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Vegetation and human communities in prehistoric Greece

The study of past plant environments is making a growing contribution to the knowledge of the natural setting for Early Holocene human groups and for the establishment of Neolithic communities. Recent investigations into Greek Prehistory are incorporating methods and disciplines such as palynology and charcoal analysis as a means of reconstructing prevailing biological and climatic conditions and of investigating changes in the plant environments caused by natural factors or anthropogenic activities. Pollen investigation in Greece offers a clear framework for the Early Holocene natural environments while local conditions and the human perception of vegetation are the outcome of charcoal analysis carried out at prehistoric sites Youra (Northern Sporades), Makri, (Thrace), Dispilio (West Macedonia), Sitagroi (East Macedonia)]. In this article, aspects of Holocene plant environments in Greece are discussed. Special reference is made to the regional variation of vegetation, the interaction between human groups and plant formations and the repercussion of human intervention upon them.

Key Words: *Early Holocene. Greece. Vegetation. Palynology. Charcoal analysis. Neolithic communities.*

INTRODUCTION

Recent investigations into prehistory are incorporating methods and disciplines that can be useful tools for the study of past environments in which prehistoric human groups are active components.

Vegetation, one of the basic elements of an ecosystem, is the main objective of palaeobotanical research applied either to natural or archaeological deposits. Data concerning past vegetation and its evolution through time can reveal the climatic conditions prevailing at a given period and the agents that can cause modifications either natural or human.

Traditionally, charcoal recovered from archaeological contexts, was used principally for radiocarbon dating. Within the framework of Environmental Archaeology however, charcoal analysis (the study of burned wood recovered in archaeological deposits) is making a growing contribution to the reconnaissance of past plant formations used and/or managed by humans. This line of research is complementary to palynological investigation in natural or archaeological sites, which has a long-established application to the reconstruction of the diachronic image of vegetation.

Charcoal data from archaeological deposits in Greece are very scarce. On the contrary, there is abundant information on past vegetation and climate from palynological investigation carried out in natural deposits in Greece. The prolific pollen record documents the history of the vegetation in long sequences that go back to the Pleistocene while shorter sequences from mainland Greece and the island of Crete add to the knowledge of Holocene vegetation.

Charcoal and pollen records are not directly comparable due to different methodologies, different temporal and spatial scales and transport agents of the deposited remains. Nevertheless, the data offered by both methods can be complementary. The pollen record provides the long temporal and spatial perspective for the study of the evolution of vegeta-

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tion, while charcoal analyses offer high-resolution data in the site's immediate surroundings. In this presentation the results of both methods are summarized in a synthesis of the available information from Greece.

There are aspects of Holocene plant environments and the interaction with human groups that are the research objective for both methods, pollen and charcoal analysis. This presentation focuses upon:

- Reconstruction of the evolution of vegetation in Greece during the Holocene based on the pollen record;
- Reconstruction of vegetation in close proximity to prehistoric sites and managed by human groups based on the results of charcoal analysis;
- Regional characteristics and differentiation in vegetation as expressed both in pollen and charcoal data;
- The interaction between human groups and the plant environment, especially during the Neolithic: the effect caused by human intervention in the environment and more specifically when and how this effect is documented.

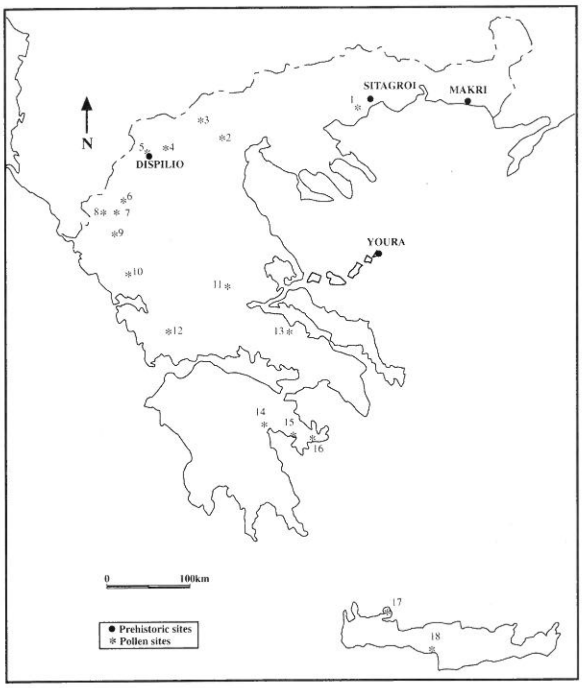

Figure 1. Map of Greece showing the location of pollen coring sites and the prehistoric settlements mentioned in the text. Pollen coring sites: 1) Tenaghi Philippon, 2) Giannitsa, 3) Edessa, 4) Khimaditis, 5) Kastoria, 6) Rezina, 7) Gramousti, 8) Tseravinas, 9) Ioannina I, 10) Ziros, 11) Xinias, 12) Trikhonis, 13) Kopais, 14) Lerna, 15) Kiladha, 16) Thermisia, 17) Tersana-Limnes, 18) Aghia Gal·lini.

THE HOLOCENE VEGETATION IN GREECE: THE POLLEN EVIDENCE

The evolution of vegetation in Greece during the Holocene has been the scope of palynological investigation carried out in both the mainland and the island of Crete. The reconstruction of the vegetation and the prevalent climatic conditions has been achieved through numerous pollen cores (fig. 1), some covering the whole Holocene and others only part of it.

The main pollen sequences summarized here are: Ioannina I (Bottema, 1974), Gramousti, Rezina (Willis, 1992a, 1992b), Tseravinas, Ziros (Turner and Sanchez Goñi, 1997) in Epirus, Edessa, Khimaditis, Kastoria, Giannitsa (Bottema, 1974) in West Macedonia, Tenaghi Phillipon (Wijmstra, 1969) in East Macedonia, Xinias (Bottema, 1979) in Thessaly and Kopais in Sterea Hellada (Allen, 1990, Turner and Greig, 1975). Other shorter sequences, Trihonis (Bottema, 1994) in mainland Greece, Kiladha (Bottema, 1990) and Lerna (Jahns, 1993) in the Peloponnese, Aghia Galini (Bottema, 1980) and Tersana-Limnes (Moody *et alii*, 1996) in Crete, are complementary to the vegetation history of the Holocene.

Vegetation in Greece from the Late Glacial/Holocene transition documents a dynamic system. In the pollen record, from an initial stage of forest expansion onwards, various phases of change are evidenced in the dominant deciduous formations. The Late Glacial/Holocene transition is characterized in all pollen sequences by a marked rise of the arboreal pollen (AP) were the dominant tree taxon is *Quercus* deciduous. This event has been dated in the Ioannina and Edessa sequences (fig. 1) to 10190±90 BP and 10645±100 BP respectively (Bottema, 1974).

Changes in the vegetation occurred between 10000 and 9000 BP throughout Greece, and the Balkans at large. The expansion of mixed deciduous forests is documented at an early stage. The pre-Boreal vegetation maintained characteristics of previous periods. Until approximately 9300 BP open habitats and steppe elements are documented parallel to the expansion of woodlands. Oak forests dominated territories between 400 and 800 m asl. The frequencies of the conifers decreased, indicating shifting to higher altitude (Bottema, 1974, 1994). Other deciduous species proliferated in places where humid conditions prevailed. There are common taxa in all pollen sequences such as *Corylus*, *Tilia* and *Ulmus*, which indicate the existence of extensive Late Glacial refugia of those taxa with wide distribution in the Balkans. In parallel, there are other taxa documented only within the Greek pollen record, namely *Carpinus orientalis*/*Ostrya carpinifolia*, *Pistacia* and *Phillyrea*, which were probably growing in restricted refugia in Greece (Willis, 1994).

Around 9000 BP the presence of *Pistacia* is a common characteristic of all Greek pollen sequences including the ones from northern regions (Khimaditis and Edessa). This heliophilous taxon is evidence for an increase in temperatures and for rather open plant formations. *Pistacia* appears earlier in the sequences from sites either from a southern location or from a lower altitude. Other Mediterranean taxa such as *Quercus ilex-coccifera* and *Phillyrea* evolve next to *Pistacia* in some pollen sequences. Around 8000 BP *Pistacia* shows an abrupt decrease. This must have been the result of deciduous formations growing in density, which in turn forced the sun-loving *Pistacia* to decrease (Bottema, 1974; Willis, 1994).

The following stage in vegetation evolution, from 8000 BP and during the Atlantic period, is characterized by internal changes in plant formations and maximum expansion of deciduous forests. Willis (1994) distinguishes two phases in the Balkan vegetation evolution: the first one between 8000 and 7000 BP is characterized by changes in the dominant taxa, and the second from 7500 to 5000 BP is a period that documents the expansion of *Carpinus orientalis/Ostrya, Abies, Carpinus betulus* and *Fagus*. Regional variation characterizes the evolution of the vegetation in different parts of Greece.

In the sequences from the Northwest (Ioannina, Gramousti, Tseravinas and Ziros) and from 8000 BP onwards, deciduous forests are the most important elements while the conifers lose terrain. Further north, in the sequences of Khimaditis and Edessa the altitudinal differentiation of the vegetation is documented from 8020 BP - 8050 BP. The conifers, *Pinus* and *Abies* proliferate and expand from 700 m onwards. Some increase in the precipitation has been postulated (Bottema, 1974). Similar trends occur to the south, but in areas located at a considerable altitude, such as Rezina at 1800 m asl (Willis, 1992b). At the same time, the southern parts of Greece do not document significant changes in the pollen record. For this reason, Allen (1990) and Turner and Greig (1975) do not distinguish different pollen zones until approximately 5000 BP in the Kopais diagrams.

The following stage is characterized by the expansion of *Carpinus orientalis/Ostrya carpinifolia* around 6500 BP and by a general decrease in the frequencies of other deciduous taxa.

The changes documented in the vegetation between 8000 and 5000 BP were the result of a combination of factors. Modifications in the composition of the plant formations must have been the result of competition between species in relation to the evolution and maturity of soils triggered by the global climatic changes of the Holocene. The establishment rates of different taxa would have played a secondary role (Willis, 1994).

From 5000 BP onwards some changes in the pollen record document the increase of human impact upon the vegetation. Human activities resulted in the modification of plant cover and new taxa appeared directly or indirectly associated with the anthropic influence on the environment: *Juglans*, *Olea*, *Platanus*, *Castanea* and Ericaceae (Willis, 1994).

Shorter sequences, mainly from the Peloponnese and Crete, show an evolution similar to the one documented in northern sites. In the former, the Mediterranean components are somewhat better represented but they do not dominate (Bottema, 1994); that is the case of Lake Trikhonis (Bottema, 1982) in central Greece where an oak woodland is recorded with *Carpinus orientalis/Ostrya*, *Corylus* and probably semi-deciduous elements.

In the Peloponnese, the Lerna diagram (Jahns, 1993) starting at 7000 BP indicates the dominance of mixed deciduous formations until 4800 BP (3600 BC) when a decrease in AP is documented. All the Mediterranean elements are present, *Quercus ilex-coccifera*, *Phillyrea*, *Juniperus*, *Pistacia, Myrtus communis,* but their occurrence is interpreted as part of an open natural environment and not as a sign of modifications in the plant cover due to human pressure. The human influence is negligible during the Neolithic but increases considerably during the Bronze Age when *shibliyak* formations are documented.

Similar characteristics are detected in the sequences of Limni Thermisia and Kiladha (Bottema, 1990; Jahns, 1993) in the Peloponnese. Bottema (1990) suggested that oak woodland expanded at higher altitude while open formations dominated in the valley floors. However, open vegetation was not the result of human impact on the environment during the Neolithic but a natural characteristic of Mediterranean plant formations. At the latitude of the Peloponnese higher *Quercus ilex-coccifera* frequencies and *Quercion ilicis* formations would be expected but the pollen record documents the prevalence of *Quercus* deciduous.

Finally, in Crete, the sequences of Aghia Galini (Bottema, 1980) in the south and Tersana - Limnes (Moody *et alii*, 1996) in the north-west include some mesic taxa such as *Quercus* deciduous, *Tilia*, *Ulmus*, *Carpinus/Ostrya* and *Corylus* together with the typically xeric Mediterranean taxa. From such data in Tersana-Limnes, the climate is described as equally hot to the present with minimum temperatures over 6°C, but significantly moister judging by the presence of *Tilia* all throughout the Neolithic (Moody *et alii*, 1996).

Human impact becomes progressively more important from 4500 BP onwards. However, this is not synchronous in all sequences. The earliest signs of human impact upon the vegetation come from the sequences of Gramousti, Rezina (Willis, 1994) and Tseravinas (Turner and Sanchez Goñi, 1997). Around 6000 BP, herbaceous taxa increase, tree taxa decrease, alogenous input augments in the sediment and microcharcoal is accumulated. Those characteristics are associated to opening up of the canopy and clearing of the vegetation to create pastureland. These changes did not last long however, and regeneration is documented in the sequences. Nevertheless, changes occurred in the composition of the formations since *Quercus* deciduous was replaced by *Quercus coccifera*. At higher altitudes as at Rezina (1800 m asl), this situation was irreversible. Mountain ecosystems were more vulnerable and never regained in density.

Letting alone this early evidence of human impact on the vegetation, the pollen record documents significant modifications only from 5000-4500 BP onwards. In such cases as the Drama plain cores (Turner and Greig, 1975, 1986) no evidence exists until historical times.

VEGETATION MANAGED BY PREHISTORIC HUMAN GROUPS IN GREECE: THE CHARCOAL EVIDENCE.

The archaeological charcoal record for the Holocene in Greece is restricted to very few sites and there is a lack of long sequences. Charcoal information included in this presentation comes from one of the pioneer charcoal studies carried out in Greece in the Neolithic/Bronze Age site of Sitagroi, eastern Macedonia (Rackham, 1986), and three recent studies (fig. 1). Two of them were carried out in sites in North Greece, namely the Neolithic site of Makri in Thrace (Efstratiou *et alii*, 1998, Ntinou, 2000, Ntinou and Badal, 2000), and the site of Dispilio in western Macedonia (Ntinou, 2000, Ntinou and Badal, 2000); charcoal from the Mesolithic/Neolithic cave site from the island of Youra in the northern Sporades has been studied (Ntinou N.D.).

The site of Youra

The cave-site of Youra (fig. 1) has revealed the longest so far charcoal sequence in the Holocene. The site is located on the southern part of the desertic island of Youra (39°22'N, 24°10'E) at 150 m asl. The excavated Mesolithic deposits have been dated between 8500 and 6500 cal BC. The Neolithic sequence covers all three phases from Early Neolithic to Late Neolithic and finally, a more recent occupation phase has been dated to the first centuries AD (Facorellis and Maniatis, 1998; Sampson, 1998).

The results of charcoal analysis are to date preliminary. Included here is a brief presentation of the plant cover in the site's surroundings for the period between 8606-8316 cal BC and 4667-4542 cal BC, in essence the Mesolithic and part of the Neolithic occupation phases (Ntinou N.D.).

The charcoal plant list includes various Mediterranean taxa, the majority are evergreen accompanied by some deciduous: *Phillyrea-Rhamnus* (buckthorn), *Juniperus* sp. (juniper), *Arbutus* sp. (strawberry-tree), *Quercus* evergreen (prickly and/or kermes oak), cf. *Ononis* sp. (restharrow), *Pistacia terebinthus* (terebinth), *Pistacia lentiscus* (lentisc), *Cercis siliquastrum* (Judas tree), *Olea europaea* var. *sylvestris* (olive-tree), *Sarcopoterium spinosum* (thorny burnet), Labiatae, Fabaceae, *Ephedra* sp., Euphorbiae.

During the initial stages of the Holocene (see fig. 4), in the surrounding environment, junipers are co-dominant together with *Phillyrea-Rhamnus*, while subsequently and from *c.* 8000 BC onwards they decrease and finally disappear. The dominant taxon throughout the sequence is *Phillyrea-Rhamnus*. This is the distinguishing feature of charcoal results from the island since a better or dominant representation of *Quercus* evergreen in the overall Mediterranean plant formations would be expected. However, this taxon is less frequent and only at a later date in the sequence it tends to increase. Strawberry-trees and Leguminosae are well represented all along the sequence. *Pistacia,* both evergreen and deciduous species, are sporadically present, while *Cercis siliquastrum,* well represented at the beginning, diminishes later on. *Olea* appears with low values during the Neolithic.

The vegetation image extracted from the above data is that of a relatively open environment at the beginning of the Holocene, reflecting probably the climatic influence of the Pleistocene in the high juniper frequencies. Nevertheless, the changes of the Holocene are in progress and various Mediterranean taxa appear to dominate in the following stages. The decrease of some deciduous taxa could be related to further change in the climatic conditions, probably the precipitation regime. However, aside from the very initial stage there are no significant changes in the plant cover that could justify modifications due to climate or human pressure.

The dominance of *Phillyrea-Rhamnus* over *Quercus* evergreen, the typical Mediterranean taxon in other coastal Mediterranean sites during the Holocene, is a sign of the variability that characterized the evolution of evergreen Mediterranean plant formations in response to different ecological conditions. For Greece, in particular, this stresses the need for the application of methods such as charcoal analysis to typical Mediterranean areas. If the occurrence of such formations was restricted, then the smaller scale but higher resolution charcoal data could give a more detailed record for such plant formations that until present have vaguely been detected in the pollen record for a great part of the Holocene.

The late appearance of *Olea* in the sequence of Youra coinciding with the onset of the Neolithic might be related to the introduction of the taxon together with other plants and domestic crops by Neolithic groups. As an al-

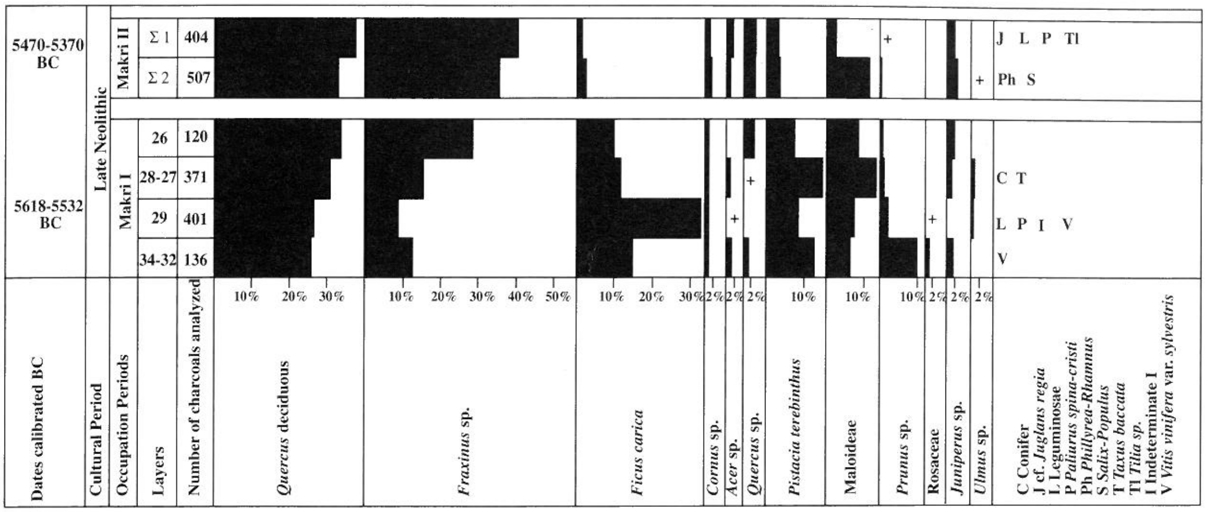

Figure 2. Charcoal diagram for Late Neolithic Makri showing percentage frequencies of taxa in the charcoal assemblages from successive layers.

ternative, a late appearance could be attributed to intrinsic and extrinsic factors influencing plant communities (see above for changes in the vegetation as evidenced in the pollen record).

The site of Sitagroi

The site of Sitagroi is located in East Macedonia (fig. 1) and has revealed various occupation phases of the Late Neo-lithic and Early Bronze Age (Renfrew *et alii*, 1986). Charcoal analysis was carried out for all occupation levels. All along the sequence deciduous plant formations were documented and *Quercus* deciduous (oak) was the dominant taxon (Rackham, 1986). The results indicate the presence of central European and other submediterranean elements in the environment while all typical Mediterranean indicators are absent. The climatic conditions must have been less Mediterranean than in the present and the summer draught period shorter. The conclusion concerning the overall image of the plant cover during the occupation of the site is the absence of ecological change.

The site of Makri

The Neolithic site of Makri lies in the eastern part of Thrace (40° 52′N, 25° 62′E). It is located on top of a cliff at 40 m asl, overlooking the Aegean sea to the south. To the east and west lies the Thracian plain. The climate is Mediterranean with continental influences due to northern winds through the Rhodopi mountains.

The excavation of Neolithic deposits at the mound of Makri revealed a four-meter deep stratigraphic sequence that is divided into two different cultural periods, a short early Makri I and a longer late Makri II, separated by a destruction layer. Each one of the two cultural periods includes several habitation phases. The site is ascribed to the Late Neolithic. On the reading of radiocarbon dating the main sequence is placed between 5618-5532 cal BC and 5470-5370 cal BC (Efstratiou *et alii*, 1998). Recent dating extends the occupation of the site back to 5840-5670 cal BC [OxA-9362, DEM-1142: 6890±90BP (Efstratiou pers.com).

At the site of Makri the analysis of disperse charcoal reveals a plant list that includes: *Acer* sp. (maple), Conifer, *Cornus* sp. (cornelian cherry), *Ficus carica* (fig tree), *Fraxinus* sp. (ash), *Juglans regia* (walnut tree), *Juniperus* sp. (juniper), Leguminosae, Maloideae, *Paliurus spina-christi* (Christ's thorn), *Phillyrea-Rhamnus* (buckthorn), *Pistacia terebinthus* (terebinth), *Prunus* sp., Rosaceae, *Quercus* deciduous (deciduous oak), *Quercus* sp., *Salix-Populus* (willow-poplar), *Taxus baccata* (yew), *Tilia* sp. (lime), *Ulmus* sp. (elm) and *Vitis vinifera* var. *sylvestris* (grape vine).

Charcoal analysis results from the site of Makri are represented in a diagram where the frequencies of the taxa in charcoal assemblages for successive layers are shown (fig. 2). The diagram consists of 6 spectra; the first four, from bottom to top, correspond to the Makri I cultural period and the last two to Makri II.

The constant taxa in all spectra are *Quercus* deciduous, *Fraxinus* sp., *Ficus carica*, *Pistacia terebinthus, Prunus* sp., Maloideae and *Cornus* sp. The rest of the taxa are sparse and appear occasionally in some of the spectra.

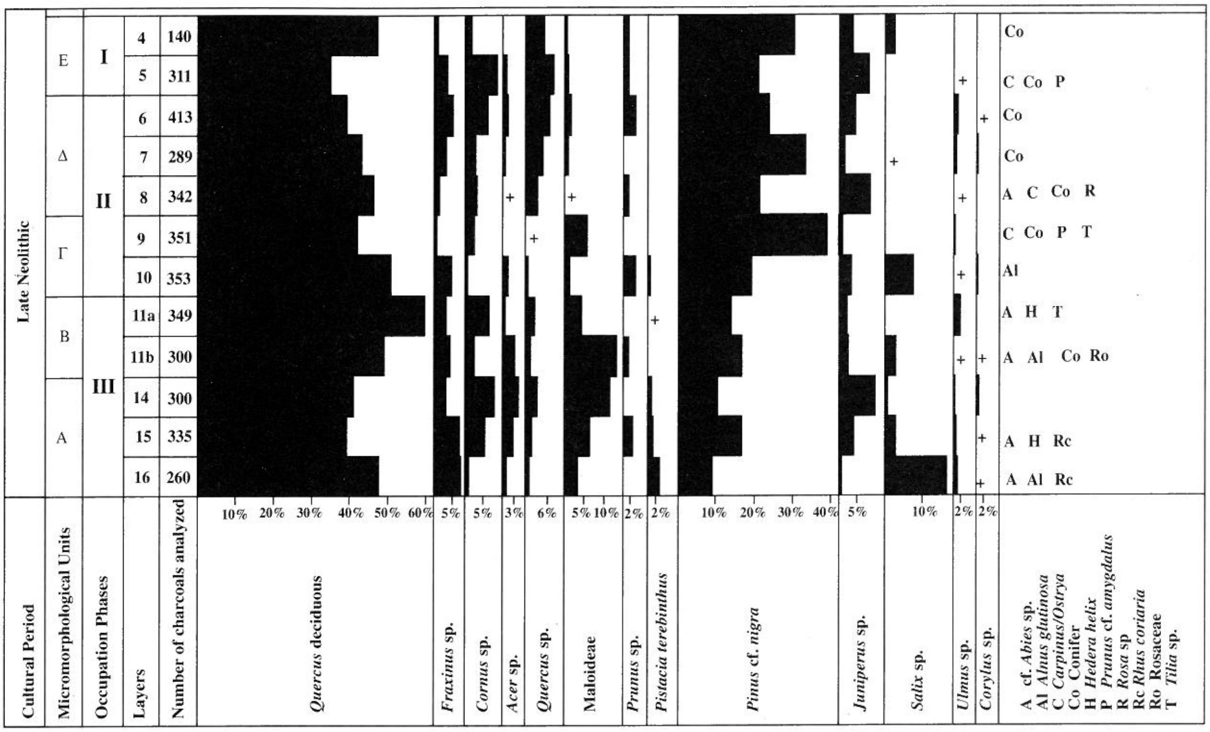

Figure 3. Charcoal diagram for Late Neolithic Dispilio showing percentage frequencies of taxa in the charcoal assemblages from successive layers.

Diachronically there are no big differences in the composition of the spectra or substitution of some taxa by others; some fluctuations in the frequencies of the taxa are documented.

In all Makri I spectra the dominant taxon is *Quercus* deciduous, except in layer 29 where *Ficus carica* is more abundant. In the Makri II spectra, the dominant taxon is *Fraxinus* sp., followed closely by *Quercus* deciduous. However, *Quercus* deciduous frequencies show an increasing trend all along the sequence and the same occurs with *Fraxinus* sp.

From the charcoal diagram we can distinguish three main plant formations:

- Mediterranean deciduous oak woodland with ash, lime, cornelian cherry, etc.;

- Open deciduous formations rich in bushy heliophilous plants, namely, *Pistacia terebinthus*, *Pyrus* sp., *Juniperus* sp., *Paliurus spina-cristi*, *Prunus* sp. and possibly *Prunus* cf. *amygdalus*. These formations would probably include junipers, fig trees and somewhere in low numbers the only evergreen species documented, *Phillyrea-Rhamnus;*

- Riverine or humid formations are slightly represented in the diagram and would include *Ulmus* sp., *Vitis vinifera* var. *sylvestris*, *Salix-Populus* and *Juglans regia*.

Deciduous forests mainly composed by oaks would cover the area surroundings the site. A distinctive feature of this deciduous oak woodland is the presence of the heliophilous components. All these genera and species grow in open formations since they require plenty of light and seem to indicate a plant cover rather open in places. The frequencies of the taxa identified in the assemblages at the site of Makri document the persistence of these deciduous formations all along the sequence. The prehistoric environment appears rather stable during the time of the occupation of the site. However, some tendencies in the frequencies of the taxa let us distinguish two charcoal zones that correspond to the two cultural periods Makri I and II.

The first and older charcoal zone is characterized by the dominance of oak woodland together with an important presence of heliophilous taxa. The second zone documents the dominance of *Fraxinus* sp. although *Quercus* deciduous increases as well. The heliophilous taxa, probably with the exception of *Juniperus* sp. decrease markedly. This does not appear to be the result of a real change in the vegetation but a reflection of modifications in the managing of the surrounding resources by humans. In this sense, during the incipient occupation (Makri I), open formations were greatly utilized probably because of their close proximity and the ease of clearing. However, oak woods provided the majority of firewood. During the Makri II cultural period, intensification of the occupation is documented. Heliophilous plants become less important while the main components of deciduous woods are dominant, especially *Quercus* deciduous and *Fraxinus* sp. The abore charcoal image might be the result of integrating firewood provisioning in the circle of other farming activities. In this sense, firewood provisioning would be an organized activity with a more effective result. Deciduous formations, which were more abundant and dense, would be more often frequented for firewood, fodder, etc. The result of that was not a change in the vegetation since deciduous formations remain the dominant, but some widening of the managed territory occurred and probably new biotopes were incorporated in the activity areas.

The vegetation around Makri was dominated by deciduous formations, mainly oak woods, rather open in places. These plant formations do not document significant changes during the time of the occupation of the site. Human groups used constantly these formations. However, there must have been a balanced interaction and Neolithic subsistence strategies did not appear to affect the plant environment. On the contrary, at the site of Makri there is a better representation of the dominant oakwoods as occupation got more intensive because the most abundant formations became more integrated in the cycle of human activities.

The site of Dispilio

The site of Dispilio (fig. 1) in West Macedonia, is a lakeside settlement, located at an altitude of 627 m, a few meters from the shore of the Lake of Kastoria. The climate in the area is transitional from Mediterranean to continental with central European characteristics. Rainfall is more or less evenly distributed through the year. The dry period is short and the mean annual precipitation ranges from 800 to 1000 mm.

The deposits excavated at the site of Dispilio offered a sequence assigned to the Late Neolithic but there is also evidence for earlier and later occupation dating from the Middle Neolithic to the Chalcolithic. Relative chronologies through pottery typology attribute the occupation of the site to the time between 5500 BC and 3500 BC (Hourmouziadis, 1996).

Analysis of disperse charcoal at the site of Dispilio revealed a plant list that consists of: cf. *Abies* sp. (fir), *Acer* sp. (maple), *Alnus glutinosa* (alder), *Carpinus/Ostrya* (hornbeam-hop hornbeam) *Cornus* sp. (cornelian cherry), *Corylus* sp. (hazel), *Fraxinus* sp. (ash), *Hedera helix* (ivy), *Juniperus* sp. (juniper), Maloideae, *Pinus* cf. *nigra* (black pine), *Pistacia terebinthus* (terebinth), *Prunus* cf. *amygdalus* (almond), *Prunus* sp., *Quercus* deciduous (oak), *Rhus coriaria* (sumac), *Rosa* sp. (rose), Rosaceae, *Salix* sp.(willow), *Tilia* sp. (lime) y *Ulmus* sp. (elm).

The frequencies of the taxa identified in each charcoal assemblage are represented in a diagram that consists of 12 spectra (fig. 3). These correspond to excavation layers of 10 cm and have been correlated to the occupation phases of the site and the micromorphological units distinguished in the analysis of the sediments.

The dominant taxon in all spectra is *Quercus* deciduous. *Pinus* cf. *nigra* is the second most important taxon after *Quercus*, with frequencies that increase steadily from the lower to the upper part of the diagram. *Fraxinus* sp., *Cornus* sp. and *Juniperus* sp. are present in all assemblages with constant values. Maloideae though well represented in the older spectra is diminishing in the recent ones. *Salix* sp. has high frequencies in the oldest spectrum but it decreases or disappears in continuation. *Acer* sp., *Ulmus* sp. and *Corylus* sp. have low frequencies. *Prunus* sp. is rather sparse. *Pistacia terebinthus* is present in decreasing frequencies in the lower part of the sequence and disappears from spectrum 9 onwards. The remaining taxa, cf. *Abies*, *Alnus glutinosa*, *Carpinus/Ostrya*, *Tilia* sp., *Hedera helix*, *Prunus* cf. *amygdalus*, *Rhus coriaria*, *Rosa* sp. and Rosaceae are rather infrequent.

Four types of plant formations can be distinguished from the charcoal diagram of the lakeside settlement of Dispilio:

- Deciduous woods where oaks are the main component. Other deciduous trees such as ash, hornbeam, maple, cornelian cherries, some Maloideae species, etc. form part of these oak woods.
- Conifer forests with black pines. Some fir would probably grow in these forests as it occurs in such present day formations. *Juniperus* sp. was probably part of these woods or grew in open formations and clearings or margins of pine or/and oak woods.
- Lake side vegetation is represented by willows. Other components of those formations would be alder, elm or hazel, this last also growing in humid places in deciduous woods.
- Open formations, as evidenced by the presence of terebinths, sumacs, some *Prunus* species or *Pyrus* from the Maloideae subfamily. *Juniperus* could also participate in these formations. The above heliophilous taxa, favored by solar radiation, would occupy open spaces between deciduous thickets.

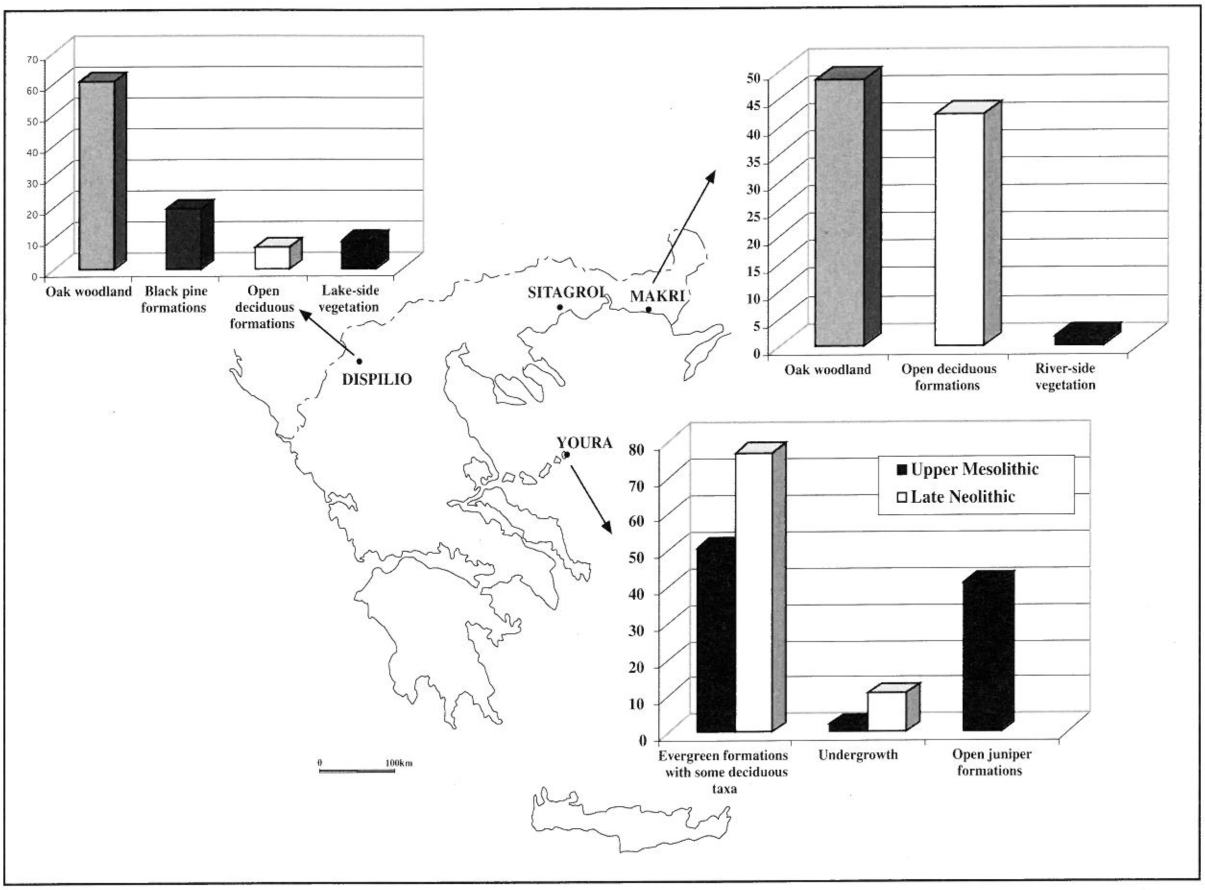

Figure 4. Representation of regional differences in plant formations as evidenced from charcoal analysis carried out in the prehistoric sites of Makri, Dispilio and Youra.

Oak woodland is the prevalent formation throughout the sequence and was probably the climax formation around the site from mid altitude and up to 1000 m. Black pine forests were the other important formation in the region and would cover the surrounding mountains not far from the site.

In relation to the increasing frequencies of *Pinus nigra*, the following hypotheses could be proposed:

- Some climatic change favored the expansion of the conifers; however, such an increase is only documented earlier in the pollen sequence of Khimaditis (between 8000 and 6500 BP) (Bottema, 1974). There seems to be no direct correlation with the sequence of the Neolithic site where occupation starts some time around 5300 BC (*c* 6500 BP).
- A change in the vegetation caused by constant human impact in the deciduous woods. In this scenario, we could think of clearings in the oak woodland, especially in contact zones with conifer forests, which were subsequently colonized by black pines. In current ecosystems these conifers are fast colonizers of degraded broad-leaved formations, mainly the ones affected by fires.
- Expansion of human activities into conifer forests and intensification of the managing of these formations.

Whatever the cause of higher conifer representation, human activities did not significantly alter the deciduous formations. The charcoal sequence of the site of Dispilio documents the predominance without significant changes of oak woodlands. Black pine forests are complementary formations that are progressively greater utilized. Increasing representation of black pines could be related to changes in the organization and structure of the settlement and the activities carried out. If occupation of the site was continuous it would lead to a better knowledge of the existing plant resources and to the widening of the areas managed.

A similar reasoning could be developed for the open and lakeside formations that are well represented in the oldest spectra but gradually become sporadic or infrequent: either they did not regenerate after their first use by human groups or they were abandoned because other more prosperous plant formations were within reach. It would certainly be easier and more beneficial in terms of adequate firewood provisioning (abundant and dry wood) to direct the activity towards the wider and denser deciduous forests than to the restricted gallery-forests and poor open formations.

In general, charcoal results from the site of Dispilio show that the predominant plant formations remain stable without significant changes all along the settlement's occupation. This would point to a balanced relation between human activities and the surrounding vegetation.

DISCUSSION

Pollen and charcoal data for the Holocene offer an in depth view of the evolution and composition of plant formations and their use by human groups. The rich pollen record documents regional variation in the vegetation through time and space. Charcoal data describe plant formations used by humans in specific moments of the Holocene. Parallel evidence from both disciplines demonstrates similar trends.

In the pollen diagrams differences in vegetation are recorded between northern and southern sites. In the North deciduous formations predominate while in the Peloponnese and Crete these formations incorporate evergreen components at varying frequencies; in some cases evergreen components are dominant. Charcoal results from the island of Youra demonstrate an early Holocene expansion of evergreen Mediterranean formations that dominate all along the sequence (fig. 4). Contrary to the island environments, northern coastal and inland sites such as Makri, Sitagroi and Dispilio are all characterized by the dominance of deciduous formations.

In mainland Greece, particularly in the North, the pollen record documents the dominance of deciduous forests and oak woodlands during big part of the Holocene. Variations in other components of these forests, fluctuations in the mountain conifer frequencies and the appearance of Mediterranean elements, mark latitudinal, altitudinal and topographic differences between regions.

The results gained from charcoal analysis from Neolithic sites in northern Greece provide an additional source of information. The sites of Dispilio, Makri and Sitagroi are all located in northern Greece but along the extremes of the east-west axes (fig. 1). There is also a marked altitudinal difference of approximately 600 m between sites and a variable location in relation to sea influence. The charcoal data obtained from all three sites document the prevalence of deciduous oak woodlands in the otherwise geographically and altitudinally distant regions. Other components of these deciduous forests are common in the charcoal results from Makri and Dispilio. At Sitagroi, temperate taxa are present all along the site's sequence (Rackham, 1986). Different location and altitudinal variation between sites is not evidenced in the predominant plant formations but in the complementary taxa (fig. 4). At the site of Makri, abundant sun-loving species reflect open formations at these low altitude territories (40 m asl), close to the sea. By contrast, around the site of Dispilio, oak woodland appears denser and the coniferous forest, mainly black pine formations with some fir are represented, reflecte the location of the site at 627 m altitude in an inland basin surrounded by high mountains.

In the pollen record parallels for Makri and Sitagroi are observed from the sequences of Tenaghi Philippon and the Drama basin in East Macedonia (Wijmstra, 1969, Turner and Greig, 1986). The results from the site of Dispilio can be compared with various pollen sequences in West Macedonia; especially the one from the Lake of Kastoria (Bottema, 1974) where the settlement is located (fig. 1). The pollen sequences from East Macedonia indicate the gradual expansion of forests in the Holocene. The forested nature of the landscape is documented while modifications of the plant cover due to human pressure appear late in the Holocene sequence, after the Neolithic or even into historical times. The sequences from Khimaditis and Kastoria in West Macedonia point to the occurrence, at medium altitudes, of a dense deciduous oak forest while pine forests with some fir covered the mountain zone. Charcoal results from the site of Dispilio are in agreement and add further information concerning the pine species. Charcoal identification of *Pinus* cf. *nigra* to species level confirmed what was only postulated in pollen results given the altitudinal, latitudinal and inland location of the Lake of Kastoria.

Furthermore, the results of charcoal analysis from the prehistoric sites give evidence for the presence of plant taxa that are not well documented in pollen sequences and consequently their history is problematic.

At the site of Makri, the fig tree (*Ficus carica*) appears already in the earliest occupation phases of the settlement, dated to 5840-5670 cal BC (AMS dating of a *Ficus carica* fragment [OxA-9362, DEM-1142: 6890±90BP]). *Ficus carica* is very abundant in the charcoal assemblages of Makri, especially during the Makri I cultural period. The wild form of the fig tree grows in the Mediterranean region from sea level to 1000 m. This deciduous tree, which well tolerates dry summers and cold winters, occupies rock crevices, gorges and streamsides. There is some doubt as to whether the species is natural in Europe but probably it was native in Greece according to the charcoal results from Makri: the taxon appears early and at high frequencies. Fig trees were used for firewood in prehistoric Makri although it does not provide good quality fuel unless dry. It must have been an important element of the vegetation in the territory around the site. Though much represented during the Makri I period, the frequencies of the taxon decrease during Makri II. An explanation for such a change could be associated with some protection of these trees for their highly nutritious fruit. Fig seeds as well as entire carbonized fruit are present in the archaeological layers of Makri II (Efstratiou *et alii*, 1998).

As far as the olive tree and the spontaneous presence of the taxon in Greece are concerned, there are no conclusive results. Managing and cultivation of the species is clearly documented from the Late Bronze Age onwards (Hansen, 1994). However, pollen evidence from Crete (Moody *et alii*, 1996) dates the appearance of the taxon as early as the Middle Neolithic and attributes it to native origin. At the island of Youra the taxon appears for the first time during the initial stages of the Neolithic. Presence or absence of the taxon cannot be conclusive as to the origin of the species. Charcoal evidence points to various possibilities:

- The appearance of the taxon relatively late in the Holocene formations and in reduced numbers could be related to various ecological factors, both biotic and abiotic;
- The taxon was sparse in the natural formations and it was favored and expanded as soon as human groups started managing it for fruit or leaf and branch fodder (Badal, 1999);
- The Neolithic groups introduced the taxon.

Early evidence from archaeobotanical seed remains is still lacking and the isolated charcoal data from the island of Youra cannot be conclusive in favor of any of the above hypothesis.

The Holocene documents climatic oscillations reflected in palaeoenvironmental studies (Bell and Walker, 1992). However, this period and mainly its recent phase are characte-rized by progressively greater human influence in the natural processes. Establishing the beginning of human impact in time and space is not easy; the composition and fragility of plant formations, species establishment rates, competence between species, topographic characteristics and prevalent climatic conditions, human subsistence strategies, population density and level of technological development are all factors in a complex interaction. It is also true that when a new phase is distinguished and characterized by modified environments this might be the result of a longer process that becomes clear only when there is an accumulation of influences (Allen, 1990).

In Greece, the establishment of the first Neolithic communities sometime around 7700 BP characterizes the Holocene; from this time onwards the gradual proliferation of sites is documented all over the region. Neolithic occupation is in part synchronous to the Atlantic period of the Holocene, the Postglacial climatic optimum. The pollen record documents optimal climatic conditions and maximum forest extension. No large scale deforestation and land degradation is detected until after 5000-4500 BP or approximately at the end of the Neolithic.

Analysis of charcoal from the Neolithic sites leads to the same conclusions demonstrating stability in plant formations. At Makri and Dispilio charcoal sequences are characterized by the quite unchanged quantitative and qualitative composition of the principal deciduous oak formations. At the site of Sitagroi Rackham (1986) draws similar conclusions and states that deciduous formations prevail throughout the occupation of the site.

In the interpretation of the charcoal data from the Neolithic sites, some issues deserve further consideration, that is duration, continuity and intensity of occupation of the settlements. At the moment the archaeological information from the sites documents that they are occupied for the first time during the Late Neolithic. No hiatuses are detected in the sequences. At Makri, according to the available ^{14}C dates, a minimum of 300 years of occupation could be estimated. For Dispilio no radiocarbon dates are as yet available. From other lines of evidence, such as pottery typology, approximately 1000 years of occupation could be suggested, however the intensity of occupation is a subject under study. At the site of Youra patterns, time and duration of occupation in relation to charcoal data are still under investigation, especially since they are even more complex at an insular environment.

Considering the occupation at mainland Neolithic sites, it has been concluded that human activities were carried out in a way that did not significantly alter the immediate surroundings.

A possible explanation should involve the organization of the communities. Subsistence strategies at the sites presented here probably provided an efficient system of maintenance of the community with a minimum impact on the environment. The farming communities of Makri and Dispilio were probably carrying out sustainable farming and grazing techniques and practices over an extended period of time. A kind of "horticulture" is postulated for the Neolithic communities, which would require small pieces of land. Rotation techniques associated with Neolithic farming technologies would be efficient and soil properties would not be exhausted easily. The same fields could be used for long periods of time. Thus, large scale clearing would not be necessary. Additionally, a small number of animals integrated in the farming system would demand little pastureland and would cause little effect on the environment (Halstead, 1992, 1996, Sherratt, 1981). Subsistence strategies of Neolithic farming communities were probably oriented to economize labor through the use of different physiographic elements of their environment in order to combine activities. Production was always under the maximum potential of the environment; thus activities and technology influenced only a small portion of this environment and at a slow temporal rate (Fotiadis, 1985).

Natural vegetation is not a static system; it has got an internal force and a regenerating potential not the least negligible. A variety of factors must come together to end up in significant alterations. Human pressure is a considerable one. However, accepting a moderate and sustainable use of the plant resources, it is very probable that the effect would be less pronounced and slower to appear.

Charcoal results from the sites here presented do not document any human pressure upon the immediate vegetation. This conclusion is consistent with the pollen record from Greece. The explanation for this picture should probably be sought in the subsistence strategies of the Neolithic communities studied, in the techniques and technology employed and probably in the regenerative potential of the vegetation. However, two additional possibilities related to the methods of analysis should be mentioned here:

- Pollen sequences in the majority of cases in Greece come from big lakes or marshes; they reflect mainly the regional characteristics of the vegetation where anthropic influence is hardly documented until after 5000 BP. However, pollen sequences from small lakes/marshes such as Gramousti, Rezina, Tseravinas, which reflect a narrower area and mainly local vegetation, document short erosive episodes succeeded by changes in vegetation cover and composition (Turner and Sanchez-Goñi, 1997; Willis, 1997). The image of the vegetation gained from pollen sequences is closely related to the dimensions and location of the site and consequently the local or regional provenance of pollen grains deposited. In this sense, the detection of short events in plant cover and composition occurring at a local level is associated to the dimensions and location of the pollen coring site. Probably, sequences from a greater number of small basins at different locations could offer additional information on local vegetation.
- Charcoal analysis in open air Neolithic sites might reflect a slightly biased image of the vegetation since human groups are the agents for the transport and deposition of the material. Even if the provisioning firewood zone is delimited within the 5 km radius of the site-catchment model (Higgs and Vita-Finzi, 1972), when firewood provisioning becomes an organized and predetermined activity then it might be oriented towards different parts in the territory. Alternation of provisioning areas would probably give a stable image of the vegetation since these areas do not get overexploited. If no substitutions or composition changes occur then potential modifications such as secondary forests, old non-regenerating forests and intermediate-transition points before a big change or a substitution are not easily distinguishable. Better evaluation of the results requires longer sequences, variation in habitat types and subsistence bases, namely data from different and distant regions all over Greece.

In Greece there is regional variability with regard to the deforestation and degradation of the environment. In general, it occurred sometime after 5000 BP and it might be related to demographic change, new farming techniques associated with the introduction of the plough and the increasing use of metals. Local factors such as altitude, climate, slope inclination and topography would influence processes but would not act independently from human activities (Willis, 1995).

CONCLUSIONS

The most important points of this presentation can be summarized as follows:

- In Greece pollen and charcoal data are complementary and in agreement with respect to the composition of Holocene plant formations, the regional variability of such formations and the detection of human influence.
- The early Holocene vegetation in Greece is characterized by the expansion of woodlands. Regional differences between north - south and mainland or insular sites are documented in the dominance of deciduous forests in northern regions and mainland Greece at large, while evergreen formations prevail in the island of Youra and sclerophyllous taxa proliferate in the south.
- The evergreen Mediterranean formations, as evidenced in the site of Youra, appear early in the Holocene and must have been the natural ones in places. More information from other early Holocene coastal and insular sites is required in order to further understand the development and history of such formations.
- Neolithic subsistence strategies do not appear to have had a serious effect on the vegetation. This could be associated with relatively stable forest managing techniques, sustainable subsistence practices, a technology level that would not cause great impact on the environment and regenerating potential of the vegetation, not negligible when humans make balanced use of the plan cover.
- Further investigation on past plant formations in necessary. In particular, charcoal analysis applied to sites with

a variable location, with long sequences (when possible) and/or ascribed to different cultural periods can contribute to an in depth understanding of the interaction between human groups and the environment.

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