC inscription, a gift to the Athenian Parthenon from the Sanctuary of Apollo at Karpathos,[46] the cypress might be the equivalent to cedar for the ancient Greeks, a valuable and at the same time sacred tree. Wood charcoal analysis from temples is still restricted to only a few cases. Even among these however, both cypress and fir are attested. An *apothetes* (depository) at the Temple of Vryokastro on Kythnos contained both cypress and fir charcoal.[47] Fir has also been identified in the charcoal samples from the Geometric temple of Artemis at Rakita, Peloponnese; in this location fir would have probably formed part of the local vegetation.[48]

At Kalaureia the few remains attributed to these species come from fills associated with construction phases. Remains of construction material, from the carpentry of cypress and fir timber might have been discarded and eventually used as firewood. Therefore, the presence of these taxa in the A III and C I period assemblages might be related to the use of their timber in the temple.

The presence of cypress at the Sanctuary of Poseidon at Kalaureia, however, may be also discussed in relation to the sacred groves that are often mentioned in the Greek literature. Pausanias reports[49] that cypresses grew around the Temple of Zeus at Nemea in the 2nd century AD. The archaeological evidence for landscaping the area around this temple are the tree-planting pits to the south-east and south of it.[50] Microscopic analysis of carbonized and decomposed material at the bottom of some of the pits indicated the presence of either cypress or fir trees.[51] These findings agree with Pausanias' report while pottery evidence from the pits proper dates the original planting to at least the 4th century BC.[52] In line with the above-mentioned finds and the descriptions from the Greek literature for the existence of sacred groves in sanctuaries, it may be suggested that the few cypress wood charcoal remains from Kalaureia could also originate from trees cultivated to embellish the sanctuary, to provide shade, or to serve other ritual purposes.

The carob is present and quite abundant in the A IV and C I assemblages. Its presence in the assemblages dates its introduction and probably cultivation in the area of the sanctuary by the end of the 6th century BC. Carob pods might be used as fodder for livestock and/or for human consumption. Tending of the cultivated trees would produce wood eventually used for fuel. Therefore the presence of carob together with olive wood charcoal in the assemblages may reflect farming activities in the area around the sanctuary.

The vegetation around the sanctuary and its uses

It has been stated earlier that the palaeoecological information, i.e. information on the characteristics of the vegetation in the past and its alterations over time, is normally gained through the analysis of wood charcoal assemblages from fills that accumulated gradually over long periods of time. We assume that these wood charcoals represent repeated uses of firewood and timber, therefore a repeated sampling on the part of humans of the vegetation.

In the case of Kalaureia the stratigraphy in the excavated Areas C and D reflects human activity that dates from the Early Iron Age to the Late Hellenistic/Early Roman period. The wood charcoal material from fills from all these phases permits the construction of a charcoal diagram that documents the use of plants at different times and thus the nature of the vegetation in the area at these same periods (*Fig. 4*).

39 Rackham 2001.
40 Darice 1992, 89–94.
41 Meiggs 1982, 423–430; Rackham 2001.
42 Hodge 1960; Meiggs 1982, 423–424.
43 Theophr. *Hist. pl.* V.I.5 & V.VI.1–2.
44 Rackham 2001.
45 Meiggs 1982, 431, 443. Exceptionally high prices for cypress timbers are mentioned in the temple accounts from Delphi and in the Delian accounts.
46 Meiggs 1982, 200–201.
47 Ntinou 2017, 280–282.
48 Psarroy 2002.
49 Paus. 2.15.2.
50 Darice 1992, 89–91, figs. 98–103.
51 Darice 1992, 91–93, n. 281.
52 Darice 1992, 93–94.

A comparative look at all the assemblages shows that the most frequent taxon is the olive, followed by the prickly oak, the Fabaceae, and the heather. In most assemblages mock privet/buckthorn, strawberry tree, the pear and *Prunus* family species are present, while Aleppo pine, lentisc, the fig, and the carob trees are less frequent. All plant taxa, with the exception of the fir (see above), form part of plant formations of coastal areas in Greece and are typical of the thermo-Mediterranean bioclimatic zone where Poros is located. The olive and the carob are the indicator plants of such climatic conditions and of the relevant plant formations, named Oleo-Ceratonion.[53] We believe however that the dominance of the olive is more the reflection of cultivation than of the abundance of the wild variety growing in the natural vegetation. The same would stand for the carob as well. The role of the olive in the natural flora and vegetation of Greece is still debatable as there is scarce evidence for the presence of the tree before the end of the Neolithic. A notable increase in olive remains from the Bronze Age onwards has been associated with olive cultivation and therefore to the human intervention for the proliferation of the plant.[54] As for the carob, it is a late introduction in the Aegean area where the first sporadic wood charcoal remains date to the Late Bronze Age,[55] hence the presence of the tree in later periods should be attributed to its cultivation.

The natural woodland and its composition can be seen in the presence and abundance of the other plant taxa. Evergreen oaks, especially the prickly oak, would prevail in formations, probably *maquis*, in which mock privet/buckthorn, strawberry, lentisc, and wild olive would grow in lower numbers. Heather, Fabaceae, and Labiatae would grow either in open formations of spiny and low aromatic bushes or as undergrowth in the oak-dominated *maquis*. The woodland would probably alternate with clearings where sun-loving species like the wild pear could grow.

Woodland as well as fields and groves were probably owned and managed by the sanctuary for wood, agricultural products, and for keeping livestock. Firewood from *maquis* and probably coppiced trees would be taken to the sanctuary for fuel but a major contribution would be from pruning of the olive trees. Other fruit-bearing trees such as the almond and the pear might grow spontaneously in natural vegetation and their wood would be collected together with that of other species. Usually such trees are found at the edges of fields and are kept there for their fruit and for shade. The dominance of the olive in all assemblages is probably an indication of the importance of this plant in the agricultural activities of the sanctuary or the production of the island. Significant presence of the species in all the assemblages of the sanctuary is most probably the result not of abundant spontaneous growth of the wild variety in the natural vegetation but of the existence of olive groves in the area. All agricultural societies tend to recycle the by-products of their activities and in this sense tree-managing and pruning would leave abundant remains, which could serve as firewood. Olive groves in particular, would be a constant and rich source of such material, very much appreciated.

An aspect of the past vegetation that does not match the present picture of the island is the scarce presence of the Aleppo pine in the assemblages. A dense pine woodland grows today on the island and near the sanctuary and given that pines are very competitive few other species mix with them. If the tree had grown on the island to the degree it does nowadays we would expect it to be more frequent in wood charcoal remains, in the way the evergreen oak is, since it would have probably been the dominant species in the corresponding plant formation. One explanation for the scarcity of pine remains is that pine woodland was protected and used only for timber or maybe for other products as the resin. Therefore, few, if any, pine wood would reach fire as carpentry by-product (similar to fir and cypress) or accidentally. Another explanation is that pines were growing in small numbers in *maquis* formations, as they usually do, and therefore the frequency of the taxon in the assemblages is representative of its minor role in the natural vegetation. Later proliferation of the species might be the result of repeated fires that favour the growth of pines since they regenerate faster than other plants and/or of human interference that encouraged the existence of pine groves for economic reasons (the resin exploitation?). The assemblages from the sanctuary are not very informative in this respect. Only during the H I phase there seems to be an important presence of the species but it is not sufficient to speak for a change in the vegetation given that in the assemblages of successive chrono-cultural periods there are no differences in the components or in the frequency of the most abundant taxa.

Concluding remarks

What do wood charcoal remains tells us about activities in the sanctuary? We may suggest that woodland, fields, and olive groves existed in the area of the sanctuary. It is possible that the sanctuary monitored these resources or in collaboration to the *polis* of Kalaureia, as was the case for other economic resources, about which we are informed by inscriptions.[56] Whatever the case, olive cultivation was an important economic activity

[53] Quézel & Barbéro 1985.
[54] Valamoti *et al.* 2018.
[55] Bottema & Sarpaki 2003, 742, 745.
[56] Meiggs 1982.

during the whole life of the sanctuary and the trees were meticulously taken care of, an activity that constantly provided the sanctuary with fuel (olive pruning). The woodland would be the additional source of firewood for the sanctuary's needs for fuel for mundane activities such as heating and cooking, for more formal ones, such as sacrifice, but also for industrial activities such as tile firing. It would also be the source of timber for construction. Those activities that are related to the reorganization of space and the expansion of the sanctuary may be reflected in charcoal of carpentry by-products as has been argued for the fir, cypress, and maybe pine remains. Evidence of the use of "exotic" timber points to the existence of a commercial network in which the island, and probably directly the sanctuary, were involved in order to cover, among others, exceptional needs of large (and "sacred") timber or maybe finished wooden objects. The existence of sacred groves where trees such as cypresses were planted is also hypothesized. Finally, sacrifice (probably reflected in the so-called altar, Feature 05) and feasting activities, took place in the sanctuary. Abundant fuel was needed. Ordinary firewood was apparently used, wood from trees and shrubs and agricultural by-products. In such activities, as far as it can be surmised from the wood charcoal assemblages, there was no selectivity of any particular plant species. A ritual character attributed to specific plants is more elusive. It is possible that the wood charcoal of fruit-bearing plants (e.g. the fig, the almond) is found in the feasting deposits because branches carrying fruit were taken to the sanctuary as offerings or simply for consumption, and the unneeded parts were thrown in fires and hearths. Alternatively the special features of certain plants such as the smoke-generating quality of the fig tree, might also have been used in cult.

A whole array of activities related directly or indirectly to wood use in the sanctuary is revealed through its burnt remains. Moreover, the characteristics of the natural local vegetation can be seen in most of the identified plant taxa. Evergreen oak woodland and *maquis* largely composed of hard-leaved evergreen shrubs, were growing on the island. Pine groves, if they existed at all, were for some reason protected or not used for firewood. Finally, the identified plants speak of mild winters, and low rainfall, concentrated in spring and autumn and dry summer periods, the characteristics of the thermo-Mediterranean bioclimatic zone in which Poros is located and which are ideal for olive growth.

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