SHEFFIELD STUDIES IN
AEGEAN ARCHAEOLOGY

Landscape and Land Use in Postglacial Greece

Edited by
Paul Halstead and Charles Frederick

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Sheffield Studies in Aegean Archaeology, 3

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Abbreviations

AAA	*Athens Annals of Archaeology*
ADelt	*Arkhaiologiko Deltion*
AE	*Arkhaiologiki Efimeris*
AEMTh	*To Arkhaiologiko Ergo sti Makedonia kai Thraki*
AJA	*American Journal of Archaeology*
AM	*Mitteilungen des Deutschen Archäologischen Instituts, Athenische Abteilung*
AR	*Archaeological Reports*
ASA	*Annuario della Scuola Archeologica di Atene*
BAM	Beiträge zur Ur- und Frühgeschichtlichen Archäologie des Mittelmeer-Kulturraumes
BAR	British Archaeological Reports
BCH	*Bulletin de Correspondance Hellénique*
BICS	*Bulletin of the Institute of Classical Studies of the University of London*
BSA	*Annual of the British School at Athens*
CAJ	*Cambridge Archaeological Journal*
CMS	Corpus der minoischen und mykenischen Siegeln
CP	*Classical Philology*
CQ	*Classical Quarterly*
Ergon	*To Ergon tis Arkhaiologikis Etairias*
G&R	*Greece and Rome*
JAS	*Journal of Archaeological Science*
JHS	*Journal of Hellenic Studies*
JMA	*Journal of Mediterranean Archaeology*
Kr Chron	*Kritika Chronika*
OJA	*Oxford Journal of Archaeology*
PAE	*Praktika tis en Athinais Arkhaiologikis Etairias*
PBA	*Proceedings of the British Academy*
PCPS	*Proceedings of the Cambridge Philological Society*
SIMA	Studies in Mediterranean Archaeology
SMEA	*Studi Micenei ed Egeo-Anatolici*

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Preface

Charles Frederick and Paul Halstead

The Round Table on Aegean archaeology held in Sheffield on 22–24 January 1999 was devoted to the subject of 'Postglacial Environmental Change in Greece'. As investigations of environmental change in postglacial Greece have proliferated over the last three decades, the competing claims of climate change and human land use, as agents of transformation of the landscape, have been vigorously championed by different groups of scholars. Palaeoecologists have sought to understand how and why the landscape of Greece has changed over the last ten thousand years. For archaeologists, the reconstruction of past landscapes is critical to an understanding of the problems and opportunities encountered by ancient human societies. Archaeologists have also been tantalized by the prospect that the palaeoecological record may bear the imprint of human activity and so reveal something of the nature and scale of past land use.

In recent years, however, there has been growing awareness of the difficulty of disentangling natural and anthropogenic agents of landscape change. In part, this results from the coarse chronological resolution of both the palaeoecological and archaeological records, issues stressed by a number of contributors to this volume. In part, it reflects the need for better understanding of the relationships *in the present* between landscape and land use and between land use and human settlement. To explore some of these issues, the meeting brought together palaeoecologists and archaeologists with an interest in land use and human settlement.

This volume presents revised versions of papers from the meeting. Participants were invited to attempt both a critical review of work to date and a consideration of avenues for future work and both of these objectives are reflected in this volume. For similar reasons, the papers which follow include both case studies of particular regions and contributions with a broader geographical focus. Several contributors emphasize the role of studies of the present and recent past as the basis for reconstruction and understanding of the more distant past. The papers are ordered along the continuum landscape-land use-settlement, although the breadth of many contributions ensures a degree of arbitrariness here. No determination or dominance is covertly implied by this ordering and the volume can be read with equal plausibility from front to back or from back to front.

Nancy Krahtopoulou presents a geoarchaeological study of landscape change in coastal Pieria, in northern Greece. Significantly, despite the relatively fine chronological resolution of her study, she encounters difficulties in differentiating between natural and anthropogenic causation on the basis of temporal patterning in alluvial deposits. Achilles Gerasimidis discusses palynological evidence for human impact on the montane forests of northern Greece. His argument that anthropogenic impact is clearest over the last two millennia is consistent with Krahtopoulou's observation that the frequency of alluvial episodes increases significantly over the same timespan. Maria Ntinou and Tina Badal compare the off-site palynological record from northern Greece with the on-site charcoal record from two Late Neolithic settlements in the same region. The charcoal evidence offers support for the argument of palynologists that early farmers in northern Greece had limited impact on regional vegetation.

A second group of papers focuses on southern Greece. Jenny Moody documents geoarchaeological evidence for widespread flood events during the mediaeval to early modern period in Crete, which she relates to the 'Little Ice Age' climatic phenomenon. An earlier Little Ice Age, during the Middle to Late Bronze Age, may have had a dramatic effect on land use and social change at the time of the Minoan 'palaces'. Margaret Atherden examines a pollen core, spanning the last millennium, from the White Mountains in Crete. Using observations on the present-day ecology of Mediterranean vegetation, she thoughtfully tackles the appropriately thorny issue of recognizing the effects of grazing/browsing and burning in the palynological record. Charles Frederick and Nancy Krahtopoulou explore the relationship between terracing and the geoarchaeological record. As well as offering a research design for exploring the (pre)history of terracing in the Aegean, they expose the complex ways in which surface archaeological traces might be concealed from, or revealed to, intensive survey projects by different forms of terrace construction.

Hamish Forbes addresses the contentious issue of livestock and overgrazing, taking a variety of documentary sources to argue that stocking densities have remained remarkably stable in the southern Argolid over the last three centuries, despite dramatic changes in human demography and economy. Recent stocking densities have been constrained by a variety of informal, density-dependent mechanisms. Whether similar mechanisms were in play in the distant past is an open question, with profound implications not only for anthropogenic impact on the landscape, but also for the nature and sustainability of early animal husbandry. Paul Halstead explores the likely impact on landscape of intensive and extensive forms of land use, and revisits earlier work on prehistoric land use in the light of palaeoecological hints of mid-Holocene destabilization of the landscape. Amy Bogaard, Mike Charles, Paul Halstead and Glynis Jones report on studies of modern weed ecology in Greece and other parts of the Mediterranean. These studies are developing a methodology for distinguishing different forms of intensive and extensive crop husbandry regime on the basis of archaeological assemblages of weed seeds.

Todd Whitelaw's paper critically reviews the evidence for changing patterns of settlement in the fourth and third millennia BC in the Aegean, arguing that apparently similar trajectories of dispersal and nucleation conceal significant regional and local divergences. Given the tendency for some palaeoecologists to squeeze poorly dated local records into a supra-regional chronological straitjacket, attempts to understand landscape degradation in terms of correlation with changing patterns of settlement have been undermined by both groups of practitioners. With closer collaboration between palaeoecologists and archaeologists, however, and with finer chronological resolution in both data sets, he is optimistic that a more reflexive and subtle understanding can be achieved of the relationship between human marginal colonization and landscape degradation. In the final chapter, the methods of geoarchaeology are applied to small rural sites discovered by surface survey in Laconia. Such sites have been found in large numbers by intensive survey projects and an understanding of their permanence, longevity and function is critical to attempts to use surface data as evidence for regional patterns of demography, land use and social organization. To this end, Chris Mee and Peter James show how the on-site analysis of soils complements the traditional evidence of surface artefact scatters.

Bill Cavanagh, Adrian Lane, Mark Macklin, Oliver Rackham, Kathy Willis, Jamie Woodward and Eberhard Zangger, presented papers at the Round Table that they could not, for various reasons, contribute to this volume. We are also grateful to Paul Buckland and Kevin Edwards, who chaired sessions at the Round Table, and to all other participants, who helped to make the meeting a success. Thanks are due to the Institute for Aegean Prehistory and the London Hellenic Society, for financial help towards the costs of holding the Round Table and of publishing this volume, respectively. 'Domestic' arrangements during the meeting were managed by Mike Lane, Eleni Nodarou, and Giorgos Vavouranakis, while the task of feeding participants was heroically undertaken by Ellie Hitsiou, Valasia Isaakidou, Vangelio Kiriatzi and Sevi Triantaphyllou, with specialist assistance from Nancy Krahtopoulou. Mike Charles, Rob Craigie and Rocky Hyacinth kindly retrieved parts of the contributions which follow from the ether.

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CONTRIBUTORS

MARGARET ATHERDEN	University College of Ripon and York St John, Lord Mayor's Walk, York Y03 7EX, UK.
ERNESTINA BADAL	Departamento de Prehistoria y Arqueología, Universitat de València, Avenida Blasco Ibañez 28, 46010 Valencia, Spain.
AMY BOGAARD	Department of Archaeology and Prehistory, University of Sheffield, Northgate House, West St., Sheffield S1 4ET, UK.
MICHAEL CHARLES	Department of Archaeology and Prehistory, University of Sheffield, Northgate House, West St., Sheffield S1 4ET, UK.
CHARLES FREDERICK	Department of Archaeology and Prehistory, University of Sheffield, Northgate House, West St., Sheffield S1 4ET, UK.
HAMISH FORBES	Department of Archaeology, University of Nottingham, University Park, Nottingham, NG7 2RD, UK.
ACHILLES GERASIMIDIS	Department of Forestry and Natural Environment, Aristotle University of Thessaloniki, PO Box 270, 54006 Thessaloniki, Greece.
PAUL HALSTEAD	Department of Archaeology and Prehistory, University of Sheffield, Northgate House, West St., Sheffield S1 4ET, UK.
PETER JAMES	Department of Geography, University of Liverpool, Liverpool L69 3BX, UK.
GLYNIS JONES	Department of Archaeology and Prehistory, University of Sheffield, Northgate House, West St., Sheffield S1 4ET, UK.
ATHANASIA KRAHTOPOULOU	Department of Archaeology and Prehistory, University of Sheffield, Northgate House, West St., Sheffield S1 4ET, UK.
CHRISTOPHER MEE	SACOS, University of Liverpool, 14 Abercromby Square, Liverpool L69 3BX, UK.
JENNIFER MOODY	Anthropology, Archaeology and Environmental Studies, Baylor University, Waco, Texas, USA.
MARIA NTINOU	Departamento de Prehistoria y Arqueología, Universitat de València, Avenida Blasco Ibañez 28, 46010 Valencia, Spain.
TODD WHITELAW	Institute of Archaeology, University College London, 31–34 Gordon Square, London WC1H 0PY, UK.

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Holocene Alluvial History of Northern Pieria, Macedonia, Greece

Athanasia Krahtopoulou

Introduction

During the last two decades, archaeological studies in Northern Pieria (Fig. 1.1) have indicated that the landscape has changed dramatically over time and that geomorphic agents of soil erosion and valley alluviation have seriously affected the preservation and visibility of the archaeological record in the area (for an overview of the history of archaeological research in Northern Pieria, see Besios and Pappa 1995). A detailed geoarchaeological study was undertaken, therefore, in order to investigate the co-evolution of landscape and human settlement in the area and to assess the potential of the surface and sub-surface archaeological records (Krahtopoulou 2001). A recent critique of geoarchaeological research in Greece has exposed the need for fine temporal and spatial resolution as the basis both for reconstructing landscape change and for evaluating alternative agents of change (Endfield 1997). For this reason, the present case study focuses on the intensive investigation of a relatively small area.

Research Design and Methodology

Two small-order streams, the Gerakaris and the Agios Dimitrios, which originate in the Pierian hills and discharge into the Thermaic Gulf, were selected for detailed investigation of late Quaternary alluvial history (Fig. 1.1). The streams drain an area of 60 km^2 and 18 km^2, respectively, and are underlain by highly erodible, unconsolidated Upper Miocene-Lower Pliocene sands, sandy loams, loamy sands and clays (IGME 1986). Surface finds from non-systematic, extensive archaeological field reconnaissance and preliminary reports from small-scale rescue excavations indicate a human presence in the Gerakaris and Agios Dimitrios catchments from, at least, the Late Neolithic onwards (5400/5300–4700/4500 BC) (Besios 1993; Besios and Pappa 1995; Grammenos *et al.* 1997; Pappa 1999).

Field observations in the lower reaches of these streams, immediately above the present coastal plain, revealed a series of alluvial deposits and intercalated palaeosols, containing in many cases *in situ* preserved archaeological sites and structures. Selection of research localities was determined by access to property and/or presence of suitable natural and artificial exposures. In the Agios Dimitrios valley, lack of adequate exposures was compensated by mechanical excavation. In all, 17 vertical sections were cut back, cleaned, examined and described, while 220 soil and sediment samples were collected and analysed for mean particle size, loss-on-igni-

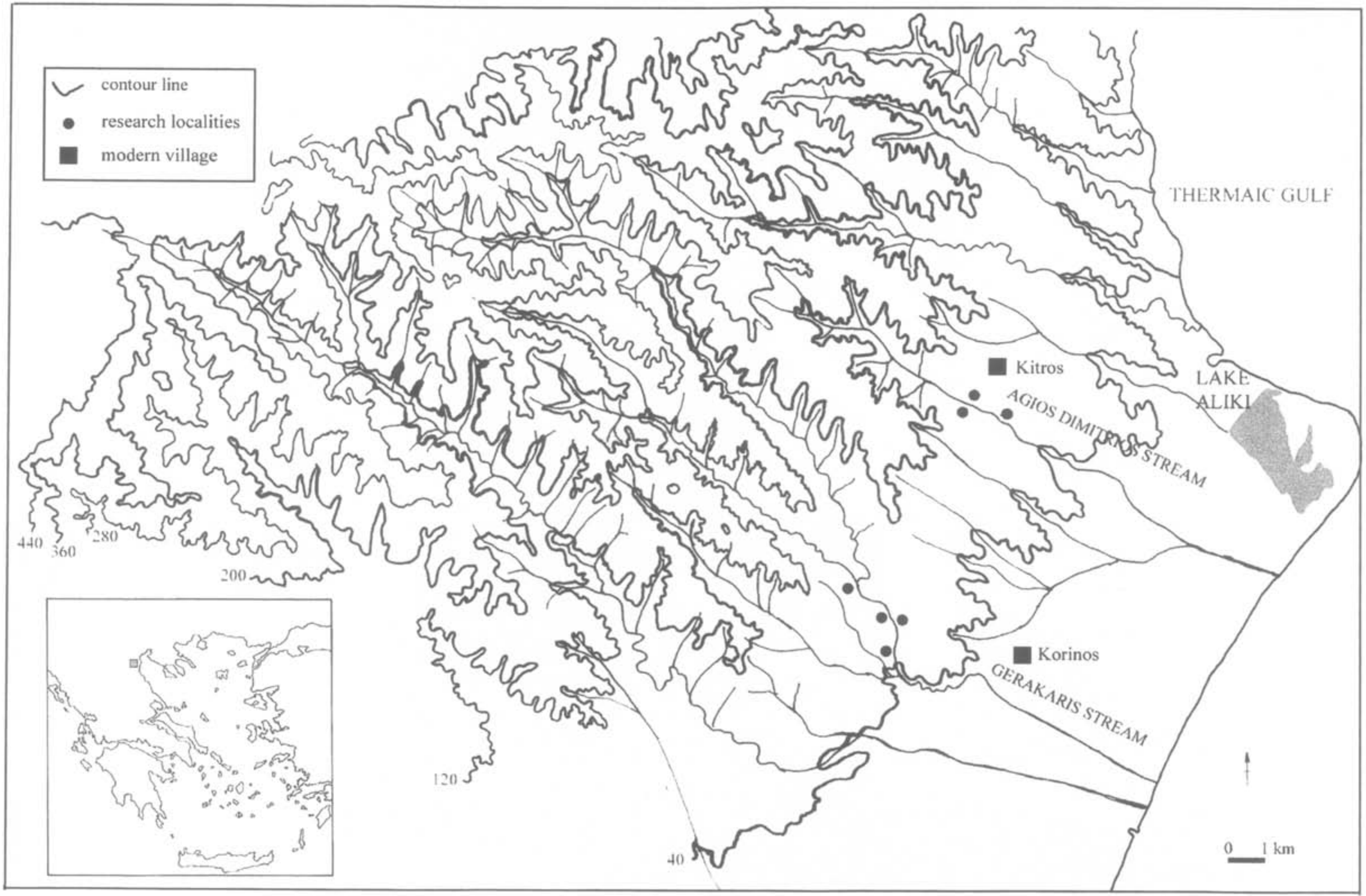

Figure 1.1 Location of the study area.

tion, calcium carbonate content and magnetic susceptibility.

Temporal control for the Gerakaris and Agios Dimitrios sequences is provided by C^{14} (AMS) dating of 17 charcoal and soil samples, collected from buried A soil horizons. *In situ* buried archaeological sites and structures associated with specific palaeosols offer additional chronological information and in many cases refinement of the chronology established by C^{14} dating.

The Gerakaris Alluvial Sequence

Field observations, as well as absolute (see Table 1.1) and relative dating of the deposits identified in the Gerakaris valley, resulted in identification of four late Pleistocene and eight Holocene alluvial units, separated by palaeosols. Two informal alloformations have been recognized. The late Pleistocene alluvial fills are named the *Nea Trapezous alloformation* and the Holocene deposits the *Kato Agios Giannis alloformation*, which are abbreviated as NT and KAG respectively. This paper focuses primarily on the Holocene alluvial record.

Four geomorphic surfaces (T0, T1, T2 and T3) were recognized in the lower reach of the Gerakaris (Fig. 1.2). The usually narrow modern floodplain (T0) lies at an elevation of 2 m above the stream bed. It is inset into the first terrace (T1), a relatively narrow, gently sloping surface, which rises to an elevation of 4.50–5.50 m above the channel. The second terrace (T2) is a wide, flat surface, which dominates the Gerakaris valley and lies at an elevation of 9 m above the active channel. The highest terrace (T3), which has been identified only near the Gerakaris valley walls, is sloping and lies 16–19 m above the present river bed. As the stream enters the alluvial plain of Katerini and flows eastwards towards the coast, these geomorphic surfaces 'disappear' under the flat, featureless surface of the alluvial plain.

The Nea Trapezous Alloformation

The four units belonging to the *Nea Trapezous alloformation* are designated NT1 to NT4 in order of decreasing age. Generally, these are rarely exposed in the lower reaches of the stream and the sequence remains poorly dated. Two C^{14} dates, archaeological inclusions, stratigraphic position and degree of pedogenic development place deposition of the *Nea Trapezous alloformation* in the late Pleistocene between 38.8 ka bp and, perhaps, 10.0 ka bp (Krahtopoulou 2001).

The Kato Agios Giannis Alloformation

Some time after the deposition of unit NT4, but before 8.5 ka bp, the Gerakaris incised and cut a new valley, which was subsequently filled in with 8.5 m of alluvial deposits of Holocene age. The Holocene sequence (the *Kato Agios Giannis alloformation*) is well dated by absolute (C^{14}) (Table 1.1) and relative (*in situ* buried archaeology and historical information) means and eight discrete alluvial units are presently recognized: KAG1 to KAG8 from oldest to youngest. The lower boundary of the oldest alluvial fill presently recognized in the Gerakaris valley (KAG1) is nowhere exposed and it is possible that more, as yet undetected, early Holocene alluvial units are buried in the valley axis.

Deposition of KAG1 predates 8,470±75 bp (7600–7351 BC) and seems to be confined within the newly cut valley floor of the Gerakaris. After a period of landscape stability and pedogenesis, the second fill (KAG2) was deposited across the Holocene valley, some time before 5,360±60 bp (4339–3999 BC; Final

Table 1.1 List of radiocarbon dates from the Gerakaris stream.

Lab. no.	Depth (cm)	Material dated	Stratigraphic unit	$\delta^{13}C$	$\delta^{13}C$ corrected age	Calibrated age AD/BC	Archaeological phase
AA31853	135	Charcoal	NT1?	–24.3	38,800±1100	Not calibrated	Palaeolithic
AA31852	250	Charcoal	NT2?	–24.3	24,930±240	Not calibrated	Palaeolithic
AA32856	860	Soil	KAG1	–11.9	8,470±75	7600–7351 BC	Mesolithic
AA32859	445	Soil	KAG2	–21.0	6,900±65	5966–5643 BC	Early-Middle Neolithic
AA32855	745	Charcoal	KAG2	–25.7	5,360±60	4339–3999 BC	Final Neolithic
AA31861	510	Charcoal	KAG3	–23.3	5,115±60	4039–3775 BC	Final Neolithic
AA32858	365	Charcoal	KAG3	–21.7	3,765±85	2464–1940 BC	Early-Middle Bronze Age
AA32854	324	Soil	KAG4	–24.7	2,715±50	973–799 BC	Early Iron Age
AA32857	215	Soil	KAG4	–22.1	1,610±50	264–566 AD	Roman-Early Christian
AA34066	210	Soil	KAG5	Post-1950	Rejected		
AA31860	120	Charcoal	KAG6	–24.3	580±70	1284–1443 AD	Late Byzantine
AA31859	82	Charcoal	KAG7	–29.0	420±45	1418–1627 AD	Late Byzantine–Post Byzantine

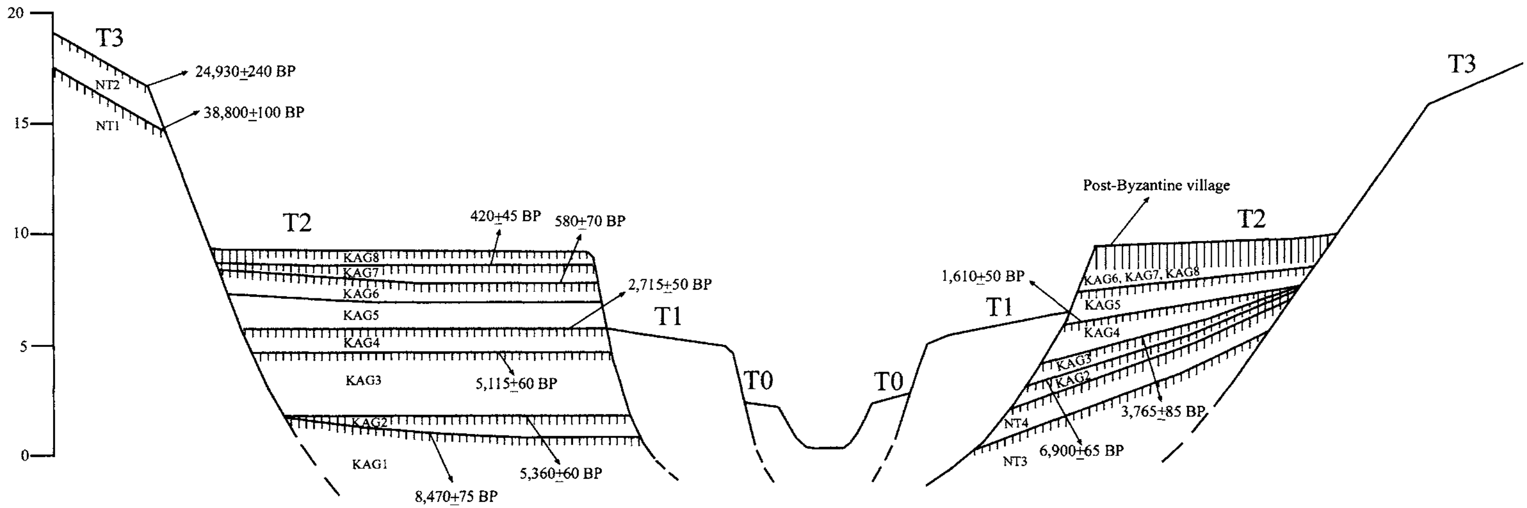

Figure 1.2 Schematic cross-section of the Gerakaris stream, depicting stratigraphic relationships and chronological data.

Neolithic). According to a radiocarbon date on the middle part of a cumulic soil preserved near the valley walls, aggradation was in progress by 6,900±65 bp (5966–5643 BC; Early–Middle Neolithic). Unlike the two oldest members of the *Kato Agios Giannis alloformation*, which are poorly exposed due to deep burial under the modern channel, KAG3 is observed valley-wide. Aggradation of the unit is closely bracketed between 5,360±60 bp (4339–3999 BC; Final Neolithic) and 5,115±60 bp (4039–3775 BC; Final Neolithic) and is followed by at least 1350 years of landscape stability, sub-aerial exposure and pedogenesis. During that period, the Gerakaris floodplain was inhabited, as indicated by an Early Bronze Age site, identified during fieldwork near the valley axis. The stream aggraded again sometime after 3,765±85 bp (2464–1940 BC; Early–Middle Bronze Age) and KAG4 alluvium covered the valley floor. By 2715±50 bp (973–799 BC; Early Iron Age), however, and for at least 1100 years, according to interbedded archaeological features across the lower reaches of the stream, the landscape was stable again. Sedimentation resumed soon after 1,610±50 bp (264–566 AD; Roman–Early Christian period) and possibly around the third or fourth century AD. Deposition of unit KAG5 was accompanied by lateral migration of the stream to the north-east, closer to the valley walls. As a result, the low Pierian hills, west of the modern village of Korinos, started to be covered with fluvial deposits. The last three units (KAG6, 7 and 8) were deposited in an episodic fashion during the last 1300 years. According to archaeological inclusions in the KAG5 soil and a radiocarbon date on the soil formed within KAG6, this unit was deposited between the sixth–seventh century AD and 580±70 bp (1284–1443 AD), and was followed by a period of stability. Deposition of the next younger unit, KAG7, began after 580±70 bp (1284–1443 AD) but ended by 420±45 bp (1418–1627 AD) when the landscape was stable once again. The last unit, KAG8, was formed some time between 420±45 bp (1418–1627 AD) and the late eighteenth century AD, when the Gerakaris aggraded again, migrated laterally to the north-east and its present position, and then incised, abandoning the T2 surface and forming a new terrace (T1). Deposits below T1 and T0 have not been examined in detail.

Architecturally, the *Kato Agios Giannis alloformation* represents a sequence of alluvial deposits, that accumulated mainly by vertical accretion during valley-wide flooding events. A single stream incision event occurred fairly recently, between the fifteenth–seventeenth and the late eighteenth century AD. Differences in depositional environment between different units indicate that the Gerakaris was moving across its floodplain throughout the Holocene. All members of the *Kato Agios Giannis alloformation* are relatively fine-grained and they range in mean particle size from loamy sands to silts, reflecting their source (the Upper Miocene–Lower Pliocene formations). The discrete sedimentary packages are separated by very weakly to moderately well developed Inceptisols (KAG1, KAG2, KAG3, KAG4, KAG5 and KAG6 palaeosols) and Entisols (KAG7 and KAG8 soils) (Birkeland 1999), that show no evidence of erosion during sub-aerial exposure and weathering. The degree of pedogenic development in the Holocene sequence mainly reflects the time available for pedogenesis before renewed sedimentation. Overall, older soils appear to be more pedogenically advanced than younger soils. There are internal differences in sedimentary character and pedogenic expression and maturity between temporally similar deposits and palaeosols in different parts of the alluvial system. Palaeosols formed in a floodplain environment are slightly more developed than contemporary channel proximal soils. Some of the lower soils in the sequence (KAG1, KAG2 and KAG3 soils) are mildly gleyed and/or exhibit manganese stains, indicating periodic saturation by a fluctuating water table (Birkeland 1999).

The Agios Dimitrios Alluvial Sequence

The Agios Dimitrios sequence proved to be less complete than the Gerakaris, mainly because of limitations on fieldwork imposed by the relatively shallow incision of the stream, its heavily overgrown banks and the intensive cultivation of the surrounding landscape.

Three discrete geomorphic surfaces (T0, T1 and T2) have been recognized in the lower reaches of the stream, immediately above the coastal plain of Korinos (Fig. 1.3). The relatively narrow active floodplain (T0) rises 2–3 m above the channel. It is inset into the first terrace (T1), which is a flat to gently sloping surface, up to 80 m wide and 5–6 m above the stream bed. The vestiges of T2 have been observed north and mainly east, and approximately 10 m above, the modern channel. Judging from their relative position and pedogenic features, the deposits beneath T2 represent Late Pleistocene alluvial units, but they were not examined in any detail during fieldwork.

Stratigraphic investigations focused on the Holocene alluvial sequence, which is informally named the *Kitros alloformation* and abbreviated KTR. It embraces at least seven sedimentary units (KTR1–7, from oldest to youngest), which are separated by palaeosols. Radiocarbon dates (Table 1.2) and archaeological inclusions indicate that these deposits span the last 7500 years at least.

The Kitros Alloformation

At some, as yet unknown, time the Agios Dimitrios incised and abandoned the late Pleistocene surface (T2) and formed the new Holocene valley, where the seven members of the *Kitros alloformation* started to accumulate in a punctuated fashion. Unit KTR1 is the oldest deposit identified so far in the Agios Dimitrios valley. It is poorly exposed and has been identified only near the Holocene valley walls at the edge of T1. The lower boundary of the unit is not exposed and it is uncertain whether or not other, older Holocene deposits are buried below KTR1. Absolute dates for deposition of this fill are not presently available. The soil formed within the unit is associated with a Late/Final Neolithic archaeological site (5400/5300–3300/3100 BC), which provides a minimum age for its deposition. There is no good maximum age for the fill. On the basis of stratigraphic position and soil morphology, however, it is certain that unit KTR1 aggraded during the Holocene. After a period of landscape stability and pedogenesis, sedimentation resumed and unit KTR2 was deposited. The A horizon of the soil formed within KTR2 is cut by a hearth, associated with pottery dated to the sixth century AD. Furthermore, the KTR2 soil is the most strongly developed of the Holocene age observed to date in the Agios Dimitrios valley and exhibits a cambic and stage II (Gile *et al.* 1966) calcic horizon. A palaeosol with similar pedogenic expression, but with a slightly less strongly developed calcic horizon, has been observed in the Gerakaris Holocene alluvial sequence (the soil formed within KAG4). This KAG4 soil had a minimum of 1100 years in which to form. This suggests that KTR2 was deposited by the Agios Dimitrios some time before the Classical period (fifth century BC), after which the channel incised, leaving the surface upon which this strong soil developed free from flooding until deposition of KTR5 alluvium.

The next unit described is KTR3, which was laid down before 2,100±100 bp (390 BC–123 AD;

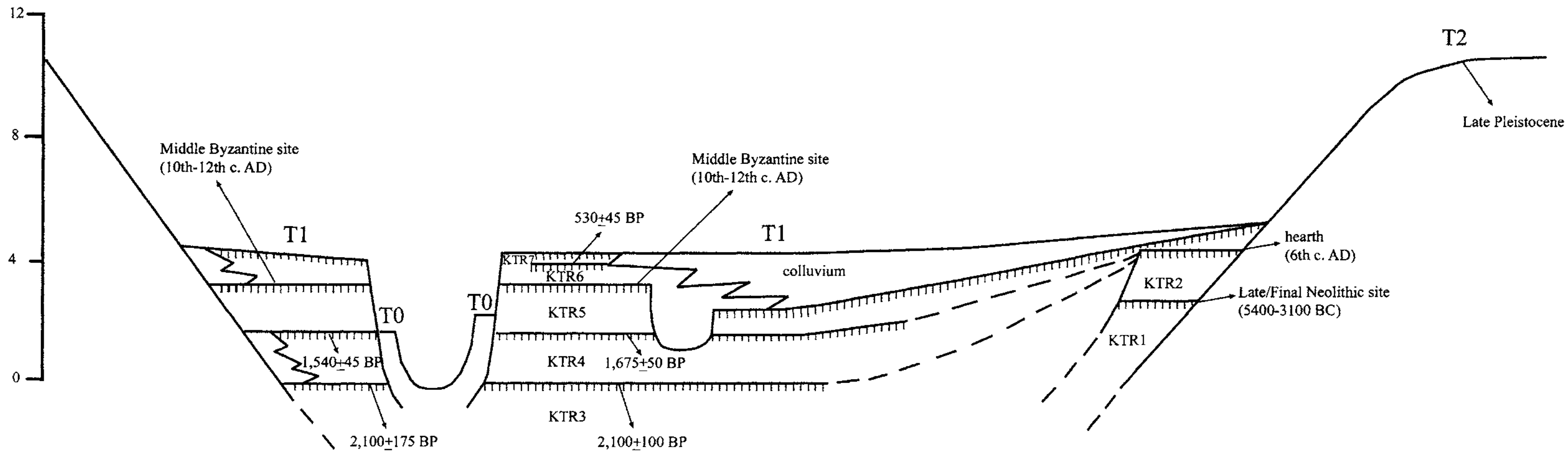

Figure 1.3 Schematic cross-section of the Agios Dimitrios stream, depicting stratigraphic relationships and chronological data.

Table 1.2 List of radiocarbon dates from the Agios Dimitrios stream.

Lab. no.	Depth (cm)	Material dated	Stratigraphic unit	δ ^{13}C	δ ^{13}C corrected age	Calibrated age AD/BC	Archaeological phase
AA31854	330	Charcoal	KTR3	–25.5	2,100±100	390BC–123 AD	Classical–Roman
AA31858	370	Charcoal	KTR3		2,100±170	517BC–318 AD	Classical–Roman
AA31855	250	Charcoal	KTR4	–26.0	1,675±50	243–530 AD	Roman–Early Christian
AA31857	200	Charcoal	KTR4	–24.1	1,540±45	419–637 AD	Early Christian–Early Byzantine
AA31856	60	Charcoal	KTR6	–24.3	530±45	1308–1453 AD	Late Byzantine–Post-Byzantine

Classical–Roman period). There is no good maximum age for deposition of this fill, and it is likely that deposits predating KTR3 are buried in the Agios Dimitrios valley axis. Incomplete exposure of the Holocene sequence in this stream, however, inhibits any conclusive argument on the occurrence, number and nature of these deposits, and additional fieldwork is necessary to clarify stratigraphic relationships and establish chronologies. The next unit detected, KTR4, was deposited in the Holocene valley between 2,100±100 bp (390 BC–123 AD; Classical–Roman period) and 1,675±50 bp (243–530 AD; Late Roman–Early Christian period) and was followed by a period of stability and pedogenesis. The Agios Dimitrios aggraded again at some point between 1,540±45 bp (419–637 AD; Early Christian period) and the tenth–twelfth century AD, according to an interbedded Byzantine site. KTR5 alluvium now covered the entire valley, overlying unit KTR4 in the centre of the valley and KTR2 at the margin. The next alluvium recognized in the sequence (KTR6) was deposited at some time after the tenth–twelfth century AD and before 530±45 bp (1308–1453 AD). An infilled palaeochannel, associated with this unit, indicates that the Agios Dimitrios was flowing closer to the valley walls at this time. The youngest deposit described (KTR7) was laid down after 530±45 bp and, judging from the minor degree of pedogenic development, not long before the present. The Agios Dimitrios changed its course, migrating slightly to the south to occupy its present bed, and incised, isolating the T1 terrace. Deposits lying below the modern floodplain (T0) have not been examined, but it seems likely that they are very recent.

Architecturally, the Agios Dimitrios sequence is slightly different from the Gerakaris. The oldest two alluvial units described (KTR1 and KTR2) are observed in vertical succession near the valley walls, while the vertically stacked units KTR3 and KTR4 are inset into these. Valley-wide sedimentation resumed with deposition of unit KTR5, which buried all older alluvial fills. Finally, the youngest units KTR6 and KTR7 also accumulated vertically above the KTR5 alluvium. Two relatively deep and narrow, infilled palaeochannels are associated with units KTR1 and KTR6 and indicate that, unlike in the Gerakaris, there has been little lateral migration of the Agios Dimitrios stream since the Late/Final Neolithic period.

All seven members of the *Kitros alloformation* are fine-textured (sandy loams, silt loams and silts), reflecting the composition of the source material (the Upper Miocene–Lower Pliocene formations), and represent floodplain deposits. Colluvial deposits interfinger within the KTR4 and KTR7 fills near the valley walls, suggesting that aggradation of these fills was triggered by slope destabilization and large-scale sediment input into the system.

The soils formed within the *Kitros alloformation* are Inceptisols, with the exception of the youngest, KTR7 soil, that shows minor pedogenic development and can be classified as an Entisol (Birkeland 1999). Overall, there is a decrease in pedogenic maturity from older to younger units. Occurrences of manganese oxides in KTR1 and of redox mottles in KTR2, KTR3 and KTR5 suggest some saturation by a fluctuating water table (Birkeland 1999).

Correlation of the Gerakaris and Agios Dimitrios Sequences

Overall, the Holocene sequences of both the Gerakaris and Agios Dimitrios streams are characterized by long periods of stability and soil formation, interrupted by infrequent, yet in some cases dramatic, intervals of valley aggradation and occasional stream incision and lateral migration. Moreover, in both streams, the frequency of alluviation increased dramatically over the last two millennia. Although the earliest Holocene deposits may be buried, the relative rarity of alluviation in the early to middle Holocene in both streams is not an artefact of the exposure of relevant deposits. In detail, however, the two streams do display some differences in the character and timing of alluviation events and stream adjustments (Fig. 1.4). In part, but only in part, these differences can be attributed to the contrasting level of chronological precision achieved for each sequence and to more restricted fieldwork in the Agios Dimitrios stream.

The more complete and better dated Gerakaris sequence will be used as the basis for the following synthesis. The earliest alluvial unit (KAG1) was deposited in the Gerakaris valley floor at some time before 8.5 ka bp. Deposits of similar age have not been identified in the Agios Dimitrios valley, owing perhaps to the incomplete exposure of its early Holocene alluvial sequence. On the basis of radiocarbon dates for the Gerakaris sequence and of archaeological inclusions in the Agios Dimitrios sequence (a Late/Final Neolithic site), KAG2 in the Gerakaris seems to be contemporary with KTR1 in the Agios Dimitrios and both were laid down before the Final Neolithic. KAG3 covered the entire Gerakaris valley between 5.3 ka and 5.1 ka bp, during the Final Neolithic, and was followed by at least 1350 years of landscape stability. No equivalent alluvial unit has yet been identified in the Agios Dimitrios valley. The next alluvium recognized in the Gerakaris sequence (KAG4) was deposited between 3.7 ka bp and 2.7 ka bp and was followed by another prolonged phase of landscape stability and soil formation, which lasted for a minimum of 1100 years. In terms of pedogenic expression and degree of pedogenic maturity, the soil formed on KTR2 and the KAG4 palaeosol are very similar (both exhibit Ab-Bwkb-Bkb soil profiles with stage II calcic horizons). Therefore, KAG4 and KTR2 could be contemporary, although at present any such correlation must be tentative and the stream downcutting, which accompanied deposition of KTR2, has not been observed in the Gerakaris sequence. KTR3 aggraded at some time before 2.1 ka bp and none of the units presently identified in the Gerakaris valley is temporally equivalent to this fill. The Gerakaris aggraded again, the KAG5 fill being deposited some time after 1.6 ka bp and most likely around the third–fourth century AD, and the stream migrated to the north-east. The KTR4 alluvium, laid down between 2.1 ka bp and the third–sixth century AD, but not accompanied by lateral migration, can be tentatively correlated with KAG5. Likewise, the three alluvial events, KAG6, KAG7 and KAG8, dated between the sixth–seventh century AD and the late eighteenth century AD, are tentatively correlated with KTR5, KTR6 and KTR7, which aggraded between the fifth–seventh century AD and the present. The Gerakaris changed its course and incised most likely between the fifteenth–seventeenth and eighteenth century AD, while the Agios Dimitrios also migrated laterally and vertically at some point after the fourteenth–fifteenth century AD.

The alluvial histories of the two streams thus appear to correlate well over the last two millennia. Both streams also appear to have experienced common phases of alluviation at some time between the late ninth and early sixth millennia bp and again in the fourth–third millennia bp. The two sequences cannot be compared for the earliest part of the Holocene, because of the incompleteness of the record from the Agios Dimitrios stream. The two streams do appear to diverge at least at two points: in the late sixth millennium bp, when the Gerakaris alluvium KAG3 is not matched in the Agios Dimitrios valley, and at some time between perhaps the fourth–third

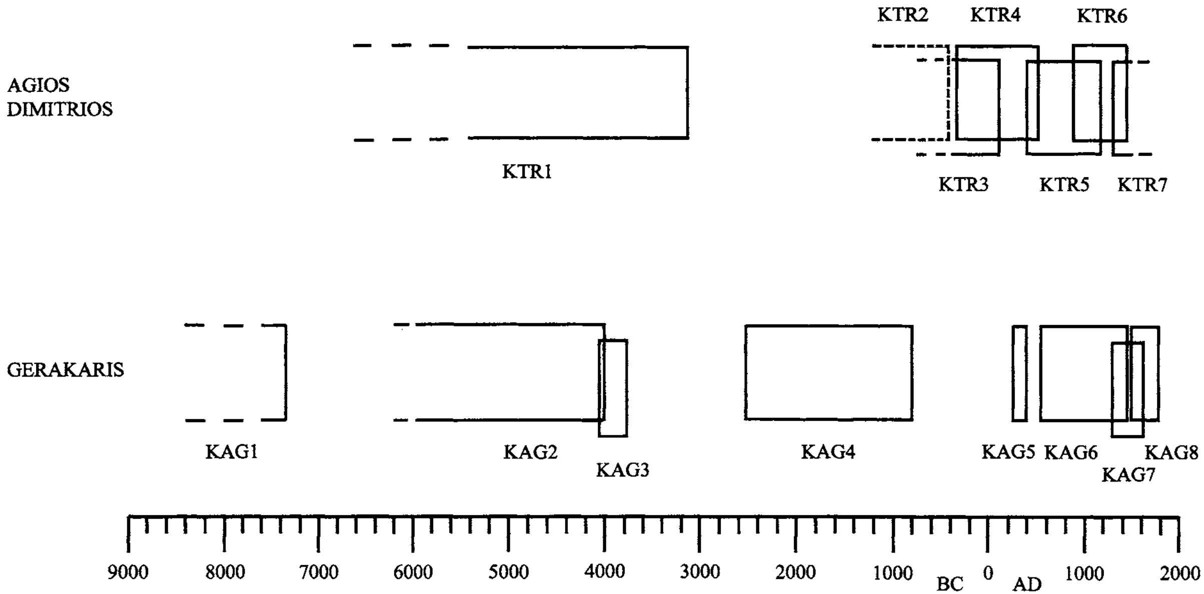

Figure 1.4 Comparative chronology of alluvial activity in the Gerakaris and Agios Dimitrios streams. The length of each rectangle indicates *not* the duration of alluviation, but the uncertainty of dating; solid, dashed and missing borders of rectangles indicate *termini* of increasing uncertainty.

millennium and 2100 bp, when the Agios Dimitrios experienced the KTR3 alluviation, apparently missing in the Gerakaris valley.

Landscape Change and the Formation of the Archaeological Record

The geomorphic processes that have altered the landscape of the study area have also seriously affected the survival and visibility of the archaeological record. Most of the known settlements in the catchments of the Gerakaris and Agios Dimitrios streams have suffered erosion, which has removed much of the pre-existing soils and archaeological deposits (Pappa 1999), and total destruction of small, ephemeral or perhaps early sites cannot be precluded. On the other hand, sediment transported by both streams has buried the lower valleys under thick alluvial deposits, obscuring 'ancient topographies' and archaeological sites from surface survey, however intensive. Chance finds in exposures demonstrate that sites buried in this way range in date from at least the Late/Final Neolithic to the Byzantine period (Krahtopoulou 2001).

Causality: Agents of Landscape Change

Landscape changes, such as have been documented in the study area, tend to be attributed to 'natural' causes, when alluvial episodes in different catchments appear to be contemporary (Vita-Finzi 1969), and to anthropogenic causes, when this is not the case (van Andel *et al.* 1990). On this basis, it might be argued that alluviation in the study area was driven by climate, or some other natural factor(s), during the early Holocene and also during the last 2000 years, with a more complex alternation between natural and cultural forcing in the intervening millennia. This interpretation would be broadly consistent with the arguments advanced by van Andel *et al.* (1990) in favour of widespread erosion triggered by agricultural activity towards the end of the Neolithic and beginning of the Bronze Age.

In the case of this study area, however, a number of considerations caution against acceptance of this conclusion. First, the mid-Holocene parts of the Gerakaris and Agios Dimitrios sequences, which have been interpreted as evidence for locally variable alluvial histories, include some serious chronological ambiguities. It is possible, therefore, that further dating evidence will undermine some of the apparent divergence between the two streams. Secondly, the Gerakaris alluvial unit KAG3, for which no equivalent has been found in the Agios Dimitrios sequence, is very closely dated to the late sixth millennium bp or Final Neolithic. Available archaeological evidence suggests human occupation of both catchments at this time, whereas the contrasting alluvial records might lead one to expect occupation of the Gerakaris catchment but not of the Agios Dimitrios. It must be stressed that the archaeological evidence is too coarsely dated to establish unambiguously its contemporaneity with KAG3. Moreover, an anthropogenic trigger for this or any other alluvial episode presumably depends on the scale, longevity and severity of human impact, which cannot be assessed from the crude evidence of the presence or absence of human settlement. On the other hand, the scant settlement evidence does nothing to strengthen the interpretation of KAG3, in anthropogenic terms, as the product of (intensive) human activity restricted to only one of the two catchments studied.

The evidence from the study area can also be approached from a rather different direction. A striking common feature of both streams is that, through most of the Holocene, the landscape has been characterized by long periods of stability and pedogenesis, punctuated by short-lived and relatively infrequent episodes or phases of erosion and alluviation. This might suggest a landscape normally under limited threat of anthropogenic destabilization. Over the last two millennia, however, both catchments were subject to frequent destabilization and alluvial deposition. In the case of the KTR4 and KTR7 units in the Agios Dimitrios valley, interleaving with colluvial deposits suggests that increased sediment input into the system was triggered by slope destabilization. Moreover, an anthropogenic contribution to these recent alluvial episodes receives some support from both historical and palynological evidence (Gerasimidis 1984) for human activity in the Pierian uplands over the last two millennia. Thus, even though the late Holocene alluvial histories of the Gerakaris and Agios Dimitrios catchments apparently correlate well, a plausible argument could be mounted in favour of a major causal role for anthropogenic disturbance. It should also be noted that the alluvial histories of the two streams developed in parallel over a period of time far longer than the usual climatic suspects, such as the early modern 'Little Ice Age' (Lamb 1982).

It might be argued that the two catchments studied here are too close for correlation of their alluvial histories to be able to discriminate between climatic and anthropogenic causation, but their proximity also factors out several other potential environmental contrasts, such as in geology, altitude, topography or climax vegetation. On the other hand, it is also striking that the chronological resolution of the present study, which is arguably finer and firmer than that of most preceding studies in Greece, sets only proxima for the beginning and end of each depositional event, and still leaves sufficient ambiguity to make it difficult to argue for a particular form of causation on the basis of the degree of synchronism between different alluvial sequences.

Conclusion

This study has revolutionized understanding of the degree to which the landscape of northern Pieria has changed during the Holocene and also of the extent to which these changes have shaped survival and visibility of the archaeological record. An understanding of the nature of landscape change will also play a valuable role in future attempts to understand the changing pattern of human settlement in this region in terms of the distribution of resources. For example, the progressive creation of an extensive coastal plain and related shift eastwards of the coastline are likely to have exercised a significant influence over settlement location. Geoarchaeological study alone is unlikely to resolve the critical issue of the cause(s) of landscape change. Well-dated sequences such as those described here, however, in combination with independent archaeological and other paleoecological records of comparable quality, would surely underpin fruitful discussion of these issues.

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2

Palynological Evidence for Human Influence on the Vegetation of Mountain Regions in Northern Greece: The Case of Lailias, Serres

Achilles Gerasimidis

Introduction

Man, directly or indirectly, has been the most significant factor in the evolution of vegetation over the last few thousand years. The antiquity and intensity of human influence on the natural vegetation differs from place to place and is related to the local history of human settlement. The magnitude of human impact on the natural environment, however, is also influenced by prevailing environmental conditions.

In Greece, human impact on the vegetation, and on the natural environment in general, is of considerable antiquity. The establishment and expansion of farming from the Neolithic onwards required the clearance of, initially, virgin forests, and agricultural activities have continued through time to influence the forest vegetation to varying degrees. An increasing need for wood, the main source of fuel, also entailed intensive use of the forests, often through clear-cutting of large areas. Such influences have resulted in fundamental shifts in the evolution of the natural vegetation and, in areas where the natural environment was sensitive and unstable, have caused complete destruction of forest vegetation. Apart from these negative effects, however, human interference has also long exercised a more positive influence on the vegetation of Greece through the introduction and establishment or the protection of various forest species.

Palynology provides a means of investigating the history of forest vegetation in Greece. For mountain regions in particular, where other sources are almost non-existent, pollen diagrams constitute the best evidence for the history of forest vegetation and of human interference in its evolution. Palynological research in Greece in recent decades has produced information on the history of vegetation from more than 30 locations in various parts of the country, particularly from areas of low or intermediate altitude (Fig. 2.1).

Evidence of Human Influence on Forest Vegetation in Greece

The effects of human activity on the evolution of vegetation are apparent in all pollen diagrams from Greece and especially those that cover the last few millennia. These diagrams reveal fluctuations in vegetation cover between alternating periods of destruction and stability, sequential modifications of the composition and dominance of forest vegetation, and changes in the frequency of pollen from plants associated with human activity. Directly or indirectly, and to varying degrees and on varying scales, humans have evidently

1. Lerna
2. Thermisia
3. Kiladha
4. Kleones
5. Osmanaga
6. Kaiafa
7. Voulkaria
8. Trikhonis
9. Kopais
10. Halos
11. Litochoro
12. Aghia Galini
13. Tristinika
14. Xinias
15. Viviis
16. Ioannina
17. Gramousti
18. Tenagi Philippon
19. Gravouna
20. Volvi
21. Giannitsa
22. Edessa
23. Vegoritis
24. Kastoria
25. Khimaditis
26. Pertouli
27. Rezina
28. Pieria
29. Voras
30. Paiko
31. Rhodopes
32. Lailias

Figure 2.1 Location of palynological investigations in Greece.

influenced the evolution of vegetation over several millennia. This influence has affected almost every vegetation type in Greece (Gerasimidis 1995).

In the lower Eu-Mediterranean zone (Quercetalia ilicis),[1] the natural vegetation includes extensive maquis (evergreen sclerophyllous shrubs), with phrygana (semi-shrub heathland) dominant in degraded areas. In certain locations, the forest vegetation comprises pines (*Pinus halepensis*, *P. brutia* and *P. pinea*). In this zone, the natural vegetation is particularly degraded, because of the antiquity of human settlement and the intensity of human activity. Pollen diagrams from this zone indicate that the extent, and in some cases initial appearance, of the Quercetalia ilicis is anthropogenic. More specifically, the more degraded vegetation units of this zone, such as the modern distribution of the Oleo-Ceratonietum association, are the result of long-term human activity and impact on the natural vegetation. Some pine forests in this zone also result, directly or indirectly, from human intervention.

The hilly/sub-montane zone of deciduous forest (Quercetalia pubescentis) replaces the Quercetalia ilicis at higher elevations and more inland locations and covers much of continental Greece. The vegetation of this zone has also been affected by thousands of years of severe human interference. Apart from the destruction of forest cover by intense human use, the natural vegetation in places appears to a greater or lesser extent degraded. Human influence is more marked in the vegetation of the lower subzone, Ostryo-Carpinion, where hornbeams (*Ostrya carpinifolia*, *Carpinus orientalis*) and kermes oak (*Quercus coccifera*) are dominant, but is also apparent in the upper subzone of Quercion confertae, where oak forests and other broadleaved deciduous trees are present. Palynological data show that this zone was also dominant at lower elevations before its anthropogenic degradation to vegetation types of Quercetalia ilicis. Anthropogenic impact also produced qualitative degradation in the vegetation types of this zone: dominant mixed oak forests were reduced either to pure oak forest of low growth or to the vegetation types of the subzone Ostryo-Carpinion.

Above the Quercetalia pubescentis zone, at altitudes higher than 900–1100 m, the climate changes gradually from Mediterranean to continental and, naturally, a similar change occurs in the vegetation. Forest vegetation in the higher zones (Fagetalia and Vaccinio-Picetalia) typically comprises beech (*Fagus*), fir (*Abies*) and other coniferous species of greater or lesser cold tolerance. In the forest vegetation Fagetalia zone, beeches and firs are dominant, with Austrian pine (*Pinus nigra*) locally more or less strongly represented. The latter species also expands into the Quercetalia pubescentis. According to pollen diagrams from the Fagetalia zone, firs were more widespread in the past and even dominant in certain areas where today this species is rare or completely absent. The reduction or disappearance of firs was mainly anthropogenic in origin. Their removal often favoured beech trees, the expansion of which was thus substantially dependent on humans.

The highest forest vegetation zone is the Vaccinio-Picetalia, in which coniferous forests with Scots pine (*Pinus sylvestris*), Bosnian pine (*Pinus leucodermis*) and spruce (*Picea*) are present. Palynological data show that destructive interference at high elevations has at various times favoured the expansion of pines, probably Scots pine which is the main representative of the genus in this zone. Spruce has always been restricted to the Rhodopi mountains. The disappearance of birch (*Betula*), which is a component of this zone, from more southerly locations than those in which it appears today may partially be attributed to the effects of human activity on forest vegetation (Gerasimidis 1996).

The destruction of forest vegetation at the highest altitudes, starting several thousand years ago, has resulted in the creation or expansion of pseudo-alpine vegetation which appears above the tree line in the Astragalo-Acantholimonetalia zone.

Palynological Records of Anthropogenic Impact from the Mountains of Northern Greece

Palynological evidence for the vegetational history of a mountain region can be derived from nearby sites at low elevations. This assumes, however, that the pollen represents not only the area adjacent to the coring site but a more or less broad region, depending on the particular conditions of pollen production, dispersal and preservation. Reconstruction of the evolution of vegetation in mountain regions is more reliable, therefore, when based on pollen diagrams from within these regions. Such diagrams are of particular significance as certain of the pollen types associated with human activity have a short radius of dispersal.

Of the palynological investigations conducted in Greece, only seven are from mountain regions. Of the latter, two (Fig. 2.1: sites 26 and 27) are from central and north-west Greece respectively (Athanasiadis 1975; Willis 1992), while the remaining five (Fig. 2.1: sites 28-32) are from northern Greece (Gerasimidis 1985; Athanasiadis and Gerasimidis 1986; 1987; Athanasiadis *et al.* 1993).

Past human activity in the mountains of northern Greece is indicated in these diagrams principally by plants regarded as anthropogenic indicators and by the ratio of arboreal pollen to non-arboreal pollen (AP:NAP). Anthropogenic indicators include pollen types directly or indirectly associated with human activity, such as those of cultivated plants, weeds and plants associated with grazing, overgrazing and also human creation of pasture (e.g. *Cerealia, Olea, Vitis, Plantago*). Other indicators are plants characteristic of destructive human impact on natural vegetation by fires, clear-cutting and so on (e.g. *Juniperus, Artemisia,* Chenopodiaceae) and also species introduced through human activity (e.g. *Juglans, Castanea*). A reduction in AP:NAP values reflects the reduction of forest cover and, when associated with anthropogenic indicators, may be attributed to human activity. Conversely, an increase in the AP:NAP ratio usually represents the expansion of forest cover, following a reduction or cessation of intense human interference in the forest vegetation.

The palynological data from the mountains of northern Greece in most cases cover only the last few millennia (Gerasimidis and Athanasiadis 1995) and so provide limited information on the more distant past. It seems from the available palynological data, however, that human influence during the prehistoric period on the natural vegetation was far less marked in northern than in southern Greece. This can be attributed, in part, to the more intensive nature of past human activity in southern Greece and, in part, to the difference in climatic conditions. In northern Greece, and particularly in the mountains, the climate is more conducive to natural recovery of forest vegetation from the effects of any human impact.

Of the pollen diagrams from the mountains of northern Greece, that from Voras covers the longest period, approximately 7000 years (Athanasiadis and Gerasimidis 1986). In this diagram, evidence of human influence is minimal before the last millennium BC and, in the palynological record in general, intense human interference in the vegetation of the mountains of northern Greece first becomes apparent to varying degrees at about this time. In the Rhodopes (Athanasiadis *et al.* 1993), destructive interference, probably by people, had changed the appearance of the upland woodlands by the end of the second millennium BC. In particular, the dominant spruce and the fir, as well as other species that were part of the forest vegetation, almost disappeared. Only birch expanded, presumably in areas where forest was destroyed. It seems that this destruction was temporary, however, as the forest vegetation of the mountains recovered, mainly in the form of conifers. The lower section of the Paiko diagram indicates that, by the early centuries of the first millennium BC (Athanasiadis and Gerasimidis 1987), the forest cover of the area, and the pine forests in particular, had already contracted in the face of human activity.

In the ensuing period and up to the beginning of the Roman era, the palynological data suggest continuous human activity in the mountains of northern Greece, but without intensive interference in the forest vegetation. The most significant impact on forest vegetation during this period is the appearance of walnut and chestnut, trees which are thought to have been human introductions (Bottema 1974; Athanasiadis 1975).

Intensive interference in the forest vegetation took place during the last centuries BC, at about the time of the Roman occupation, when the palynological data suggest that intense interference at high elevations resulted in the reduction of coniferous woodland. The firs were most affected, becoming less abundant or almost extinct in many regions where they were previously dominant. Conversely, this contraction favoured the expansion of beech forests, which occurred immediately afterwards. Similar anthropogenic destruction of fir and pine forests during the same period is also reported for numerous areas in Bulgaria (Bozilova *et al.* 1995).

The pollen diagrams from the mountains of northern Greece reflect the importance of the mountains as a periodic refuge for those fleeing insecurity or economic crisis in the plains. Palynological evidence of reductions in forest cover and increases in agricultural activity may be correlated roughly with historically documented periods of insecurity or crisis in the plains. Conversely, in periods of stability, the return of population to the plains allowed the expansion of forest in the mountains. As yet, however, palynological evidence from the mountains is not dated closely enough to distinguish between the effects of short-term insecurity, for example during periods of warfare, and longer-term changes in land ownership, taxation, market prices or international trade. Palynological evidence of intense human interference in forest vegetation was more or less localized prior to the fifteenth century AD.

Around the time of the Turkish conquest of northern Greece, forest vegetation in the mountains was subject to intense anthropogenic pressure, perhaps from refugee populations, as reflected in the pollen diagrams by a reduction of forest cover and an increase in indicators of human presence and activity. An exception is the Lailia diagram which is discussed below.

Thereafter, during the course of the Turkish occupation, a general decline is observed in human activity in the mountains of northern Greece, although periodic episodes of intensive human activity may be associated with historical events. For example, following the failure of a revolutionary movement during the seventeenth century AD, refugees first fled to the western foot of the Pieria mountains and later withdrew to near the summit where they established the village of Katafigi (Nastos 1971). This event may be reflected in the palynological data from the Pieria mountains in a reduction of forest cover and an increase in indicators of human settlement (Gerasimidis 1985).

The uppermost sections of pollen diagrams from the mountains of northern Greece indicate a gradual decline in anthropogenic influence and an expansion of forest cover. This can be attributed to the gradual reduction of mountain population and to the introduction of systematic measures for the protection of the natural environment. The historical evolution of mountain vegetation in northern Greece and its relationship with human influence may be illustrated by analysis of the Lailias pollen diagram in the light of historical information for the same area (Gerasimidis 1985).

Anthropogenic Influence on the Development of Vegetation in the Mountain Region of Lailias

Environmental Setting

Geography, geology and climate. Lailias is situated in the western part of the Vrontou mountains which extend north of Serres and south of the Greek–Bulgarian border. In the study area, acid igneous rocks prevail. Climatic conditions change with increasing altitude from Mediterranean to continental. In the mountain area, the climate may be characterized as humid continental with warm summers and harsh winters.

Vegetation. The lower part of the mountains lies within the Quercetalia pubescentis zone. Scrub of varying density or low woodland, with hornbeams (*Carpinus orientalis* and *Ostrya carpinifolia*), kermes oak (*Quercus coccifera*), field elm (*Ulmus minor*), flowering ash (*Fraxinus ornus*) and so on, prevail in the lower subzone, Ostryo-Carpinion, up to 600–800 m altitude. Between 600–800 m and 900–1200 m, the majority of the area is in fields or meadows or bare ground. Some relict oak trees reveal that the area belongs to a greatly degraded Quercion confertae subzone. The higher part of the mountain up to the summit (Ali Baba at 1849 m) is occupied by the Fagion moesiacae subzone of the Fagetalia zone. Beech woods prevail from 1200 to 1800 m, although beech trees occur singly or in clusters in some places down to 800 m. Scots pine (*Pinus sylvestris*) is a very important element of the Lailias forest, but is gradually giving way to the expanding beeches. In this area, where it is considered extrazonal, Scots pine occurs both together with beech and, where conditions are not appropriate for beech, in unmixed stands.

Material and Methods

The coring site. The profile for pollen analysis was taken from a small (3 ha) peat bog at an altitude of 1420 m and at coordinates 41°16′ 4″ N, 23° 35′ 58″ E Greenwich. In the surrounding area, the vegetation belongs to the Fagetum moesiacae association.

Radiocarbon dates. The following three radiocarbon dates were obtained:

	Depth (cm)	Lab. ref. no.	Years bp
1.	58–61	VRI–746	250±80
2.	127–132	VRI–747	910±80
3.	175–200	VRI–748	1870±140

The third date is considered too young for this section of the profile, but it may be correct if it corresponds to the upper part of this rather long (25 cm) sample.

The diagram. The pollen diagram (Fig. 2.2) was drawn by the TILIA program. The percentages are based on the total pollen sum excluding the spores of fern and hydrophytes.

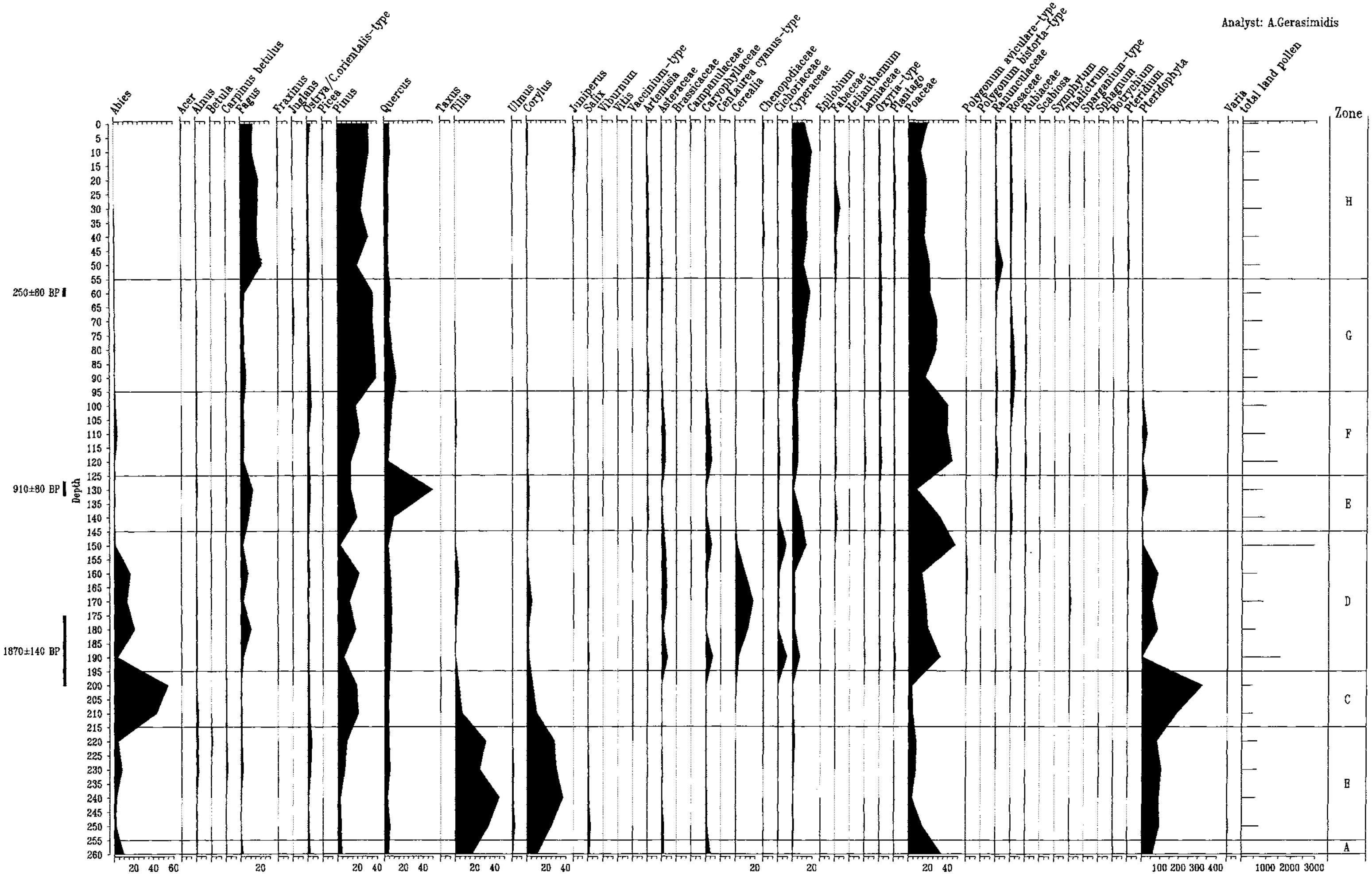

Figure 2.2 Pollen diagram of Lailias.

Analysis of Diagram: Results and Discussion

The diagram was divided into eight phases (A–H, from oldest to youngest), primarily on the basis of human influence on the development of the vegetation. The dating of each phase is approximate and based on the radiocarbon dates and on comparison with other pollen diagrams from mountain areas. Local historical data are mainly derived from Sakellariou (1982).

Phase A: Tilia-Corylus-*NAP, 260-255 cm, AP:NAP=56:44 (c. 4000 BC).* In the oldest part of the core, forest vegetation appears to be limited. At the same time, certain anthropogenic indicators such as *Plantago, Artemisia, Oxyria*-type and Chenopodiaceae are present at a low level. Interpretation of this initial phase is complicated, however, by the sudden change in vegetation that follows.

Phase B: Tilia-Corylus, *255-215 cm, AP:NAP= 87:13 (4000–2000 BC).* Dense deciduous forests dominate, with *Tilia* and *Corylus* the major species. There is no clear evidence of human activity.

Phase C: Abies-Pinus, *215–195 cm, AP:NAP= 93:7 (2000–300 BC)*
The vegetation of Quercetalia pubescentis retreats to lower elevations and the mountain is covered with dense coniferous forests, dominated by *Abies*. The change is probably attributable to changing climatic conditions, as there is no evidence of human influence.

Phase D: Abies-Pinus-Fagus-*NAP, 195–145 cm, AP:NAP=42:58 (300 BC–800 AD).* The phase starts with a marked retreat of forest vegetation. An anthropogenic cause for the change in vegetation is suggested by indicator taxa, such as *Plantago, Oxyria*-type and Chenopodiaceae, and in particular by the sudden increase of cereals and appearance of *Juglans*. Given the evidence of human activity, the abundant indicators of dry environment should probably be attributed to the clearance of forest and the increase in *Artemisia* related to clear-cutting. This destructive interference is dated to the second century BC, when the region was occupied by the Romans. The period between the end of the second century BC and the middle of the first century AD also saw numerous destructive raids by barbarian tribes, using the valley of the Strimon as a corridor from the North. As a result, inhabitants of the lowlands may have moved to the mountains for protection, causing large changes in vegetation. Following the major destruction of the forest vegetation, continued human activity is indicated by the palynological evidence, and particularly by values for cereal pollen, but the forest expanded once more (with *Fagus* an important component) and, despite some fluctuations as a result of human interference, maintained a large percentage cover. The phase ended as it had begun, with an even more severe destruction of forest vegetation, which may be correlated with Slavic incursions into the area. These reached their peak at the end of the seventh century AD, perhaps forcing the local population once again to move to the mountains. This destruction caused a significant qualitative change in the composition of the Lailias forest vegetation, leading to the disappearance of Abies, which was hitherto the dominant species in the forest vegetation of the area. Following this there was a small recovery of Abies but then it became extinct.

Phase E: Fagus-Quercus-Pinus, *145–125 cm, AP:NAP=61:39 (800–1100 AD).* During this phase, a major increase is observed of forest, particularly of broad-leaved, deciduous species. Especially significant is the increase in *Fagus*, which becomes dominant. Increased pollen values for *Quercus* and, especially, *Ostrya / Carpinus orientalis*-type indicate a general stability in the region which allow the expansion of forests to lower elevations. Human presence is indicated by *Juglans, Vitis, Plantago, Oxyria*-type, and so on, but the impact on forest vegetation is limited. The decrease of cereal pollen values also indicates a reduced level of human activity.

Phase F: Pinus-*NAP, 125–95 cm, AP:NAP=35:65 (1100–1400* AD*).* During this phase, the forest cover is once again reduced. *Fagus* declines and there is also a significant reduction of *Quercus*. The decline of oak forest, together with the reduction in vegetation of the Ostryo-Carpinion subzone, indicates destruction of the lower-elevation forests. This was particularly important for the oak forests of the Quercion confertae, as the forest vegetation of this subzone did not subsequently recover and its presence today is minimal. Indicators of dry environment, such as Caryophyllaceae, Asteraceae, Cichoriaceae, Poaceae, *Juniperus* and so on, confirm that extensive clearings existed during this phase. Also present, but at low levels, are indicators of cultivation and grazing. During this period, the area was successively invaded and occupied (with some interludes of renewed Byzantine rule) by Normans, Franks, Bulgarians and Serbs. These historical events seem to have had a more or less destructive impact on the forest vegetation.

Phase G: Pinus-*NAP, 95–55 cm, AP:NAP=54:46 (1400–1800* AD*).* The recovery of forest cover during this phase is attributed to the increase of *Pinus*, while *Fagus* is present in low numbers. Indicators of cultivation and clearings occur throughout this phase, but with low values. In general, no destruction of forest vegetation is observed, although the extrapolated date for the beginning of the phase is the time when the Turks invaded the area. In pollen diagrams from other mountain areas in northern Greece, the Turkish occupation may have been accompanied by destruction of the forest vegetation, albeit to varying degrees in different areas. Serres was one of the first Macedonian cities to be taken by the Turks (in 1383 AD) and showed no great resistance. To influence the population of other areas, the Turks treated Serres well, not converting churches into mosques and allowing the people of the city to be self-governing. For this reason, the inhabitants of the plains did not move to the mountains for protection, as in previous periods.

Phase H: Pinus-*NAP, 55–0 cm, AP:NAP=54:46 (after 1800* AD*).* During the last phase, the AP:NAP ratio suggests that the scale of forest cover remained as in the previous phase. A significant qualitative change took place, however, in the composition of the forest vegetation, as *Fagus* became more dominant, particularly at the beginning of the phase, while *Pinus* declined. The sudden but impressive increase of *Fagus* indicates an expansion over large areas and implies the replacement of pines by beeches, perhaps partly because of selective cutting of pine trees by humans. Thereafter Fagus remained dominant despite increased impact by humans and livestock (increased pollen values for cereals, Chenopodiaceae, *Plantago, Juniperus* and so on). The observed recovery in *Pinus* during the phase may be attributed, at least in part, to its recolonization of areas previously devoid of vegetation, perhaps because of fire at the beginning of the phase (implied by the sudden increase in Fabaceae and *Artemisia*). Perhaps in the first half of the twentieth century AD, *Fagus* declines and there is an increase of indicators such as cereals, *Juniperus* and *Oxyria*-type. This suggests that human interference in the forest, direct or indirect, became particularly intense during this period of major historical events, including the Balkan wars, liberation from the Turks, two world wars, German occupation and civil war. A renewed but limited increase in *Fagus*, observed in the surface sample from the profile, reflects what is apparent in the Lailias forest today—the expansion of beech as a result of protective measures (particularly restrictions on grazing) taken a few decades ago.

Conclusion

The analysis of the Lailias pollen diagram indicates that the evolution of the forest vegetation of the region has a complex history. The forest vegetation of the Lailias mountain region, which is evidently still evolving, is the end-product of a long period of development, during which a dominant influence has been exercised by humans. Comparison with other pollen diagrams from the mountains of northern Greece reveals common trends in the evolution of vegetation under anthropogenic influence, but also local differences due to contrasting environmental conditions and, especially, to the divergent history of each area.

Note

1. The classification of Greek vegetation follows Athanasiadis (1986) and Dafis (1975).

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3

Local Vegetation and Charcoal Analysis: An Example from Two Late Neolithic Sites in Northern Greece

Maria Ntinou and Ernestina Badal

Introduction

The study of past vegetation records is a primary concern of palaeoecology, as a means of reconstructing prevailing biological and climatic conditions and of investigating changes in the environment caused by natural factors or anthropogenic activities.

The pollen record of Greece includes long sequences and detailed information for the Late Quaternary. The Early Holocene natural environment was the setting for the establishment of Neolithic farming communities, when changes in human activity initiated modification of the landscape and vegetation. This subject has been explored by various authors and has triggered discussion of criteria for the identification of human impact on vegetation, its timing and intensity. Pollen investigation in Greece offers a clear framework in this respect. Neolithic environments, vegetation and climate have been reconstructed in detail through pollen sequences in lakes and marshes, especially in the most humid areas of north and north-west Greece.

A complementary source of information on vegetation and natural environments is the analysis of charcoal from archaeological sites. Charcoal is the result of daily, or periodic, domestic activities. Wood gathered for fuel and burned during the occupation of a settlement, then deposited in the archaeological layers, is the basis for palaeoecological interpretation (Stieber 1967; Vernet 1973). Charcoal retains the anatomical structure of wood. Charcoal structures are compared to those described in the atlases of wood anatomy (Jacquiot 1955; Jacquiot *et al.* 1973; Greguss 1955, 1959; Schweingruber 1978, 1990), thus permitting identification to family, genus or species level. In charcoal diagrams, comparison of the quantitative and qualitative composition of consecutive spectra reflects local vegetation and human influence thereon and, in long sequences, changes caused by natural factors or anthropogenic activity (Badal 1992; Heinz 1991; Chabal 1988, 1997).

The results of charcoal analysis at two Late Neolithic sites in northern Greece, Makri in Thrace and Dispilio in West Macedonia, are presented here and compared to the pollen record of the same period. The way in which the complementary results of these two disciplines can be combined in palaeoecological interpretation is discussed in the context of these two sites. Charcoal analysis may shed light on local conditions and on human perception of vegetation. It may reveal how natural vegetation was managed, which (at least for the Neolithic) may have involved other processes than just clearance, deforestation and degradation. Besides their ecological value, such results enrich our knowledge of multi-dimensional prehistoric subsistence strategies.

The Holocene Pollen Record in North and North-West Greece

The pollen record of the Holocene in Greece has been investigated most intensively in north and north-west Greece, in part because wetter climatic conditions are more favourable than in the south of the country to the preservation of sediments for palynological investigation. The following brief summary is based on the pollen diagrams from Tenaghi Phillipon (Wijimstra 1969), Ioannina, Edessa, Khimaditis, Kastoria, Giannitsa (Bottema 1974), Gramousti, Rezina (Willis 1992a–c), Tseravinas and Ziros (Turner and Sánchez-Goñi 1997) (Fig. 3.1) and on a synthesis of the vegetation history of the Balkans by Willis (1994a).

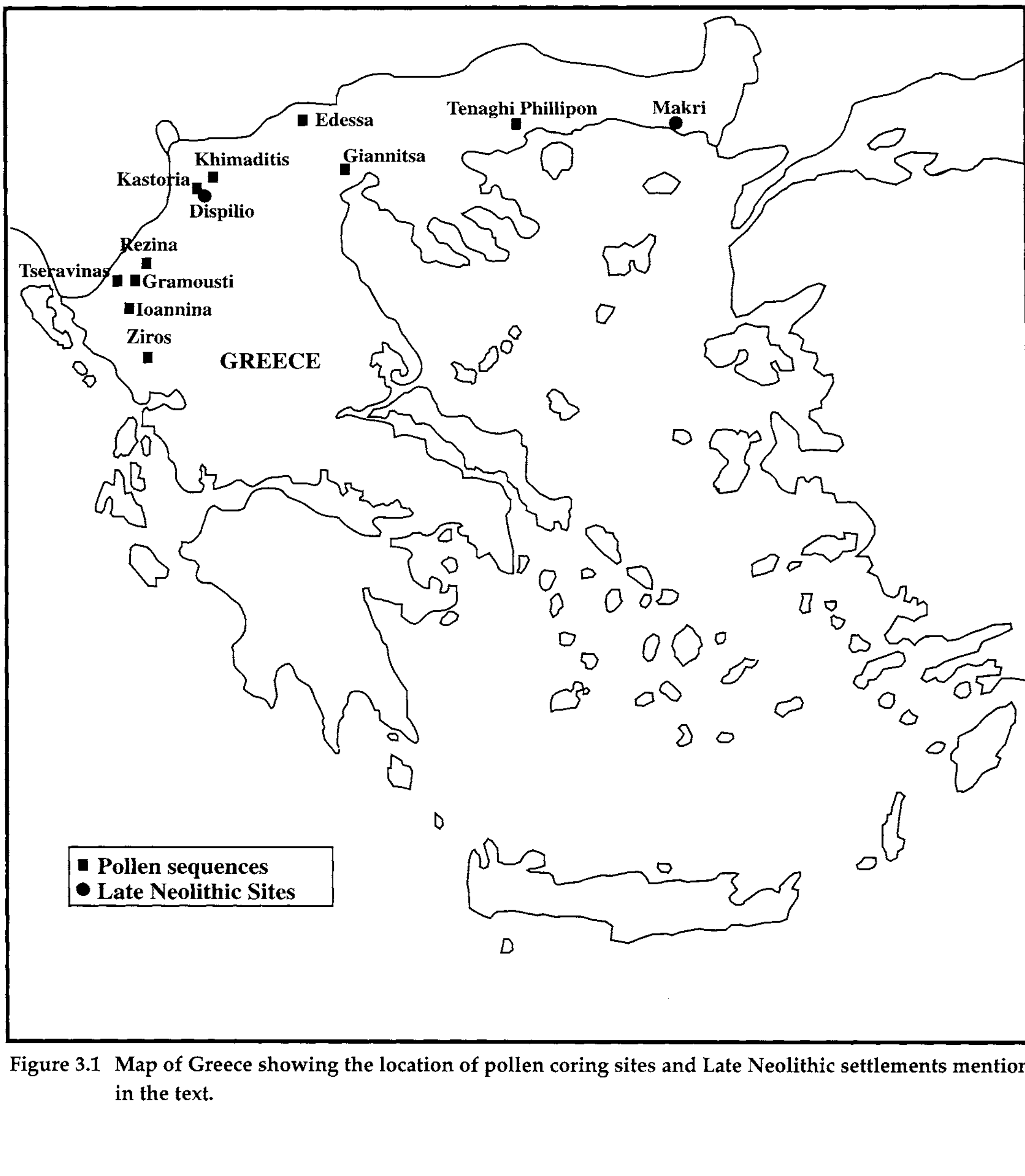


Figure 3.1 Map of Greece showing the location of pollen coring sites and Late Neolithic settlements mentioned in the text.

The expansion of oak and the simultaneous appearance of other species mark the Late Glacial-Holocene transition at the majority of sites. There is no evidence of the time-transgressive appearance of taxa that would indicate differential migration rates. The pollen record points, therefore, to the existence of mid-altitude vegetation refugia during the last glacial in the Greek mountains, from which tree taxa expanded rapidly following the amelioration of climatic conditions (Bennett *et al.* 1991; Bottema 1974; Willis 1994a). The Holocene vegetation in all coring sites from north, north-west and eastern Greece has some common characteristics: the establishment of open oak woodland and the increase in the frequencies of other deciduous species. Differences in establishment rates between sites are due to altitudinal and latitudinal variation (Willis 1994b).

After this first stage of more or less open oak formations, evidenced by the increase of *Pistacia* between 9000 and 8000 bp, this sun-loving species declines sharply, denoting the closing up of the canopy (Bottema 1974; Turner and Sánchez-Goñi 1997; Wijmstra 1969; Willis 1994a). Up to 7500 bp, other temperate deciduous taxa proliferate in the pollen diagrams at the expense of oaks, reflecting changes in the diversity and density of vegetation. At higher altitudes, conifers (*Abies*, *Pinus*) expand, as evidenced by the Rezina, Edessa and Khimaditis sequences (Bottema 1974; Willis 1992b; 1994b). Local climatic differences, maturation of soils and differing establishment time for different taxa were responsible for these changes in the composition of vegetation (Willis 1994a). From 7500 to 5000 bp mixed deciduous oak forests prevailed in most sites, with increasing frequencies of *Carpinus orientalis/Ostrya*; at higher elevations, conifers maintained their position (Bottema 1974).

Between 5000 and 4500 bp all sequences show the first signs of anthropogenic disturbance, manifested by reduction in the diversity and density of the forest. After 4000 bp, this is accompanied by an increase in open ground herbaceous types and the establishment of tree taxa directly or indirectly related to human intervention, such as *Olea*, *Fagus*, *Juglans*, *Castanea* and *Platanus*.

The Neolithic Site of Makri

Regional and Cultural Setting

The Neolithic site of Makri lies 10 km west of modern Alexandropoulis in Thrace, north-east Greece (Fig. 3.1). It is located on top of a cliff at 40 m asl, overlooking the Aegean sea to the south. To the east and west extends the Thracian plain. To the north the landscape rises in altitude to the peaks of the Rhodopi mountain range (1000 m), that forms the natural border between Greece and Bulgaria.

The cliff on which the Neolithic site is situated corresponds to the distal end of a broad, slightly concave platform of stepped waterfall travertine deposits (Efstratiou *et al.* 1998); locally, the different growth phases of travertine usually favour swamp formation (Efstratiou *et al.* 1998).

The climate and vegetation of the region are influenced by the sea to the south and the Rhodopi mountains to the north. The climate and precipitation regime is Mediterranean, though continental influences become stronger with increasing distance from the coast. From sea level to an altitude of 500 m, the bioclimatic conditions in the region are of the mesomediterranean type—dry, with mean annual precipitation under 500 mm. Winters are cold (average January temperature 0–5 °C) and summers relatively hot (average July temperature 20–25 °C) (Forest Service 1989; Polunin 1980). The fertile plain is intensively used for agriculture, mainly cotton, tobacco, cereals and occasionally olive trees in the warmest niches. Near the coast, the vegetation forms a tall maquis dominated by evergreens, *Phillyrea media*, *Quercus ilex*, *Arbutus unedo* and so on. Deciduous vegetation grows as well, represented by *Pistacia terebinthus*, *Fraxinus ornus*, and *Pyrus amygdaliformis*. Less frequent are *Arbutus andrachne* and *Carpinus orientalis*. From 500 m upwards, the bioclimatic sequence follows the supramediterranean vegetation of subhumid to humid type, characterized by deciduous oak woodlands with hornbeam, ash, maple and so on. Oromediterranean beech forests cover the peaks of the Rhodopi mountains (Forest Service 1989).

The excavation of Neolithic deposits at the mound of Makri revealed a four-metre deep stratigraphic sequence that is characterized by two distinct depositional units. These correspond to two different cultural periods, a short early Makri I and a longer late Makri II, separated by a 'destruction layer'. The pottery study confirms this division into two periods through changes in the shape and decoration repertory. Each of these two periods includes several habitation-architectural phases (Efstratiou *et al.* 1998).

The site is ascribed to the Middle and Late Neolithic horizons of the southern Balkans. The three available radiocarbon dates confirm this. One dates the deeper layers of the sequence (Makri I) to 5540 BC (GrN-20475: 6640±50 bp), and the other two indicate a date of 5500 BC (GrN-21266: 6580±40 bp; GrN-21267: 6560±30 bp) for the transitional destruction layer. The ceramic traits relate the Makri II cultural period with the phases Sitagroi I–II and Paradimi I–II in Greece, Karanovo III in Bulgaria, early Hoça-Çesme in European Turkey and Ilipinar IV in Anatolia (Efstratiou *et al.* 1998).

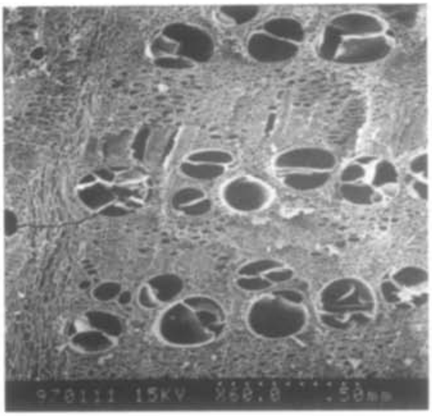
Charcoal Analysis at Makri

Charcoal analysis covers only part of the sequence at Neolithic Makri. For the earlier period Makri I, scattered remains of firewood were collected from all layers in one trench. For the later Makri II period, only two layers beneath the second habitation phase were sampled.

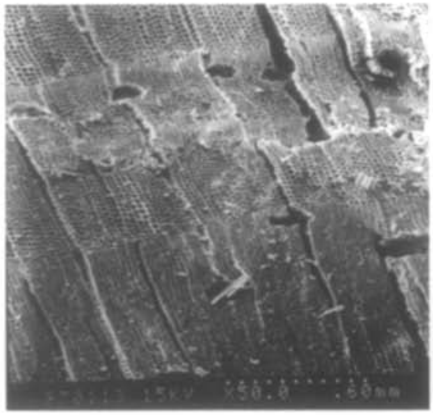
The analysis of 1939 charcoal fragments led to the identification of 20 plant taxa and one that remained indeterminate. The plant list from Makri, in alphabetic order, consists of: *Acer* sp. (maple), conifer, *Cornus* sp. (Cornelian cherry), *Ficus carica* (fig) (Fig. 3.2 [4]), *Fraxinus* sp. (ash) (Fig. 3.2 [5]), *Juglans regia* (walnut), *Juniperus* sp. (juniper), Leguminosae, Maloideae, *Paliurus spina-christi* (Christ's thorn), *Phillyrea-Rhamnus* (buckthorn), *Pistacia terebinthus* (terebinth), *Prunus* sp., Rosaceae, *Quercus* deciduous (deciduous oak), *Salix-Populus*, *Taxus baccata* (yew), *Tilia* sp. (lime), *Ulmus* sp. (elm) and *Vitis vinifera* var. *sylvestris* (grape vine) (Fig. 3.2 [6]). In the case of *Prunus* sp., we have included a few charcoal fragments attributable to *Prunus amygdalus* (almond).

The lignifying angiosperms are represented by 15 plant families including various genera, all deciduous except for *Phillyrea-Rhamnus*. Anatomical differentiation between the latter is not possible, so it must be noted that *Phillyrea* genus, *Rhamnus alaternus* and *R. lycioides* are Mediterranean evergreens while *Rhamnus alpinus* and *R. sibthorpianus* are deciduous mountain species. Conifers are generally scarce, including only *Juniperus* sp. and *Taxus baccata*.

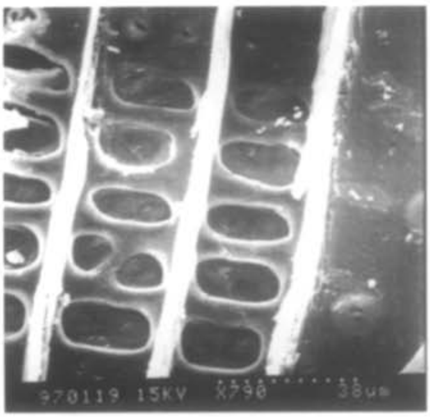
Because of the scarcity of charcoal, the data have necessarily been analysed independently of the thickness of the archaeological layers. Some layers did not contain sufficient charcoal fragments for analysis and, for this reason, samples had to be amalgamated in order to assess the representation of the taxa. Layer



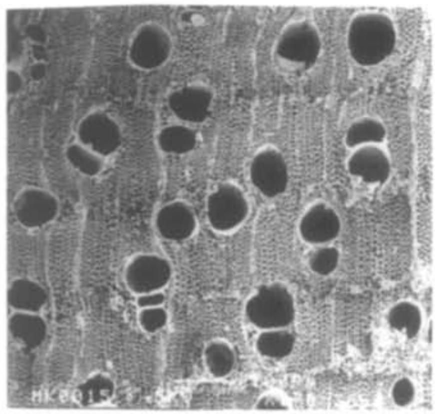
1. Quercus deciduous, transverse section, x60



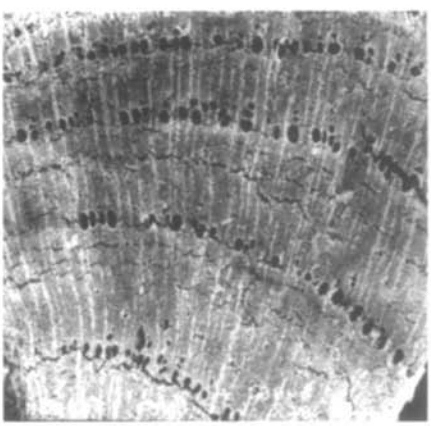
2. Pinus cf. *nigra*, transverse section, x50



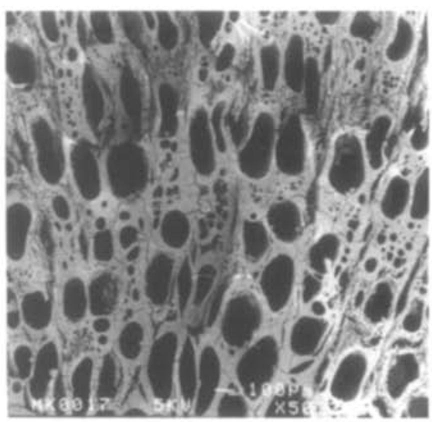
3. Pinus cf. *nigra*, longitudinal radial section, x790



4. Ficus carica, transverse section, x170



5. Fraxinus sp., transverse section, x40



6. Vitis vinifera var. *sylvestris*, transverse section, x50

Figure 3.2 SEM images of archaeological charcoal from Late Neolithic Dispilio (1–3) and Makri (4–6).

29 of Makri I and layers 1 and 2 of Makri II were relatively rich in charcoal. Charcoal from layer 29 has been dated to 5540 BC.

The charcoal diagram for Makri (Fig. 3.3) consists of six spectra, four from the earlier Makri I period and two from the later Makri II. Although the floristic composition of these spectra is quite similar, there are variations in the frequency of taxa. In all Makri I spectra, the dominant taxon is Quercus deciduous (c. 30%), 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.

The charcoal diagram seems to indicate the presence of deciduous oak woodland, in which oaks are accompanied by other deciduous taxa such as *Fraxinus* sp., *Cornus, Acer,* Maloideae genera and *Tilia. Fraxinus* could belong to the oak woodland or grow in areas of greater soil humidity, like water courses or travertine swampy formations. Its increasing frequency in the four lower spectra and predominance in the upper two suggest two possibilities, bearing in mind the limitations caused by the segmented sequence:

1. Parts of the deciduous oakwoods were managed in a way that did not alter the oak forest, as implied by the stable *Quercus* deciduous percentages, but opened up the canopy, so favouring the growth and proliferation of the heliophilous manna ash.
2. Swamps near the site, as indicated by travertine formations, were rich in ash and other resources and so were frequented by humans as complementary sources to the oakwood.

Cornus and *Acer* have low but steady frequencies. *Cornus* sp. may have grown in the hedges of humid areas or in the oak woodlands. *Acer* has not been identified to species, but this genus is very common in oak forests, as are *Taxus baccata* and *Tilia,* which are both very rare in the spectra. Maloideae genera are difficult to differentiate and so the subfamily name is retained, but *Crataegus* and *Pyrus-Sorbus* are probably represented in our samples. Maloidae are more or less stable except for the upper spectrum.

A distinctive feature of this deciduous oak woodland is the presence of the heliophilous

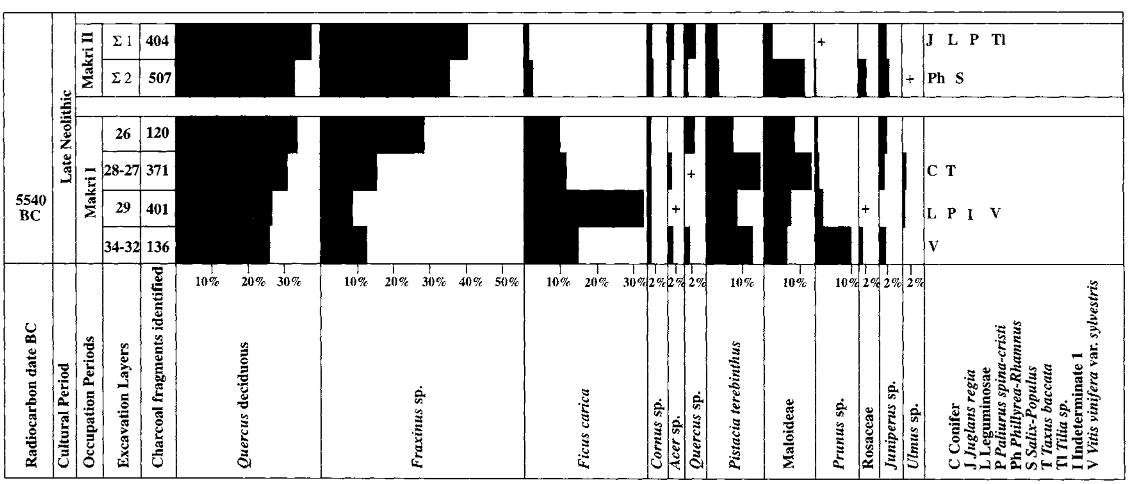


Figure 3.3 Charcoal diagram for Late Neolithic Makri: percentage frequencies of taxa in the charcoal assemblages from successive layers.

components, *Pistacia terebinthus*, *Prunus* sp. and *Prunus* cf. *amygdalus*, *Juniperus* sp., *Paliurus spina-christi*, and *Pyrus* from the Maloideae. These genera demand plenty of light and do not strictly belong to the bushy formations that prosper under tree cover. Such taxa indicate a plant cover rather open in places where sun-loving species could flourish. These formations could develop in a dry to subhumid pluviometric regime, a feature that differentiates these particular deciduous oak woods from their European equivalents needing higher precipitation.

Pistacia terebinthus, although well represented in Makri I, diminishes in the spectra of Makri II. *Ficus carica* would likewise have been quite abundant in the environment according to its frequencies in the Makri I spectra, but is quite scarce in Makri II. The wild form of the fig tree grows in the Mediterranean region from sea level to 1000 m. This deciduous tree, which tolerates dry summers and cold winters well, occupies rock crevices, gorges and stream sides. In the territory of Neolithic Makri, fig trees probably grew on the steep slopes overlooking the sea. The anatomical characteristics do not permit distinction between the wild and domesticated forms. The fig tree was used for firewood in prehistoric Makri, although it does not provide good quality fuel unless dry. Ethnographic studies in Morocco report the occasional use of fig wood for firing the base of pottery kilns (Peña-Chocarro *et al.* 2000). In prehistoric sites, specific uses of wood are difficult to define, but short-term or isolated events may cause unexpectedly high frequencies of taxa, the interpretation of which can only be speculative. The sampling gap between Makri I and II makes it difficult to interpret the low *Ficus carica* frequencies in the upper layers. Some protection of these trees for their highly nutritious fruit is possible and fig seeds, as well as entire carbonized fruits, are present in the archaeological levels of Makri II (Efstratiou *et al.* 1998).

Riverside vegetation is represented at Makri by *Ulmus* sp., *Vitis vinifera*, *Salix-Populus* and *Juglans regia*.

In the charcoal diagram for Makri, a large part of the sequence is missing. Nevertheless, the earliest occupation and part of the latest are represented, covering the period between the middle of the sixth millennium BC and the beginning of the fifth millennium BC. During that time, the surrounding vegetation was dominated by deciduous oak and in general remained unaltered. This deciduous formation was probably the climax vegetation of the area and developed under mesomediterranean dry to subhumid climatic conditions. Although the climate was very similar to that prevailing in the region today, the plant formations were drastically different. Nowadays, in the environs of the site, only evergreen formations thrive and among these the bioindicators of human activities are quite frequent.

Dispilio Lakeside Settlement

The Regional and Cultural Setting

The site of Dispilio, West Macedonia, is a lakeside settlement, located at an elevation of 625 m, a few metres from the south shore of Lake Kastoria (Fig. 3.1). The region is mountainous, forming part of the North Pindos range that reaches 2128 m on the Vitsi peak to the north-east, 2111 m on the Siniatsiko mountains to the south-east, and 2520 m on the Grammos to the far south-west on the border with Albania. Rivers, some feeding the lake and others receiving its outflow, dissect this mountainous landscape. The plain to the south of the lake is drained by the River Aliakmon and its tributaries and is surrounded by hills.

The climate and precipitation regime of the region is transitional from Mediterranean to continental. Rainfall is more or less evenly distributed through the year, the dry period is short and mean annual precipitation ranges from 700 to 1000 mm. The annual temperature amplitude is approximately 20 °C, while snow and frost are frequent in winter (Bottema 1974; Ntafis *et al.* 1997; Polunin 1980).

The natural vegetation at lower elevations and close to the lake has almost completely disappeared. The plain supports intensive arboriculture. Around the lake, *Phragmites australis* is dominant (Ntafis *et al.* 1997). *Salix*, *Populus* and *Ulmus* are the most frequent trees close to the lake, while *Pyrus amygdaliformis*, *Paliurus spina-christi* and *Prunus spinosa* thrive on the limestone hills to the south-west. To the south-east, the hills present a stage of regeneration where *Juniperus oxycedrus* is frequent, together with *Carpinus orientalis*, *Fraxinus ornus*, *Ostrya carpinifolia* and some *Quercus cerris*. The potential vegetation under natural circumstances would be a deciduous forest of supramediterranean bioclimatic conditions (Bottema 1974). The mountains are covered by *Pinus nigra* forests with *Abies borisii-regis* and *Fagus* woods (Polunin 1980).

The deposits excavated at the Dispilio lakeside settlement offered an approximately two-metre stratigraphic sequence and plentiful information on various aspects of the prehistoric occupation of the site. The earlier occupation phases represent a settlement built over shallow water or swampy ground which dried up periodically. The later occupation phase was built on dry ground, though probably affected periodically by lake waters (Karkanas in preparation). The Dispilio sequence can largely be assigned to the Late Neolithic, but the pottery study offers evidence for activity dating back to the Middle Neolithic and extending down to the Early Chalcolithic (Andreou *et al.* 1996; Hourmouziadis 1996).

Charcoal Analysis

At the lakeside settlement of Dispilio, the entire stratigraphic sequence was sampled in various trenches. The charcoal diagram is based, however, on samples from two trenches which contained scattered charcoal, in contrast to the other trenches where evident remains of architectural timber complicated palaeoecological interpretation. Nonetheless, the nature of the waterlogged deposits, where differentiation between charcoal from architectural remains and fuel is difficult, makes it necessary to consider the possibility that at least some of the samples analysed include mixed material.

The analysis of 3743 charcoal fragments led to the identification of 21 plant taxa. The plant list of Dispilio, in alphabetical order, 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) (Fig. 3.2 [2–3]), *Pistacia terebinthus* (terebinth), *Prunus* cf. *amygdalus* (almond), *Prunus* sp., *Quercus* deciduous (oak) (Figure 3.2 [1]), *Rhus coriaria* (sumach), *Rosa* sp. (rose), Rosaceae, *Salix* sp. (willow), *Tilia* sp. (lime) and *Ulmus* sp. (elm). This plant list almost certainly underestimates the diversity of species exploited, given that identifications to genus may include several species, as for example in the case of *Quercus* deciduous. In this plant list, the majority of the taxa identified (18) are deciduous angiosperms. The remaining three taxa are conifers.

The charcoal diagram for Dispilio (Fig. 3.4) consists of 12 spectra, each corresponding to an approximately 10 cm excavation layer. The layers between 11 and 14 with timber remains have been excluded. The dominant taxon in all spectra is *Quercus* deciduous, which fluctuates around 40–50%. Records of *Quercus* sp.

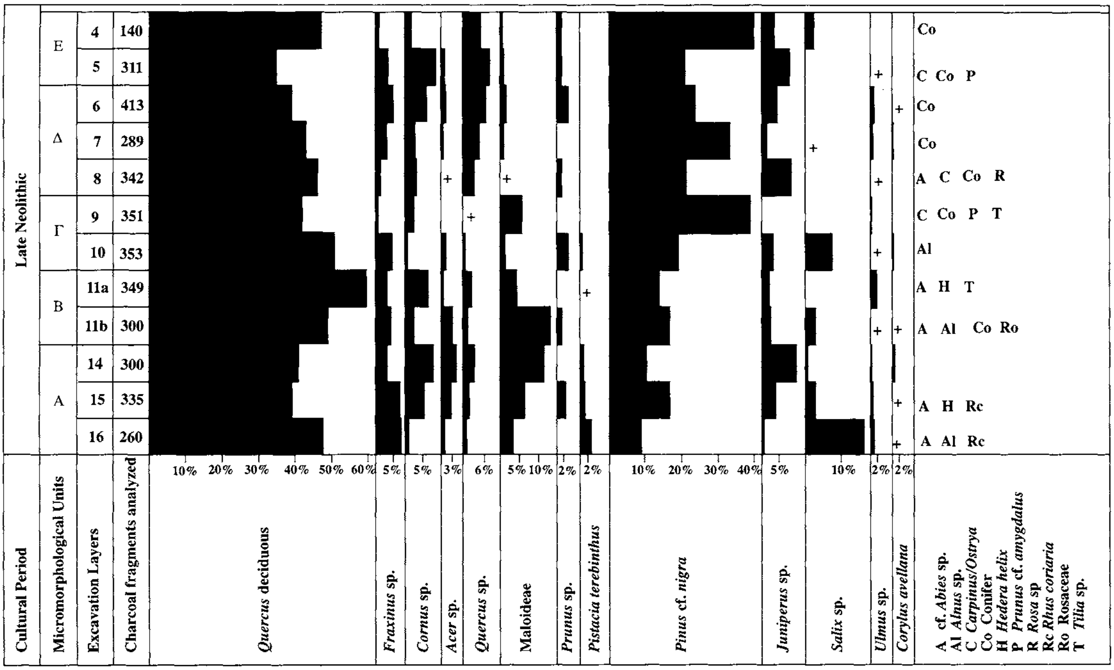


Figure 3.4 Charcoal diagram for Late Neolithic Dispilio: percentage frequencies of taxa in the charcoal assemblages from successive layers.

also probably belong to deciduous oak, but are shown separately because the ring porous zone was not clearly observable.

Other deciduous components of oakwoods, like *Fraxinus*, *Acer* and *Cornus*, present low but steady frequencies. *Tilia*, *Carpinus/Ostrya* and *Hedera helix* are rather infrequent. Frequencies of *Ulmus* sp. are low but stable and this taxon may have formed part of the riverside or lakeside woods. *Corylus* sp. would be a less frequent component of the forest undergrowth.

Maloideae is a big subfamily of the Rosaceae; anatomical differentiation between genera is difficult, so the generic term has been retained. Various members of the Maloideae, such as *Sorbus*, *Malus* and some *Crataegus* and *Pyrus* species, are components of deciduous woods. The frequency of Maloideae increases in the lower part of the sequence, reaching a maximum in spectrum 11b, but thereafter clearly declines.

Pistacia terebinthus is present in decreasing frequencies in the lower part of the sequence and disappears from spectrum 9 onwards. *Rhus coriaria* is present in the two lower spectra. Both are sun-loving species growing in open woods and dry places. *Prunus* sp. is rather sparse. There are various *Prunus* species in northern Greece, the majority of them growing in open, sunny and rocky places. In our samples, *Prunus amygdalus* has been differentiated, on the basis of its distinctive anatomy (Bazile-Robert 1980; Schweingruber 1990).

Lakeside vegetation is evidenced by *Salix* sp. and *Alnus glutinosa*. *Salix* reaches its maximum (16.5%) at the bottom of the sequence and from then on is rare or absent. *Alnus* is rather infrequent.

Conifers are represented by *Pinus* cf. *nigra*, *Juniperus* sp. and sparsely by *Abies* sp. *Pinus* cf. *nigra* is the next most important taxon after

Quercus deciduous. The percentages in spectra 9, 7, and 4 may be rather exaggerated, probably as a result of the admixture of charcoal from construction timber, but its frequencies increase steadily from c. 10% in the lower to c. 20% in the upper part of the diagram. *Juniperus* sp. occurs throughout the sequence with variable frequency.

The charcoal diagram points to the existence of two dominant formations, a deciduous oak woodland and a coniferous forest. Deciduous oak woodland is the prevalent formation throughout the sequence and, judging from the frequencies of taxa, it was of stable composition.

Black pine forests were the other dominant formation in the region. The increasing frequencies of *Pinus nigra* are interpreted in terms of an intensification in human exploitation of the pine forest rather than a change in vegetation cover, since there is no evidence for alterations to the predominant oak woodland. *Juniperus* thickets would border the oak woods or grow in the less dense parts of the deciduous formations.

Bushy, sun-loving, open formations represented by *Pistacia terebinthus*, *Rhus coriaria*, *Prunus* sp. and probably some Maloideae, such as *Pyrus amygdaliformis*, are less well represented in the upper part of the sequence. The same occurs with lakeside vegetation. In our view, these formations would be the closest to the site and, during the initial stage of occupation, were probably the most affected by clearance for housing and other subsistence activities. If the charcoal record shows the vegetation used by prehistoric people during the time of occupation of the site (Badal *et al.* 1994), then these two formations were not extensive in the first place and, once cleared (and the wood used), either did not regenerate because their niche was occupied by humans (open places, fields?) or were ignored because other formations were more convenient (wood gathering would certainly be more efficient in oak forests than in restricted gallery-forests along the lake).

Oak forests were probably the climax formation for the latitude (40°30′N, 21°18′E) and altitude (625 m) of the site of Dispilio, while black pine forests would cover the surrounding mountains not far from the site. The prevailing climatic conditions would be similar to the present, though the vegetation around the site has changed considerably.

Discussion

The Late Neolithic sequences of Dispilio and Makri cover part of the sixth millennium and at least the beginning of the fifth millennium BC, corresponding to the period from 6500 to 6000 bp (Demoule and Perlès 1993: 366, fig. 2). The charcoal data from these sites are consistent with the pollen record for the same period, when deciduous oakwoods are prevalent, though altitudinal variation is evident in the presence, distribution and abundance of mountain conifers and Mediterranean or temperate taxa at different locations.

The Late Neolithic vegetation sequence at Dispilio presents similarities to the pollen record of this region in the Atlantic period (Bottema 1974). Zone Y in the Khimaditis and Kastoria pollen diagrams points to the occurrence, at medium elevations, of a dense deciduous oak forest mixed with *Ulmus*, *Fraxinus*, *Tilia*, *Carpinus* and *Corylus*. Pine forests with some fir would cover the mountain zone.

The pollen diagram from Tenaghi Phillipon indicates the gradual expansion of forests in the Holocene (zone Z). The oak is attributed to evergreen oak and there is reference to the existence of a *Fraxinus* zone (Wijmstra 1969). The Tenaghi Phillipon coring site is the closest to Makri and there is agreement between the pollen and charcoal records as regards the forested nature of the landscape and the relative importance of ash and other heliophilous species.

Charcoal analysis at the two Neolithic sites also reflects the prevalent local vegetation formations. At both sites, oak woodlands constitute the main vegetation cover, but the secondary formations reflect regional differences in climate related to altitude and exposure to the influence of the sea. In the case of Dispilio, the coniferous forest, mainly of black pines with some fir, reflects the location of the site at 625 m altitude in an inland basin, surrounded by high mountains. At Makri, by contrast, abundant sun-loving Mediterranean species reflect the low elevation (40 m) and proximity to the sea. The deciduous oak woodland seems denser around Dispilio, where oak makes up 40–50% throughout the sequence; other components are sparse, including ash that does not exceed 6%. At Makri, on the other hand, the oakwood would have been less dense, with ash a well-represented component and other Mediterranean species constantly present.

Despite these differences resulting from location and altitude, both sequences are characterized by the unaltered quantitative and qualitative composition of the principal deciduous oak formations. This implies minimal human impact on the local environment. In this respect, the pollen record too does not detect anthropogenic disturbance and land degradation until after 5000–4500 bp (Bottema 1974; Willis 1995). Even though the first Neolithic farming communities were established a few thousand years earlier, their impact on the landscape seems to have been negligible. Oakwoods were predominant and changes in the composition of the woodland were principally caused by competition between species and changing climate rather than anthropogenic intervention (Willis 1994a). In the pollen record, land degradation and deforestation, accompanied by evidence for agriculture and grazing, post-dates the Neolithic and the charcoal results from the two Neolithic sites provide corroborative evidence of stability in local vegetation cover.

In interpreting the charcoal data from the Neolithic sites, some issues deserve further consideration. First, since the charcoal spectra reflect local conditions, these are likely to be influenced by the duration and intensity of occupation at the sites: occupation of shorter or longer duration, with or without interruption, would probably have different effects on the local environment. The charcoal sequences are attributed to the Late Neolithic, but the existing evidence is insufficient for precise dating. At Makri, a very short duration is suggested for the earliest Makri I period by the radiocarbon dates (5540 BC for the bottom and 5500 BC for the top of this part of the sequence), while the rest of the sequence would correspond to some time at the beginning of the fifth millennium BC. For Dispilio, no radiocarbon dates are as yet available and the intensity of occupation is a subject still under study; more archaeological information is needed. Assuming a 500-year occupation span for these sites, however, which is consistent with existing information, the transformation of the vegetation is minimal and the pollen record points in the same direction. In this respect, the climatic and geographical characteristics of the two regions may play some role. Higher precipitation at inland Dispilio would favour regeneration of the vegetation, while the gentle topography at Makri would be less vulnerable to erosion. In the pollen record, high-altitude sites in rough terrain show signs of degradation earlier than lowland sites (Willis 1995).

Secondly, anthropogenic factors should be considered: the nature of subsistence strategies and techniques and the ways in which natural vegetal resources were exploited. The stability of vegetation cover may indicate balanced exploitation of the natural vegetation. Some kind of forest management may have been practised, which did not result in clearance or deforestation but rather maintained the natural equilibrium; it seems that agriculture and animal husbandry caused little modification. To what extent this is true, and whether it reflects stable farming and grazing methods or repeated use of the same pieces of land and thus did not affect forest cover, is a matter for investigation in each individual case and by the relevant disciplines. Techniques of land use are another important factor and it is has been argued that, only during the Bronze Age, did innovations in this area become a serious agent of landscape change (Sherratt 1981).

Clearly, there is an extensive pollen record for Greece but charcoal data from archaeological sites are very restricted. As palaeoenvironmental studies on prehistoric sites become the norm, it would be worthwhile to conduct charcoal analysis more widely, as it is complementary to palynology and has the advantage of reflecting local environments directly related to human activities. Questions of vegetation change, degradation and human impact would be illuminated by systematic charcoal analysis at sites over a broader temporal and geographical range.

Conclusions

1. Charcoal analysis at two Neolithic sites in northern Greece offers a picture of local vegetation at the time of occupation of the sites. Deciduous oak formations are predominant at both, but secondary formations reflect the altitudinal, geographical and, consequently, climatic differences between the two sites.
2. The results of on-site charcoal analysis are complementary to the broader off-site pollen record for the Holocene in northern Greece.
3. The evidence of pollen and charcoal points to minimal human influence on vegetation during the Late Neolithic.
4. The unchanging nature of the vegetation throughout the sequence at both sites may reflect:
   - sustainable methods of forest management;
   - practices and techniques of farming and grazing that would not cause large-scale disturbance of vegetation cover;
   - the duration and intensity of occupation (issues requiring further investigation).
5. It is necessary to broaden the charcoal record with results from other sites in the same and other regions, and in earlier and later periods, in order to achieve a more precise understanding of local vegetation and of the impact on this of human activities.

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4

Holocene Climate Change in Crete: An Archaeologist's View

Jennifer Moody

Major variations in climate such as the waxing and waning of glacial epochs have long been recognized as having had a profound influence on the organization of human societies (Sherratt 1997), but lesser fluctuations, such as the 'Medieval Little Ice Age', have received little attention from Mediterranean archaeologists until recently. During the last ten years increasingly refined climate proxy data have become available (such as the GIPS2 core), demonstrating that the Holocene climate, as we know it today, is not typical of the last 10,000 years. In fact there have been at least five substantial 'blips' in this interstadial's journey to the present-day climate. One such anomaly, occurring c. 2200 BC, has recently received much attention in the Near East and Egypt (Dalfes *et al.* 1997).

In the Aegean, however, the views of van Andel *et al.* (1986) and Zangger (1994), who interpret most geomorphological events occurring since the beginning of farming (c. 7000 BC) as anthropogenic, continue to prevail. Although not perhaps as marginal for agriculture as the Near East, parts of the Aegean, where near desert conditions occur naturally, can be considered precarious for the prehistoric farmer. Such environments prevail in the south and east, especially on the lee side of mountains where strong rain-shadow effects come into play. Today, winter rains come to Crete from the north-west, creating strong rain shadows to the south and east of the island's 1500–2500 m mountain backbone. These areas are the most vulnerable to drought. Similarly, the north-west of the island is more vulnerable to killing frosts and snow damage if colder temperatures were to become a concern. In 1991–92, as part of the EC project 'Crete and the Aegean Islands: Effects of Changing Climate on the Environment',[1] Dick and Jean Grove, Oliver Rackham and the author observed substantial frost damage and limb breakage to olives in the White Mountains of western Crete as low down as 500 m. This weather event depressed olive production in the hard-hit parts of west Crete for about four years and prompted the replacement of many ancient olive trees with younger and more 'fashionable' stock. Similarly, in 1999 a withering series of sirrocos blasted Crete from the south-west in early May, shrivelling olive flowers and effectively wiping out the olive crop for the year in the hard-hit areas. Such scenarios are part of the wild annual variation that is characteristic of Crete today, and modern farmers are well adapted to it. But what if the winter rains did not come for several years in a row? What if spring and autumn sirrocos increased in severity and frequency? What if low-lying frosts and snow increased in frequency?

Would the farming system in place today be able to cope?

The Medieval Little Ice Age

Although these questions may seem far-fetched at the beginning of the twenty-first century AD, such weather seems to have been the norm in Crete during the sixteenth, seventeenth and eighteenth centuries AD, according to the archival studies of Grove and Conterio (1994; 1995). Numerous letters from the Dukes of Crete to the authorities in Venice describe devastating weather anomalies which destroyed crops over and over again. For example, in January 1595 'the continuous rain and snow, going on for 3 months...have been excessive, and so the low parts of the country have suffered from frost' (quoted in Grove and Conterio 1995: 239). Or, as Corner wrote on 2 February 1645:

> The need for building material is now greatly increased due to the conspicuous damage to and collapse of buildings which took place in every piazza, following the extraordinary violence of the rain and wind...at Suda, Gravusse, and Spinalonga... all the buildings are greatly damaged. At Gerapetra and in other places many dwellings were damaged and in the fields the sowing lost, the trees uprooted, and the animals swept away (quoted in Grove and Conterio 1995: 242).

Grove and Conterio (1994; 1995: 224) convincingly compile evidence for increased 'winter and spring drought, exceptionally severe winters, and summer rain' from 1548 to 1715 (see Grove and Conterio 1995: figs. 8, 10). These centuries correspond to the middle and latter part of the Medieval Little Ice Age (LIA) in Europe, an increasingly well-documented global climate event (Grove 1997). It seems likely that the anomalous weather in Crete was the result of perturbations in the prevailing westerlies—which normally bring winter rains to the Eastern Mediterranean—due to the developing Little Ice Age climate in Europe. It is probable that this less predictable climate regime began as early as the late thirteenth century AD in Crete, with the global onset of the Medieval Little Ice Age.

In addition to the archival data compiled by Grove and Conterio for significant impact of the Medieval Little Ice Age on Crete, there is a list of perennial rivers dating to 1625 AD (Rackham and Moody 1996: 44, n. 13). This list includes 25 rivers, some 18 more than reach the sea today (see Rackham and Moody 1996: 40, fig. 4.3). Although it is possible that the reduction in year-round rivers is a result of over irrigation, it seems more likely to be related to increased evaporation due to the shift from Medieval Little Ice Age to the modern climate.

Climate proxy data also help round out our picture of medieval climate in Crete. At the moment, such data consist of a pollen core, a handful of geomorphologic studies, and personal field observations.

The Asi Gonia B Core

This core (see Atherden and Hall 1999: 188, fig. 3) dates from c. 1100–1985 AD, and should reflect the transitions from the 'Medieval Warm Period' to the 'Medieval Little Ice Age' to the present-day climate. Atherden and Hall attribute most of the pollen changes visible in the core to anthropogenic factors. Although I do not disagree with their views for the most part, there are a few changes which seem to correspond to the climate regime described by Grove and Conterio.

For example the marked increase in *Arbutus* (probably *Arbutus unedo*) and *Hedera* (ivy), both considered moisture-loving plants in

Crete today, suggests decreased evaporation or increased precipitation, which would be consistent with the climate regime described by Grove and Conterio. Most telling, however, is the olive pollen profile. Olive pollen is relatively abundant at the bottom and top of the Asi Gonia B core, but between 170 and 30 cm it is present in only trace amounts—except at 55 cm where it resurges and then disappears again. Olive is a frost-intolerant tree. As noted above, a single year with low-lying frost can devastate the olive crop. Imagine what a series of frost years could do. Frosts alternating with spring sirrocos would be equally damaging—and possibly more likely—given the Grove and Conterio reconstruction. The slight peak in olive pollen in the early eighteenth century may have been associated with a series of more favourable years, suggesting that whatever weather was depressing olive flowering, it was not severe enough to actually kill the trees. This is an important point, since by 1730 Crete was exporting 1600 tons of oil a year to Marseilles (Triandafyllidou-Baladie 1988).

Buried Chapels[2]

Over the years, it has become apparent that numerous Venetian and some Byzantine chapels on Crete are buried by sediments, some a metre or more in depth. In many cases 200- to 400-year old trees (usually olives or carobs) are growing on the surface of the deposits burying the chapels. This allows us to determine the timing of the depositional sequence within a century or two, squeezed in between the construction of the chapel and the germination of the tree.

Figure 4.1 shows the chapel of Aghios Nikitas in the Frangokastello Plain, south-west Crete, buried by about 50 cm of a greyish coarse material containing Greco-Roman and Byzantine sherds. The sediment is capped by a carob about 1 m in diameter. Exposed annual rings suggest an average growth rate of about 2 mm per year, resulting in a tree age of c. 250 years. This indicates that the grey deposit has to have been laid down between the construction of the chapel in the fifteenth century AD and the germination of the carob tree c. 1750 AD, that is, the middle of the Medieval Little Ice Age.

Figure 4.2 shows a similar, roughly contemporary event, but in an entirely different topography. The chapel of Sotiris o Christos (1358 AD) is in the valley of the Aghia Irini River about 1.5 km west of the entrance to the

Figure 4.1 **The chapel of Aghios Nikitas, Frangokastello plain, south-west Crete: the foundations are buried by a deposit containing Greco-Roman and Byzantine sherds.**

Figure 4.2 **The chapel of Sotiris o Christos, south-west Crete: olive trees, c. 275–300 years old, seal the deposit which has buried the foundations of the chapel.**

Aghia Irini Gorge in Selinou, south-west Crete. It is buried by about 80 cm of sediment. Again, this sediment is capped by olive trees ranging in diameter from 1.1 to 1.2 m. Exposed annual rings suggest a maximum growth rate of 2 mm per year, resulting in a tree age of 275–300 years. This places the alluviation event between the construction of the chapel in the fourteenth century AD and the germination of the trees, around 1700 to 1775 AD.

These are not isolated events. Buried Venetian chapels can be found in the mountains and plains, in the west, east, north and south of the island.

Flash-Floods and Debris Flows

A horizon of flood events and debris flows also seems to be contemporary with the Medieval Little Ice Age in Crete (Fig. 4.3). For example, in 1988 a horizon of medieval pottery—including a sgraffito ware sherd dating to the fifteenth–sixteenth century AD[3]—was found in a bulldozed channel in the Istron river floodplain. It is buried by 1.7 m of very coarse channel deposits and capped by an olive c. 400–500 years old (Fig. 4.4). Sandwiched between the tree and the sherds, the flood deposits must date from 1400–1600 AD.

At Stomion in western Crete, the current river channel is filled with coarse gravel and cobble deposits about 3 m in depth, now retrenched. Near the base of these deposits is a horizon of Roman to Byzantine sherds (Fig. 4.5), indicating that at least 2 m of the deposit has accumulated since the Byzantine epoch (c. 800–1200 AD). Upstream from the locale with the sherds, this flood sequence is overgrown with pine trees. The oldest trees were cored and found to be c. 100–150 years old, dating this striking series of floods to between 1200 and 1850 AD.

A recent study in the Omalos Plain (1150 m) indicates that the intensification of flood events in Crete during the Medieval Little Ice Age was not confined to coastal plains and river systems. The south side of the Omalos Plain is dominated by a huge alluvial fan which probably originated in the Middle Pleistocene (Hempel 1991: 57-60). In recent times it has been retrenched and heavily

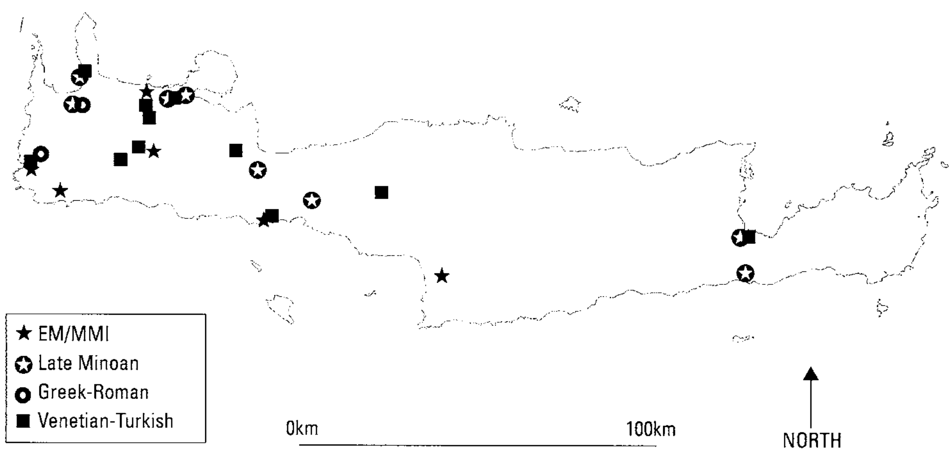

Figure 4.3 **Map showing flash-flood and mudflow deposits. The majority of events seems to date to the Middle and Late Bronze Age or to the Venetian and Turkish periods, both periods of global glacial advance. The concentration of flood and flow events in the west is probably the result of uneven fieldwork.**

Figure 4.4 Section in Istron river floodplain: coarse channel deposits overlie a fifteenth–sixteenth century AD sgraffito ware sherd (indicated by the author).

Figure 4.5 Section at Stomion, western Crete: the coarse deposits overlie a horizon (indicated by arrows) with Roman to Byzantine sherds.

Figure 4.6 The Omalos fan: two pollarded pear trees (centre of photograph) overlie debris from eighteenth–nineteenth century AD flood events.

reworked (Maas *et al.* 1998: 160, fig. 12.4). Radiocarbon dates the recent series of flash floods to the seventeenth and eighteenth century AD. Two pollarded pear trees survive on an island in the middle of the retrenched channel. They have diameters of 80 cm and an average growth rate of 2 mm, indicating that they are about 200 years old (Fig. 4.6). This indicates that the Omalos flood events took place between the eighteenth and nineteenth century AD, or in the latter part of the Medieval Little Ice Age.

Summary

The evidence clearly indicates that the Medieval Little Ice Age impacted on the Cretan landscape by burying earlier surfaces with debris flow and flash-flood deposits. The economic effects of these events is amply illustrated in the archival work of Grove and Conterio: loss of crops, soil, animals; damage to buildings; inability to pay taxes. The severe droughts which also plagued Crete during the Medieval Little Ice Age are harder to demonstrate geomorphologically and the pollen data are not sensitive enough to pick them up, but perhaps with new, developing technologies we will be able to document this aspect of the Medieval LIA climate in Crete in the future.

A Minoan Little Ice Age?

An intriguing result of the study of medieval flood deposits has been the discovery of an earlier flood and debris flow horizon. This horizon largely dates between the early Middle Bronze Age and the Late Bronze III period, and can be found from one end of the island to the other (see Fig. 4.3). For example, while working on the EC project 'Threatened Mediterranean Landscapes: West Crete',[4] channel deposits exposed in a road cut immediately south of the National Highway and the village of Nerokourou in the Khania Plain were noted but no datable pottery was found (Fig. 4.7). Subsequent examination of the scarp found Middle to Late Minoan I sherds mixed in with the gravels and cobbles. The top of the cobble deposit is 60–80 cm below the surface. Similar deposits containing Minoan sherds can also be seen in recent road cuts north of Mournies and north and south of the National Highway. Roman to Turkish period sherds litter the surface above both these deposits, indicating that the flood events have to have occurred between the LMI and Roman periods. The absence of any non-Minoan pottery in the channel deposits suggests, however, that these were Bronze Age events.

In the Frangokastello Plain, on the south coast of Crete, a debris flow deposit containing MMIII/LMI pottery was discovered during the Sphakia Survey[5] (Fig. 4.8). This deposit is capped by the same grey, coarse sediments that buried the chapel of Aghios Nikitas discussed above (Fig. 4.9). The sedimentary details of this section are described by Nemec and Postma (1993: fig. 8).

South-west of the village of Angouseliana (in west-central southern Crete), an LMIII pithos buried by a flood event was found by the Aghios Vasilios Valley Survey[6] (Fig. 4.10). The section is presently located about 15 m above the modern river channel at the west end of a soccer field. The Late Minoan flood horizon contains only Bronze Age sherds and is capped by another flood deposit containing Late Roman and Byzantine sherds. The Byzantine horizon is in turn capped by a sixteenth–seventeenth century AD chapel, which is not buried. The absence of Greek or Roman pottery in the deposit burying the LMIII pithos, in spite of nearby sites, suggests that this event took place near the end of the Late Bronze Age.

Figure 4.7 Section at Nerokourou, showing coarse channel deposits which contain MM-LMI sherds.

Figure 4.8 Debris flow with possible Minoan wall: the pen points to an LMI cooking pot base.

Figure 4.9 Section in Frangokastello plain, showing coarse sediments which overlie a debris flow with MMIII-LMI pottery (see Fig. 4.8) and are capped by the chapel of Aghios Nikitas. The chapel is indicated in the background.

Figure 4.10 **Section near Angouseliana, west-central southern Crete, showing two flood deposits. The older flood deposit contains Minoan sherds and buries an LMIII pithos (indicated by arrow). The younger flood deposit contains mostly Late Roman and Byzantine pottery and is capped by the sixteenth–seventeenth century AD chapel of Aghios Giorgos.**

Discussion

Flashfloods are an integral part of the Mediterranean environment and on their own are not remarkable. The Pachyammos deluge of 1986 (Rackham and Moody 1996: 20-22; Moody 1997), where nearly a year's rainfall fell in 36 hours, is rare but not unusual in the modern Cretan climate. What is striking is the dearth of these kinds of deposits for the Neolithic to Early Minoan, and Early Iron Age to Byzantine periods, especially when compared to their frequency in the Middle to Late Minoan and Venetian to Turkish periods. So far only two flood deposits dating to the Archaic-Hellenistic periods have been identified: at Nopigia, in north-west Crete, and Vathi, in south-west Crete.

Why do the Minoan and Venetian flood deposits survive? I suggest that the magnitude of the Minoan and Venetian events wiped out the preceding flood deposits. The fact that so many Minoan deposits survived the Venetian events suggests that they were initially even more extensive and bigger in scale than those associated with the Medieval Little Ice Age. The implication is that the Minoan climate was not only substantially different from today's, but also from that of the Medieval Little Ice Age.

Other Cretan climate proxy data, which might clarify the situation, are not forthcoming. The pollen data from Crete for the Middle to Late Minoan period are confined to the Tersana core (Moody *et al.* 1996). Increases in deciduous trees and a decline in olive at the top of the pollen preserving spectra are remarkably similar to the changes noted in the Asi Gonia core for the Medieval Little Ice Age, though on a larger scale.

Meagre as they are, when combined, the flood and pollen data from Crete suggest that the Middle and Late Minoan periods may have coincided with another Little Ice Age event. Is there any other independent evidence for such an event? In fact there is a near global horizon of glacial advance between 3600 and 3000 bp, which calibrates to c. 2000–1250 BC, that is, MMI-LMIII (Table 4.1). Furthermore, there may have been five or six such episodes during the last 10,000 years.

How would the proposed Little Ice Age event have affected Minoan weather and subsistence? Tempting as it is to transpose the manifestations of the Medieval LIA (severe winters, drought, summer rain and floods) onto the Minoan LIA, such correlations would be simplistic, especially since the Minoan LIA will have been imposed on a climate regime (that existing during the EMI-II period) quite different from that on which the Medieval Little Ice Age was imposed (the so-called 'Medieval Warm Period'). Nevertheless, it seems clear that the rhythm of agricultural life which formed the basis of Minoan civilization would have been disrupted by periodic debris flows and floods that far exceeded those of the Medieval Little Ice Age in scale—let alone those that we experience today. The construc-

Table 4.1. Episodes of significant Holocene glacial advances in Europe compared with cultural periods in Crete (after Grove 1998).

Date bp	Date BC/AD*	Cultural phase	Comment
	1250–1850 AD	Venetian and Turkish occupation	600 years. Medieval Little Ice Age. Advances in Swiss Alps, Caucasus, Rockies, Andes up to 2.5 km beyond modern front. Especially intense around 1350, 1600–50, 1770–80, 1815–20, and 1850–60.
	800–900 AD	Early to Middle Byzantine	100 years, 3.3 generations. Advances in Alps.
3000–3600	2000–1250 BC	EMIII/MMI to LMIIIB	750 years, 23 generations. Loebben Advance in Alps, advances greater than Medieval Little Ice Age.
4200	2800 BC	EMI/II?	100 years?, 3.3 generations.
4600	3450 BC	FN/EMI?	100 years?, 3.3 generations.
6000–6600	5515–4871 BC	Late Neolithic	644 years, 21.5 generations. Less intense.
7300–7700	6495–6097 BC	Early Neolithic at Knossos	398 years, 13 generations.
8100–8400	7450–6950 BC	Pre-pottery Neolithic	500 years, 16.5 generations.
9000–9400	8550–8029 BC	Mesolithic	521 years, 17 generations. Schlaten Advance in Alps, advances on same scale as Medieval Little Ice Age

* calibrated by OxCal 14L.

tion of Minoan dams, such as the one at Pseira, make more sense within this sort of climate reconstruction.

Such environmental unpredictability is likely to have spawned a new approach to subsistence, as well as a serious revamping of belief systems and ritual in an effort to control the perceived chaos. The enormous food stores that evolve at this time within the 'palaces' and then the 'villas' may witness the importance of banking against crop failure due to erratic weather patterns. The well-documented proliferation of ritual sites—public and private; peak top, palace and town—may witness the desire to control/appease/supplicate the unpredictable powers that be. No doubt other variables came into play in the evolution of Minoan civilization, but the importance of a climate change at both the beginning and the end of the so-called palace period in Crete and the southern Aegean and its ramifications deserves further consideration.

Conclusion

Environmental data for Middle and Late Bronze Age Crete consistently argue for a different climate from today's. Evidence that the Minoan palaces may have evolved, flowered and declined during a Little Ice Age that was even more intense than the Medieval Little Ice Age is beginning to accumulate. Exactly how this climate shift affected Crete needs to be more thoroughly investigated. In addition to continued fieldwork, a fruitful area of research would be computer modelling of Minoan LIA weather by combining our understanding of the baseline Early Minoan environment with the parameters and magnitude of change which accompany the development of a Little Ice Age, based on the Medieval LIA data now assembled.

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Notes

1. This project was funded by the EC and directed by A.T. Grove (Cambridge) and N. Margaris (University of the Aegean).
2. This phenomenon was first brought to my attention by Oliver Rackham, to whom I am greatly indebted.
3. This scarp was examined by the author, George Postma and Oliver Rackham while working on the Vrokastro Survey Project directed by Moody and Hayden in 1988 (Hayden *et al.* 1992). Sherd date is courtesy of Margrete Hahn.
4. This project was funded by the EC and directed by A.T. Grove (Cambridge) and V. Papanastasis (University of Thessaloniki).
5. The Sphakia Survey is directed by Moody and Nixon under the auspices of the Canadian Institute and the Greek Archaeological Service (Nixon *et al.* 1990).
6. This discovery was made while running test transects for the Aghios Vasilios Valley Survey under the general direction of Alan Peatfield and Stavroula Markoulaki and field direction of Jennifer Moody (Moody *et al.* 2001).

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5

Human Impact on the Vegetation of Southern Greece and Problems of Palynological Interpretation: A Case Study from Crete

Margaret Atherden

Introduction

The traveller in southern Greece and the Greek islands is presented today with a mosaic of vegetation types, ranging from woodland to steppe and cultivated land. Although it is sometimes assumed that the 'natural' vegetation of southern Greece would be evergreen woodland, dominated by *Quercus ilex*, there is little evidence in the present landscape to support this theory. Another common assumption is that the present vegetation cover represents the result of centuries or millennia of degradation and soil erosion—a theory termed the 'ruined landscape' theory by Rackham and Moody (1996). However, modern vegetation communities appear to be relatively resistant to change and well adapted to variations in moisture availability and soil type. The impacts of grazing, burning and wood cutting have combined with the environmental factors to produce a complex and fascinating array of plant communities.

At one end of the spectrum there are surviving examples of mature woodland. These include woods dominated by *Abies cephalonica*, *Pinus brutia* and (on Crete) *Cupressus sempervirens* in the mountains; *Pinus halepensis* around many of the coasts; and a wide variety of deciduous trees at low and middle altitudes. Rackham (1982) recognizes about 12 types of woodland in southern Greece today and believes that there would have been more types in the past when deciduous trees were more widespread. Scrub and maquis (on acid soils) are dominated by shrub species which are capable of growing up to form real woodland in the absence of grazing/browsing or other pressures. They are dominated by species such as *Quercus coccifera*, *Pistacia lentiscus*, *Arbutus unedo* and *Erica arborea* and vary greatly in height and growth form. Other communities are described as garigue or phrygana, the former dominated by woody undershrubs and the latter by aromatic herbs, although there is much overlap in species between the two. Grassland areas are found in the mountains or as patches of steppe between other vegetation types. Grasses are not necessarily dominant and a wide range of herbs and bulbs may be found growing among them. There is also overlap in species between steppe/grassland and cultivated land—a problem exacerbated for palynologists by the fact that the pollen of many taxa is only recognizable to family level (e.g. Apiaceae, Brassicaceae). Wetland communities are generally confined to permanent watercourses and coastal sites, although occasional surprises occur, including the peat bog near Asi Gonia which forms the case study below.

The impact of grazing/browsing in the Mediterranean region goes back at least two million years (Naveh 1990) and includes the effects of Pleistocene herbivores, for example the dwarf hippo and dwarf deer found as fossils on the island of Crete (Rackham and Moody 1996). In the Holocene period, much of this grazing has been by domesticated stock, although the continuing effects of wild animals should not be discounted. The main domesticated grazing animals are sheep and goats, which are almost ubiquitous in upland areas, but cattle, mules and donkeys also play a role. Most grazing by sheep and goats is organized by a system of shepherding, which enables the animals to take advantage of extensive areas of grazing land without overgrazing specific areas. Although grazing is most often associated with herbaceous or dwarf shrub communities today, browsing within woodlands is also practised in some areas and may have been more widespread in the past, affecting both the lower branches of the trees and the undergrowth. In some upland areas of southern Greece, a form of transhumance is practised, whereby men and boys spend the summer living in summer villages (e.g. Asfendos on Crete), from which their flocks and herds graze the better-watered pastureland at higher altitudes. Lewthwaite (1981) argues that this is an inherently unstable system of land management, introduced as a tactical adaptation in mediaeval and early modern times, but it seems to be an enduring feature of the landscape in many areas. In Crete, archaeological and palynological evidence (see below) suggests that the system probably dates from about 1000 AD.

Grazing is often accompanied by burning, designed to remove unpalatable woody tissue and stimulate a fresh growth of herbaceous material. Naveh (1990) suggests that deliberate burning has been practised since late Upper Palaeolithic times in the Middle East. Plant beneficiaries include grasses, legumes, bulbs and tuberous plants, but most of all burning gives a competitive advantage to woody shrubs, many of which sprout quickly after a fire from buds near the base of the stem. Pine trees also benefit through preferential regeneration from seed after a fire. Mediterranean species, such as *Pinus halepensis*, are fire adapted, in common with most other members of the genus. Today, 'occupational' and accidental burning are common in southern Greece, affecting perhaps 2% of the landscape each year (Rackham 1983). Documentary sources record the practice from at least the seventeenth century onwards. For example, Randolph recorded annual burning of grass and 'bryers' in Arcadia to promote new pasture growth in the seventeenth century (Rackham 1986), and de Boblaye described the burning of forests by shepherds to provide pasturage for their flocks in about 1825 (Wright 1972).

Many of the deciduous tree species found in southern Greece are highly palatable but relatively slow-growing, and this fact has led to their retreat to inaccessible ledges and cliffs in areas where grazing pressure has been intense. They are also slow to respond after burning and take several years to reach the flowering stage. In Boeotia, for example, trees such as *Tilia*, *Ulmus* and *Ostrya* are today confined to habitats such as cliff faces on Mt Helicon, whereas pollen analysis suggests that they were formerly more widely distributed. Deciduous oaks seem to be less palatable than most other deciduous trees, which offers an explanation for their more frequent survival in woods today (Rackham 1982). Shrub species, on the other hand, often respond more quickly after grazing or burning and can produce flowers within a few months or even weeks of serious fires or periods of intense grazing. The typical maquis shrubs, such as *Pistacia lentiscus*, *Genista* spp. and the ubiquitous *Quercus coccifera*, are distinguished by their remarkable powers of regeneration after such pressures and are often the main beneficiaries of increased grazing or burning. Rackham (1982) attributes the present widespread distribution of *Quercus coccifera* to the effects of goat grazing, without which the species might occupy a more restricted range of both climate and soil. Garigue species, for example *Sarcopoterium spinosum*, *Lavandula* spp. and *Cistus* spp., also respond well to grazing but are less capable of rapid recovery after severe fires. Steppe species, especially Poaceae and *Asphodelus* spp., are extremely resistant to both grazing and burning, and often characterize areas of over-exploitation.

Wood cutting is another human impact which has affected southern Greek vegetation for many centuries. Its impact varies according to the species' ability to regrow from coppiced stumps; for instance, most of the deciduous trees/shrubs coppice easily, whereas pine does not. *Abies cephalonica* and *Cupressus sempervirens* both show some ability to regrow and are sometimes encountered today in a coppiced or pollarded form (Rackham 1983). On pollen diagrams it is often difficult to distinguish between the effects of wood cutting and those of grazing or burning, as all lead to a diminution in pollen production.

If these various forms of pressure are relaxed or abandoned, changes occur as the plant communities adjust to the new situation. Secondary woodland regenerates easily from maquis or scrub and, as it does so, impacts on the other plant communities. Garigue and phrygana seem to be largely dependent on grazing for their continuance and lose their competitive edge over steppe without it. Rackham (1982) suggests that a possible explanation may lie in the greater water demand from maquis shrubs as they mature, depriving the garigue/phrygana plants of their moisture supply. He envisages a landscape of woodland interspersed with steppe in the prolonged absence of grazing, burning or wood cutting in southern Greece.

Using this knowledge of the modern ecology, it is possible to make some predictions about the probable effects on the vegetation as reflected in the pollen diagrams when human impact increases or decreases. A sustained increase in grazing pressure should result initially in more vigorous growth of the understorey plants and later in the reduction of woodland to maquis/scrub and the spread of garigue/phrygana and steppe communities. The early stages might be expected to show an increase in arboreal pollen (AP), especially light-demanding taxa, but the later stages should show an increase in maquis shrubs (e.g. Ericaceae, *Arbutus*) and garigue/phrygana taxa (e.g. Cistaceae). Poaceae would also increase and are likely to be the most abundant pollen indicators of the steppe communities, as species such as *Asphodelus* are under-represented on pollen diagrams (Bottema 1980). A relaxation in grazing pressure should produce a gradual decrease in diversity, as garigue/phrygana give way to steppe and maquis shrubs grow up into woodland, shading out understorey species, such as ferns. The effects of burning as shown by pollen diagrams might be seen in increases for pyrophytic species such as *Arbutus*, Cistaceae, *Quercus coccifera*-type, but these will be impossible to differentiate from the effects of grazing. An increase in *Pinus* might offer most promise, especially as its pollen is well distributed. The effects of wood cutting are unlikely to be distinguishable from those of grazing/burning on the pollen diagrams.

The Palynological Record

Palynologists have long recognized certain non-arboreal (NAP) pollen types as indicators of human activity. Behre (1990) lists cultivated species as 'primary' anthropogenic indicators and several types of NAP as 'secondary' anthropogenic indicators, although some of them (e.g. *Artemisia*, Chenopodiaceae) can also indicate steppe conditions, not necessarily associated with human impact. It is usually easier to recognize indicators of cultivation than grazing, as the latter often involves changes in the distributions or abundance of native species whereas the former usually involves the introduction of non-native or domesticated species. However, the fact that many of the cultigens (e.g. the cereals) are native to the Mediterranean area blurs the distinction. The two groups are also closely associated in all but modern intensive horticulture, as cultivated fields in southern Greece commonly have fringing areas of grassland or are alternated with fallow. Indicators of grazing/browsing are particularly difficult to spot on pollen diagrams when the activity takes place in woodlands, as this may result in very little change in species composition. As noted by Bottema and Woldring (1990), the initial effects of 'clearance' in woodland environments may be to stimulate production of AP, as the lower branches of the trees receive more light and flower more profusely.

Despite these difficulties, Bottema and Woldring (1990) recognize several indicators of grazing/meadow management, including *Plantago lanceolata*-type, Poaceae, *Poterium*/*Sanguisorba minor*-type and *Rumex acetosa*-type. They distinguish other taxa as being associated with both burning and grazing, namely, *Quercus coccifera*, *Arbutus unedo*, *Buxus sempervirens*, *Pinus halepensis*, *P. brutia* and *Cistus* spp. A general assumption has been made that increased grazing or burning will lead to a decrease in arboreal or shrub pollen, and there has been a tendency to look for 'clearance phases' in the pollen record, as in northern Europe. Although it is acknowledged that some tree and shrub species do respond to increased light availability, decreases in arboreal and shrub pollen have normally been interpreted as indicating an increase in human impact on vegetation. A particular difficulty is encountered in the interpretation of pollen of the taller maquis shrubs, such as *Quercus coccifera* and *Arbutus unedo*, many of which fit uncomfortably within northern European conventions of arboreal pollen (AP) or shrub pollen (SP), owing to their ability to exist in a variety of growth forms. Nevertheless, the AP:NAP ratio has been used as a crude indicator of human impact and has also been linked with the concept of botanical diversity (Bottema 1982; Jahns 1993). Some of these interpretations may be challenged in the light both of observations made in the field in southern Greece and also comparison of the palynological and documentary/archaeological evidence for grazing activities.

Although several pollen diagrams have been published from southern Greece and the Greek islands, few of them consider the impact of grazing/browsing in any detail. Some pollen diagrams—for example, Kopais (Greig and Turner 1974; Allen 1990), Tersana (Moody *et al.* 1996)—are limited in their usefulness by the plotting of deciduous and evergreen oak pollen as a single curve. This makes it impossible to estimate how much of the *Quercus* pollen is from *Q. coccifera* and therefore possibly from a maquis rather than a woodland situation. However, even when divided into deciduous and evergreen types, the *Quercus* pollen curves always present a particular challenge of interpretation, as will be seen below. Several pollen diagrams show the development of *Pinus*-*Quercus* woodland in the early Holocene being replaced by a woodland dominated by *Quercus* species in the middle Holocene—for example, Malo Jezero (Jahns 1992), Xinias (Bottema 1979), Aghia Galini (Bottema 1980). However, there is evidence for non-woodland communities alongside the woodlands in nearly all the diagrams, suggesting that although the woodland cover was more extensive in the middle Holocene, it was not continuous. Certainly by Neolithic times, secondary woodland with a higher proportion of evergreen oaks is recorded at several sites, such as Thermisia (Sheehan 1979), Lake Lerna (Jahns 1993), Kleonai (Atherden *et al.* 1993). These diagrams also show an increase in the pollen of maquis shrubs following the first major agricultural phase of the Bronze Age, as do those from Kiladha (Bottema 1990) and Osmanaga lagoon (Wright 1972). Most writers show greater interest in indications of cultivation on the pollen diagrams than in signs of grazing, but the diagram from Lake Lerna (Jahns 1993) has good evidence for grazing and probably for burning as well from about 1000 AD onwards. In lowland areas, grazing activities are likely to have been closely associated with cultivation; for instance, livestock are often grazed under olive trees. This makes it difficult to distinguish the effects of arable and pastoral agriculture on the pollen diagrams. In upland areas, on the other hand, the impact of grazing is likely to have been more significant than that of cultivation, so it is from sites at higher altitude that the clearest evidence might be expected of the effects of grazing/browsing on the local vegetation.

A Case Study from the White Mountains of Crete

In order to explore some of these ideas further, a peat bog was studied from Asi Gonia in the White Mountains of central Crete (Atherden and Hall 1994, 1999; Grove *et al.* 1991). The site lies at an altitude of 780 m; it is a spring-fed bog at the head of one of the feeder streams of the River Koularas. It lies just above the present limit of cultivation for olives and other crops and, although there are some old terraces close to the site, it is likely that grazing has been the dominant land use in most periods. Today, the area is used for grazing flocks of sheep and goats, which are shepherded from the summer village of Kallikrati, less than 2 km away. The site therefore presents an opportunity to study human impact on the vegetation in an area where grazing is likely to have been the most significant influence over the last few millennia. An added advantage is that a major archaeological survey has been undertaken over the past few years in Sphakia, a few kilometres to the west, which provides a source of archaeological and documentary evidence to complement the palynological record (Nixon *et al.* 1988, 1989, 1990, 1994).

The area of peat measures approximately 190 m by 60 m and reaches a maximum depth of 4.7 m. The peat contains wood fragments towards the bottom and occasional mineral bands, but most of the sediment is organic, which has led to good preservation of pollen and spores. Such peat deposits are rare in southern Greece, adding to the interest of the site. However, tapping of the spring for irrigation purposes and sporadic burning of the bog surface have led to considerable drying out of the peat over the past decade, so its days may be numbered. Today the surface is mostly dry and dominated by bracken (*Pteridium aquilinum*) and rushes (*Juncus effusus*), with a few sedges (e.g. *Scirpoides holoschoenus*) and mosses (e.g. *Polytrichum commune*) in the damper spots. High percentages of Cyperaceae pollen and significant levels of *Sphagnum* spores in some layers of the peat suggest that the bog was considerably wetter in the past. A solitary clump of *Sphagnum auriculatum* grows near the site today (Turland and Wilson 1995).

The vegetation surrounding the site is a mosaic of *Erica-Arbutus* maquis, phrygana and steppe but there are also some mature trees of *Platanus orientalis* on the edge of the bog and trees of *Quercus ilex*, *Quercus pubescens* and *Castanea sativa* within a few hundred metres of the site. The changing balance of these plant communities (woodland, maquis, garigue/phrygana and steppe) as inferred from the pollen evidence should provide a proxy record of grazing pressure in the immediate area.

Two cores were taken from the site, one with a vibro-corer and one with a Hiller borer. The former (core AG-B) recovered only the top two metres of peat but the latter (AG-A) provides a full record from the site. Seven radiocarbon dates have been obtained, one of which (from near the base of the vibro-core AG-B) is almost certainly unreliable (Table 5.1). The other dates form a sequence ranging from 1510±100 bp to 85±50 bp, indicating that the peat accumulated since Early Byzantine times. Full details of the correlation of the two cores and the interpretation of the radiocarbon dates have been published elsewhere (Atherden and Hall 1999). Correlation between the pollen diagrams from the vibrocore and the top two metres of the Hiller core is close, so only the longer diagram (AG-A) will be presented here.

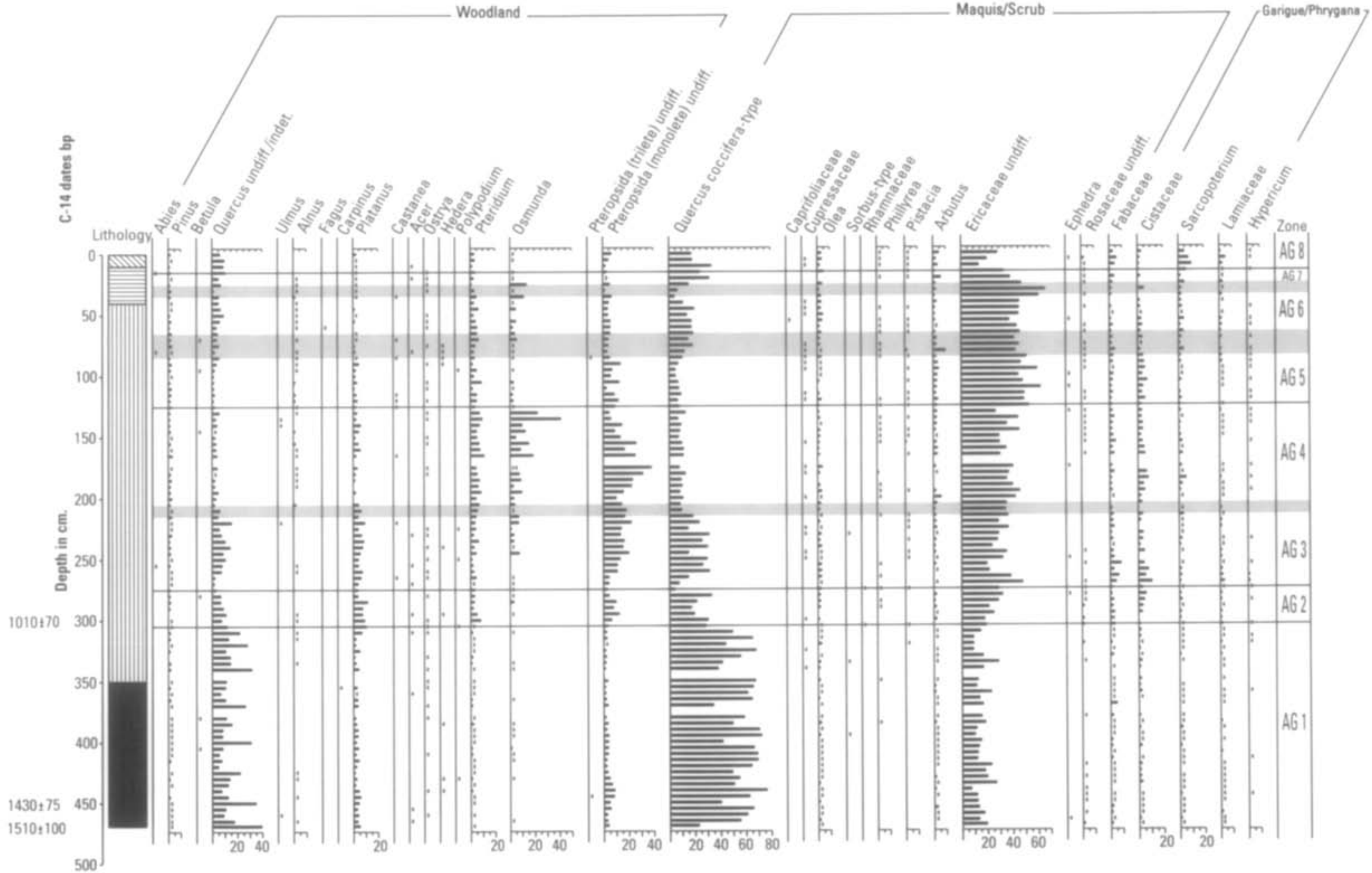
The use of incremental cluster analyses (CONISS) within the TILIA computer program enables an objective approach to be taken to the zoning of the pollen diagram (Grimm 1991). The technique also reveals which zone boundaries are most significant in terms of vegetation change. In zoning the two pollen diagrams from the site, four different methods of cluster analysis were applied and zone boundaries drawn at points which appeared as significant changes according to several methods. On all four methods, 305 cm marked the most significant change on the diagram. Similarly sharp transitions may be seen at 15 cm, 125 cm and 275 cm. More variation was found between the four methods in other parts of the cores, so gradual transitions have been used for the zone boundaries at 25–35 cm, 65–85 cm and 205–215 cm (Fig. 5.1).

Table 5.2 shows the pollen taxa recognized on the diagram and gives examples of the species they are likely to represent, based on knowledge of the present flora of Crete (Turland *et al.* 1993) and plants found growing in the area around the site today. Six broad vegetation groups are recognized, namely woodland, maquis/scrub, garigue/phrygana, steppe, cultivated/planted land and wetland. The pollen taxa are arranged in Figure 5.1 according to these groups. There is some overlap between groups where taxa such as evergreen oaks occur in several different plant communities or where families such as Lamiaceae or Fabaceae include species characteristic of different communities. Two pollen traps were set on the edge of the site to

Table 5.1. Radiocarbon dates from the two Asi Gonia cores.

Core	Depth of sample	C-14 date bp	Lab. ref. no.	Position in core
AG-B	13 cm	85±50	Q-2707	Base of AG-8
AG-B	72 cm	320±60	Q-2706	AG-5/6 boundary
AG-B	127 cm	700±70	Q-2705	Top of AG-4
AG-B*	191 cm	1220±75	Q-2704	Near base of AG-4
AG-A	300 cm	1010±70	AA-16472	AG-1/2 boundary
AG-A	459 cm	1430±75	Q-2709	Near base of AG-A core
AG-A	469 cm	1510±100	Q-2708	Base of AG-A core

* This date is considered to be unreliable.


Woodland
Maquis/Scrub
Garigue/Phrygana
C-14 dates bp
Lithology
Depth in cm.
Abies
Pinus
Betula
Quercus undiff./indet.
Ulmus
Alnus
Fagus
Carpinus
Platanus
Castanea
Acer
Ostrya
Hedera
Polypodium
Pteridium
Osmunda
Pteropsida (trilete) undiff.
Pteropsida (monolete) undiff.
Quercus coccifera-type
Caprifoliaceae
Cupressaceae
Olea
Sorbus-type
Rhamnaceae
Phillyrea
Pistacia
Arbutus
Ericaceae undiff.
Ephedra
Rosaceae undiff.
Fabaceae
Cistaceae
Sarcopoterium
Lamiaceae
Hypericum
Zone
AG 8
AG 7
AG 6
AG 5
AG 4
AG 3
AG 2
AG 1
1010±70
1430±75
1510±100
0
50
100
150
200
250
300
350
400
450
500
20 40
20
20
20 40
20 40
20 40 60 80
20 40 60
20
20

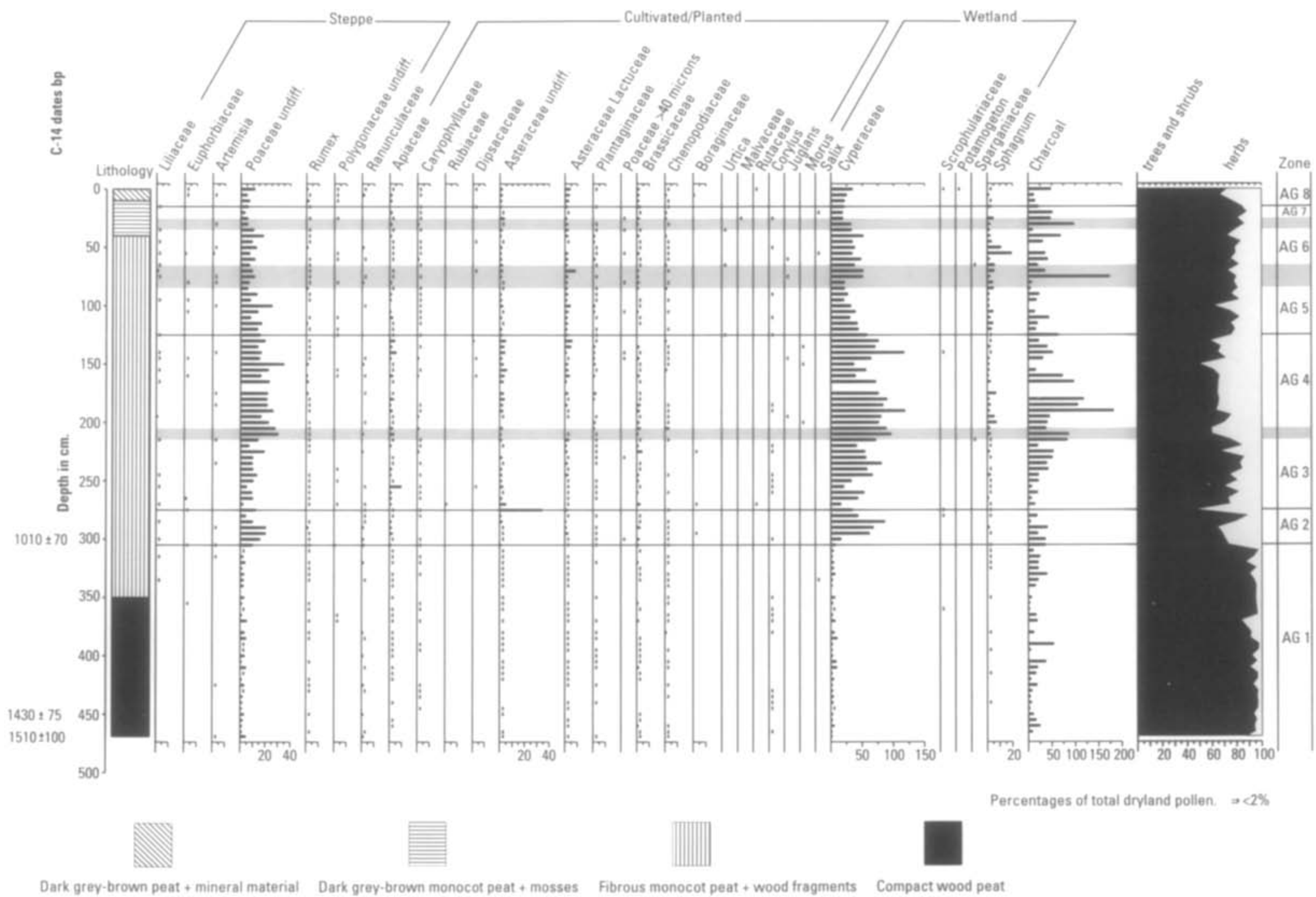


Figure 5.1 Pollen diagram AG-A from Asi Gonia. Figures are percentages of total dryland pollen. Charcoal fragments are also expressed as percentages of total dryland pollen. Radiocarbon dates refer to this core only (see text).

Table 5.2. Ecological interpretation of pollen types

Pollen/spores	Probable species	Habitat type	Provenance
Abies	Abies cephalonica	Woodland	Mainland
Pinus	Pinus brutia	Woodland	Regional
Cupressaceae	Juniperus oxycedrus	Maquis/Scrub	Regional
	Cupressus sempervirens	Woodland/Planted	Regional
Betula	Betula pendula	Woodland	Mainland
Quercus coccifera-type	Quercus coccifera	Woodland/Scrub	Local
	Quercus ilex	Woodland	Local
Quercus undiff./indet.	Quercus pubescens	Woodland	Regional
Ulmus	Ulmus minor	Woodland	Regional
	Zelkova abelicea	Woodland/Scrub	Regional
Alnus	Alnus glutinosa	Woodland/Wetland	Mainland
Fagus	Fagus sylvatica	Woodland	Mainland
Carpinus	Carpinus betulus	Woodland	Mainland
	Carpinus orientalis	Woodland/Scrub	Mainland
Platanus	Platanus orientalis	Woodland/Planted	Local
Castanea	Castanea sativa	Woodland/Planted	Local
Juglans	Juglans regia	Planted	Regional
Ostrya	Ostrya carpinifolia	Woodland	Mainland
Acer	Acer sempervirens	Woodland	Local
Morus	Morus alba	Planted	Regional
Olea	Olea europaea	Planted/Maquis	Regional
Rutaceae	Ruta chalepensis	Steppe	Regional
	Citrus fruits	Planted	Regional
Salix	Salix alba	Wetland	Regional
Corylus	Corylus avellana	Planted	Regional
Sorbus-type	Sorbus aria	Scrub/Maquis	Regional
	Sorbus umbellata	Scrub/Maquis	Regional
	Crataegus monogyna ssp. azarella	Woodland/Scrub	Local
Hedera	Hedera helix	Woodland	Local
Rhamnaceae	Rhamnus lycioides	Scrub/Maquis	Local
Phillyrea	Phillyrea latifolia	Woodland/Maquis	Regional
Pistacia	Pistacia lentiscus	Maquis/Phrygana	Regional
	Pistacia terebinthus	Woodland/Maquis	Regional
Arbutus	Arbutus unedo	Maquis/Woodland	Regional
	Arbutus andrachne	Maquis/Woodland	Regional
Ericaceae	Erica manipuliflora	Maquis	Local
	Erica arborea	Maquis	Regional
Cistaceae	Cistus salvifolius	Maquis/Garigue	Local
	Other Cistus spp., Fumana spp., Helianthemum spp.	Maquis/Garigue	Regional
Sarcopoterium	Sarcopoterium spinosum	Garigue/Phrygana	Local
Ephedra	Ephedra campylopoda	Maquis/Scrub	Regional
Caprifoliaceae	Sambucus ebulus	Scrub	Regional
	Lonicera etrusca	Woodland/Scrub	Regional
Poaceae undiff.	e.g. Anthoxanthum sp., Briza minor,	Steppe	Local
	Aira elegantissima	Steppe	Local
Poaceae >40 microns	Cereals, e.g. barley	Cultivated land	Regional
Cyperaceae	e.g. Scirpoides holoschoenus	Wetland	Local
Rumex	e.g. Rumex bucephalophorus	Steppe	Regional
Polygonaceae undiff.	e.g. Polygonum aviculare	Steppe	Regional
Fabaceae	e.g. Genista acanthoclada, Lotus spp., Trifolium spp.	Maquis/Phrygana/ Steppe	Local
Apiaceae	e.g. Daucus carota, Eryngium campestre	Steppe/Cultivated land	Regional
Artemisia	Artemisia arborescens	Phrygana	Regional

Table 5.2 continued

Pollen/spores	Probable species	Habitat type	Provenance
Asteraceae undiff.	e.g. Carduus spp., Carlina spp., Pulicaria dysenterica	Cultivated land/Steppe/ Wetland	Regional/Local
Asteraceae Lactuceae	e.g. Crepis vesicaria	Steppe/Cultivated land	Regional
Plantaginaceae	e.g. Plantago afra	Steppe/Cultivated land	Regional
Lamiaceae	e.g. Teucrium spp., Phlomis fruticosa, Coridothymus capitatus	Phrygana	Local/Regional
Rosaceae undiff.	e.g. Pyrus amygdaliformis	Maquis/Scrub	Regional
Brassicaceae	e.g. Biscutella didyma	Cultivated land	Regional
Caryophyllaceae	e.g. Arenaria cretica, Bufonia stricta, Silene spp.	Steppe	Regional
Chenopodiaceae	e.g. Chenopodium album	Cultivated land	Regional
Ranunculaceae	Ranunculus ficaria	Wetland	Local
	Anemone coronaria	Steppe	Regional
Boraginaceae	e.g. Echium italicum	Cultivated land	Regional
Scrophulariaceae	e.g. Sibthorpia europaea	Wetland	Local
Urtica	Urtica pilulifera	Cultivated land	Regional
Rubiaceae	e.g. Asperula spp., Galium spp.	Cultivated land/Steppe	Regional
Dipsacaceae	e.g. Knautia integrifolia	Cultivated land/Steppe	Regional
Euphorbiaceae	e.g. Euphorbia characias	Steppe	Regional
Malvaceae	e.g. Lavatera bryoniifolia	Cultivated land	Regional
Hypericum	e.g. Hypericum empetrifolium	Maquis/Phrygana	Regional
Liliaceae	Asphodelus aestivus	Phrygana/Steppe	Regional
Potamogeton	e.g. Potamogeton pectinatus	Wetland	Regional
Sparganium-type	Sparganium erectum	Wetland	Regional
Polypodium	Polypodium cambricum	Woodland/Scrub	Regional
Pteridium	Pteridium aquilinum	Woodland/Scrub	Local
Osmunda	Osmunda regalis	Woodland	Regional
Pteropsida	e.g. Blechnum spicant, Athyrium filix-femina	Woodland	Local
Sphagnum	Sphagnum auriculatum	Wetland	Local

record the present day pollen rain and a moss polster growing close to the coring site in the middle of the bog was also analysed. Comparison of the present flora around the site with the results from the pollen traps and moss polster helps with interpretation of the pollen diagrams.

The woodland group includes trees such as *Pinus*, *Quercus* (evergreen and deciduous), *Alnus*, *Platanus* and *Ostrya* as well as *Hedera* and various ferns. *Pinus* is not found close to the site and never forms a substantial curve on this pollen diagram. Most of the deciduous trees are highly palatable to livestock and therefore confined to woodlands or inaccessible cliff faces. Their pollen records may be taken as indicating woodland conditions in this context. The only genera with significant pollen records are *Alnus* and *Platanus*, both of which were probably associated with wet sites, possibly growing around the site itself. In the pollen traps, woodland trees excluding evergreen oaks constituted 26.4% and 14.5% of the total pollen; in the moss polster the figure was slightly higher at 31.4%, suggesting a greater regional component to the pollen rain in the centre of the site. Records for *Olea* pollen could derive from wild olive growing in maquis vegetation or from cultivated olive groves. The amounts of *Olea* pollen are never very high on this pollen diagram and it is unlikely that olives were grown close to the site. In the pollen traps, *Olea* pollen contributed 12.0% and 6.0% and it contributed 4.0% in the moss polster. These records confirm that *Olea* pollen is well distributed today and that low amounts on the pollen diagram do not signify olive cultivation close to the site.

Evergreen oak pollen presents a particular challenge to interpretation, as it includes pollen of *Quercus ilex* and *Q. coccifera*. The former is palatable to grazing animals and is normally found in woodlands, whereas the latter is more resistant to grazing pressure and varies in growth form from a shrub a few centimetres high to a mature tree, sometimes growing in scrub/maquis or garigue/phrygana and sometimes forming part of a woodland community. On the pollen diagram from Asi Gonia (Fig. 5.1), the curve for evergreen oaks follows closely the curve for deciduous oaks. This close association between the two curves suggests that in this case the evergreen oaks are behaving as woodland trees rather than shrubs, despite the fact that they can produce pollen when less than one metre in height. The records for evergreen oaks from the pollen traps and moss polster were extremely variable, ranging from 5.0% to 56.0%! The highest figure was from the moss polster in the middle of the site, which could suggest that most of the pollen was regional rather than from the local maquis. There is a well-developed *Quercus coccifera* wood a few kilometres from the site, near Alones. This reinforces the idea that most of the evergreen oak pollen on this diagram has come from woodland trees rather than from the surrounding maquis/scrub. Spores from ferns indicate woodland conditions but may be expected to increase in woodland edge situations or when the canopy is opened up to create only a light shade. In the pollen traps, fern spores only accounted for 1.4% and 7.0% of total pollen and in the moss polster, 4.9%. Most were Pteridium spores and bracken grows on the site today, so they are probably of local origin. However, in the past when the bog surface was wetter, ferns probably grew further away.

The local maquis flora is currently dominated by *Erica arborea* and *Arbutus unedo*, both of which are useful indicators of maquis on the pollen diagram. Other typical maquis taxa include *Phillyrea*, *Pistacia* and Fabaceae, all of which tend to be under-represented on pollen diagrams from Greece/Crete. Interpretation of the extent of maquis will rely heavily on the Ericaceae curve. Figures for maquis/scrub taxa from the pollen traps were 8.6% and 13.0%, compared to only 1.4% for the moss polster. This suggests that high levels of pollen from maquis shrubs are likely to indicate maquis/scrub growing close to the site. Taxa taken as representing garigue/phrygana include Cistaceae, Sarcopoterium, Fabaceae, Lamiaceae and Euphorbiaceae. All are under-represented on pollen diagrams and none is strictly confined to garigue/phrygana, for example some members of the Fabaceae are common in maquis (such as *Calicotome villosa*). The two pollen traps set near the site recorded relatively high levels of *Sarcopoterium* pollen (18% and 19%), but these were probably from plants growing very close to the trap, as the moss polster from the middle of the site had a much lower figure of 0.7%. Other garigue/phrygana taxa contributed negligible amounts to the traps and polster, confirming the poor representation of this group in pollen records.

Taxa characteristic of steppe and cultivated land have been grouped together in this paper, as many types of NAP, such as Plantaginaceae, are characteristic of both habitats. Figures from the pollen traps were 7.6% and 31.0%, the latter figure being inflated by a figure of 17.0% for Brassicaceae in one of the traps. The moss polster had only 1.5% for steppe/cultivated land taxa. Poaceae is the dominant taxon within this group, with well-distributed windblown pollen. At the present day, most of the pollen probably derives from steppe, as the site is above the current level of cultivation, but the existence of old terraces near the site presents the possibility of some of the pollen coming from cultivated land in the past. Finally, the wetland group of taxa comprised mainly Cyperaceae and *Sphagnum*, with very occasional records for *Sparganium*-type and *Potamogeton*. These taxa are likely to have been derived from the peat bog itself, so they have been excluded from the pollen sum. Modern figures are 8.0% and 10.0% from the pollen traps and 3.6% from the moss polster but, as noted above, the surface of the bog is drying out fast today.

Changes in the impact of grazing should be reflected on the pollen diagrams in variations in the balance between the vegetation communities, as outlined above. Clues to the significance of grazing/browsing may be sought in the relative proportions of taller communities, such as woodland, maquis or scrub, and the low-growing communities, such as garigue/phrygana or steppe. Evidence for burning may be sought in the status of garigue/phrygana communities, which are believed to be particularly sensitive to this factor. A curve has been plotted for microscopic charcoal fragments over 10 microns in diameter. This should give an independent indication of the frequency of burning (either accidental or 'occupational') in the past, which may be compared with the pollen evidence.

The Pollen Diagram

The pollen diagram will now be interrogated for changes in vegetation which may have been produced by variations in the intensity of grazing/browsing and burning.

Zone AG1

This corresponds to the Early Byzantine and Saracen periods. The Sphakia Survey has shown that a shift of settlement took place away from the uplands towards the coast, starting in the first century AD. By the time peat accumulation started in the fifth or sixth century AD, the vegetation around the Asi Gonia site would have had several centuries of relatively light human impact. There is no archaeological evidence for occupation of summer villages in the mountains at this time, so grazing/browsing is likely to have been light, although it is not likely to have been absent altogether. The prediction from the archaeological evidence would be for a regeneration of woodland and a reduction in garigue/phrygana and steppe communities. This is in perfect accord with the situation in Zone 1 on the pollen diagram. Oak pollen (both deciduous and evergreen) is dominant, with a scattering of records for other trees, including *Pinus*, *Ostrya*, *Acer* and *Corylus*. There are occasional records for *Hedera* but values for fern spores are low, suggesting fairly dense shade. The only pollen from cultivated trees is from *Olea*, which could either have been growing in the local maquis or have blown from cultivated land at lower altitude. Values for maquis/scrub taxa in general are low, as are those for Poaceae and steppe taxa. There are low charcoal records, indicating little burning near the site.

Zone AG2

The lower boundary of this zone is the most significant one using all four methods of incremental cluster analysis. A radiocarbon date of 1010 ± 70 bp places it near the start of the Second Byzantine period. The Sphakia Survey records the re-establishment of settlements in the middle and upper zones of the landscape around 1000 AD. It is probable that the upland pastures (*madhares*) were used for summer shepherding from this time onwards, with men and boys spending the summer in temporary settlements at high altitude (Nixon *et al.* 1989). The exploitation of wood and timber probably increased as new settlements would have needed both firewood and building timbers. The prediction would therefore be for a major impact on the vegetation at this time, with an increase in both wood cutting and grazing/browsing pressure. The pollen diagram records a major decrease in AP at the start of Zone 2, affecting mainly the oaks (both deciduous and evergreen). Pollen of the light-loving *Platanus* increases and there are also more records for *Pteridium* and other fern spores, as the woodland edge habitat expands and light levels increase. Pollen of Ericaceae and almost all maquis/scrub and garigue/phrygana elements increases. Poaceae and steppe taxa also increase at this point. There is only a slight increase in charcoal records, so burning may not have been important at this stage. The surface of the bog itself may have become wetter, as there is a marked increase in the pollen of Cyperaceae. The palynological evidence thus supports the notion of a major change in the settlement and land use pattern in the Second Byzantine period.

Zone AG3

This zone dates from the late Second Byzantine period. On the pollen diagram a recovery of woodland taxa is seen, but not to the high levels of Zone 1. The records for *Platanus* pollen are maintained and those for fern spores increase, suggesting plenty of woodland edge habitats available, despite the regeneration of trees. Ericaceae and other maquis/scrub taxa mirror the *Quercus* curves, decreasing and later increasing again towards the top of the zone. Garigue undershrubs show an increase, particularly Cistaceae. Poaceae levels are slightly lower but records for other steppe/cultivated land taxa increase in frequency, for example Asteraceae and Brassicaceae. The charcoal curve rises steadily throughout the zone. The picture from the pollen diagram is thus one of maquis growing up into woodland but with grazing pressure maintained on garigue/phrygana and steppe communities. An increase in burning would give a competitive advantage to maquis shrubs, perhaps accounting for their recovery towards the top of the zone. The archaeological evidence provides few clues to these changes, so in this case the palynological record may be used to suggest changes in the settlement/land use history. The picture is consistent with a slight decrease in human impact, perhaps as land at lower altitude was exploited again, but with continuing grazing/browsing pressure on the uplands sufficient to prevent a major regeneration of woodland to its former levels.

Zone AG4

In the Early Venetian period there are documentary sources which suggest greater prosperity and much use of timber and wood. The prediction would be for renewed impact on the upland environment, through both wood cutting and grazing activities. The pollen diagram shows a decrease in woodland taxa but an increase in Ericaceae and other scrub/maquis taxa and relatively high values for garigue/phrygana taxa. Poaceae and steppe herbs also increase and charcoal levels are high. Cyperaceae levels are high, suggesting an increase in surface wetness on the bog itself. This fits in well with the prediction from the documentary evidence. Wood cutting could account for some of the decrease in woodland taxa but this clearly coincided with considerable grazing pressure and increased use of occupational burning to improve pastures. A mosaic of communities is indicated, with relatively little woodland but plenty of scrub/maquis (probably with ferns growing in the understorey), garigue and steppe. Local wetland species on the site itself would have added to the vegetation diversity.

Zone AG5

In the Late Venetian and early Turkish periods, documentary evidence and visible remains in the landscape suggest a period of relative prosperity but one in which demographic fluctuations were seen as a result of outbreaks of plague. The prediction would be for generally high levels of human impact, such as wood cutting, punctuated by periodic declines but probably sustained high levels of grazing throughout, as numbers of livestock do not necessarily correspond closely to population levels. On the pollen diagram, woodland taxa remain very low but Ericaceae and other scrub/maquis levels are very high. Poaceae and other steppe taxa show a very slight decrease but Cistaceae records are relatively high, suggesting that garigue was holding its own. This would fit in with the lower records for charcoal, as garigue is susceptible to burning. A period of intensive grazing pressure is indicated, as predicted, but with less burning and wood cutting. Maquis and garigue communities were favoured over woodland and steppe. Records for ferns decreased as the dense maquis shaded out the undergrowth.

Zone AG6

This zone is also within the Turkish period. Various rebellions and outbreaks of plague in the seventeenth century might be expected to have led to relaxed pressure on upland vegetation from time to time. On the pollen diagram, a small increase is seen in woodland taxa, especially the fast-growing evergreen oak. Ericaceae and other maquis/scrub taxa reach high levels; garigue and steppe taxa stay much the same as in the previous zone. There are peaks for charcoal at the beginning and end of the zone. Cyperaceae and *Sphagnum* records increase a little, indicating wetter conditions on the bog, possibly linked to the climate changes in the Little Ice Age, when more extreme conditions were recorded in the seventeenth century (Grove *et al.* 1992). The interpretation of the palynological evidence is for periods of high grazing pressure being interrupted by years of lower impact, when some maquis shrubs managed to grow up and form woodland once again.

Zone AG7

During the late Turkish period, prosperity and population increased in Crete. Olive growing expanded from the eighteenth century onwards. The prediction might be for sustained high grazing pressure in the uplands but it is also possible that more agricultural effort was being concentrated on the lowlands and the olive groves. This seems to have been the case, as the pollen diagram records an increase in evergreen oaks and a gradual decrease in Ericaceae. There are lower records for garigue and steppe taxa, too, and charcoal records decrease. All this suggests a diminution in grazing pressure, which allowed the fast-growing *Quercus coccifera* to grow up and flower more profusely. Garigue and steppe taxa were outcompeted by the tall shrubs and developing woodland.

Zone AG8

The final zone on the pollen diagram dates from the Late Turkish period onwards, when documentary records are plentiful and augmented by oral history. Political and demographic changes led to rural instability until the mid-twentieth century, but the period from 1950 onwards saw a revitalization of agriculture in the lowlands and further expansion of olive groves. This was accompanied by some rural depopulation in the uplands, which would be predicted to lead to an increase in woodland at the expense of maquis, garigue and steppe. The pollen diagram confirms these predictions in all respects but one: there is relatively high *Sarcopoterium* pollen. Perhaps this thorny undershrub dominated the remaining areas of garigue/steppe, as grazing pressure was concentrated on them, as it is resistant to grazing by having both thorns and an unpleasant taste. Charcoal levels are relatively low, as would be expected if the emphasis had shifted away from upland grazing lands and on to the cultivated lands in the lowlands. The site at Asi Gonia is too far away from these agricultural operations to have recorded them in any detail but it is just possible to pick out an increase in the *Olea* curve in Zone 8. The increase in the amount of woodland cover in the uplands is well illustrated in photographic and sketchbook evidence, as detailed by Rackham and Moody (1996).

Conclusion

Close analysis of the pollen diagram from Asi Gonia reveals a complex picture of changing vegetation cover over the past 1500 years. Most of the changes seen may be interpreted as the result of variations in the pressures exerted by grazing/browsing and burning. Where documentary or archaeological evidence is available, the correspondence with the palynological evidence is striking. This suggests that the palynological interpretations are probably correct and enables interpretation of zones for which documentary sources are scarce to be made with some confidence. A great advantage of the Asi Gonia site is its good and consistent preservation of pollen and spores, as compared with some other sites in southern Greece where pollen preservation is patchy, such as Kleonai (Atherden *et al.* 1993). There are few sites in Greece with such a complete and detailed record of changes during the recent past (compare, for instance, the diagram from Aghia Galini, which does not extend beyond the middle Holocene).

There is a need for further work on the historic period in southern Greece, particularly from sites in the uplands. Such analyses have been carried out in northern Greece (e.g. Gerasimidis and Athanasiadis 1994), although the impact of grazing/browsing was not highlighted in the interpretation. Other research questions concern the role of transhumance in Greek mountain environments and the relationship between upland and lowland sites. Despite the growing interest in Greek palynology over the past few decades, there is still much to be learned about the human impact on the environment of southern Greece and the Greek islands.

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6

Deconstructing Agricultural Terraces: Examining the Influence of Construction Method on Stratigraphy, Dating and Archaeological Visibility

Charles D. Frederick and Athanasia Krahtopoulou

Introduction

Geoarchaeological studies are a common component of many archaeological survey projects in Greece. These studies often identify the spatial and temporal framework of natural sedimentation that may impede archaeological visibility. None, however, have examined the implications of anthropogenic sedimentation associated with terracing. Agricultural terraces are an ubiquitous component of many Aegean landscapes, and their construction may hold significant implications for interpreting archaeological survey data. This paper explores terraces from a geoarchaeological perspective, and examines how their internal stratigraphy and archaeological visibility may be influenced by the construction method employed. The review demonstrates that terrace stratigraphy is strongly influenced by the construction method and that they may impede or improve archaeological visibility. Unfortunately determination of how a terrace was made and the degree to which archaeological visibility is affected is impossible from surface examination alone. Attention is also directed toward identifying the best way to date terrace construction and thereby evaluate the antiquity of this agricultural strategy.

Background

Terracing is one of the most common forms of soil conservation in the Aegean. Although terracing may be found across Greece, it is most common in the southern mainland and islands, where it plays a significant role in the creation of new agricultural land. Although ubiquitous, the significance of terracing is only fully appreciated when the magnitude of this agricultural strategy is examined in detail. For instance, Whitelaw (1991: 405) estimates that c. 70–80% of the entire island of Keos had been terraced at some time in the past. In landscapes such as this, the most significant factor affecting the visibility of archaeological sites to surface survey (excluding surface visibility associated with vegetation cover) is the transformation from a natural sloping landscape to an intensively manipulated and managed one. This is the opposite of many landscapes where the most significant impediment to archaeological visibility is geological processes such as erosion and sedimentation. Attempts to compensate for such limitations is one of the main thrusts of geoarchaeological research, especially in the New World, where the majority of such studies seek to elucidate periods of landscape activity and delineate portions of the landscape where archaeological visibility may be impeded.

Armed with such geographic and geologic information it is then possible to tailor archaeological survey strategies to compensate for compromised visibility. In terraced landscapes, it is clear that it is human activity associated with the physical restructuring of slopes that poses the major limitation on archaeological visibility.

Outside of the Aegean, the origins of terraced landscapes have been investigated archaeologically, resulting in significant information on the nature and timing of terrace construction (e.g. Denevan *et al.* 1987; Fish *et al.* 1984) as well as the long-term edaphic effects of agriculture (Sandor 1997). Despite the ubiquity of terraces in the Aegean, studies concerning the history of terracing are few, and most features are readily dismissed by field workers who more often than not assume they are of recent origin (French and Whitelaw 1999; Krahtopoulou 1997) despite evidence that indicates that the technology first appears in the Middle and Late Bronze Age (cf. French and Whitelaw 1999: 173-75; Moody and Grove 1990: 190). This may in part be due to the fact that, although terracing has been a viable agricultural strategy for several thousand years, many are of relatively recent age (Krahtopoulou 1997; French and Whitelaw 1999). Nevertheless, the absence of detailed, systematic examination of agricultural terraces is a prominent gap in the regional literature and one that holds significant implications for studies of long-term settlement and land use.

This paper has two principal goals: (1) to examine how terrace construction may influence the visibility of cultural material and thereby affect the accuracy of pedestrian archaeological surveys; and (2) to deconstruct agricultural terraces in order to examine how they may best be dated. The approach is largely theoretical, but grounded upon previous empirical results where applicable.

Basic Considerations

Nomenclature

Agricultural terraces are step-like, generally slope or contour parallel platforms that are constructed in order to permit cultivation of slopes with minimal soil erosion. These man-made or anthropogenic landforms generally consist of a vertical or near vertical wall or bank, known as a riser, and a flat or nearly so surface that lies up-slope and behind the riser which is known as the tread (see Fig. 6.1 for an illustration of the components of a basic slope

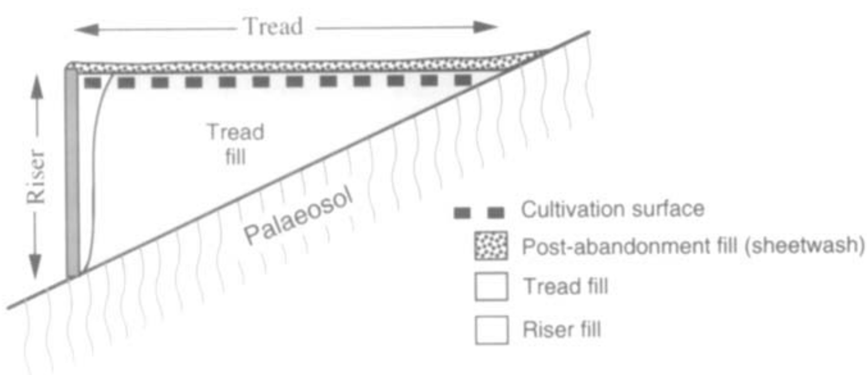

Figure 6.1 Terrace components discussed in the text.

terrace). Risers may be of masonry or earthen, and the treads vary in slope from flat to gently sloping. There is a tremendous literature on methods of soil conservation, and the reader is referred to a number of texts which discuss the details of slope terracing (e.g. Hudson 1971; Morgan 1986).

Terraces are generally constructed in order to facilitate the management of soil, water, crops or microclimate, although the construction of a terrace clearly influences all of these factors. Owing to their multi-functional nature there is an extensive range of descriptive terms for a variety of features that, as Hudson (1992: 153) observes, fall into the general category of 'cross-slope barriers'. These features range from simple earthen (or conservation) banks to formal masonry walls and benches.

Terraces may be classified by their geomorphic occurrence, function, morphology, and construction method. For instance, Donkin (1979) recognized three kinds of terraces, according to their geomorphic occurrence: (1) cross-channel; (2) contour; and (3) valley floor. Morgan (1986: 226), on the other hand, also identified three kinds of terraces, but primarily organized according to their function: (1) diversion; (2) retention; and (3) bench. Diversion terraces are intended to intercept overland flow and divert it to an acceptable outlet, whereas retention terraces are designed to conserve slope water. Bench terraces are principally employed to permit cultivation of steeply sloping land. Moody and Grove (1990) classified terraces in Crete according to their plan configuration and recognized three basic kinds: (1) parallel (or stepped as they were later referred to by Rackham and Moody 1992); (2) braided; and (3) pocket. Although this classification is based upon plan form, Moody and Grove (1990) infer a functional use for two of the three types. Braided terraces have ends that slope together to form a continuous, albeit zigzag slope and are linked with cereal cultivation and use of a plough. Pocket terraces are small slope benches which are generally semi-circular in plan form and are specifically linked to the cultivation of trees. Parallel or stepped terraces follow contours and are not linked with a special function other than arable agriculture.

Because these features may have been constructed for a variety of reasons, no single classification scheme is widely accepted by researchers. Modern studies tend to adopt either a nomenclature that stresses terrace function or method of construction, whereas studies of ancient fields tend to adopt descriptive schemes because it is often difficult to ascertain with confidence the motivation behind ancient terracing. This paper intends to examine the manner in which terraces were built and is not concerned with their function. Hence the term terrace is used in the most general sense to refer to cross-slope barriers of various forms that lead to the formation of a near vertical riser and a near level tread, although both of these components may deviate from the vertical and horizontal, respectively. Although terrace morphology can be and often is related to the specific function (e.g. pocket terraces most commonly used for cultivation of trees; the distinct morphology of irrigation terraces), this is not necessarily the case and the following discussion should apply to all terraces regardless of their specific function.

Reasons for Terrace Construction

As mentioned briefly before, terrace construction can be instigated for a number of reasons, the most common of which are the management of soil, water, crops and microclimate (Table 6.1). The primary benefits of terrace construction are erosion control, water conser-

Table 6.1. Reasons for the implementation of terraces (modified from Hudson 1992: 152)

Soil management	to modify slope to contain erosion with low inputs to contain erosion with minimal earth-moving on steep slopes to increase depth of soil
Water management	to increase effective rainfall to catch and hold all run-off to absorb some run-off with emergency overflow to control reduced run-off to reduce the velocity of run-off and promote infiltration
Crop management	to provide level areas on steep slopes or ease cultivation to ease harvesting to provide drainage for crops to modify microclimate to facilitate plant growth

vation and land reclamation. Although any one of these factors may stimulate terrace construction, once constructed, terraces will influence all of these factors to varying degrees (see Treacy and Denevan 1994 for a good discussion of the effects of terracing). Rackham and Moody (1996: 142) note several other possible reasons for terrace construction, which although they may fit into the general descriptions above, are not common suggestions among most modern soil reclamation books. Some of their alternative suggestions include: soil redistribution to mitigate patchy soils on bedrock surfaces, increased root penetration, and the removal of large stones from the fields. Although a common technique, terracing is not necessarily an ideal solution to erosion, water or crop management goals as their creation may expose less fertile subsoils, or be more prone to slope failure on some geologic substrates (Morgan 1986: 230).

Modern Methods of Terrace Construction

There are numerous ways to construct a terrace. The most common involve constructing a slope obstacle, and then forming a level planting surface by either filling behind it by hand, borrowing earth from immediately upslope, or encouraging natural erosion, a process known as 'controlled erosion'. However, it is possible to form a terrace by merely cutting a level platform, or employing a combination of hand filling and controlled erosion to make up the tread fill.

Regardless of the specific method employed, terrace construction always necessitates the shifting of earth, and decisions concerning the morphology of the resulting fields strongly control how much earth is moved during construction. The main factors are the width of the bench, and the slope of the tread. The volume of earth moved is proportional to the square of the bench (or tread) width (Hudson 1992: 154-55) so it is beneficial to keep the tread as narrow as cultivation techniques permit; wide treads require higher risers and therefore a greater volume of earth movement. Outward sloping treads require less earth movement, but can spill earth over onto the next lower tread and this can be problematic with easily erodible soils (Hudson 1992: 155).

How a terrace is filled has prominent implications for the visibility of cultural materials that were on the slope prior to construction. There are four basic processes associated with terrace construction and use that may affect the visibility of cultural material: (1) burial of the existing surface by the introduction of a fill or controlled erosion; (2) controlled erosion or excavation of slope deposits during the filling process; (3) the introduction of new (exogenous) cultural material if earth is imported to make up the fill; and (4) tillage-related mixing.

It is most common for earth to be shifted locally on the slope because it is the most labour-efficient means. There are also numerous records of earth being imported from nearby (often cited as adjacent alluvial lowlands, e.g. Donkin 1979: 17) to fill terraces. However, this is an incredibly labour-intensive method. A brief review of some of the modern methods of terrace construction provides some clues as to how these processes may influence terrace stratigraphy and the visibility of pre-existing cultural materials.

Terraces which Bury the Topsoil

One of the most common means of terrace construction is the formation of a level planting surface by borrowing earth from immediately upslope (cf. Morgan 1986: 232). This method risks reducing soil fertility by using and shifting less fertile subsoils or minimally weathered bedrock on top of the pre-existing topsoil. Generally this process will lead to an over-thickened buried A horizon at the base of the terrace fill that is overlain by sediment derived from the subsoil or bedrock.

Terraces which Conserve the Topsoil

Modern methods often favour the reuse and conservation of the existing A horizon, but it is clear from the stratigraphy revealed by the study of relict terraces that ancient cultures did not necessarily share this preference. One example of a modern method favouring conservation of the topsoil is illustrated by Peace Corps (1986; see also Hudson 1992: 155). In this example, the lowest terrace tread is prepared with fill created by cutting into the hill up-slope, and then the topsoil is stripped from the area of the next higher terrace and used to fill the tread of the lower terrace. Terraces thus constructed only bury the pre-existing topsoil on the lowest terrace, and shift all the rest of the topsoil down one step.

Fanya Juu

This method of progressive terracing is an incremental process that involves the excavation of a small ditch parallel to the slope contour and the deposition of the spoil from the ditch immediately up-slope of the ditch. The term *fanya juu* means 'to throw upwards' (Hudson 1992: 161-63). The bank thus created begins to accumulate soil which is moved downhill by natural erosion, controlled erosion, or merely cultivation tillage. Over a period of years, the bank height is increased and the terrace tread width gradually increases. This method creates a terrace which lacks a masonry wall, and the terrace fills generated from this process will resemble those which bury the topsoil, unless the A horizon is very thick, in which case it may create an over-thickened A horizon. The bank will show a similar stratigraphic progression, but may shift into less weathered material more rapidly owing to the near vertical excavation of the ditch.

Bulldozing

Although not mentioned in most soil conservation manuals, heavy machinery such as bulldozers are one of the most common modern methods of terrace construction (personal observation; Rackham and Moody 1992). Terraces constructed in this fashion generally create the treads by cutting or scraping away the soil on the up-slope side, and then using this earth at the end of the terrace to form ramps between successive terrace levels, hence most of these fields are of the morphologic form Moody and Grove (1990) describe as braided. Some earth may be displaced laterally to form a fill in the traditional sense, but most appears not to be, so these terraces exhibit soil profiles that are most complete near the riser and become progressively truncated toward the rear of the tread.

Cross-channel Terraces

Check dams or cross-channel terraces are generally built across water gathering, concave slopes such as channels and gullies in order to trap sediment and thereby reduce channel depth and slope (Morgan 1986: 242). These features are nearly always self-filling, and are often constructed incrementally. Their deposits are typically stratified and reflect the nature of sediments transported down the channel (see Smith and Price 1994, for a profile of one such field in Mexico). Unlike most terraces, this method may permit the development of numerous buried soils if their use and construction occurred gradually over a very long period of time.

Terrace Stratigraphy

The stratigraphic elements associated with terraces are a direct artefact of their construction method and use, and scrutiny of these features may inform on these processes, as well as the nature of the slope soil prior to terrace construction. Six major components are recognized (see Fig. 6.1): (1) the pre-existing surface (generally a palaeosol); (2) the riser; (3) the riser fill; (4) the tread fill; (5) the cultivation surface; and (6) the post-abandonment fill.

The Pre-existing Surface

Previous investigations of prehistoric terraces have found buried A horizons beneath the terrace deposits and this pre-existing surface may be the entire soil or a fragment of it (e.g. Sandor 1997). The nature of the palaeosol may indicate the completeness of the slope soil at the time the terrace was constructed. Given that some construction methods may have resulted in truncation of the existing soil, however, care must be taken in evaluating the significance of truncated profiles. The highest probability of palaeosol preservation is beneath the tread fill adjacent to the riser and/or beneath the riser.

The Riser

The riser may be a masonry wall, an earthen bank, or a cut vertical surface. Its character depends on the terrace construction method. In some instances more than one riser may be present if the field has been improved or used over a long period of time (see the illustration in Williams and Walter 1988: 184). If the riser is an earthen bank, then the stratigraphy of the riser may, if distinguishable, indicate how the riser was constructed. If the terrace was formed by cutting (as in some bulldozer constructed fields), then no riser deposit or structure may be present.

The Riser Fill

In some instances the space immediately adjacent to and behind the riser is filled with coarse rubble (Krahtopoulou 1997: 256; Treacy and Denevan 1994: 100). These deposits form a V-shaped wedge immediately behind the riser, and are generally a feature of terraces with masonry risers. The function of these deposits is not clear, but may be associated with drainage, disposal of waste created during the construction of riser masonry walls, or merely a discrete fill added to fill the space formed between the earthen terrace and the riser wall.

The Tread Fill

The tread fill is generally the most significant deposit in terms of both volume and internal structure. The character of the tread fill will be a function of the construction method, tillage, and whether the terrace was constructed completely before use, or was formed under cultivation. Informative aspects of these deposits include: (1) their composition; (2) their structure or stratigraphy; (3) their cultural material content (and their temporal depth); and (4) their degree of pedogenic development.

Composition. The sediment that comprises the tread fill will inform on the source of material used to construct the terrace, and how that material may have changed during the construction or use of the terrace. For instance, terraces that are formed by controlled erosion may change from redeposited topsoil initially to redeposited subsoil, and eventually bedrock in a sequence that is basically reversed soil stratigraphy. Earth imported for tread fills, such as alluvium from nearby streams, should differ significantly from the natural slope deposits and soils.

Structure or stratigraphy. The internal structure or stratigraphy of the tread fill may inform on the construction process as well. The character of this deposit is a function of the construction process, tillage mixing, and inputs of materials to the tread (most often organic matter). Several kinds of deposits may occur within tread fills and these include: (1) anthropogenic fill earths; (2) natural slope deposits; and (3) soils and buried soils. Treacy and Denevan (1994) contrast 'self filling or accretional terraces' with those filled by hand (an anthropogenic fill earth). Deposits generated by sheetwash or controlled erosion will be thin-bedded and in some cases laminated (Treacy and Denevan 1994: 105; see also Smith and Price 1994 for an example). If these deposits are cultivated while sedimentation fills the terrace, tillage will most likely obliterate them and little evidence of this process will remain whereas their preservation is a testament to either minimal tillage cultivation or lack of use of the terrace prior to the completion of filling. Treacy and Denevan (1994) fail to provide any criteria for recognizing hand filled terrace deposits, perhaps because it is difficult to distinguish sediments shifted by hand from those altered or mixed by tillage. Buried soils are also common components within terrace tread fills (see Fish 1994: 58 for a graphic example). Sandor (1997: 238-40) noted that buried A horizons were commonly encountered within the tread fill of Peruvian terraces he examined in the Colca Valley. These soils and intervening fills were interpreted as evidence of multiple fill events associated with terrace reconstruction events, the original soils buried by terrace construction or additions of organic material by farmers.

Perhaps the most common attribute of tread fills is the poorly sorted matrix-supported gravelly deposit (see French and Whitelaw 1999 for a good description of terraces exhibiting this attribute). This kind of deposit results from haploidization of the tread fill during tillage, whereby fine matrix and coarse fragments are mixed together destroying any vestiges of sedimentary structures or other forms of stratification. Extremely thick mixed zones indicate either deeply dug soils or cultivation during progressive formation of the tread fill. Figure 6.2 illustrates the nature of the two most prominent processes that influence terrace stratigraphy following the major construction event.

Cultural inclusions. Cultural material within the tread fill may preserve vestiges of stratigraphy that inform on the period of construction or the progressive denudation of pre-existing cultural deposits during the filling of the terrace. Although tillage may destroy internal bedding associated with controlled erosion, cultural material added to the terrace during cultivation (such as is widely attributed to manuring—cf. discussion in Miller and Gleason 1994) may provide information on the period of construction or use of the terrace. In order to detect if such relict stratigraphy is present it is critical to examine the stratigraphic occurrence of cultural material within the terrace. At least three basic scenarios can be envisioned (and many more combinations are possible): (1) incorporation of cultural material to the field once the terrace is completed; (2) cultivation and addition of cultural material to the terrace while controlled erosion is employed to fill the terrace; (3) re-deposition of pre-existing cultural deposits from controlled erosion of slope sediments. In the first case, presuming that the slope deposit did not contain any artefacts to begin with, then the cultural material in the terrace tread fill will be concentrated in the plough zone at the top of the tread fill. The depth of their occurrence will reflect the depth of tillage and their temporal duration will reflect the period of use. In the second instance, again assuming an artefact sterile slope deposit, the artefacts within the terrace will date the period of initial use and construction, and crude stratigraphic order may be retained, despite the mixing associated with tillage. In this scenario tillage will effectively act as a moving average, mixing assemblages of adjacent periods but still providing a vestige of stratigraphic order. Clearly, this will only work if the filling process is prolonged. The last case (but by no means the last possible combination) presumes that the slope deposit contains some pre-existing cultural material, in a crude stratigraphic order. In this situation, controlled erosion of the slope deposits above the riser may lead to the formation of a reverse cultural stratigraphy which may mimic trends in the tread fill deposit composition.

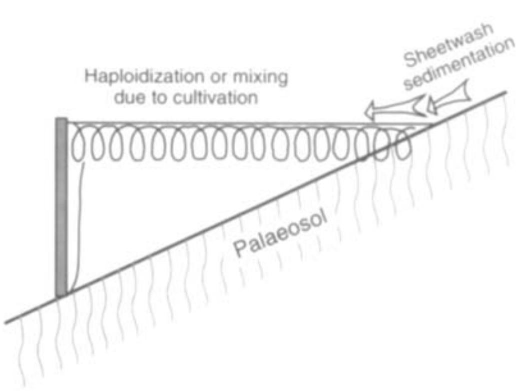

Figure 6.2 Processes affecting terrace stratigraphy following initial construction.

Degree of pedogenic development. The last major aspect of the tread fill is the degree of pedogenic development. Prehistoric terraces constructed several thousand years ago will have persisted long enough to permit pedogenic alteration of the deposits. The initial attribute will be the formation of a new A horizon in proximity to the tread surface. This horizon will form naturally, but its development can be greatly accelerated by manuring. In a natural setting such horizons may form in less than a hundred years (Birkeland 1984), but with anthropogenic additions of organic matter such horizons may form in less than a decade, as my own garden activities have demonstrated. Subsoil horizons form more slowly, but even significant B horizons may form in as little as 1000 years (Krahtopoulou, this volume). Hence it is likely that ancient terraces will exhibit incipient to moderately developed soils.

Evaluating Terrace Construction Methods: Some Hypothetical Examples

In the field, excavation of trenches perpendicular to the long axis of the terrace (basically upslope from the terrace wall to the rear of the terrace) and down to bedrock may reveal clues to the manner in which the terrace was constructed. Figure 6.3 is a hypothetical example of how eight different construction methods may influence the internal stratigraphy of monogenetic terraces. For the sake of clarity, these illustrations do not depict tillage-related mixing nor soils that form during cultivation. For this reason they are perhaps a bit oversimplistic. Despite this obvious shortcoming, they are provided to illustrate how various construction techniques will affect the terrace stratigraphy. The basic variables at play are the degree to which the terrace is cut into the slope, and whether the fill deposit is anthropogenic or formed by natural slope sedimentation behind the terrace wall, as in the case of 'controlled erosion'. Table 6.2 summarizes the implications of each method for archaeological visibility of cultural materials that were present in the soil A horizon prior to terrace construction, as well implications for terrace stratigraphy which are illustrated in Figure 6.3. It is clear from these basic examples that terrace construction may either enhance or inhibit archaeological visibility and that it is impossible to discern which has occurred

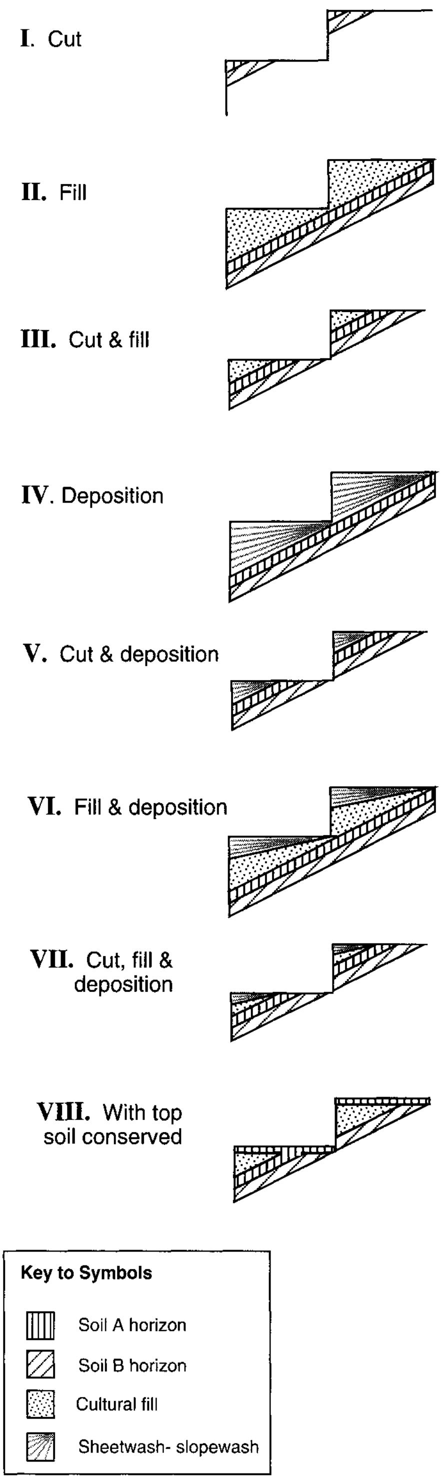

Figure 6.3 Hypothetical examples of how construction method may affect terrace stratigraphy.

Table 6.2. Implications of terrace construction methods for archaeological visibility and terrace stratigraphy

Method	Implications for archaeological visibility	Implications for terrace stratigraphy
I Cut	• Near total removal of cultural material. • Remaining material will be situated near the riser and have relatively high visibility.	• Cutting should truncate the pre-existing soil leaving the most complete fragments adjacent to the riser. • Sediment created from this process will be used locally, most likely as fill to form graded slopes or braids between adjacent treads. • Ancient terraces constructed by this method may be difficult to identify owing to the complication of tillage and pedogenesis following construction, which would tend to obfuscate the remaining vestiges of the former soil.
II Fill	• Complete or nearly complete burial of pre-existing cultural material if the fill is introduced. • If the fill is derived from the same slope, good visibility may be retained but the original contextual significance lost. Hence the distribution of cultural material will be an artefact of terrace construction, not previous occupation.	• The introduction of fill earth to form the terrace will most likely result in the complete preservation of the original slope soil (as a palaeosol) unless some form of A horizon retention program is employed. The latter may result in the removal of the A horizon prior to burial by fill.
III Cut and Fill	• If the fill is derived from cutting/borrowing of earth from immediately up-slope, the terrace should retain good visibility of pre-existing material owing to exposure of the A horizon up-slope and redeposition of material towards the riser. • Visibility could be quite low if the fill is largely derived from the subsoil or bedrock.	• Filling should preserve the original soil beneath and immediately up-slope of the riser, whereas the cutting will truncate the same soil immediately down-slope of the next higher riser.
IV Deposition	• If the sediment comprising the tread fill is locally derived from the A horizon, visibility should be good.	• Deposition may preserve complete or nearly complete portions of the original soil, especially in proximity to the riser. Whether this soil is preserved up-slope depends upon the thickness of the original soil, the width of the terrace, and the depth to which erosion up-slope occurred during the filling process. • This process can yield a cumulic A horizon if the fill is derived solely from A horizons up-slope • Such fills should retain some semblance of bedding unless cultivation occurred concomitant with sedimentation, in which case the entire fill may be mixed by tillage.
V Cut and Deposition	• Similar to III until erosion cuts into the subsoil or bedrock, at which point the leading edge of the tread may be buried in sterile earth. The truncation of the A horizon in the middle of the tread, however, should assure some, albeit diminished, visibility.	• Deposition should preserve the original soil beneath and immediately up-slope of the riser, whereas the cutting will truncate the same soil immediately down-slope of the next higher riser. • The deposit behind the riser may preserve evidence of bedding at a depth greater than the average tillage if cultivation did not occur concomitant with sedimentation.

Table 6.2 continued

Method	Implications for archaeological visibility	Implications for terrace stratigraphy
VI Fill and Deposition	• Visibility in this scenario is entirely contingent upon the source of the tread fill. If it is topsoil from up-slope, then visibility should be good. Sloping treads, however, together with cultivation, could promote significant down-slope movement of cultural material if spill-over occurs. • If subsoil or bedrock is the source, visibility may be poor to non-existent.	• Complete preservation of the former soil may be achieved if fill is derived from elsewhere. Otherwise some erosional truncation may occur in the up-slope portions of the tread. • It may be difficult or impossible to identify fields constructed in this fashion because tillage will most likely destroy diagnostic depositional attributes.
VII Cut, Fill and Deposition	• Similar to V; exposure of the A horizon in the middle of the tread should provide good exposure across part of the tread, but not necessarily all of it.	• Filling should preserve the original soil beneath and immediately up-slope of the riser, whereas the cutting will truncate the same soil immediately down-slope of the next higher riser. • It may be difficult or impossible to identify the depositional component of the fill because tillage will most likely destroy diagnostic attributes of these deposits.
VIII Filling with Topsoil Conservation	• Pre-existing cultural materials will be visible on the tread of every terrace and buried in the palaeosol beneath the tread fill of the lowest terrace.	• This method forms a complete palaeosol beneath the tread fill in the lowest terrace, and a truncated palaeosol beneath every other terrace. • Tread fill should be derived from the subsoil and bedrock.

Note: Discussion pertains to Figure 6.3. These inferences are predicated upon the following assumptions:
(1) that the original cultural material was situated in the A horizon at the time the terrace was constructed;
(2) that terraces have been maintained and have not collapsed;
(3) that terraces are monogenetic and formed during one discrete constructional phase.

from surficial inspection alone. Furthermore, the addition of soil mixing associated with tillage may make it difficult to unravel the construction method with certainty.

Methods of Dating Terrace Construction

Dating terrace construction can be problematic and a wide variety of evidence has been used to estimate terrace age (see Table 6.3). In general terms, previous efforts to date terrace construction have based age estimates upon: (1) cultural material in the area around the terraces; (2) various aspects of the riser or wall elements; (3) attributes or inclusions derived from the fills and soils which comprise the terrace; and (4) the relationship of walls with archaeological remains of known age. Estimates based upon surrounding scatters of cultural material or settlements provide no firm linkage with the terraces in question and must be regarded carefully. It is possible to date the riser by architectural style but the fact that construction methods may be copied leads to some uncertainty in such ages. It is also possible to directly date the rocks by means of lichenometry or cosmogenic isotopes, but both of these methods have limitations. If the rocks used to form the walls were collected from the surface, then these methods may yield anomalously old ages. Furthermore, lichenometry will only work for rocks favoured by lichens, and therefore its suitabil-

Table 6.3. Methods of dating agricultural terraces.

Component	Method	Strength and implication of the derived date	Reference
Surrounding Landscape	• Their relation or association with ancient settlements.	• A weak means of dating the fields. • Possibly erroneous unless stratigraphically linked.	Treacy and Denevan 1994: 105
	• Age of cultural material found in the vicinity of the terraces.	• May not bear a direct relationship to the terraces. • Not necessarily associated with terrace construction and use. • Significance depends upon mode of arrival in the field. • Distribution in proximity to fields may have been affected by slope and tillage processes.	
	• Ties to periods of known occupation (especially in regions where past settlement was temporally limited or of short duration).	• Circumstantial argument. • Cannot be used to date terraces in any way other than to identify periods when construction could have occurred.	
Riser or Wall Attributes	• Masonry style and phasing of wall construction.	• Wall construction methods may be copied or repeated by later groups, leading to erroneous age estimates.	Denevan 1987: 21; Whitelaw 1991
	• Lichenometry.	• May provide an accurate date for the point of lichen growth. • Difficult to rule out lichen growth that began prior to incorporation in the wall. • Lichens are not common on all rock types. • Studies require some information on rate of growth and taxonomy.	Whitelaw 1991; Given *et al.* 1999
	• Cosmogenic isotopes from wall rocks.	• May provide an indication of how long rocks have been exposed. • Can lead to anomalously old ages if rocks used in wall were initially gathered from the surface.	

Table 6.3 continued

Component	Method	Strength and implication of the derived date	Reference
Deposit Attributes	•Stratigraphic constraint (e.g. structures built on top of terrace, or terrace overlain by isochronous deposits such as tephra).	• Provides a minimum age for the construction event. • Potentially very accurate means of dating terrace construction as it provides a firm terminus ante quem.	Betancourt *et al.* 1990; Betancourt and Hope Simpson 1992
	• Ceramic inclusions in the tread fill.	• Significance is conditional upon the manner in which they are incorporated. • Generally provide a maximum age for the field. • Can date from period of use if input as manure or incremental waste disposal. • Can be irrelevant to the period of construction or use of field when incorporated by construction process or controlled erosion of pre-existing deposits.	Malpass 1987; Shea 1987
	• Ceramics in the palaeosol beneath the terrace wall and tread fill.	• Provide a maximum age for the construction of the terrace. • Perhaps one of the most accurate means of dating a terrace.	
	• Radiocarbon dating of organic inclusions (scattered charcoal).	• Direct age on organic material within the field. • Does not necessarily date use or construction.	Malpass 1987
	• Radiocarbon dating of buried soils.	• Dates will yield a maximum age for soil burial. • Mean residence time effect will lead to chronometric uncertainty about time of burial. • Can provide support for other forms of data.	Sandor 1987
	• Degree of soil development.	• Cannot date the field accurately. • Can be used to support inferences that the field has been present for a significant period of time (one or more thousand years).	
	• Luminescence dating of controlled erosion (sheet wash/rill wash) fill.	• Dates period of filling. • Samples may not be adequately zeroed (or bleached) resulting in anomalously old ages.	

ity will vary as a function of bedrock. Dates derived from terrace deposits are problematic owing to two principal factors: (1) that cultivation mixes the deposits (Treacy and Denevan 1994: 106); and (2) that inclusions within the terrace may be associated with pre-existing deposits that comprise terrace fills, use of the feature or post-depositional processes.

Given the complexity and problems associated with these dating methods, it is clear that the best approach is to employ more than one technique in order to estimate terrace age. Secondly, attention to stratification, soil development, stratigraphic distribution and sequence of sherds, sedimentary character of the deposits, and nature of and inclusions in the soil beneath the terrace may provide clues to the nature and timing of filling and use. Ultimately, such investigations can be best expected to provide brackets for terrace construction rather than firm dates.

Implications of Terrace Construction for Archaeological Visibility

The limitations imposed upon archaeological survey by geological processes are well appreciated in Greece, as is demonstrated by the frequent inclusion of geoarchaeological studies in survey projects. Most of these projects, however, have only considered natural and anthropogenically accelerated (indirect) sedimentation. As a result, such studies have focused primarily upon alluvial environments, and less frequently on slopes. The thrust of this paper is that terraced slopes are potentially as problematic for archaeological surveys as are alluvial valleys.

The manner in which terrace construction may influence archaeological visibility is primarily a function of: (1) if and where in the pre-existing soil cultural material was present; (2) the construction method employed; and (3) the amount of post-construction sedimentation. Because these variables are wide ranging and almost impossible to estimate from surficial examination, we should treat terraced lands as if they are dynamic landscapes with the potential to obscure archaeological visibility.

Given the nature of sloping land, the probability of large settlements being sited on and subsequently obscured by slope terracing is probably relatively small. The major problem lies with small farmsteads, special function sites, and small, early sites which could easily be buried or destroyed by extensive terracing programs at any point in time. In a more regulatory oriented environment such as contract archaeology, this conclusion would necessitate pedestrian surveys augmented by some form of subsurface exploration to evaluate the seriousness of the problem. This response reflects an attempt to tailor survey strategies to the terrain in order to attempt to compensate for limited archaeological visibility. Where deposition is less than a metre, such areas are generally surveyed in conjunction with shovel tests or some other form of keyhole excavation. Where deposition is in excess of a metre, there are presently no adequate and time efficient strategies that will permit exploration of such landscapes and a wide range of compensatory procedures have been used. Most involve the use of mechanical excavation (i.e. a JCB or backhoe), but this would be problematic on many terraced slopes, especially steep lands such as are the subject of this paper. Hence, knowledge of the problem is key to interpreting the survey of terraced lands.

Summary

If we continue to assume that all or most terraces are recent, and infer that sherds have been incorporated via modern slope processes, then we are potentially missing a significant part of the archaeological record. The sites thus missed may not be big ceremonial sites or villages, but rather small, rural family dwellings. Furthermore, given the rugged terrain of many Greek landscapes, the implementation of terracing may have had significant implications for the subsistence base at one or more times in the past. Understanding when this occurred is critical to understanding settlement of these landscapes, and this is a significant research domain in the understanding of rural Greek landscape history. Hence, the investigation of terrace history has the potential to yield information relevant to the landscape archaeology of Greece, as has been pointed out by numerous previous studies. Unfortunately, to realize this goal requires systematic investigation by means of excavation because this history generally cannot be reconstructed from surficial examination alone. Hence, terraced landscapes should be considered what they are, dynamic cultural landscapes with a potential to hide or reveal evidence of pre-existing occupations.

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7

Landscape Exploitation via Pastoralism: Examining the 'Landscape Degradation' versus Sustainable Economy Debate in the Post-Mediaeval Southern Argolid

Hamish Forbes

'The most critical step in the degradation of the Greek environment was the invention of the bulldozer' (Rackham 1996: 42).

Introduction

In this chapter I examine some of the arguments surrounding the status of the soils and vegetation of Greece. In particular, I consider the question of the role that grazing has played in producing the apparently 'degraded' nature of much of Greece's vegetational communities and soils. Within this debate, however, is an underlying current, rarely visible but nonetheless, highly treacherous: the issue of uniformitarianism in archaeology—the assumption that well-documented behaviours in the present and immediate past can be read back into the more distant past.

The application of uniformitarian assumptions concerning human behaviour is a major methodological issue in archaeology, relating to fundamental questions about the applicability of analogies, whether conscious or unconscious (e.g. Johnson 1999: 54-63; Trigger 1989: 362-67, 389-91). Whatever the rights and wrongs of uniformitarian assumptions, it is generally accepted that analogies based on them are more convincing in contexts where there is a direct cultural continuity between the present and the past (Johnson 1999: 61; Trigger 1989: 391)—a situation which pertains in the context of the present discussion (though cf. Johnson 1999: 61, who suggests that it is inapplicable in European archaeology). Nevertheless, it is a matter of debate whether the direct historical approach can be readily applied to Greece in the Classical period, for instance. Its applicability to prehistoric Greece is even more debatable (e.g. Johnson 1999: 61-62; Trigger 1989: 362, 364).

Despite the uncertainties both about uniformitarian assumptions relating to human behaviour and about the direct historical approach, the idea that the apparently 'degraded' vegetational communities and soils of present-day Greece can be explained as being the direct result of overgrazing, excessive wood cutting and other forms of land abuse is dependent on uniformitarian arguments. The aim of the present contribution is neither to question nor to uphold the uniformitarian approach in archaeology. Rather, I attempt partially to sidestep the issue by examining the actual historical and ethnographic evidence concerning the exploitation of a specific uncultivated Greek landscape. In this way I set the issue of the use/abuse of the 'wild' landscapes of Greece within the more integrated cultural context of real, functioning, rural economies over time.

Two different strands of uniformitarian thinking are involved in more extreme versions of the idea that Greece's present landscape represents centuries, if not millennia, of environmental abuse. The first is the attempt to impose ideas derived from temperate zone ecology onto Greece's ancient (and not so ancient) past. This approach is perhaps better described as pseudo-uniformitarianism, and it is allied with what has been described as pseudo-ecology (Rackham 1996). Rackham has argued that the idea of ancient Greece as a land of noble forests and crystal fountains, now destroyed by centuries of mismanagement, has a history which dates back at least to the later eighteenth century (1996: 27-28). These ancient forests and fountains owed more to the France of Marie Antoinette, the natural environment of their author, the Abbé Barthélémy (1788), and his fertile imagination, than to the reality of ancient Greece. This kind of uniformitarian thinking is a hardy perennial (Rackham 1996: 27-28). Less than 20 years ago a forestry specialist declared that the lack of perennial grasses in Mediterranean plant communities was a result of pastoral mismanagement (Thirgood 1981: 68). In actuality, perennial grasses typify temperate zone grazing environments: in Greece 'natural' pastures recognizable in temperate European terms are largely restricted to Alpine-type environments for good climatic reasons, not because of mismanagement (Rackham 1983: 322; Forbes 1998: 21).

The other uniformitarian issue concerns the extent to which it is possible to apply observations on present-day pastoralism to antiquity and prehistory in the Mediterranean. Recent thinking has tended to suggest that models based closely on present-day or even mediaeval practices of transhumant pastoralism have little relevance to Classical antiquity or prehistory (Halstead 1987; Hodkinson 1988; Garnsey 1988; though cf. Isager and Skydsgaard 1992: 96-104). Nevertheless, claims that the degraded state of soils and vegetational communities in Greece stem from inappropriate grazing and wood-cutting regimes over long periods are heavily dependent on uniformitarianist assumptions.

There are many variants of the basic theme that past mismanagement of landscapes in Greece explains the present state of soils and vegetation. Many are carefully documented and cautiously worded (e.g. van Andel *et al.* 1997). At their crudest, however, the arguments involved tend to use both the uniformitarian approaches identified here. A writer observes that most vegetational communities in the uncultivated landscape are radically different from 'natural' plant communities found 'back home' in the temperate zone, being usually both much lower-growing and often more widely spaced than in temperate zone woodland. Signs of recent grazing activity and woodcutting are then observed within these environments. The writer then jumps to the conclusion that if humans and their herbivores had been excluded from these communities, 'natural' forests would have grown up providing fine stands of trees which could have been felled for good quality timber. I explore the Western cultural background to this contradictory thinking elsewhere (Forbes 1997: 187-91), but it is salutary to remember that English forests have been subject to regular wood cutting and to grazing by both domesticated and managed 'wild' animals for hundreds of years (Rackham 1989: 1-19) yet are perceived by most who visit them to be 'natural' environments, untrammelled by regular interference from humans or their animals. Also, those of us who live in the temperate zone and are tempted to decry the wanton mismanagement of the Greek landscape should be aware of Rackham's (1983: 346) observation on the vegetation of the Boeotian landscape, which has changed less in 2500 years than that of England in the last 1000 years and that of New England in the last 180 years.

Although anthropologists and others are becoming increasingly aware of the utility of sources, both oral and documentary, from previous centuries (e.g. Bennet and Voutsaki 1991; Cherry *et al.* 1991; Davis 1991; Sutton 1991), as yet forms of land use even two to three centuries ago are not well understood (Forbes 2000). A clear and detailed understanding of the ways in which exploitation of the Greek landscape has occurred in the immediate past and how that exploitation has or has not changed over recent centuries is an essential first step to understanding the history of postglacial soils and vegetation. It is also an essential prerequisite to uniformitarianist attempts to explain present-day Greek vegetational communities and soils. Yet this strand in the investigation of the Greek past is still in its infancy. Thus we find ourselves in a situation where there is little detailed understanding of the ways in which the Greek landscape was exploited in the eighteenth, nineteenth and earlier twentieth centuries. At the same time the complex details of research on the subject relating to the later twentieth century are easily ignored by those who prefer to paint stark pictures on broad canvasses. This is evidently a fragile academic environment.

The Problem

The existence in present-day Mediterranean landscapes of 'degraded' vegetation types and abundant examples of erosion is a leitmotif of Western scholars who concern themselves with the region (e.g. Goudie 1990: 53-54; Vita-Finzi 1969). Of particular significance in this context has been the growing realization that substantial erosional events or phases have occurred in postglacial—including historical—times. Although Vita-Finzi (1969) originally argued for a climatic cause for a phase or phases of postglacial erosion in the Mediterranean, a number of observers have blamed them on the destruction of the natural vegetation by human communities and their animals (e.g. Thirgood 1981: 112, 153-55; Jameson *et al.* 1994: 325; van Andel *et al.* 1997: 54-55). The activities of pastoralists, and above all the effects of the appetite of the goat, are still regarded by many as the main cause of degraded vegetational communities and of erosion, although others have questioned the extent to which human activities have been the cause of environmental changes in the Aegean area (e.g. Moody 1997).

The idea that pastoralists, heedless of the long-term consequences, over-exploit or otherwise damage their grazing if given the chance, is a long-standing one (e.g. Goudie 1990: 52-53; Thirgood 1981: 66, 73, 75). Over-exploitation and resultant environmental degradation are considered particularly likely where, as in much of Greece, grazing lands are common lands (e.g. Thirgood 1981: 123-49; for a much more balanced picture, see Koster 1997). Moreover, the assumption that, all things being equal, resources in common ownership will be over-exploited by all, has been given something approaching scientific status (if not holy writ) in Garrett Hardin's influential 'The tragedy of the commons' (1968).

It is often forgotten that the apparent causal relationship between 'degraded' vegetation and eroded landscapes, on the one hand, and destructive pastoralism, on the other, has had very little genuinely scientific study to substantiate it. Hardin's original article, and many of the publications which followed from it (e.g. Hardin and Baden 1977) are primarily political position-papers, not detailed ecological or ethnographic studies. (Significantly, in England, Rackham (1989: 140) notes that the historical record demonstrates that the removal of commoners' rights generally resulted in the rapid destruction of forests by their private owners, not their long-term preservation.) Other observers of Mediterranean landscapes, having noted the existence of what they perceive as 'degraded' plant communities (though cf. Rackham 1983; 1996: esp. 18-22) and the regular presence of flocks of sheep and/or goats in them, have jumped to the conclusion, without further investigation, that the one is directly caused by the other.

A small number of studies have examined in some detail the relationship between caprovines and the Mediterranean plant communities on which they graze and browse, although they have usually been very limited in both spatial and chronological terms. Some of the more detailed studies of the effects of exploitation by humans and their animals on local vegetational communities have questioned the received wisdom (e.g. Kolars 1966; Forbes and Koster 1976; Koster 1997). But they seem to have been largely ignored by those who believe, with Thirgood (1981: 66) that 'the proclivity of the Mediterranean shepherd ... is too well established to require documentation'. Likewise, Rackham's (1983) detailed study of the effects of grazing and wood cutting on vegetational communities and erosion is still being discounted in favour of environmental mismanagement explanations for historical period erosion.

An example of the ways in which uniformitarian assumptions are employed even in carefully researched publications can be seen in van Andel *et al.* (1997: 50). They present observations of erosion, made during the 1970s and 1980s in one extremely small valley in the southern Argolid; evidence for the presence of grazing caprovines and of abandoned terraces is used to explain the observed erosion. These observations are then used to explain widespread evidence of erosion in classical antiquity, based on the unsupported claim that terraces 'have been used since at least Classical times' (van Andel *et al.* 1997: 47). Foxhall (1996), however, has demonstrated that clear historical or archaeological evidence for terracing in classical antiquity is very hard to discover, and that trenching rather than terracing was the land management system probably practised on the estates of the elite—the group from whom we derive our historical records. She concludes that it 'is unrealistic to expect that the present system of land management can be projected back infinitely into the past on a substantial scale' (Foxhall 1996: 64).

The idea that pastoralists mismanage common pastures to secure and indeed maximize their short-term advantage has been undermined by a number of recent studies. First, although over two thirds of the pastures in modern Greece are publicly owned (i.e. 'commons'), a large amount of grazing is privately owned (Koster 1997: 172). Not only are substantial areas of uncultivated pasture under private ownership, but also a significant proportion of pastures consists of privately owned arable land which is exploited by caprovines when not under cultivation. The existence of these extensive areas of privately owned grazing and the extent to which livestock management strategies incorporate the use of privately owned arable land are often forgotten by those who assume that pastoralism is associated almost exclusively with the uncontrolled exploitation of common land (see Forbes 1995: 330-31). In addition there seems to be a correlation between high rural population densities and those areas in which private pasture is found (Koster 1997: 167-70, 173). In other words, the areas where population pressure on resources is highest, and therefore the risk of over-exploitation by overgrazing is the greatest, tend to be those in which grazing is privately owned, and therefore not open to an unmanaged free-for-all.

It is likewise a fact that claims of mismanagement of pastures are frequently made by those who have little understanding of the exigencies of making a living from the uncultivated landscape. These, therefore, are the views of outsiders, some of whom are convinced that indigenous peoples are incapable of understanding their own long-term advantage or, indeed, of responsible management of their own environments. Those who adhere to the 'Mediterranean-as-goat-desert' school of thought too often seem to consider indigenous populations as no different from naughty and ignorant children who do not know how to behave; hence the complex ways in which local communities interact with their own environments have rarely been considered (Forbes 1997).

The present paper investigates two issues. (1) It views the exploitation of the uncultivated landscape from the point of view of local populations: of the people who depend on their local environments for fuel and other necessities, and the pastoralists whose livelihoods are dependent on the well-being of their animals. This viewpoint is in marked contrast to that of Western pundits, whose livelihoods depend on eye-catching headlines and doom-laden statements, but who have no such lifelong relationship with these landscapes. (2) It emphasizes the need to investigate genuine historical data, rather than making historical assumptions based largely on synchronic data—if anything at all. Both of these issues will be considered within the context of a specific area of Greece: the Southern Argolid.

The Indigenous Viewpoint

In this section I indicate that, although the uncultivated landscapes in the Southern Argolid region are, technically speaking, common lands, there is no unregulated free-for-all in which pastoralists maximize their short-term gains at the expense of long-term sustainability. Indigenous thinking and practices within the community ensure that numbers of animals do not exceed the capacity of the landscape to support them. In addition, I show that the majority of the rural population, and not merely pastoralists, has been dependent on the products of the region's common lands. Nevertheless, the amounts of material removed in the last two or three decades have been well within sustainable levels and, furthermore, the tradition of grazing 'territories' in common land areas has ensured that pastoralists have been able to control the levels of exploitation of these landscapes both for grazing and for non-pastoralist purposes.

The Southern Argolid is part of the driest sector of Greece: mean rainfall is under 400 mm annually (Kayser and Thompson 1964: 1.03), and generally restricted to the winter months from November to March, even in normal years. Annual agricultural returns (NSSG unpublished) from Kranidhi, the main urban centre of the region, between 1968 and 1977 are especially instructive because during that time-span they included comments on rainfall and other aspects of weather conditions. In 50% of these years rainfall was reported as less than adequate for arable agriculture. Weather conditions for livestock were reported as favourable only once in the decade, and growth of natural pasture was reported as regular in only two years out of the ten.

The factors of low rainfall with a relatively high interannual variability, allied with low winter temperatures in upland locations and thin soils on the hillsides, combine to restrict plant growth severely on non-cultivated hill slopes. Such conditions are, at least potentially, tailor-made for producing imbalances between the rate of exploitation of the plant communities in these locations and plant regeneration rates. Were this to occur, we would expect the result to be rapid environmental 'degradation' and potential erosion of remaining slope soils. The extent to which such imbalances do actually occur, or have occurred in the past, must depend on whether the local population has achieved some form of long-term regulation of the exploitation of these rather delicately balanced ecological systems.

Greek agricultural service figures for the early 1980s indicated the importance of pastoralism in the region's rural economy at that time. Although only 1.6% of agrarian enterprises were entirely dependent on pastoralism, 68% of the total agrarian enterprises kept sheep and/or goats. Furthermore, in the early 1980s some 38,400 sheep and goats were grazed in the Southern Argolid annually, giving a density of over 90 caprovines for every square kilometre of the region's surface (0.9 caprovines/ha). Only 27% of this figure comprised the flocks of transhumant pastoralists; hence approximately three quarters of the sheep and goats in the region were herded by farmer-shepherds employing a variety of strategies to combine agriculture with the management of their caprovines (see Koster 1977, especially chs. 4 and 7, for a detailed discussion of some of the varied strategies employed). This represents a figure of just under five head of stock for every individual actively engaged in agriculture (*sensu lato*) in the region or 2.3 caprovines for every human in the region (based on unpublished agricultural service figures). Given the relatively low levels of plant growth and high numbers of caprovines supported by the local environment, the region is an ideal location to evaluate ideas concerning overgrazing and environmental degradation.

In the Southern Argolid, as elsewhere in rural Greece, use of the uncultivated landscape as grazing for sheep and above all for goats, has provided an income to those who might otherwise not have been able to support themselves on the produce of their own agricultural land. Detailed studies by Koster (1977) indicated that various social, economic and biological mechanisms have ensured that grazing resources have not been over-exploited. In particular, two features stand out in his work. One is the interdigitation of local-level agro-pastoralists with seasonally appearing transhumants. In this coastal area transhumant pastoralists have traditionally brought their flocks to graze during the winter months. During the summer months, when plant growth is limited by high temperatures and lack of rainfall, the transhumant pastoralists have removed their flocks to the high mountain pastures of the central Peloponnese. This has ensured a reduced level of grazing during the hot dry summer months when grazing resources are under most pressure (Koster 1977: 72-82; Koster and Koster 1976).

The other feature which has controlled animal numbers has been the explicit understanding that herders' livelihoods have depended on an adequate plane of nutrition for their flocks, which in turn has depended on controlling the numbers of animals grazing particular areas of the landscape. The most important product for these pastoralists' animals has traditionally been, and still is, milk. Without adequate nutritional levels milk production will drop drastically. Because of this, as Koster (1997: 163) notes, shepherds do not need to measure their pastures or the condition of their animals visually: they feel the quality of the grazing with their hands—via milking. Declining nutrition levels will rapidly be translated into declining milk yields. It is for this reason that, despite the appearance of cheap hired labour, via the employment of illegal Albanian immigrants, they are still reluctant to entrust the vital monitoring task of milking to those who do not have a deep personal investment in their flock's success.

For these reasons overgrazing, and the consequent drop in animals' plane of nutrition, has not been an option: undernourished animals produce little of the milk on which the pastoralist's economy depends. In addition, the period when natural grazing is frequently at its poorest occurs during the ewes' gestation period. A poor level of nutrition in pregnant ewes at this time leads to pregnancy toxaemia ('twinning disease')—a fatal disease. Herders in this region have therefore ensured that they do not overstock their pastures. This is accomplished via the maintenance of exclusive grazing territories (Koster 1977: 181-85; Koster and Forbes 2000), a practice which has controlled other, non-pastoral, aspects of the exploitation of the uncultivated landscape in the process. Each herder has aimed to maintain a sustainable number of animals in his own grazing territory and ensure that other aspects of the exploitation of the uncultivated landscape would not materially affect the grazing. Traditionally, when animal numbers exceeded the ability of the mountain grazing to support them adequately (e.g. in severe droughts), there was a significant increase in stock mortality (Koster 1977: 167-68), which kept stock numbers in a rough equilibrium with grazing resources.

The ways in which local-level mechanisms work to regulate the numbers of caprovines exploiting local natural grazing areas in the Southern Argolid and elsewhere in Greece have been documented by Koster (1997: 160-67). The system of maintaining *de facto* grazing territories (the *thesis* system) in areas in which, *de jure*, an open-access free-for-all is allowed, is one way in which pastoralists ensure the long-term viability of their grazing. Related to the maintenance of territories is the existence of density-dependent violence between competing pastoralists. Since pastoralists cannot afford to increase stock numbers beyond the level at which their grazing can support them, any expansion must be at the expense of herders with neighbouring territories. The losers in this system must of necessity reduce stock numbers if they are forced to reduce the sizes of their territories (Koster 1997: 162). Obviously, stealing another pastoralist's animals or grazing, or destroying his property, are not part of the state-sanctioned legal system, but these behaviours, like the *de facto* establishment of grazing territories in contradiction of the *de jure* rules on the exploitation of the commons, act as effective local-level checks on the overstocking of pasture.

The assumption, held by some, that the uncultivated landscapes of Greece are only used by a relatively small number of shepherds and goatherds for pasturing their animals is likewise erroneous. As I have described elsewhere (Forbes 1997) the exploitation of the uncultivated 'wastes' of Greece for all manner of products has been a vital element in rural economies until after the Second World War. In particular, it has traditionally provided fuel both for domestic use and for small-scale commercial enterprises involved in the production of charcoal and lime. Nevertheless, despite the very substantial amounts removed annually from the environment, estimates of the level of wood consumption for one southern Argolic community in the 1970s (Forbes and Koster 1976: 120-21) indicated that it was well below the one ton per hectare per year suggested by Rackham (1983: 326) as a sustainable level in Boeotia. Prior to the Second World War the use of wood cut from the uncultivated landscape had been important in the region for the commercial production of charcoal and lime (see below). Nevertheless, the cutting of wood for these activities was only conducted with the permission of the shepherds and goatherds in whose grazing territories it was carried out. In this way pastoralists were able to control the level of exploitation of their *de facto* territories, thus ensuring that their flocks' milk yields were not adversely affected (Forbes 1997: 200-201; Koster and Forbes 2000).

Historical Data

In this section I evaluate the 'tragedy of the commons' argument via the examination of historical documentary sources. So far I have considered the situation concerning the exploitation of the uncultivated landscapes of the Southern Argolid largely from a synchronic viewpoint. The question arises: can these essentially synchronic data be 'read back' further into the past? Part of the answer lies in a diachronic analysis of populations of caprovines and humans in the region over a period of 300 years, indicating that the region's indigenous populations have been able to exploit their environments in a sustainable way over the long term.

While the evidence presented in the previous section can tell us how uncultivated landscapes have been exploited at sustainable levels over the last few decades, it does not tell us whether it used to work in the same way in the past. For example, in the 1960s, the Greek government introduced regulations on the exploitation of the uncultivated landscape of the Southern Argolid for commercial activities, such as the production of charcoal and lime. Thus by 1970 only 10 tonnes of brush was cut for lime-burning—and none thereafter—and production of charcoal from non-cultivated sources averaged 44 tonnes in the years 1970 and 1971. These figures contrast with recorded peaks of production in the inter-war years: over 2100 tonnes of brush cut for lime burning in 1938 and almost 800 tonnes of charcoal produced in 1937 (Dhasonomio unpublished: the figures include public and private land). The data therefore suggest that government regulations were instrumental in bringing about the complete cessation of the use of fuel cut from common lands for commercial lime and charcoal manufacture in the 1970s. In the past, central government in Greece was less able to exercise effective control over matters such as wood cutting and grazing. Does this mean that in earlier periods there was no effective means of controlling the exploitation of the uncultivated landscape?

In reality, the apparent picture of successful government intervention is largely illusory. Forest Service personnel emphasized that, in the Southern Argolid at least, these regulations were largely superfluous. The use of fuel cut from the uncultivated environment for charcoal and lime burning stemmed from the needs of the local community for cash. The work was highly unpleasant and sometimes dangerous; usually only the poorest in the region participated in these activities. By the later 1960s a surge in Greece's economic development was well under way. Other sources of paid employment, especially in the merchant marine and the tourist and construction industries, provided far better financial reward for less effort. At the same time, the appearance of bottled gas cooking stoves and the ready availability of factory-produced cement and lime drastically undermined demand for locally produced charcoal and lime. Forest Service personnel therefore attributed the demise of these local industries less to government regulations than to economic development.

The unpublished data provided by the Forest Service indicate that the production of charcoal and lime burning was only important for a short period during the twentieth century. Its rise and demise closely parallels that of the commercial exploitation of another product of the 'wild' landscape, on the peninsula of Methana not far from the Southern Argolid: wild oregano (Clark 1997). Like the Methanites' exploitation of wild oregano, lime and charcoal burning in the Southern Argolid rose to importance in the inter-war years of the twentieth century, as an opening for those with few other economic options for obtaining cash, at a time of increasing monetization of the Greek economy. The Forest Service records indicate a rapid rise in the production both of charcoal and of lime during the 1930s. Thus the amount of scrub cut for lime burning from common lands rose from 4250 *zighia* in 1932 to more than 12,800 *zighia* in 1938 (1 *zighi* = 100 *okadhes*; 1 *oka* = 1.27 kg). The annual production of charcoal from common lands rose from 9500 *okadhes* in 1932 to 18,000 *okadhes* in 1937 (the figure for charcoal was not recorded in 1938).

The economic catastrophe of Greece's entry into the Second World War, and the subsequent occupation of the country by Axis Alliance powers, put a temporary halt to these activities. Nevertheless, it is important to stress that their cessation owes nothing to a lack of fuel brought about by over-exploitation. Continuing economic problems associated with the Greek Civil War following the end of the Second World War meant that charcoal and lime burning did not resume on a commercial scale until the beginning of the 1950s. The entry in the Forest Service log for 1958 indicates no charcoal produced from common lands but brush cutting for lime at mid-1930s levels. Nevertheless, just over a decade later these activities on the common lands had all but ceased, because of economic changes, not because of the effectiveness of government regulations nor because of the exhaustion of the fuel resources.

It is evident therefore that the commercial exploitation of common lands in the Southern Argolid was a short-term episode, responding to particular circumstances of industrialization and monetization in the economy. It cannot be directly applicable to previous centuries in uniformitarianist terms. It is likewise evident that external, central government regulation of these activities in this case was not primarily responsible for their cessation. Rather, as noted in a previous section, effective control over the exploitation of the fuel resources on the common lands was wielded at the local level by the shepherds in whose grazing areas the fuel-cutting occurred.

What of these shepherds controlling their *de facto* grazing territories? Is there any evidence that they have resisted the urge to maximize their short-term advantage by over-grazing their territories? Koster's study of twentieth-century archival sources for a large village in the Southern Argolid, where pastoralism was a major economic activity, indicate that the total number of sheep and goats pastured within the community remained remarkably stable from 1940, when the document began, to the mid-1970s (Koster 1977: 171-73). Stocking densities for this community have largely stayed between 1.0 and 1.5 head of stock per hectare of grazing land over a period of some 35 years, despite the upheavals caused by the Second World War, the ensuing civil war and major changes in the Greek agrarian economy. Only in one year did the stocking density rise above 2.0 head per ha (Koster and Forbes 2000).

Other historical documents provide us with longer-term historical data on caprovine numbers in the Southern Argolid. Although they lack the detail of Koster's archival sources, they nonetheless indicate that local-level mechanisms for maintaining sustainable numbers of animals were not merely a twentieth-century phenomenon. The following discussion is dependent on Table 7.1, which tabulates the data derived from historical sources.

A cadastral survey undertaken in the last decade of the seventeenth century is the start-

Table 7.1. 300 years of pastoralism in the Southern Argolid

	Total sheep + goats	Sheep + goats per ha of total area	Goats per ha of uncultivated area	Sheep + goats per head of agricultural population	Sheep + goats per head of total population	Olive trees
1980s	38,400	0.90	0.81	<5.0	2.3	660,000
1960s	41,075	0.94	0.84			
1930s[1]	50-55,000	1.15-1.26				
1880s						163,000
1860s[2]		(1.11)		(9.4)	(4.4)	
1690s[3]	23,900	1.15-1.57	0.88		14.5	9,000

1. Informed estimate.
2. Data for 1860s derived from *nomos* of Argolis and Korinthia, not *eparkhia*.
3. Administrative area significantly smaller in 1690s than in the nineteenth and twentieth centuries.

ing-point of the sequence (Topping 1976; Forbes 2000). The *catastico ordinario* lists the region's population and agrarian wealth from the period of the short-lived Second Venetian Occupation of the Peloponnese (1684–1715). Particularly noteworthy are the very low human population—less than one quarter of the population in the region in 1928 (Panaghiotopoulos 1985: 247-48)—and the evidence of ruined houses and uncultivated land. The existence of land lying uncultivated is supported by a letter to Venice from the Venetian chief administrator: 'they love idleness and cultivate only enough for their precise needs, being inclined to maintain large flocks in order to get a return without sweat' (Topping 1976: 95).

Despite the administrator's statement, which may relate primarily to his frustration at not being able to raise more taxes, analysis of the *catastico ordinario* suggests that the region was not suffering from over-exploitation by pastoralists at that time. Thus the figures for caprovines per ha of the total surface area indicate that stock numbers were being carefully controlled. Three groupings of communities identified as being independent grazing nexuses (Forbes 2000) show a narrow range of 1.15–1.57 head per ha, which is closely comparable to the estimated figure for the inter-war years of this century of 1.15–1.26 sheep and goats per ha of surface area.

If we examine the cadastral data in more detail we see further similarities with the twentieth century. Thus the overall figure of 0.88 goats per ha of non-cultivable land area in the Southern Argolid in the 1690s is not much higher than the figure for goats per ha of uncultivated land documented for the 1960s, which stands at 0.84 per ha. It is also virtually identical to the 1982 figure for the village of Dhidhima, the main pastoralist community in the region today: 0.87 goats per ha.

On the other hand, because of the low human population, the figure of 14.5 caprovines per person is extremely high. All the available evidence suggests that pastoralism was the region's primary cash-generating activity, with agriculture being practised largely for subsistence (Forbes 2000). Thus at that time there were less than 9000 olive trees in the region, compared to c. 660,000 in the 1980s. On the other hand, some wealthy landowners kept large numbers of beef cattle: two monasteries, the region's main landowners, accounted for 330 between them. The existence of beef cattle in large numbers at that time is an important indirect indicator that, despite relatively large numbers of caprovines, grazing was anything but under pressure. Cattle need significantly better quality grazing than either sheep or goats.

Some 160 years after the period of the *catastico ordinario* we have a further document which helps us to follow the course of pastoralism in this part of Greece. In 1867 Alexandros Mansolas published the results of statistical researches into the population and economy of Greece at that time. The data are more general than we might wish, but are nevertheless suggestive. For the province of Argolis and Corinthia, of which the Southern Argolid was a part, we have an overall figure of 1.11 caprovines per ha. This generalized, province-wide figure is very close to that from Ermionis at the end of the seventeenth century. Significantly, however, stock numbers per head of population had dropped since the earlier date, to c. 9.4 per head of population engaged in agriculture. This is because human population levels had risen very sharply following the end of the Greek War of Independence some 30 years previously. Caprovine numbers, however, were apparently being kept pegged at a relatively steady level which would not endanger the area's grazing potential (Mansolas 1867: 89-90).

The fact that the human population increased dramatically over approximately 150 years, but that there was no corresponding increase in caprovine numbers, emphasizes the effectiveness of the local controls over animal numbers. This is not at all what one would expect from a population engaged in unregulated exploitation of the local environment.

Accurate figures of the caprovine population of the region in the twentieth century prior to the 1960s do not seem to exist. However, an informed estimate by a member of staff at the region's agricultural service veterinary clinic suggests a figure of 50,000–55,000 during the inter-war years. This would give figures of 1.15–1.26 sheep and goats per ha of surface area. Unpublished Forest Service statistics and accompanying explanatory notes (Dhasonomio unpublished) for 1968 support informant comments that stock numbers dropped after the Second World War although the decline was apparently not spectacular: 0.94 caprovines per ha of total surface area, and 0.84 goats per ha of grazing land. Statistics for the 1980s also confirm informant comments on a continuing decline: 0.88 caprovines per ha of the total area and 0.73 goats per ha of grazing land (NSSG unpublished).

These bald statistics, while less than ideal, nevertheless give us an idea of the trend of caprovine numbers in the Ermionis region of Greece over a time-span of some 300 years. Historically the time-span includes three invasions, two violent revolutions, phases of profound economic stagnation as well as major economic development, and above all, massive human population change. During much of these three centuries, the amount of control over the exploitation of the local environment provided by centralized government has been minimal. These conditions could be considered ideal for encouraging short-term thinking and consequent over-exploitation of the natural grazing resources of the area, especially as the local human population expanded and more mouths had to be fed, bodies clothed, and so on. Yet the documentary and oral history data indicate that this is precisely what the local population did not do.

Of course, the figures indicating that the numbers of caprovines in the region have remained remarkably constant over three centuries do not by themselves indicate a sustainable level of grazing. However, as noted above, detailed estimates of the amount of vegetation removed by a rural community in the Southern Argolid via grazing and wood cutting (Forbes and Koster 1976) indicated that the levels concerned were well within sustainable limits. Since a substantial portion of the vegetation removed was for domestic fuel, it is likely that this element in the equation would have been lower in previous centuries when population levels were lower.

Geological evidence supports these observations on sustainability. Van Andel *et al.* (1997: 53-54—see also Jameson *et al.* 1994: 412-14) have identified only thin and sparsely distributed alluviation dating to the period from the mediaeval Frankish occupation to the present day (the 'Kranidi alluvium'). The age and history of the different deposits belonging to this phase seem to vary in the different drainage basins, although there are problems with dating the deposits (van Andel *et al.* 1997: 53). It is suggested that these variable ages and histories, even within the restricted area of the Southern Argolid, are 'related to very local economic and demographic changes, which bring about changes in land use and, especially, the neglect of terracing' (Jameson *et al.* 1994: 414). Significantly, the most recent examples quoted are all well away from the sectors of the landscape in which grazing and fuel-cutting have traditionally been concentrated (van Andel *et al.* 1997: 53-54). Nevertheless, it is also admitted that the period of the deposition of the Kranidi alluvium includes the period of the climatic changes brought about by the Little Ice Age. Although some of the small patches of alluvium seem to postdate this climatic oscillation, van Andel *et al.* (1997: 54) accept that some examples might be attributable to it. Jameson *et al.* (1994: 194), however, place the overall level of mediaeval and postmediaeval alluviation into a longer term perspective by noting that 'Extrapolating generously, human activity has aggravated the erosion of the mountains, but the landscape of Classical times was not much richer in soil than it is now'. Thus the varied lines of evidence present a strong case that the amounts of grazing and wood cutting conducted in the uncultivated landscapes of the Southern Argolid over the last 300 years have not been beyond sustainable levels.

How did the expanding local population continue to support itself via the land if expansion of pastoralism was not an option? One answer can be seen in the right hand column of Table 7.1. Over the course of 300 years there has been a massive expansion of olive cultivation in the region. The reasons behind the phenomenon seem to have been complex, but involved economic, demographic, sociological and technological factors. These are discussed in some detail elsewhere (Forbes 1993); here it is sufficient to note that, although some expansion of olive cultivation into previously uncultivated areas would have taken place, much would have occurred on land already under cultivation. Thus olive cultivation allowed new avenues for intensification of production without competing directly with pastoralism. In addition, during the nineteenth and earlier twentieth centuries most of those who owned substantial areas of olives were from the wealthier end of the social spectrum. Oral testimony, backed up by Forest Service records (Dhasonomio unpublished), suggests that households at the poorest end of the social spectrum were the most likely to engage in the exploitation of the uncultivated landscape for forest products: lime-burning and charcoal burning in particular, but also resin tapping. As noted above, these activities were only conducted with the explicit permission of the pastoralists within whose grazing territories they occurred, and pastoralists would only give that permission if their own livelihoods were not jeopardized.

Conclusions

Ethnographic studies indicate that, under the conditions prevalent in the Southern Argolid in the twentieth century, short-termism, over-exploitation and degradation of grazing resources have simply not been an option. In addition, historical data indicate that local-level practices to maintain grazing animals and grazing resources have been in existence in the region for at least the last 300 years. It is not possible to move on from these observations to say that no pastoralists over-exploit their resources anywhere: what I have presented here is merely a case study. Neither do I wish to claim that the very clear evidence of Holocene period erosion in Greece cannot have an anthropogenic cause and therefore must be explained climatically. Nor yet do I wish to claim knowledge of levels of grazing and wood cutting in the Southern Argolid prior to the late seventeenth century.

This study does, however, indicate that those who maintain that pastoralists generally —or even Greek pastoralists generally—are constitutionally incapable of exercising self-restraint in the exploitation of common grazing resources must provide more evidence than the forestry specialist who stated:

> In modern times, grazing is the most obvious, and probably the most significant force in the destruction of the Mediterranean landscape. The effects of over-grazing may be seen throughout the basin: degraded soils, active erosion and plant denudation are apparent almost everywhere. Over many hundreds of square miles, soils are trampled and rock outcrops visible, perennial grasses are depleted and replaced by annuals and less palatable herbs. Trees and bushes are browsed to cushions or drastically lopped for fodder. Too often, generations of overgrazing by goats have stripped great tracts of land of the plants which hold the soil together, churning the topsoil to powder; wind and rain complete the devastation, transforming great expanses to desert wasteland (Thirgood 1981: 68).

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8

Land Use in Postglacial Greece: Cultural Causes and Environmental Effects

Paul Halstead

The relationship between landscape change and land use has attracted the interest of both palaeoecologists and archaeologists. The palynological and geoarchaeological records document dramatic alterations to the landscape of Greece during the postglacial period (e.g. Bottema 1994; van Andel *et al.* 1990) and there can be little doubt that these changes result from the interaction of natural and anthropogenic processes. Human land use has thus been widely cited as a destructive agent by palaeoecologists, while inferred changes in vegetation or land forms have been treated as evidence for the nature and scale of agricultural or pastoral land use (e.g. Bottema 1982; Willis and Bennett 1994; van Andel *et al.* 1986). Models of early land use have, in turn, been deployed in attempts to understand such diverse aspects of human culture as Neolithic settlement patterns (e.g. van Andel *et al.* 1995) and residential strategies (e.g. Kotsakis 1999), Bronze Age settlement nucleation (Gamble 1982) and regional redistribution (e.g. Renfrew 1972; 1982), and Neolithic–Early Iron Age upland colonization (e.g. Sampson 1992; Halstead 1991) and artefactual style zones (Cullen 1984; Kilian 1973).

Unfortunately, it is often hard to disentangle anthropogenic causes of landscape change from natural processes, such as climatic change, rising sea-level, tectonic activity, ecological succession, or expansion of plant species from glacial refuges. Neither anthropogenic nor natural processes have left wholly unambiguous signals in the palynological and alluviational records, so that most attempts to infer causality have revolved around temporal and spatial patterning in landscape change (Endfield 1997; also Frederick 2000). Climatic forcing tends to be invoked if landscape changes appear to be contemporary over a wide area, while anthropogenic causation is favoured if landscape changes coincide with cultural phenomena: for example, with alterations in the density and distribution of settlements or, more enigmatically, with the chronological periods (Late Bronze Age, Roman, and so on) into which prehistorians and historians conventionally divide the past (e.g. Bottema 1982).

Two major weaknesses of this approach are obvious. First, correlation is often assumed rather than demonstrated. In Greece, absolute dates for palaeoecological sequences tend to be sparse and so practitioners may be reduced to circular reasoning based on similarities between palynological cores or geoarchaeological sections. Dating evidence for archaeological sites is usually more abundant, but the chronological resolution of surface survey data may still be too coarse to detect significant short- or medium-term shifts in patterns of settlement or land use. Secondly, correlation is not the same as causation (Buckland *et al.* 1997), because of the complexity of natural and cultural processes and of the relationship between them (e.g. Frederick 2000). Because of threshold effects in environmental systems, there may be a time lag between natural or anthropogenic cause and its effect on the landscape. Likewise, the sensitivity of the landscape to such forces varies in space, in accordance with local and regional variation in geology, relief, aspect, altitude, latitude and so on. Moreover, the severity of anthropogenic impact on the landscape depends not only on the amount of land use, which might be inferred very crudely from settlement pattern data, but also on the types of land use practised. For example, the introduction of terracing has been invoked to account for the inconsistent relationship during the Bronze Age between alluvial deposition and settlement density in the hilly southern Argolid (van Andel *et al.* 1986). The type of land use practised is, in turn, related to human settlement and demography in complex ways which further obscure the relationship between cultural causes and environmental effects (e.g Cherry *et al.* 1991; Davis 1991; Whitelaw 1991; Acheson 1997).

This last issue, neglected in some previous literature, is the initial focus of this paper. To this end, alternative models of land use are explored, together with their possible relationship with other aspects of human culture and their likely impacts on the palaeoecological record of landscape change. Current debate on the nature of early agro-pastoral land use in Greece is then reviewed and, in conclusion, some implications for future investigation of changing landscape and land use are briefly discussed.

Land Use in Postglacial Greece: Research Strategies and Alternative Models

Analyses of charred plant remains and animal bones from excavated settlements present a fairly consistent picture of the range of crop and livestock species raised by Neolithic and Bronze Age farmers (e.g. Payne 1985; Hansen 1988; Halstead 1994: 204-205, table 1; 1996: 28-29, table 1) and also sporadic insights into the ways in which these species were managed, but fall far short of a clear picture of the nature and scale of early agro-pastoral land use. For the Late Bronze Age, Linear B texts provide some detail on patterns of land use, but only in so far as this was of administrative interest to the palatial elites (Halstead 1992a). For early historic Greece, classical writers may reveal more of contemporary agronomic theory and cultural values than of agricultural practice, while potential bioarchaeological evidence has largely been neglected. In consequence, whether implicitly or explicitly, rival reconstructions of early land use have relied heavily on the accommodation of the patchy and ambiguous available data to competing models.

One influential model has been that of 'traditional' (pre-mechanized) Mediterranean land use, as described by historians and geographers (e.g. Semple 1922; Braudel 1975; Grigg 1974). Two distinctive and inter-related features of such traditional farming were: (1) extensive growing of cereals, in alternation with bare (i.e. cultivated) fallow, in the lowland plains; and (2) 'transhumant' movements of large flocks of sheep and goats between winter pastures in the lowlands and summer pastures in the high mountains. These twin characteristics have been widely regarded as necessary or optimal responses to the long-term constraints and challenges of Mediterranean climate and topography and, on these grounds, have been extrapolated to later prehistory and early history (e.g. Jarman *et al.*

1982; Isager and Skydsgaard 1992). Recent examples of sedentary herding (in both the uplands and lowlands) and of intensive continuous cropping of cereals and pulses, however, show that traditional farming is not a *necessary* response to Mediterranean environment (Halstead 1987a). Closer examination suggests that extensive cereal agriculture and transhumant pastoralism are only optimal responses to the Mediterranean environment under specific historical conditions.

Extensive agriculture has been characteristic of large land holdings, on which the ground was prepared for sowing by plough oxen, weeds were controlled by bare-fallowing (again using plough oxen rather than human labourers), and cereals were grown in preference to labour-intensive pulses. In this way, despite modest area yields, cereals were grown on a large scale with minimal investment of human labour, so that a large surplus was available for sale to urban consumers. Large amounts of human labour were only needed at harvest time, when gangs of reapers were temporarily mobilized. Traditional extensive agriculture is thus based on sharp inequalities of land ownership, whereby some can maintain plough animals and use large tracts of land unproductively but profitably, because many others with little or no land provide a market for staple grains and a source of seasonal harvesting labour (Karavidas 1931; Vergopoulos 1975; Halstead 1995).

Mobile pastoralism has likewise been characteristic of large-scale, specialized herders, who produced cheese, wool or textiles and, latterly, lambs or kids for the urban market and bought cereal staples from lowland farmers. The extent of dependence on the market is made clear by the negative impact on these pastoralists of competition from imports of wool and cheese, in recent decades, and of textiles, during the Industrial Revolution. Seasonal mobility between lowland winter and upland summer pastures served two ends. On the one hand, it enhanced the quality of nutrition and productivity of livestock. On the other hand, by securing access to large expanses of natural pasture rather than cultivated or collected fodder, it made possible the extensive management of large flocks with modest human labour. In winter, these herders depended on the fallow fields of lowland arable estates to provide the consolidated blocks of rich pasture essential for efficiently running large flocks of milk-sheep. Following the nineteenth–twentieth century AD dissolution of such estates in lowland land reform, numbers of transhumant animals declined sharply, giving way to more intensive husbandry of smaller and more sedentary flocks (Karavidas 1931; Campbell 1964; Vergopoulos 1975; Koster 1977; Psikhogios and Papapetrou 1984; Nitsiakos 1985; Chang 1992).

Traditional extensive cereal agriculture and mobile pastoralism enjoyed a symbiotic relationship (Karavidas 1931) and both were dependent on the existence of urban markets and on markedly inegalitarian patterns of land ownership. In Braudel's terms, they are not exemplars of a timeless Mediterranean *longue durée* but are contingent on a medium-term, historical *conjuncture* and, as such, should not be extrapolated uncritically to the distant past.

An alternative model of land use can be distilled from the activities of recent small-scale farmers, who cultivated modest areas of land and kept modest numbers of livestock, largely for domestic consumption (du Boulay 1974; Psikhogios 1987; Chang 1994; Forbes 1976; 1982; 1998; Blitzer 1990; Halstead 1990; Halstead and Jones 1989; Jones *et al.* 1999). Such farmers typically used more intensive methods of husbandry (manual weeding, regular manuring, cereal-pulse rotation, stall-feeding and so on) and raised a relatively balanced mixture of both crop and livestock species, partly to secure a broad range of products, partly to make full use of household labour and land, and partly to minimize the risk of total subsistence failure. Such farmers, of course, were also products of a particular historical *conjuncture*. On the one hand, small-scale farming activity was often the result of deliberate circumscription by wealthier land- or herd-owners (e.g. Karakasidou 1997). On the other hand, the economic viability of smallholders was often dependent on periodic employment, whether as seasonal labourers in extensive agricultural enterprises or as artisans within the urban market economy. Nonetheless, the intersection between small-scale, intensive and diversified farming may offer a useful model for a putative, prehistoric–early historic 'domestic mode of production', preceding or peripheral to the appearance of markedly unequal access to the means and fruits of production.

This heuristic opposition between extensive/specialized and intensive/diversified farming masks a great deal of variability in husbandry practices, with complex implications for the relationship between land use and landscape change. Nonetheless, there are several reasons why, other things being equal (e.g. for a given size of human population and degree of settlement dispersion/nucleation), extensive systems of land use might be expected to leave a stronger palaeoecological signal than intensive systems.

First, extensive crop husbandry is primarily geared to minimizing labour costs rather than maximizing area yields and so, for a given level of grain production, is likely to involve annual sowing of a larger area than would be needed under intensive husbandry. Extensive husbandry also tends to involve regular cultivated fallowing, to control weeds, and so is likely to entail annual *tillage* (for sowing and fallowing combined) on a much larger scale than would intensive husbandry, which tends to be characterized by crop rotation with infrequent fallowing. Extensive crop husbandry should thus be more amenable to detection in the palynological and geoarchaeological records because it would entail a greater overall scale of clearance and tillage, respectively, than intensive husbandry. Secondly, the cultivated fallow commonplace in extensive cultivation leaves more of the landscape bare of vegetation, and so vulnerable to erosion by wind or rain, for more of the year.

Thirdly, because cultivated land is often divided into units of a size which can be tilled and sown in a day, individual land parcels tend to be larger under extensive plough-agriculture than under intensive hoe-cultivation. Extensive crop husbandry also tends to be more specialized and so favours the devotion of large contiguous blocks of land to the same crop sown at the same time, whereas small-scale husbandry typically involves a broad range of crops and these are often scattered in space to reduce the risk of wholesale failure. Likewise, with animal husbandry, contiguous blocks of land, sown and harvested at the same time and subdivided by insubstantial boundaries, greatly facilitate grazing by large herds and, in recent decades, both large arable estates and village communities have often coordinated crop-growing regimes for this reason. Conversely, small-scale mixed farmers are more likely to favour plot boundaries which impede the movement of livestock and so allow them to be enclosed rather than herded while grazing. Such walled and hedged boundaries tend to harbour trees which are often managed as a source of fresh leafy fodder or dried leafy hay, but such provision is usually practicable only for modest numbers of livestock. Thus, extensive land use, both arable and pastoral, tends to create large blocks of cleared land, relatively amenable to the transport of 'anthropogenic indicator' pollen and relatively vulnerable to erosion. Conversely, intensive cultivation is characterized by more fine-grained cultural landscapes in which both pollen transport and erosion should be impeded by surviving vegetation cover. The planting of trees and construction of field terraces, which involve investments of human labour more compatible with intensive than extensive farming, similarly create more fine-grained and stable landscapes. Such 'conservationist' practices have certainly been undertaken widely by small-scale farmers within living memory and the hilly regions of Greece, of which they are typical, were relatively free of large agricultural estates during the nneteenth and twentieth centuries AD (McGrew 1985; Psikhogios 1987; see also Silverman 1968).

Fourthly, although livestock are kept all year round in all parts of Greece, the highest stocking densities have typically been achieved by specialized pastoralists, who move large flocks seasonally between complementary summer and winter pastures. In mountainous areas such as the Pindos, the tree-line is now advancing upwards with the recent contraction in transhumant pastoralism (e.g. Halstead 1991), making it clear that the extensive summer pastures of the high mountains have partly been created and maintained by grazing pressure. This pressure has largely been exerted by seasonally transhumant flocks, because livestock resident year-round in the high mountains must be stall-fed over winter and so their numbers are limited by the labour-costs of collecting leafy hay and other forms of winter fodder (Halstead 1998a). The shredding of trees for leafy hay plainly played a major role in shaping the recent mid-altitude vegetation of the Pindos, but as part of a mosaic of small fields interspersed with managed and unmanaged trees (Halstead and Tierney 1998). Thus, specialized pastoralism, by suppressing tree cover on watersheds, might be expected to accelerate highland erosion, while a lowered tree-line might well lead to reduced arboreal:non-arboreal pollen ratios in a nearby, high-altitude coring site. Conversely, sedentary mixed farmers would again be expected to create a less detectable, mid-altitude mosaic of open patches and woodland, while the impact of shredding for leaf fodder on pollen rain would depend on such details of management as whether or not the crowns of trees were cut (cf. Rasmussen 1990: 79).

In the lowlands, the contrasting influence of large- and small-scale animal husbandry on the cultivated landscape has already been noted. The extent to which grazing transforms *uncultivated* parts of the landscape depends, of course, on the number and type of animals, and the duration, season and frequency of their presence. The effects of overgrazing are rapidly apparent to herders in declining milk yields or weight loss (e.g. Forbes 1997; Koster 1997) and, contrary to the popular assumption that herding inevitably involves overgrazing, recent pastoralists in Greece have adopted a number of formal or informal mechanisms for controlling access to pasture (e.g. Nitsiakos 1985; Chang 1992; Koster 1997; Forbes this volume). Nonetheless, grazing and browsing have plainly influenced the composition and structure of vegetation, as has herders' periodic use of burning to create pasture which is more palatable and nutritious or available at a more critical time of year (e.g. Turrill 1929; Rackham 1983). The extent to which grazing pressure or burning may be evident in the palaeoecological record partly depends on the palynological visibility of different plant communities, but the abundance of microscopic charcoal in pollen cores may provide an independent measure of burning (see Atherden this volume).

Although herding activity is highly variable, and its impact on the landscape complex, a broad contrast can again be drawn between large- and small-scale animal husbandry. In the recent past, only large herds (sedentary or transhumant, owned by pastoralists or rich arable farmers) have tended to make much use of distant rough grazing lying beyond the limits of cultivation, while small household flocks have usually been run in the interstices of the cultivated landscape. Thus, for a given overall number of livestock, a few large herds are more likely than numerous small herds to range outside the cultivated sector and so to transform also the uncultivated part of the landscape. Because the uncultivated parts of the landscape are often relatively steep, with a relatively thin soil covering, extensive herding is also more likely to trigger severe erosion and, in consequence, radical degradation of vegetation. Incendiary interventions aimed at improving pasture quality are probably attributable, for the most part, to those managing large herds, because herders of small groups of animals can usually find adequate patches of good grazing (e.g. along field edges, or by seasonal streams). Overall, therefore, extensive systems of land use, pastoral as well as arable, seem more likely than intensive systems to have left their mark in the palaeoecological record.

Early Agro-Pastoral Land Use in Greece: The Intensive Mixed Farming Model

A definitive diachronic account of the changing nature of agro-pastoral land use in the Aegean area would be premature and, anyway, beyond the scope of this paper. Instead a brief outline of previous arguments will attempt to highlight the key assumptions which underpin them and to identify areas of uncertainty or contention.

From the Early Neolithic (seventh millennium BC) onwards, archaeobotanical and archaeozoological evidence from habitation sites is strongly dominated by remains of domestic crops and livestock, leaving little doubt that some sort of agro-pastoral farming supported most of the archaeologically visible population (Halstead 1989). The relative importance of crops and livestock to subsistence or land use cannot be inferred directly from such evidence, but consideration of the size and distribution of human population allows this issue to be approached indirectly.

From a fairly early stage of the Neolithic, the most frequent form of settlement in the more fertile, and apparently most heavily populated, lowland areas of eastern mainland Greece seems to have been some form of 'village', housing between several tens and a few hundreds of persons. In at least one region, eastern Thessaly, long-lived settlements of this sort were spaced as closely as 2–3 km apart from the Early Neolithic (Perlès 1999), while the patchy Neolithic evidence for season(s) of occupation is perhaps most economically interpreted in terms of year-round habitation (Becker 1999; Halstead 1999). Local communities of such size and permanence, and regional populations of such density, could have been supported by crop production on a relatively modest scale, but a major contribution to subsistence from livestock would arguably have required intensive 'dairy' management and/or the keeping of very large numbers of animals. Mortality evidence for the commonest domestic animals, sheep (or goats), suggests a 'meat' or mixed purpose strategy of management rather than intensive dairying (Halstead 1989; cf. Payne 1973; Halstead 1998b), while the difficulty of detecting evidence for Neolithic clearance in the admittedly coarse palynological record from large basins (Bottema 1982; Willis and Bennett 1994) does not favour belief in animal keeping on a very large scale. During the Bronze Age (third and second millennia BC) and early historical period (first millennium BC), as a settlement pattern of villages interspersed with larger centres progressively characterized most of lowland Greece, the nutritional dependence of most of the population on crops is likely to have become even more inevitable (e.g. Foxhall and Forbes 1982).

Nonetheless, livestock are likely to have been of considerable economic, cultural and social significance to such crop-growing communities: as a form of 'indirect storage' against the periodic failure of staple crops (Halstead 1993); as a vehicle for the accumulation and display of wealth and status (Chang and Koster 1986); and as means of negotiating and reaffirming social ties through the exchange of livestock and use of meat in hospitality (e.g. Halstead 1992b). The cultural significance of livestock in the Neolithic is perhaps mirrored by the frequent occurrence of animal figurines alongside representations of humans, houses and various domestic facilities and furniture (e.g. Toufexis 1994). For the Late Bronze Age and early historic period, this is confirmed more explicitly by artistic and textual evidence for the consumption of domestic animals in elite-sponsored feasts and sacrifices (e.g. Vanschoonwinkel 1996; Killen 1994; Jameson 1988). Late Bronze Age texts also imply that woollen textiles, woven in palatial workshops, played a role in the marking and perhaps negotiation of social status (Killen 1985) while, for the early historic period, the keeping of horses was an indicator of high status (Hodkinson 1988; 1991).

As regards the scale and intensity of land use, the diversity of crops (in particular, the relatively balanced representation of cereals and pulses) and livestock in Neolithic and Bronze Age assemblages from Greece is more reminiscent of recent small-scale, intensive husbandry than of extensive farming (Halstead 1994; 1996; cf. Forbes 1976). The link between the diversity of crops and livestock and the intensity and scale of husbandry is partly based on assumptions of economic rationality (e.g. efficient use of land and labour; risk avoidance) and so must be extrapolated to the past with caution. The diversity of the bioarchaeological record contrasts strikingly, however, with the textual evidence from Late Bronze Age southern Greece for highly specialized palatial involvement in farming. Palatial intervention in grain crops was apparently restricted to the large-scale production of one or two types of cereal, using palatial oxen for tillage and dependent labourers for harvesting. Palatial interest in livestock was concentrated on the management of tens of thousands of wool sheep, run in individual flocks of up to several hundred head. Thus, there is unambiguous evidence of large-scale, extensive agriculture and specialized animal management in the Late Bronze Age, but perhaps restricted, as in the recent past, to a powerful minority, while the bulk of the population continued to practise small-scale, intensive husbandry (Halstead 1992a). More direct evidence for the nature of arable farming, from the analysis of weed ecology, is so far restricted to Late Bronze Age Assiros Toumba, a possible crop storage centre in northern Greece (Jones 1987), where growing conditions of cereals seem, in part, to have resembled those characteristic of intensive horticulture (Jones 1992; cf. Jones et al. 1999; Bogaard *et al.* this volume). Although a single site is an inadequate basis for generalization, this study lends support to the argument that extensive agriculture was not practised universally in Late Bronze Age Greece. Bioarchaeological evidence is extremely sparse for the early historic period, but written sources again imply that extensive agriculture and large-scale herding were restricted to the wealthier elements in society and co-existed with intensive mixed farming by those less well-off (Hodkinson 1988; also Forbes 1995; Horden and Purcell 2000).

Thus it is argued that early agro-pastoral land use was initially dominated by small-scale mixed farming, with elements of extensive agriculture and large-scale herding being adopted by part of the population during the later Bronze Age and early historic period, but not demonstrably from an earlier date. This model of changing land use is consistent with increasing evidence during the later Bronze Age for marked social inequality—a corollary of recent extensive husbandry. It is also consistent (if extensive farming is more amenable than intensive farming to palynological detection—see above) with the first unambiguous traces during the second millennium BC of anthropogenic impact, including both crops and 'disturbance' indicators, in regional-scale pollen diagrams (Bottema 1982; Jahns 1993; Zangger *et al.* 1997).

Van Andel and Runnells (1995) have suggested that Early Neolithic cultivation in Greece exploited naturally irrigated and fertilized floodplains. The predominant late winter (snow-melt) floods of major north Greek rivers, however, may have been incompatible with the probable autumn germination season of early cereal crops (Hillman 1981: 147-48) and, for simple topographic reasons, floodwater farming can never have been practised by many Neolithic communities (Wilkie and Savina 1997; Perlès 1999). Anyway, *if* agronomically viable, the floodwater farming model is not incompatible with small-scale, intensive husbandry. A more serious and radical challenge to the intensive mixed farming model is posed by an issue neglected in the preceding discussion, that of the relationship between land use and 'marginal colonization'.

Land Use in the Later Neolithic and Initial Bronze Age: Pastoralism, Herding and Marginal Colonization

Whereas early farming villages are concentrated in relatively fertile and well-watered parts of lowland Greece, Late-Final Neolithic (late sixth to fourth millennia BC) and Early Bronze Age (third millennium BC) sites are also widespread in agriculturally more marginal parts of the Greek landscape, including the southern mainland and islands of the central and southern Aegean. Over much of this area, growing-season rainfall is, on average, close to the minimum needed for successful cereal and pulse crops and, in many years, falls below this level, while relatively thin and infertile soils often exacerbate the risk of drought and pose other limitations on crop growth. Other things being equal, therefore, crop husbandry would have been a less reliable subsistence base than in the core areas of early farming settlement, and an expansion of herding or foraging may have been favoured.

If colonization of areas marginal for crop growing provided the motive for subsistence change, associated changes in the pattern of settlement provided the opportunity. Early settlement in these marginal areas tended to be relatively dispersed, often taking the form of 'hamlets', comprising just a handful of family households, or even perhaps of isolated 'farmsteads' (e.g. Blackman and Branigan 1977; Cherry 1982; Whitelaw 1983; Branigan 1999). Such occupation sites also tend to be relatively short-lived, perhaps lasting just a few generations, making it harder to assess the density of contemporaneously occupied settlements than in the core areas, where tell villages were often occupied more or less continuously for several millennia. As a result, it cannot be argued for these marginal areas that crop-based subsistence was enforced by the large size of individual communities or the density of regional population. Although early settlers introduced various wild animals to the Aegean islands (Jarman 1996; Halstead 1987b), the sparse bioarchaeological record from LN-EB dispersed sites, such as Phylakopi (Gamble 1982), Kalythies cave (Halstead and Jones 1987), Skoteini cave (Mangafa 1993; Kotjabopoulou and Trantalidou 1993), and Zas cave (Zachos 1999) is dominated by remains of crops and livestock. This suggests that, if subsistence change accompanied marginal colonization, it would have taken the form of greater reliance on herding rather than foraging. Chronologically, this phase of marginal colonization partly overlaps with Sherratt's proposed 'secondary products revolution' (Sherratt 1981), encouraging some scholars to assume that dairy products, woollen textiles and animal traction came into use in the Aegean at this time (e.g. van Andel and Runnels 1988). Research elsewhere in Europe, however, particularly into the antiquity of dairying (e.g. Legge 1981; Halstead 1989; Rowley-Conwy 1997), suggests that this important model is better regarded as a source of stimulating questions than of ready-made answers. To what extent are motive and opportunity for increased dependence on livestock during LN-EB marginal colonization matched by evidence of a less circumstantial nature?

Widespread human use of caves is first attested in Greece in the later Neolithic, and is particularly common in agriculturally marginal areas of the southern mainland and islands. Many of these caves are ill-suited, in terms of size, illumination or accessibility for long-term residence, but some have been used in the recent past as temporary shelters for herders and/or livestock. On the other hand, caves were obviously used for a variety of purposes in later prehistory, including burial and other forms of ritual (Demoule and Perlès 1993) and also storage (Sampson 1992), and need not be linked with herding. Moreover, although caves tend to be located, for obvious reasons, in rocky terrain, many have nearby traces of recent or even current cultivation and so cannot be regarded as herding sites simply on the basis of location. For example, the LN-FN cave of Skoteini, in the hills of Evvia in central Greece, has been interpreted as a seasonal base for mobile herders partly because of its location in an area of broken terrain, more suited to herding than mechanized cultivation (Sampson 1992; 1993). Non-mechanized cultivation is still practised in the vicinity of the cave (Jones *et al.* 1999), however, and abandoned terraces show that crop growing was very widespread a few decades ago. During the twentieth century, the cave has regularly been used to shelter livestock—but by mixed farming households living year-round in the nearby village of Tharounia. Even if LN-EB cave use was largely related to herding, therefore, this might simply represent the expansion of mixed farming communities into areas well endowed with caves (i.e., convenient, natural shelters) rather than a significant shift in the balance between arable and pastoral land use.

Some LN-EB open sites have also been interpreted as herders' camps. In the hills of Epirus, north-west Greece, in an area now largely given over to grazing rather than cultivation, excavation of the tiny FN site at Doliana revealed two successive floors which could have belonged to a small hut of the sort occupied seasonally by recent transhumant pastoralists (Dousougli 1996), but flimsy structures are not a wholly reliable indicator of seasonal habitation. In the southern mainland, several survey projects have encountered a rash of LN and/or FN open sites, often small in area and sometimes in similar locations to the folds of modern shepherds or goatherds (Johnson 1996; Cavanagh 1999). Several of these sites have yielded restricted ranges of artefacts which, if not the result of partial preservation, might indicate some function other than permanent habitation (Johnson 1996: 65-66; Cavanagh 1999: 36). There is no unambiguous link, however, between assemblages lacking ceramics or quernstones and herding. There are also dangers in viewing the arable potential of such sites from a modern, mechanized perspective and some of the steeper and barer slopes of southern Greece may have been blessed with a significant covering of soil in the Neolithic (Wells *et al.* 1990). On the other hand, Cavanagh notes that, in some parts of southern Greece, LN-EB 'marginal colonization' took place against a background of apparently sparse occupation of areas more favourable to cultivation. Thus the location of sites on barren limestone outcrops may not have been the enforced outcome of population pressure and could be seen instead in terms of the selective occupation of parts of the landscape favourable to grazing (Cavanagh 1999: esp. 36-37). Such areas may have been particularly susceptible to destabilization by grazing, which might in turn be reflected in the palaeoecological record.

In a comparative analysis of geoarchaeological evidence from inland north-east Thessaly and from the Argive plain and adjacent hills of the southern Argolid in the southern mainland, van Andel *et al.* (1990) argued that the postglacial period has been characterized for the most part by landscape stability, periodically interrupted by brief phases of erosion and deposition. The dating of these sequences is rather coarse, but the phases of instability apparently occurred at different dates in each study area, favouring anthropogenic rather than climatic causation, and in each case started several centuries after local evidence for the inception of farming, suggesting anthropogenic disturbance related to cultivation or grazing. Broadly similar sequences have subsequently been reported for the coastal area of southeast Thessaly (Zangger 1991) and for coastal Pieria in central Macedonia (Krahtopoulou this volume). Substantial Neolithic–EB episodes of anthropogenic landscape destabilization are not easily compatible with the model of small-scale and stable early horticulture (van Andel *et al.* 1990), but might be explicable in terms of an expansion of herding from the later Neolithic onwards. On the other hand, phases of landscape instability appear to have been short-lived (van Andel *et al.* 1986) and, in at least some cases, may have taken the form of rare catastrophic events (Zangger 1991; 1994; Moody 1997). In the latter case, human land use may well have made the landscape more or less susceptible to extreme weather conditions (with extensive grazing rather than intensive cultivation perhaps the more plausible agent of *widespread* disruption—see above), but alluvial deposits are unlikely to be a reliable guide to the timing, nature and scale of anthropogenic alteration of the landscape.

Palynological evidence is also ambiguous. A widespread expansion of hornbeams during the sixth–third millennia BC has been interpreted in terms of increases in both precipitation (van Zeist and Bottema 1982) and browsing or cutting (e.g. Jahns 1993; Halstead 1994; Willis 1994a; but cf. Willis 1994b). In the long Quaternary sequence from L. Giannina, however, these taxa appear to have expanded at a similar stage during earlier warm periods (Tzedakis 1994), thus casting doubt on an anthropogenic interpretation. Most of the pollen evidence from Greece comes from large lakes or bogs with extensive catchments and so would be insensitive to local anthropogenic interference with vegetation. Small catchment cores, however, spanning the mid-Holocene expansion of hornbeams, have been taken in Epirus, north-west Greece: from Rezina at 1800 m (Willis 1994a) in the Pindos mountains; and from Gramousti at 400 m (Willis 1994a) and Tseravinas at 450 m (Turner and Sánchez-Goñi 1997), both in the nearby inland basin of Doliana. At Rezina, some time after the initial expansion of hornbeams, a clear decrease in arboreal pollen relative to that of herbaceous taxa, possibly accompanied by influx of sediment from surrounding slopes, occurs in zone RM5 from c. 5000 BC (6000 bp). Willis argues for similar changes at a similar date in Gramousti zone GL4 and, on this basis, suggests anthropogenic impact in the form of transhumant herding (Willis 1994a; 1997), but the claimed relative expansion of herbaceous pollen is not unambiguous until the later zone GL5 and dating is complicated by inconsistencies in the available C14 dates. Nonetheless, in the nearby Tseravinas core, the expansion of hornbeams after c. 5500 BC (6500 bp) in zone TS5 is accompanied by a clear reduction in arboreal pollen and an increase in herbaceous pollen, and also by high magnetic susceptibility values and an abundance of charcoal fragments. Together these complementary lines of evidence do suggest anthropogenic disturbance in the vicinity of, and roughly contemporary with, the FN site of Doliana. This unusually early evidence for human impact in the palynological record from Epirus should probably be attributed to the sensitivity of small catchment cores, however, rather than to regional differences in land use, because archaeological evidence for Neolithic settlement is much more abundant in most other parts of mainland Greece.

Neither the geoarchaeological nor the palynological record is easy to interpret, in terms of the *causes* of landscape change. In each case, however, there is evidence of mid-Holocene landscape change, potentially compatible with anthropogenic disruption and perhaps, more particularly, with an expansion of herding activity. This evidence is sufficient to justify, at least, a reconsideration of the archaeozoological evidence for the scale of LN–EB herding.

Heavy reliance on livestock for subsistence in agriculturally marginal areas would arguably have required one or more of the following strategies: the keeping of very large numbers of animals; highly productive, intensive dairying; and specialization in animal products (e.g. cheese, meat or livestock, wool or textiles) for exchange (Halstead 1996). Absolute numbers of livestock are rarely retrievable from faunal evidence, but seasonal movement and specialization in one species help to relax the constraints on stock numbers posed by pasture and herding labour, respectively. As regards seasonality of occupation, the three cave sites of LN–FN Skoteini in central Greece (Kotjabopoulou and Trantalidou 1993), LN–EB Zas on Naxos in the central Aegean (Halstead 1996), and LN–FN Kalythies on Rhodes in the south-east Aegean (Halstead and Jones 1987), and the 'marginal' open sites of LN Kastri on Thasos in the northern Aegean (Halstead 1987b: 79 fig. 3b) and Doliana in Epirus (Halstead *et al.* in prep.) have yielded remains of very young livestock. This suggests a human presence at least in late winter/early spring, the time of year when, according to some scholars, mobile herders might have abandoned the higher sites of Zas (630 m), Skoteini (450 m) and Doliana (400 m) for pasture at lower altitude. Thus the available evidence does not support mobility over distances long enough to entail seasonal occupation of sites, although it does not preclude the use of these sites as winter bases for summer grazing at higher altitudes. In terms of species composition, none of these sites is highly specialized: at Doliana, sheep, cattle and pigs are all well represented; at Kastri and the three cave sites, and also at the marginal open site of FN Kefala on the central Aegean island of Kea, there are few cattle or pigs but fairly balanced proportions of sheep and goats (Halstead 1996: 31 fig. 2).

At Zas, Skoteini, Kalythies and perhaps Doliana, the slaughter of sheep and goats combined was consistent with an unspecialized 'meat' strategy and, at Zas, this was separately demonstrable for each of these two species. Thus at none of these sites does mortality evidence suggest intensive dairying and so strengthen the plausibility of direct dependence on livestock for subsistence, while neither mortality evidence nor body part representation indicates specialization in animals or animal products for exchange (Halstead 1996: 32). Faunal evidence implies, therefore, albeit indirectly, that dependence on livestock for subsistence in areas of LN–EB 'marginal colonization' is unlikely. No support is offered to Cavanagh's (1999) suggestion, that marginal LN–EB sites in southern Greece may have been occupied by herders living in a symbiotic exchange relationship with other, crop-growing communities. On the contrary, the faunal record is consistent with the argument that specialized pastoralism is dependent on a market economy and so unlikely to have developed in the Aegean in prehistory (Lees and Bates 1974; Cherry 1988; Halstead 1991; but cf. Chang and Koster 1986).

As Cavanagh (1999) has pointed out, however, it is an unhelpful oversimplification of the problem to consider only the polarized alternatives of small-scale, sedentary mixed farming and large-scale, mobile pastoralism, ignoring the possibility of intermediate herding strategies characterized by short-distance mobility. It was argued above that, at early farming villages, livestock played an important role in indirect storage, in negotiating wealth and status, and in lubricating social relationships. An LN–EB expansion in the scale of animal keeping might be expected, therefore, for two reasons. First, as already noted, farmers in agriculturally marginal areas are likely to have been more frequently and heavily dependent on livestock as a means of banking against, and responding to, crop failure. Secondly, even in core areas of early farming settlement, the progressive LN–EB isolation of the family household and reduction in social pressures towards sharing (Halstead 1999) would have increased the incentives to accumulate wealth in the form of livestock. The faunal record may offer indirect support for such an expansion in numbers of livestock.

Faunal assemblages from early village sites are overwhelmingly dominated by sheep, the domestic animal most suited to the grazing and manuring of cultivated land, as well as consumption of crop residues and food waste. Early animal husbandry may, therefore, have been closely integrated with, and thus limited by the scale of, arable farming. LN–EB assemblages in the same areas tend towards a more balanced mixture of sheep, pigs and cattle, while the marginal assemblages from Skoteini, Kalythies, Zas, Kastri and Kefala (but not Doliana) have low percentages of pigs and cattle and are dominated by sheep and goats. This divergence in the composition of faunal assemblages may be explicable in terms of the contrasting environments of these two types of site, with pigs and cattle exploiting woodland pannage and browse in the fertile lowlands, and goats exploiting the more rugged, scrubby parts of the landscape in 'marginal' areas. This would imply that LN–EB stock rearing may have expanded, in terms both of numbers of animals and of the scale of herding movements, beyond the limits set by close integration with the cultivated landscape.

The sorts of grazing movements hypothesized by Cavanagh and Johnson, therefore, may reflect such a growing scale of animal husbandry within an essentially mixed farming regime. The steep and barren areas described by these authors would have supported seasonal (early) flushes of grazing. Such patches of nutritious pasture are keenly sought after today, for their ability to fatten animals, improve milk yields, or enhance reproductive success. For the Neolithic farmer, the use of surplus grain or flushes of natural pasture would have been alternative ways of building up the household herd which served as both a subsistence bank and a store of wealth. For example, for a household recovering from a bad harvest, with no grain to spare as fodder and with most of its livestock either eaten or exchanged for grain, intensive use of good seasonal pasture might have been an effective way of fattening up, or improving the fertility of, remaining animals. Likewise, a household with 'surplus' herding labour (e.g. with teenage children) could have enhanced its wealth in this way. Under such circumstances, even in a lightly populated landscape, seasonal patches of distant but good pasture might well have been sought and efforts might well have been made to extend their availability in time or space by measures such as burning. Seasonal herding at a distance from the 'home' village is also likely to have served other cultural roles (cf. Broodbank 1993; Barrett 1994: 132-53; Edmonds 1997: 105): as a rationale for exploring the wider landscape and acquiring arcane knowledge or exotic resources; as an opportunity for meeting members of other communities engaged in similar movements; and perhaps as a rite of passage for those guarding wandering livestock against predators.

This 'narrative' moves beyond the polar opposition between large-scale, mobile pastoralism and the household herd tethered to the vicinity of the settlement. The suggestion that livestock, although subsidiary to crop growing, was increasingly important through time, is consistent with available faunal data, does not entail potentially anachronistic assumptions about pre-market symbiosis between herders and crop growers, and can accommodate the possible hints in the site survey and palaeoecological records that LN–EB livestock may have ranged some distance away from cultivated areas. Perhaps more important than the capacity of the model to reconcile apparently conflicting lines of evidence is that it carries implications for future research. For a full understanding of the nature and scale of early animal husbandry, and of its relationship with crop husbandry, it is necessary to track the movement of livestock through the prehistoric cultural landscape. To this end, isotopic analysis may shed light on the broad geographical scale of movements (across watersheds or between lowland and highland—d'Angela 1992; Wiedemann *et al.* 1999), while dental microwear and coprolite evidence of diet may provide finer-grained insights into the particular pasture or fodder niches occupied (e.g. Mainland 1998a; 1998b; Anderson and Ertug-Yaras 1998; Charles 1998).

Conclusion

Previous debate on the nature of early farming in the Aegean area has largely revolved around two related issues: the opposition between extensive ('traditional') and intensive strategies of crop and stock husbandry; and the balance between arable farming and herding. The available evidence, though sparse and often circumstantial, is compatible with the dominance of intensive mixed farming during the Neolithic, with the patchy adoption of extensive farming from the latter part of the Bronze Age, and with the absence of specialized pastoralism before the historical era.

Care must be taken, however, not to conflate pastoralism (a more or less specialized way of life), herding (the management of livestock by either mixed farmers or specialized pastoralists), and seasonal mobility (practised, on varying spatial scales, by both mixed farmers and pastoralists). If, as seems almost inevitable, prehistoric livestock served as a buffer against subsistence failure, as a medium of social interaction, and as a form of wealth, it is also highly likely that attempts were made to fatten up livestock by taking advantage of seasonally available and spatially scattered flushes of rich grazing. The scale of stock-rearing may have expanded during and after the later Neolithic, partly as a consequence of the increasing isolation of the household as a basic unit of production and consumption and partly, in 'marginal' areas, as a response to increased risk of crop failure. These expectations are consistent with the apparent divergence in composition of faunal assemblages between 'core' village sites and 'marginal' caves and hamlets. The proliferation of cave sites and small, ephemeral open sites during the later Neolithic may also be related to such herding activity, but may partly reflect the expansion of settlement at this time into areas well endowed with caves and widely subject to intensive survey. In other words, the apparent changes in settlement evidence in the later Neolithic may reflect increasing archaeological visibility and detection of herding activities rather than an expansion of mobile herding. Independent investigation of the movement of early livestock within the landscape, as reflected in bone chemistry and dental microwear, might clarify this issue.

The relative contributions of natural and cultural agents to the postglacial development of the landscape of the Aegean will continue to be disputed until changing patterns of both climate and land use can be inferred reliably and independently. The relationships between landscape change and land use, and between land use and human settlement, are too complex and too variable for patterns of land use to be inferred solely from palaeoecological records or for the latter to be explained solely in terms of settlement patterns. Rather the scale and nature of land use must be inferred through multi-disciplinary research, combining both on-site and off-site approaches. For example, ecological analysis of arable weeds and demographic analysis of domestic animals may illuminate the intensity of farming practice; the study of plant inclusions in animal dung may clarify the degree of integration between arable and pastoral farming; and surface survey data may serve to map both the scale of human activity and its spatial distribution in the natural and cultural landscape.

While palaeoecological evidence should not be regarded as a short-cut to the reconstruction of land use, viable models of early farming practice must obviously be compatible with the palaeoecological record. In the preceding discussion, possible geoarchaeological and palynological traces of anthropogenic destabilization of the landscape have played an important heuristic role in encouraging a re-evaluation of later Neolithic land use. This re-evaluation has, in turn, identified new priorities for future research into patterns of land use. Similarly, it is hoped that the broad distinction drawn here between extensive and intensive systems of land use, with contrasting implications for the severity and detectability of landscape change, may aid attempts to interpret the postglacial palaeoecological record of Greece in terms of human impact.

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9

The Scale and Intensity of Cultivation: Evidence from Weed Ecology

Amy Bogaard, Michael Charles, Paul Halstead and Glynis Jones

Fascination with the issue of agricultural origins has perhaps diverted the attention of archaeologists from investigation of the very variable ways in which crops have been managed during the postglacial period. Methods of tillage or sowing, practices of rotation or fallowing, the weeding or watering of growing crops, and a range of other husbandry practices are of interest for a host of reasons. Such practices play a major part in determining the productivity, labour costs, reliability and long-term sustainability of crop growing and help to shape the potential for integration with animal husbandry (e.g. Fleming 1985; Halstead 1987; Hodkinson 1988; Palmer 1998a). Different crop husbandry regimes may also entail very different degrees of impact on the landscape (e.g. Acheson 1997) and, through reliance on scarce resources (such as land, work-animals or human labour), may be a trigger or symptom of social inequality (e.g. Goody 1976; Sherratt 1981; Halstead 1995).

Although details of agricultural technology or agronomic know-how may be gleaned from artefactual or artistic evidence and, in historic periods, from written sources, these rarely provide a representative picture of crop husbandry practices. For Neolithic and Bronze Age Greece, the range of staple grain crops commonly grown is now reasonably well documented by archaeobotanical evidence (Hansen 1988), but insights into likely husbandry practices from the ecological characteristics of crop species are rare. Most crops tolerate a wide range of growing conditions and have also been subject to centuries or millennia of selective breeding (e.g. Davies and Hillman 1988). For this reason, the richest source of archaeobotanical evidence for crop husbandry practices is the ecological characteristics of the weed species which once accompanied growing crops and whose seeds can be found with samples of ancient grain (Hillman 1981).

The use of archaeological weed assemblages as evidence for past crop husbandry practices must be based on modern ecological studies of relevant agricultural regimes. One of the first difficulties encountered in such studies, given the remarkable uniformity of modern agriculture, is that of locating present-day examples of the range of husbandry practices likely to have existed in the distant past. For example, whereas non-mechanized farmers in some parts of the Mediterranean basin still practise extensive cultivation of cereals and pulses (characterized by modest inputs of human labour and organic fertilizers), early cultivation may have been on a small scale and characterized by intensive inputs of human labour and/or organic fertilizers (e.g. Jones 1992). Today such a radically different arable environment is normally associated with vegetable gardens rather than with staple grain crops.

One area which satisfies at least some of the requirements for a comparative study of intensive and extensive methods of cultivation is found on the island of Evvia, central Greece, where pulse crops, especially broad beans, are grown on a range of scales and at varying levels of intensity (Jones *et al.* 1999). Here plots of cultivated pulses range from tiny gardens within the village to larger fields at some distance from habitation. Gardens are more intensively tilled and more heavily manured than fields and are more likely to be weeded and watered.

The weed species growing in these plots were systematically recorded during a field study in April–May 1988. Analysis of these data revealed that, in terms of species composition, the weed floras of these plots were closely related to three proxy measures of cultivation intensity, that is plot size, distance from village and plot type (garden, field, and so on). For example, in Figure 9.1, correspondence analysis arranges garden and field plots on the basis of weed species composition alone and reveals an ecological trend, from the smallest and most intensively managed plots in the top left of the diagram, through intermediate cases at bottom left, to the largest and least intensively managed plots on the right.

The relationship here between weed flora and husbandry regime is sufficiently strong that, if samples of harvested grain were collected from modern pulse farmers in the study area, it should be possible to gauge the intensity of cultivation on the basis of the

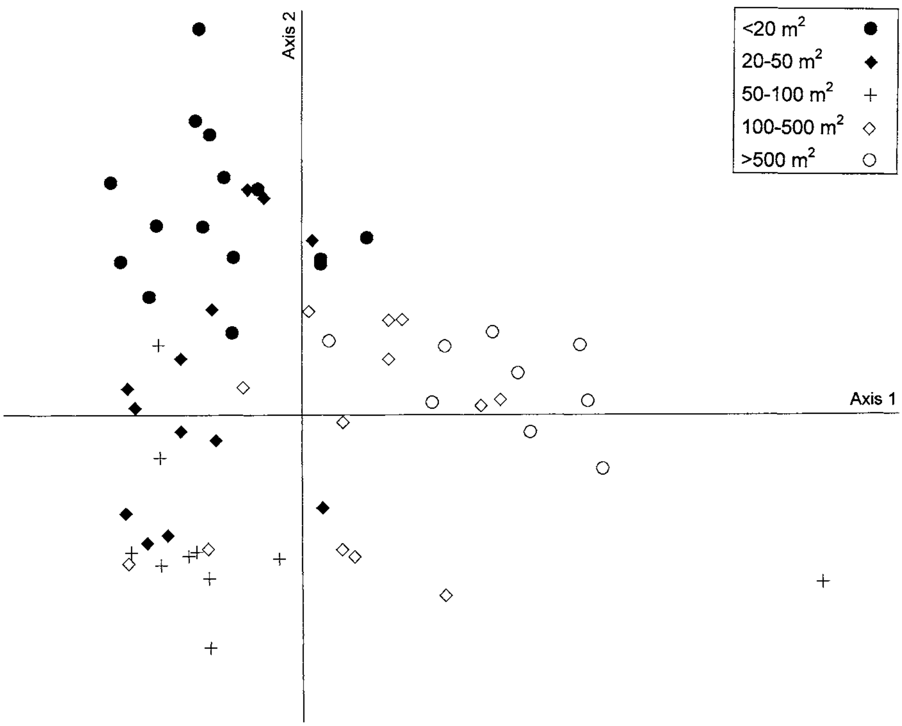

Figure 9.1 **Correspondence analysis diagram showing Evvia pulse plots arranged along the first two correspondence axes according to their weed species composition (number of 1 m^2 quadrats out of ten per plot in which each species occurred). Only species present in six or more plots (c. 10%) were included. Data points represent individual plots, with symbols indicating plot size. Axis 1 is plotted horizontally and axis 2 vertically.**

associated weed seeds. Two important limitations should be noted, however, on the practical application of this modern analogue to *archaeobotanical* weed data. First, because level of fertility and intensity of tillage are highly correlated in the Evvia pulse plots, it would be difficult to determine which of these two factors was responsible for the observed differences in weed floras. Secondly, and even more critically, it would be impossible to apply the results of this study to other times and places with a different range of weed species.

To solve both of these problems, a further field study was conducted in May–June 1997 to explore the ecology of the species encountered (Jones *et al.* 2000). Plant attributes studied included ones which measure species' ability to respond to a fertile environment (e.g. leaf area) and ones which indicates species' ability to recover from disturbance (e.g. length of flowering period). Both categories of attribute are related to plot type in a manner indicating that fertility and disturbance each played a part in determining weed species composition (Fig. 9.2). Because the same attributes can be measured on any weed species, this provides a modern analogue which can be applied to archaeological weed floras composed of species not encountered in the Evvia plots.

Although the Evvia study has not yet been applied in an archaeological context, it is worth noting that Evvia garden plots tended to be rich in weeds of the group Chenopodietea, while the field plots were rich in weeds of the Secalinetea. The Secalinetea are weeds typical of winter cereal fields while the Chenopodietea are characteristic of more fertile and more disturbed habitats (e.g. summer 'row-crops' such as potatoes). Archaeological weed assemblages containing a mixture of Chenopodietea and Secalinetea species have been recovered from a range of sites in Europe of varying date and, in a Greek context, from Late Bronze Age Assiros Toumba (Jones 1992). This encourages the view that the Evvia pulse gardens are a relevant and fruitful analogy for early crop husbandry regimes.

Prospects for archaeobotanical application would be greatly enhanced if the Evvia study were extended to embrace intensive cultivation of winter cereals. To this end, a field study is currently under way in Asturias, north-west Spain, where winter-sown spelt and emmer wheat are grown in small and intensively farmed plots (see also Peña-Chocarro 1996), in rotation with summer row-crops (potatoes and maize). Here, garden-scale cultivation of winter cereals is characterized by a mixture of the Chenopodietea and Secalinetea groups of weeds.

It should also be noted that neither the Asturias nor the Evvia study encompasses the full range of variation in cultivation intensity. In both areas, cereal crops were grown until recently in plots larger, more distant and more extensively farmed than those studied. A parallel field study in Jordan has focused on the extensive end of the spectrum of cultivation regimes, investigating alternative rotation and fallowing practices (Palmer 1998b; Bogaard et al. 1999). The ability to distinguish between continuous cropping and regular fallowing adds a useful additional dimension to the investigation of intensive versus extensive crop husbandry.

Conclusion

As has been emphasized above, the potential of weed ecology to unravel past husbandry regimes is dependent on the study of present-day weed floras and so is constrained by the availability of relevant modern analogues. Weed floras growing under husbandry conditions of potential relevance to the distant past are fast disappearing and so opportunities for

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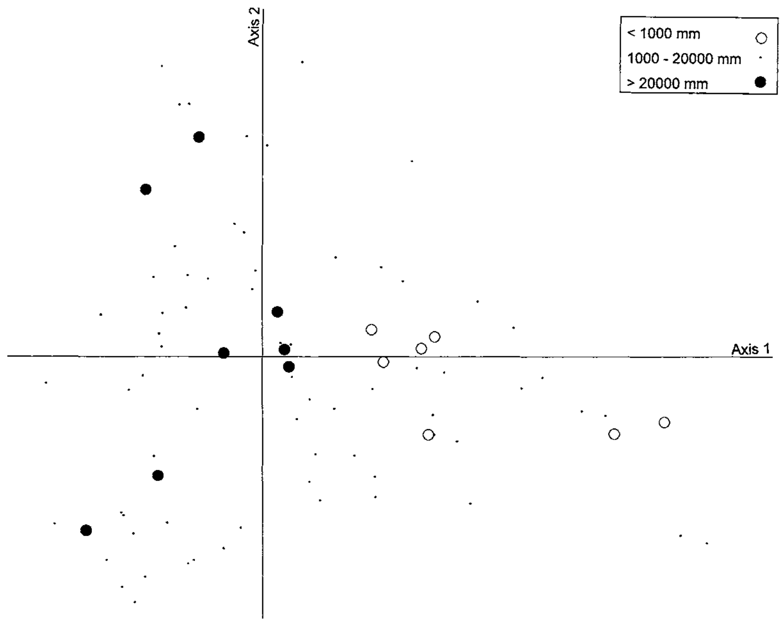

(b)

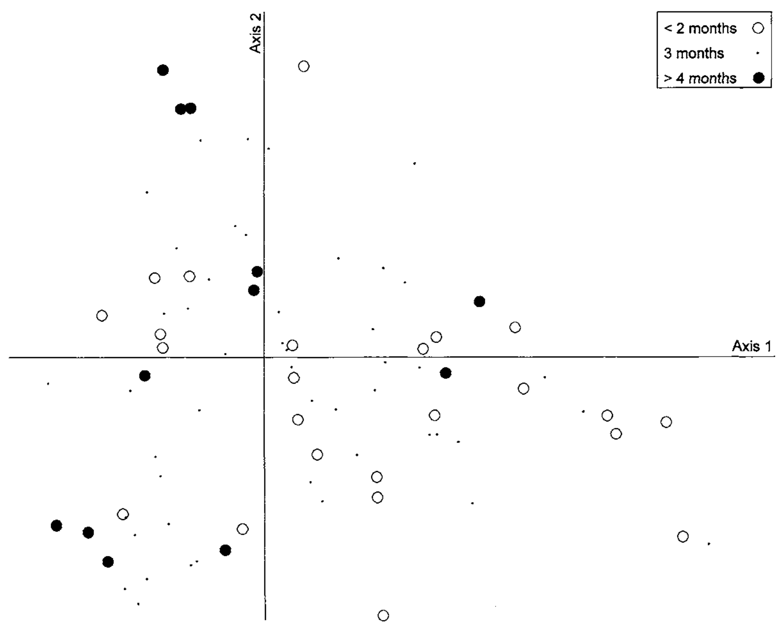

Figure 9.2. Correspondence analysis of the Evvia pulse plots—diagrams showing weed species arranged along the first two correspondence axes (extracted from the same analysis as shown in Fig. 9.1). Data points represent species coded to show (a) ratio of leaf area per node to leaf thickness, an attribute measuring species' ability to respond to a fertile environment, and (b) length of the flowering period, an attribute measuring species' ability to recover from disturbance. Axis 1 is plotted horizontally and axis 2 vertically.

actualistic research should be grasped with urgency.

Nonetheless, the preceding discussion has demonstrated the ability of weed palaeoecology to clarify the scale and intensity of ancient cultivation regimes and also to identify some of the husbandry practices which constituted these regimes. In addition to its intrinsic importance for an understanding of past economies, the intensity of cultivation regimes has great relevance to the degree to which human land use destabilizes the landscape. In general, extensive regimes seem more likely to be registered in the palynological and geoarchaeological records (see Halstead, this volume). If the nature of husbandry regimes can be independently established from on-site archaeobotanical data, therefore, interpretation of the off-site palaeoecological record should be less open-ended. Conversely, archaeobotanical evidence for the intensity of cultivation cannot reveal the aggregate scale of agricultural land use at a local or regional level, which is more appropriately explored through off-site palaeoecological studies. Closer integration of such archaeobotanical and palaeoecological studies, coupled with off-site evidence from intensive surface surveys, may in the future enable a serious investigation of both land use and its impact on the landscape.

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10

Settlement Instability and Landscape Degradation in the Southern Aegean in the Third Millennium BC

Todd Whitelaw

Introduction

Intensive surface surveys are dramatically transforming our understanding of the prehistoric Aegean (Cherry 1983; 1994; Rutter 1993; Shelmerdine 1997). To date, however, much of the discussion in the literature has been on the methodologies of field survey and site recovery, and rather less on methodologies of interpretation (though see Cherry *et al.* 1988; Alcock *et al.* 1994; James *et al.* 1994; Laxton and Cavanagh 1995; Whitelaw 1998; French and Whitelaw 1999). Similarly, while there is an increasing interest in palaeoenvironmental investigation (van Andel *et al.* 1990; Bintliff 1992; Bottema 1994), there are, as yet, relatively few studies which attempt to integrate fully these two sets of data (e.g. Halstead 1984; 1994; Jameson *et al.* 1994; van Andel and Runnels 1987; 1995). To a fair degree, this is a consequence of the relatively coarse chronological resolution of both datasets, such that attempts at causal linkage generally rest on circumstantial assumptions, or only broad synchronizations of settlement and environmental sequences within a region. At the same time, the models considered for human–environment interactions remain at a fairly simple and generally deterministic level (e.g. van Andel *et al.* 1986; Runnels and van Andel 1987).

To move beyond current interpretative assumptions will require the investment of both time and resources to establish greater chronological resolution in both settlement and environmental sequences, and more direct investigation of contexts where cultural and environmental sequences can be directly linked.

Intensive Surface Survey and Settlement Pattern Changes in the Early Bronze Age Southern Aegean

Nearly three decades ago, Colin Renfrew (1972a; 1972b) drew the attention of Aegean prehistorians to issues of regional demography, and the importance of understanding the number, relative distribution, and patterns of change in population, to the construction of Aegean social histories. Subsequent research, primarily based on the results of intensive surface survey, has demonstrated that the basic patterns he identified owe more to biases in data collection than to patterns in past behaviour. In addition, however, his basic interpretative assumptions about the size of typical sites and the proportion of sites remaining undiscovered can now be seen to have been unrealistic. Equally, recognition of the significance of changing patterns of settlement nucleation and dispersion (Bintliff 1977), calls into question all of Renfrew's original inferences derived from comparing population trajectories based on site numbers from different areas of the southern Aegean. This is hardly surprising, since no surveys comparable to what would today be recognized as intensive had been conducted in the Aegean prior to the publication of Renfrew's *Emergence of Civilisation* (Cherry 1983).

More substantively, Aegean prehistorians continue to be ambiguous about the significance of demography in the development of past societies. In Renfrew's work, this was represented by placing 'population' outside of the core interacting elements of 'the system' (1972a: 225), in an intellectual climate in which population growth was often viewed as an 'exogenous' factor in cultural development (e.g. Hill 1977).

A more effective social and dynamic perspective on regional settlement patterns and population change was initiated in the prehistoric Aegean context by John Cherry, in his interpretation of intensive survey data from Melos (Cherry 1979; Wagstaff and Cherry 1982a; 1982b). In particular, he considered the changing character of sites, not simply changes in site numbers, in a reconstruction of changing settlement systems, within a broader inter-regional context. The shift from a dispersed pattern of small sites in the Early Bronze Age, to nucleation at a single major site—Phylakopi—in the Middle Bronze Age, has become widely extrapolated as a general model for settlement pattern change in different regions throughout the southern Aegean (e.g. Dickinson 1994: 50-60).

While variants on this pattern are increasingly being documented, as other intensive surveys reach final publication (e.g. Cherry *et al.* 1991; Jameson *et al.* 1994; Cavanagh *et al.* 1996; Wells and Runnels 1996; Mee and Forbes 1997), the Cycladic data still carry considerable weight, since it is the only region of the southern Aegean where both settlement and cemetery sites of the Early and Middle Bronze Age are reasonably well known through excavation. For this reason, inferences about the character of settlement sites of different sizes are somewhat better founded than in other areas (Fig. 10.1).

The investigation of numerous Cycladic cemeteries of the Early Bronze Age indicates that the communities burying their dead in them were small, in agreement with the settlement evidence. However, in addition, the small number of individuals buried in most cemeteries demonstrates that the sites were also relatively short-lived, few representing more than the dead of a single family for more than a couple of generations (Fig. 10.2). Such temporal definition is still not possible with the coarse-grained chronologies monitored through ceramic stylistic change, so that in other areas of the Aegean, where fewer cemeteries have been investigated, documented settlement patterns are likely to be palimpsests.

General standardization of intensive survey field-walking methods, since the early 1980s, has documented the small size of most Early Bronze Age sites in the southern Aegean with greater precision (Fig. 10.3). A small number of somewhat larger sites, usually situated in low-lying valleys or plains, has generally been interpreted as the focal points of small-scale settlement systems. However, if one considers not just the distribution of sites of different sizes, but also the boundaries of the areas surveyed intensively, any tendency toward the clustering of smaller sites around the larger examples, may be more a function of the size of the survey 'windows', than a real behavioural pattern (Fig. 10.4). Similarly, the large gaps between areas intensively surveyed, if not dictated principally by topography, may give an unrealistic idea of the spatial extent of such small-scale settlement systems.

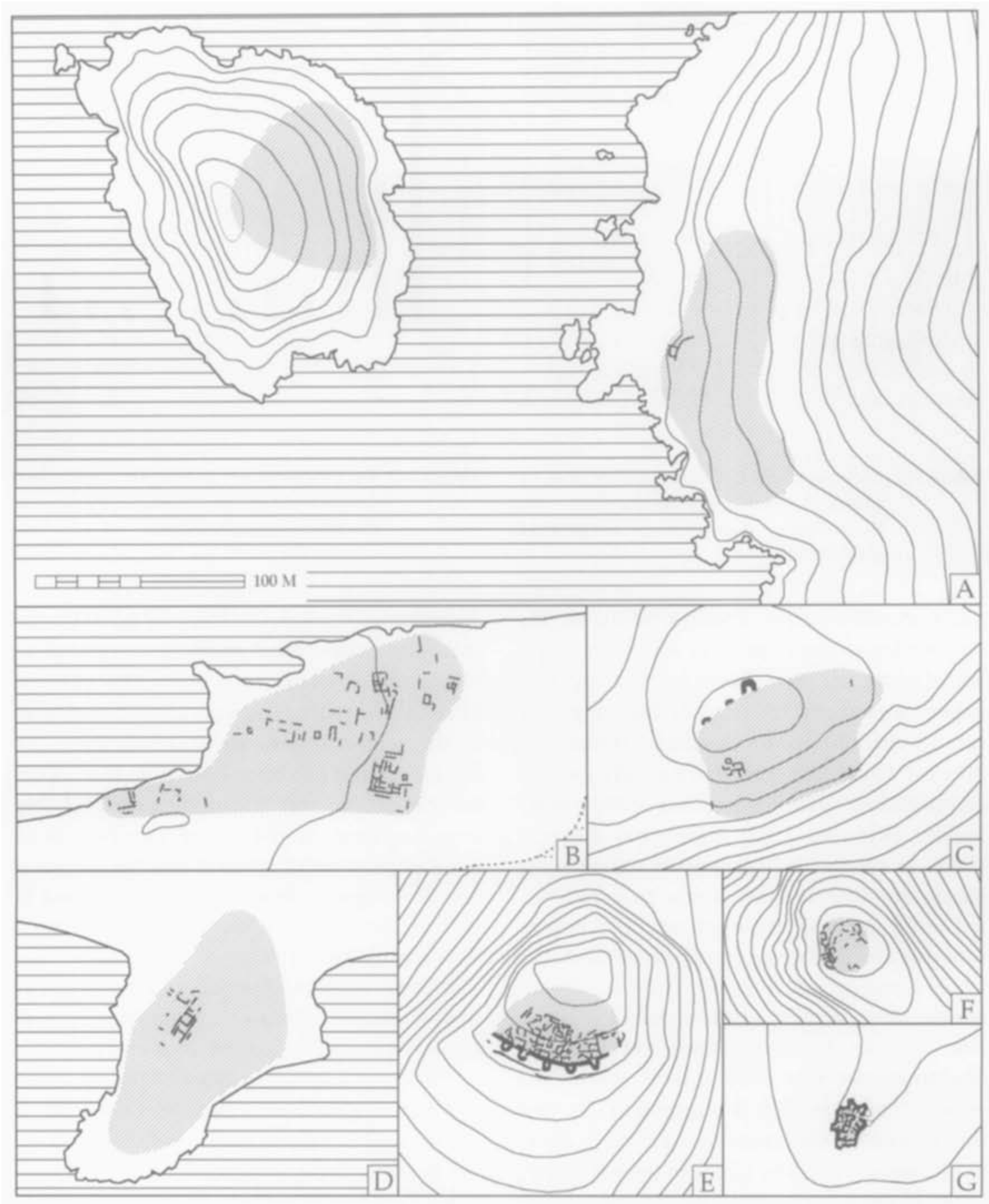


Figure 10.1 Excavated Early Cycladic settlement size comparison: (a) Dhaskaleio, Keros; (b) Phylakopi I, Melos; (c) Markiani, Amorgos; (d) Ayia Irini, Keos; (e) Kastri, Syros; (f) Mount Kynthos, Delos; (g) Panormos, Naxos. Estimated occupation areas shaded; 5 m contours.

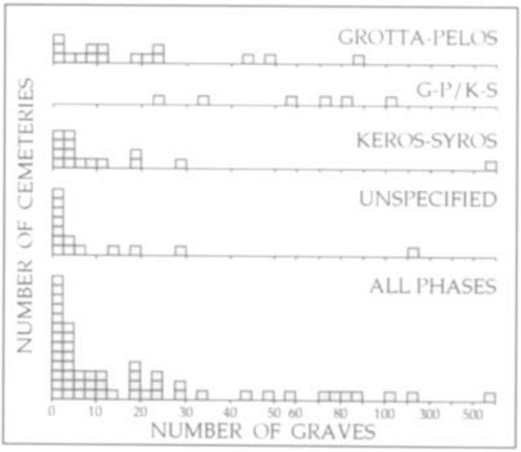


Figure 10.2 Excavated Early Cycladic cemetery sizes, by phase: Grotta-Pelos; Grotta-Pelos and Keros-Syros; Keros-Syros; unspecified phase; total.

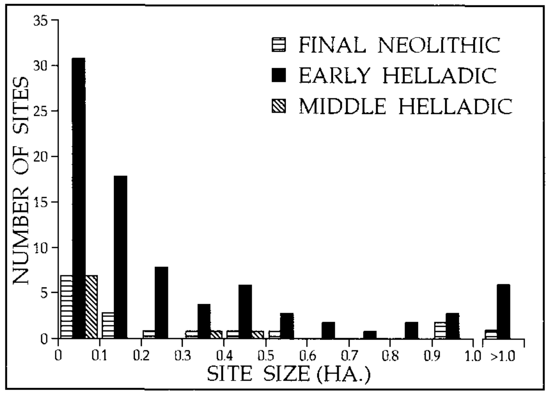


Figure 10.3 Documented site sizes: Berbati-Limnes, Laconia, Methana, Nemea, Pylos and Southern Argolid surveys.

Unfortunately, our understanding of the larger sites is less clear than we might hope, since many of them have later occupation superimposed, making the definition of site size specifically during the Early Bronze Age difficult. Excavation has preferentially focused on such sites, giving some idea of their complexity (Konsola 1984; Hägg and Konsola 1986). In several Peloponnesian surveys, the character of the finds recovered from individual sites, such as obsidian working debris, roof tiles and impressed hearth rims (Kardulias 1992; Jameson *et al.* 1994: 353-54, 356-66; Forsen 1996), serves to differentiate the larger sites as probably playing some sort of central organizational role within their immediate region. There is also a suggestion (as one might expect) that larger sites are more likely to be demographically viable in the long-term, with evidence for multiple periods of occupation in the Early Bronze Age, and often continuity into the Middle Bronze Age (Fig. 10.5).

While a small number of relatively large sites has been identified in the Cyclades in the middle of the Early Bronze Age (Fig. 10.1: Ayia Irini, Dhaskaleio), there is no evidence that they formed focal points for surrounding settlement systems, except in the case of Dhaskaleio, where the agricultural resources of the region immediately surrounding the site are unlikely to have been able to support its population, and resources were probably imported from neighbouring islands such as the Kouphonisia. Rather, it has been argued that these larger sites generally developed in the context of inter-island exchange systems (Broodbank 1989; 1993).

In Crete, a relatively small number of larger sites similarly stands out from the mass of small hamlets and farmsteads (Whitelaw 1983), though again, in the absence of intensive surveys in their immediate environs, it cannot yet be argued clearly that they stood at the head of local integrated settlement systems. Preliminary reports on several surveys, however, are suggestive (Watrous *et al.* 1993; Muller 1996), and the sequence of use of tombs in the Mesara suggests a pattern of population nucleation at a few focal sites through time.

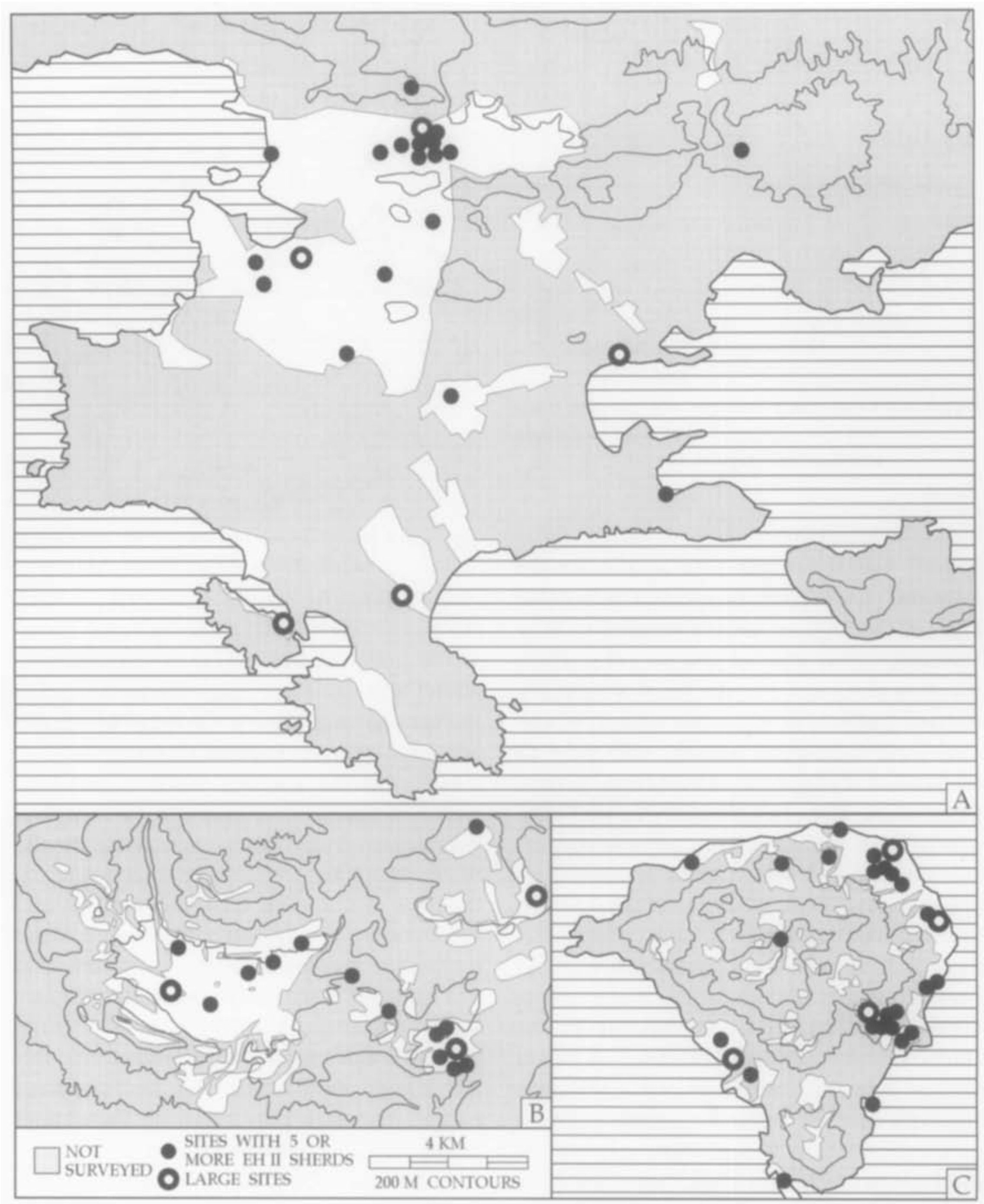


Figure 10.4 Surveyed areas and Early Helladic II site distributions: (a) Southern Argolid; (b) Berbati-Limnes; (c) Methana.

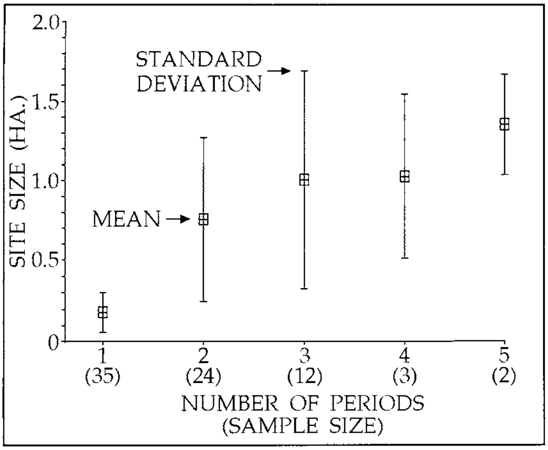


Figure 10.5 Relationship between site size and duration of occupation, Berbati-Limnes, Laconia and Southern Argolid surveys.

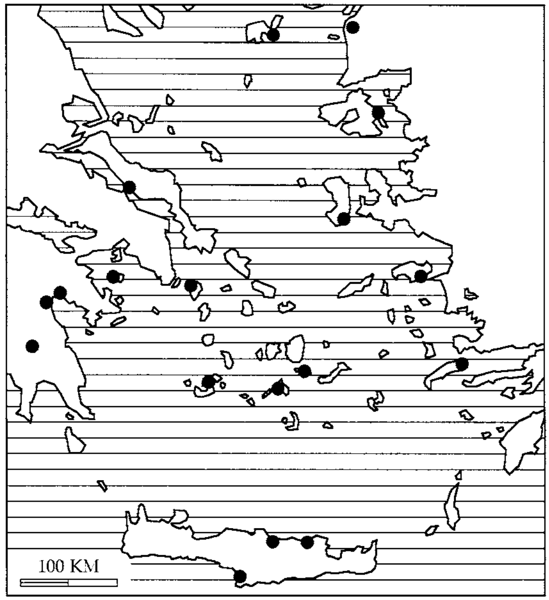


Figure 10.6 Distribution of excavated substantial nucleated sites of Early Bronze Age date.

A considerable number of large Early Bronze Age settlement sites is also known from the past century of excavation in other areas of the Aegean, usually situated in large lowland, often coastal plains (Fig. 10.6). Whether these stood at the head of local settlement systems, or represent a totally nucleated local settlement pattern, will only be established through intensive survey in their hinterlands. The predominantly coastal location of such sites, while not entirely surprising, since many lowland areas in the Aegean open onto the coast, raises the possibility that the development of such sites owes something both to their links with smaller inland sites, as well as extra-local connections, by sea.

There are also broad similarities in the chronological distribution of sites in different regions, with large numbers of Early Bronze Age sites, and very restricted numbers of sites in the later Early Bronze Age and Middle Bronze Age (Dickinson 1994: 50-60). Crete is a clear exception to this pattern, where, despite some nucleation in the late prepalatial period, site numbers expand dramatically in most regions surveyed in the Middle Bronze Age, undoubtedly part of the processes involved in the development of the Protopalatial states. While numerous surveys have been undertaken in Crete, none in a major lowland location has yet been published in the detail which will be necessary to understand this process.

In the Melian context, where these shifts were first documented in detail, it was argued that the island population nucleated at the site of Phylakopi, late in the Early Bronze Age. On the basis of information on site numbers and site sizes, it was suggested that overall island population increased, at the same time that site numbers declined dramatically (Cherry 1979; Wagstaff and Cherry 1982a). Attempting to explain this process, it was argued that this was simply the first example of a recurrent pattern, in which population on Melos (and potentially other small-scale regions) nucleated when the island was integrally tied into off-island economic and political systems (Wagstaff and Cherry 1982b; Renfrew 1982). In the prehistoric case, nucleation was considered to be a response to the expansion of the influence of Minoan Crete into the Cyclades.

This remains the principal attempt to explain, rather than simply to describe these settlement pattern transformations. However it is problematic, in that the beginning of settlement nucleation on Melos can be firmly placed during the Phylakopi I period, c. 2200–2000 BC, whereas the first Minoan imports arrive in Phylakopi II, after 2000 BC. Even then, very few MM IA sherds have been recovered from the early phase of the Middle Bronze Age at the site, and intensive 'Minoanization' only begins late in the Middle Bronze Age, with large-scale importation and imitation of Minoan Neopalatial ceramics (Papagiannopoulou 1991: 116-22). Settlement pattern changes in the Peloponnese, broadly contemporary with those on Melos, similarly predate the earliest Minoan contacts, represented by imports of MM IA date at Ayios Stephanos and Lerna (Rutter and Zerner 1983). The situation in the Cyclades may be further complicated, if the gap in the sequence proposed by Rutter (1983; 1984) is sustained, since the transformation from a dispersed EB II to nucleated EB III-MB pattern might not represent a continuous process.

Even if one challenges the specific explanation proposed and widely accepted for Melos, the social perspective on settlement pattern change developed by Cherry remains crucial. The shift between dispersed and nucleated settlement systems must represent significant social transformations on Melos and elsewhere in the Aegean where a similar change has been documented (Fig. 10.7), but whether similar social changes are documented, depends crucially on how similar the settlement changes were in the different areas.

While some differences have been identified among Early Bronze Age settlement patterns in different parts of the southern Aegean (e.g. Cosmopoulos 1991), these have generally been noted at the descriptive level, and not pursued in terms of what they might mean for

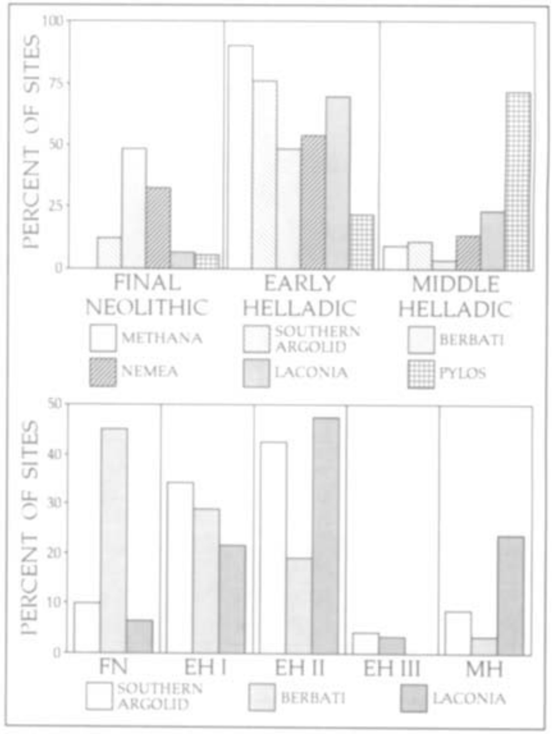


Figure 10.7 Chronological distribution of sites identified in Peloponnesian surveys: (a) by period; (b) by phase, where data is available.

the social histories of the different areas. In fact, ostensibly similar patterns (Fig. 10.8), may have very different implications. On Melos, no large centre is known through most of the Early Bronze Age, until Phylakopi emerges late in the period, when its excavated extent indicates that it was a substantial community, and it would appear that the population of the earlier small, dispersed communities, nucleated at Phylakopi, and that overall population also expanded significantly. In the Southern Argolid, in contrast, there was a small number of substantial nucleated lowland communities occupied throughout the Early Bronze Age, and a considerable number of small hamlets and farmsteads which fluctuated through time, and disappeared late in the Early Bronze Age. In this case, the large lowland communities formed a relatively stable

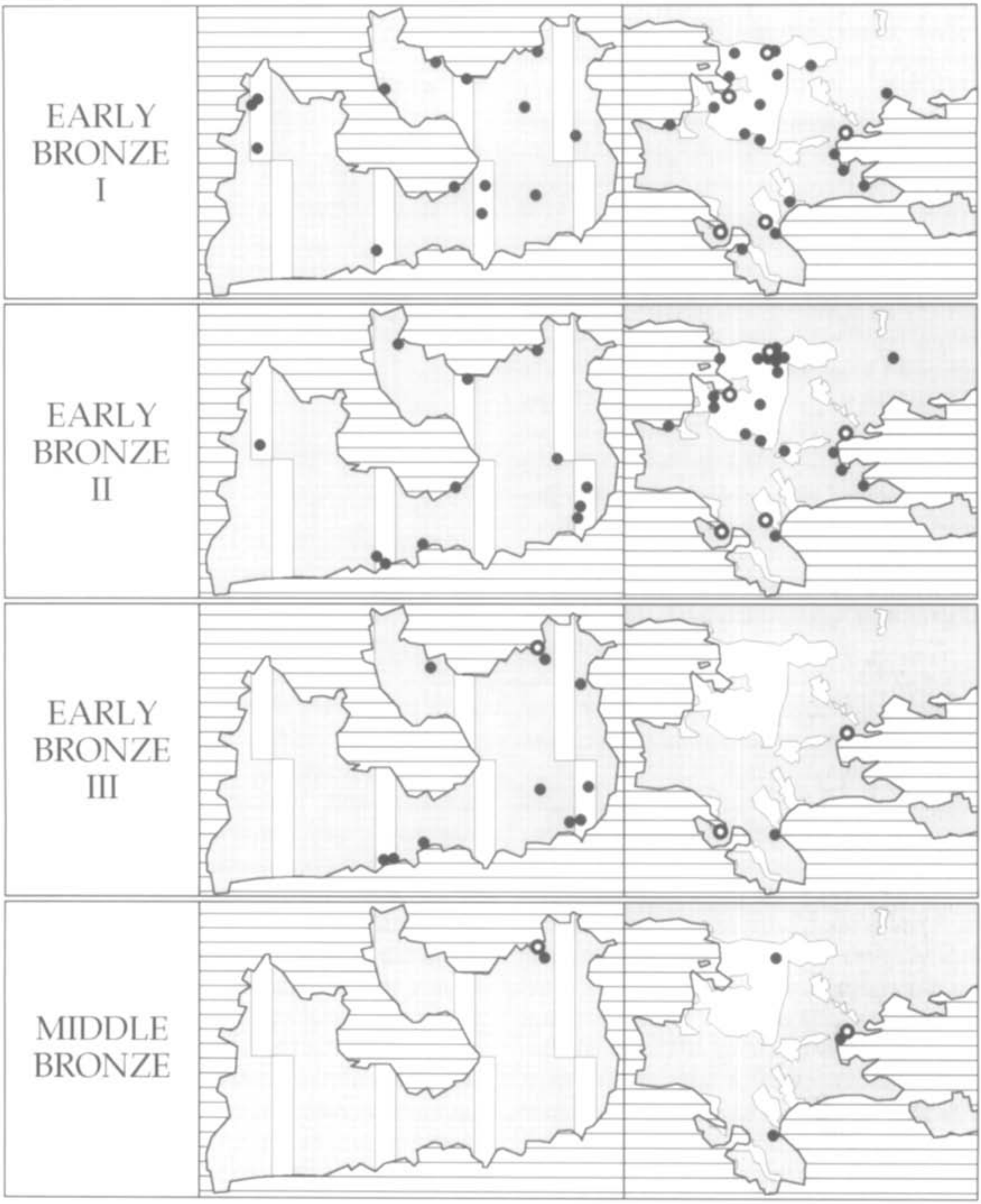
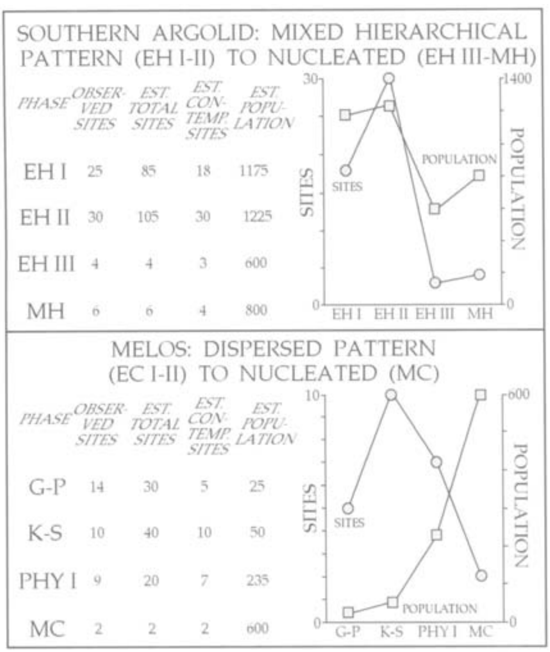


Figure 10.8 Settlement pattern comparison by phase, Melos and the Southern Argolid, large sites distinguished. Shading indicates areas not surveyed.

demographic pool throughout the period (and in some cases into the Middle Bronze Age), while the smaller, short-lived hamlets and farmsteads, despite their number, never represented the majority of the regional population.

Therefore, superficially similar patterns appear to represent significantly different demographic and social histories (Fig. 10.9). Areas such as the Cyclades, generally lacking such larger, nucleated settlements during most of the Early Bronze Age, would have been much less densely occupied, and any settlement systems that existed would have been less complex. In Melos, instability in small dispersed sites was the norm during most of the Early Bronze Age, whereas in the Southern Argolid, it was a minority variation, around the stable, large, lowland centres. Such a contrast would have engendered a very different pattern of interactions between sites, and a different climate for cultural, as well as for longer-term demographic development.



PHASE	OBSERVED SITES	EST. TOTAL SITES	EST. CONTEMP. SITES	EST. POPULATION
EH I	25	85	18	1175
EH II	30	105	30	1225
EH III	4	4	3	600
MH	6	6	4	800

PHASE	OBSERVED SITES	EST. TOTAL SITES	EST. CONTEMP. SITES	EST. POPULATION
G-P	14	30	5	25
K-S	10	40	10	50
PHY I	9	20	7	235
MC	2	2	2	600

Figure 10.9 Site number and population estimate comparisons, by phase: the Southern Argolid and Melos. For phase abbreviations, see Figures 10.2 and 10.7 and text.

Critical to understanding such differences in regional development is the recognition and comparative exploration of variation between different study areas. Broadly comparable intensive survey methodologies are beginning to allow such comparisons, and the distinction between differences due to biases in site preservation and recovery, and those which actually represent differences in behaviour in the past. Despite concerns over biases, it is possible to approach extensively or haphazardly collected data in as critical a fashion, with results which also recognize and address variability in past behaviour (e.g. Forsen 1992; Broodbank 2000).

The Environmental Context for Human Settlement in the Third Millennium BC

While geomorphological investigations were conducted as part of the Melos project (Davidson *et al.* 1976; Davidson and Tasker 1982), and proceeded in parallel with the intensive survey of the island, the implications of the Melian environment for past settlement were approached in static, rather than dynamic terms (Wagstaff and Gamble 1982; Wagstaff *et al.* 1982; Wagstaff and Cherry 1982a; 1982b; Renfrew 1982; see also Bintliff 1977). To some extent this has been the model for subsequent surveys, whether detailed geomorphological studies have accompanied the survey fieldwork (e.g. Methana: James *et al.* 1997; Berbati: Wells *et al.* 1990; Zangger 1992) or not (Keos: Cherry *et al.* 1991). A more integrated and dynamic perspective has characterized a number of studies reporting on the work of the Argolid Exploration Project (Pope and van Andel 1984; van Andel *et al.* 1986; van Andel and Runnels 1987; van Andel *et al.* 1990;

van Andel and Zangger 1990; Jameson *et al.* 1994; Runnels 1995). Regardless of how directly such specific results have been integrated into the interpretation of the archaeological survey data, each study, along with much other, purely environmental research, has contributed to a move away from models of the Aegean environment which argued that changes were climate driven (Vita-Finzi 1969; Bintliff 1977; Rackham 1982), toward the recognition of the importance of anthropogenic factors in landscape change (Davidson 1980; Wagstaff 1981; Bruckner 1986; van Andel *et al.* 1990; Bintliff 1992).

There is an increasing number of soil and vegetation studies pointing to major changes in the southern Aegean environment during the fourth and third millennia, usually (but not universally) argued to be the result of human action (Fig. 10.10).[1] By far the most detailed case has been made for the Southern Argolid, by Tjeerd van Andel and his colleagues (Pope and van Andel 1984; van Andel *et al.* 1986; van Andel and Runnels 1987; Jameson *et al.* 1994). There, a major phase of soil erosion has been linked to the expansion of settlement in the Final Neolithic and Early Bronze Age.

In fact, the dating evidence for this episode in the Southern Argolid is extremely limited: an undated cist grave and a Late Helladic site sit on top of the Pikrodaphni alluvium, a thorium/uranium disequilibrium determination on carbonate yielded a date of 2700±1400 BC, and the most recent sherds recovered from the deposits are said to have been Early Helladic II (Pope and van Andel 1984: table 3; Jameson *et al.* 1994: 355). A similarly massive phase of erosion is better documented, dated, and published, in Zangger's work in the plain of Argos, around Tiryns and Lerna (Zangger 1991a; 1991b; 1993; 1994a) and in the Asine plain (Zangger 1994b). He has suggested a similarly significant episode of slope instability and large-scale erosion in his work in the nearby Berbati valley (Wells *et al.* 1990; Zangger 1992), though in the latter case, no independent dating evidence has been reported.

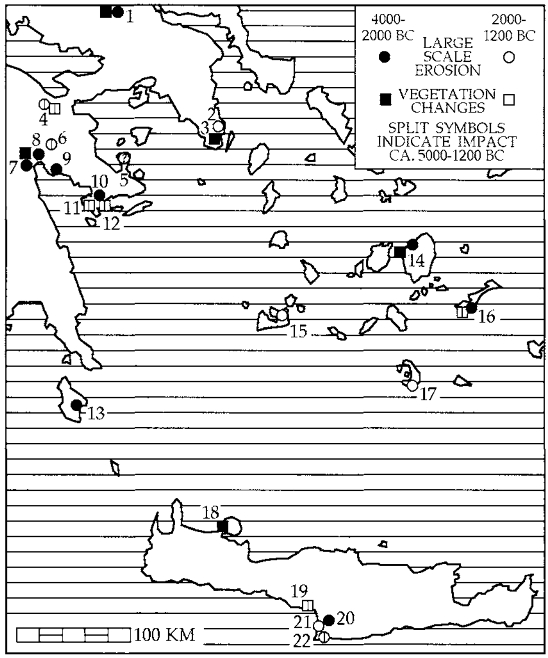


Figure 10.10 Locations with evidence for mid-Holocene environmental change in the southern Aegean (for sites and references, see note 1).

Following the perspective developed in the Southern Argolid, in each case catastrophic slope erosion is seen as a consequence of the expansion of Final Neolithic and Early Bronze Age settlement, slope clearance, and the degradation of vegetation through grazing by domestic stock (Pope and van Andel 1984; van Andel *et al.* 1986; 1990). This colonization of slopes and upland areas is documented widely throughout the Aegean (e.g. Warren and Tzedakis 1974; Watrous 1982; Halstead 1984; 1996), and parallels the widespread colonization of the smaller Aegean islands, well documented as a fourth and third millennia phenomenon (Cherry 1981; 1990; Broodbank

1999). Both patterns appear to represent an expansion of settlement into relatively marginal landscapes, almost certainly facilitated by the diversification of agricultural strategies and an increased reliance on pastoral production (Halstead 1989).

Some have also linked increased soil erosion to possible evidence for the introduction of the plough in the middle of the Early Bronze Age (van Andel *et al.* 1986; Pullen 1992; Manning 1997: 164), though the potential productive impact of the plough may be grossly exaggerated, given the costs of traction animals (Halstead 1987; Halstead and Jones 1989) and evidence that, in the Late Bronze Age, plough oxen may have been monopolized by the palaces (Palaima 1989; 1992; Halstead 1992).

Despite the enthusiasm with which this model for landscape change has been disseminated, it has been imposed on poorly dated sequences (Bintliff 1992; Endfield 1997), sometimes actually against the cited evidence (Jameson *et al.* 1994: 192 citing Demitrack 1990). Extrapolating the date of this phenomenon, from two well-dated contexts (the plains of Argos: Zangger 1993; Jahns 1993; and Asine: Zangger 1994b) to others without independent chronologies, also imposes a uniformity on the process which is likely to mask the local diversity which was initially so important in arguing for anthropogenic, rather than climatic, causes for landscape change in the southern Aegean (Davidson 1980; Wagstaff 1981; van Andel *et al.* 1990; Bintliff 1992).

While there is no precise synchronization of geomorphological change across the Aegean region, there are hints of a more dynamic relationship with the pattern of development of agriculture in different regions (van Andel *et al.* 1990). In addition, relatively small scale climatic variations during the fourth and third millennia (Wright 1972; Rackham 1982; Bottema 1985; 1994; Allen and Katsikis 1990; Moody *et al.* 1996) are likely to have affected individual areas in different ways, given different geologies, vegetation patterns, histories of human settlement, and micro-climatic conditions. In other words, we are likely to be dealing with much more subtle interactions between climate, soils, vegetation, and human exploitation strategies, which played through in different ways, even in adjacent valley systems. While local variation is acknowledged to be significant (van Andel *et al.* 1990; Zangger 1992), this is masked by attempting to conflate different sequences to a common model without independent chronological support (e.g. Zangger 1992; Jameson *et al.* 1994: 192). As developed to date, the model is also over-deterministic (van Andel *et al.* 1986; Runnels and van Andel 1987), allowing little scope for the possibility of alternative exploitation strategies, differentially pursued by different local groups and individuals, depending on how they evaluated their social as well as environmental opportunities and constraints.

Overall, the coarse chronological resolution of most environmental studies in the southern Aegean allows considerable ambiguity as to the date of environmental change in specific areas, and about the degree to which vegetation and geomorphological changes can be synchronized with each other, and with settlement pattern changes in specific regions. The evidence for anthropogenic causation is circumstantial, synchronization of processes between regions is often assumed rather than demonstrated, and even the correlation between the environmental and settlement sequences is ambiguous.

Dating of sediment or pollen sequences is problematic and expensive, and it is undoubtedly the case that environmental studies usually focus on relatively long periods of time, such that a few dates are viewed as sufficient to anchor a sequence within the Holocene.

With so few absolute dates, individual pollen cores are often dated by similarities in the pollen assemblages to other cores, thereby ruling out the possibility of detecting variations in local sequences. However, as analysts are increasingly considering anthropogenic causes for landscape and vegetation changes, more fine-grained dating will be crucial to establish correlations with cultural sequences, and to document and explain variation in these processes in time and space.

In the previous section, it was suggested that Aegean prehistorians have attempted to fit varying local settlement sequences to a single simple model, thereby obscuring the differences of detail which are likely to be crucial to understanding the variable processes actually involved. In this section, it has been suggested that environmentalists have tended to follow a similar path. At an early stage in analysis, this is crucial for assembling disparate data and allowing the detection of broad trends, but at some point, forcing data to fit too rigid a model becomes counter-productive and inhibits the recognition and potential for understanding complex processes. If, in addition, both sequences are significantly over-simplified, there is likely to be little insight in bringing them into conjunction. We need to employ models which are specific, but also open-ended, such that we can recognize when they do not fit, yet learn from the divergences from our expectations.

So to develop a more effective understanding of the ways in which humans interacted with their environments, and in turn, how those environments acted back on the human populations, both in specific cases and more generally, we need far finer resolution in both cultural and environmental datasets, and in particular, more direct associations between both sets of patterns—linking cause and effect—as well as more detailed modelling of the potential dynamic interactions.

Linking Behavioural Cause and Environmental Effect: Occupation and Erosion at Markiani, Amorgos

Some progress towards resolving these uncertainties can be made by more explicit integration of environmental and archaeological investigations. A trial investigation along these lines has been undertaken at the site of Markiani on the island of Amorgos, in the south-east Cyclades (Fig. 10.11).

Markiani is a small site, occupied from the late Grotta-Pelos, through to the Kastri phases of the Cycladic Early Bronze Age (Davis 1992: 752-53; Marangou 1994: 470-71). Later occupation of the site was primarily in the Hellenistic period, when it may have been an isolated farmstead. Intensive surface collection has documented a 14 ha distribution of Early Cycladic sherds, which have eroded from an original occupation area of c. 0.3 ha on the summit of the hill. The site is badly eroded, and was investigated through limited excavation. Together with the surface material, this documents the expansion of the occupied area from the summit of the hill, down onto the upper southern slope, during the course of perhaps 700 to 800 years. While the initial assumption has been that the site gradually expanded through time, continuous occupation from the late Grotta-Pelos through the Kastri phase would make it exceptional among the usually short-lived Early Cycladic settlement sites. However, the extremely battered condition of the pottery from the first two phases, and the very slight depth of preserved deposit, suggest that occupation was episodic rather than continuous. Similarly, while differences in patterns and rates of deposition can be anticipated both between sites, and at different times on the same site, a gross comparison of depositional rates at prehistoric sites across the Aegean suggests that the depth of deposit at Markiani would be

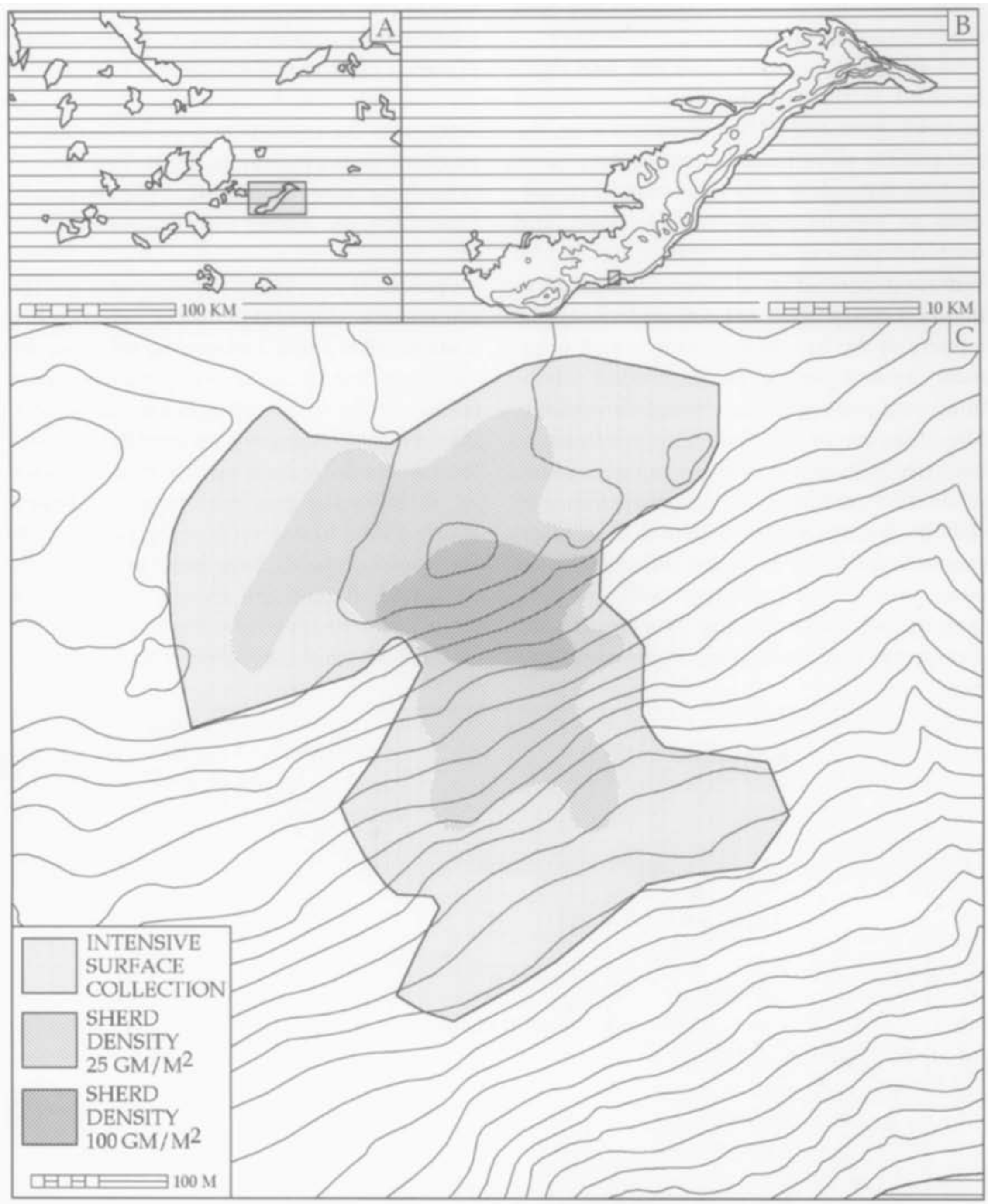


Figure 10.11 Location of Markiani, Amorgos.

completely anomalous if occupation had been continuous (Fig. 10.12).

In trying to understand the processes involved in the post-depositional spread of material from the hilltop, sediments on the site and the slope immediately below it were studied through *in situ* examination of sections at various points on the slope, and micromorphological analysis (French and Whitelaw 1999). This allowed the identification of a redeposited red soil underlying the terraces at the base of the slope, which originally formed during more wooded conditions, and subsequently eroded downslope. The structure of the sediments indicates at least two subsequent phases of slope erosion, while the formation of an A horizon indicates stability for a substantial period after slope erosion ceased. The fill of the collapsed Kastri phase structures at the summit of the site indicates deflation and capping by a lag deposit, protecting the underlying sediments and marking the onset of slope stability, relatively soon after the abandonment of the site. A later phase of erosion is documented by the substantial fills which were subsequently reworked in the construction of the recent terraces still preserved on the slope. This erosion is likely to have resulted from the re-occupation of the site during the Hellenistic period (Fig. 10.13).

Because of the physical linkage between the site and the slope immediately below, it has been possible to tie the erosion sequence on the slope directly to the occupation sequence on the site above. Sampling below the occupation site at Markiani, we are probably not seeing the erosion effects of clearance for fields *per se*, since the gentler-sloping and better-watered land to the north of the site (Fig. 10. 11) would probably have been preferentially cultivated. Rather, the erosion episodes are more likely to represent the impact of firewood collection and over-grazing in the

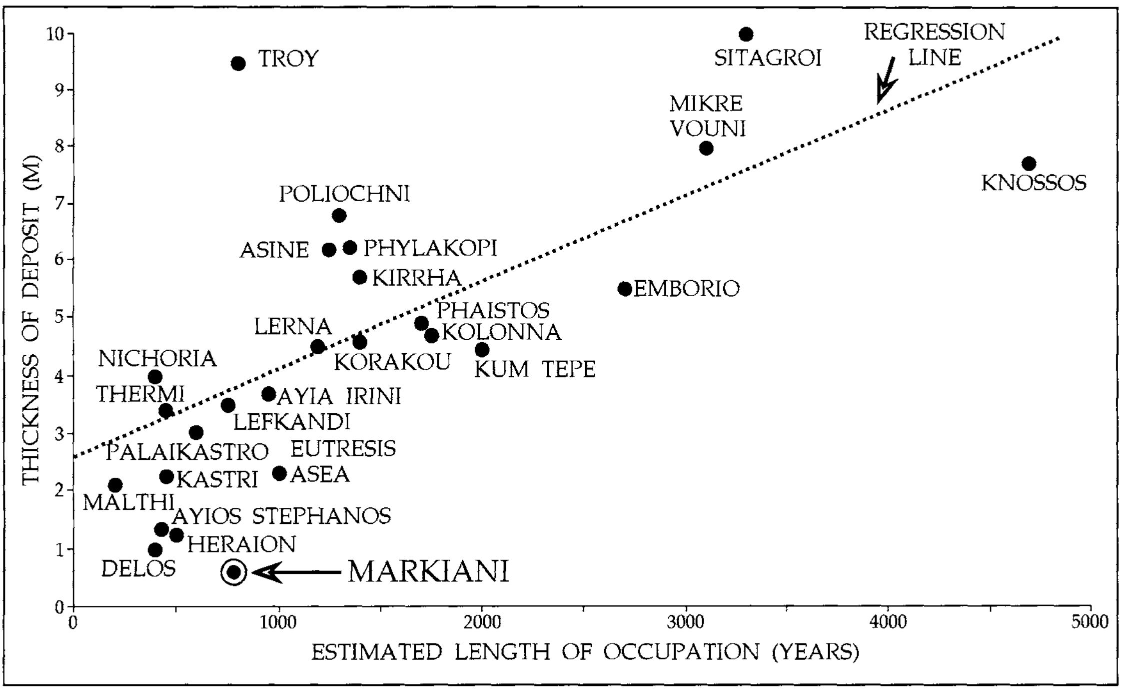


Figure 10.12 Deposit build-up rates for stratified sites in the Bronze Age Aegean.

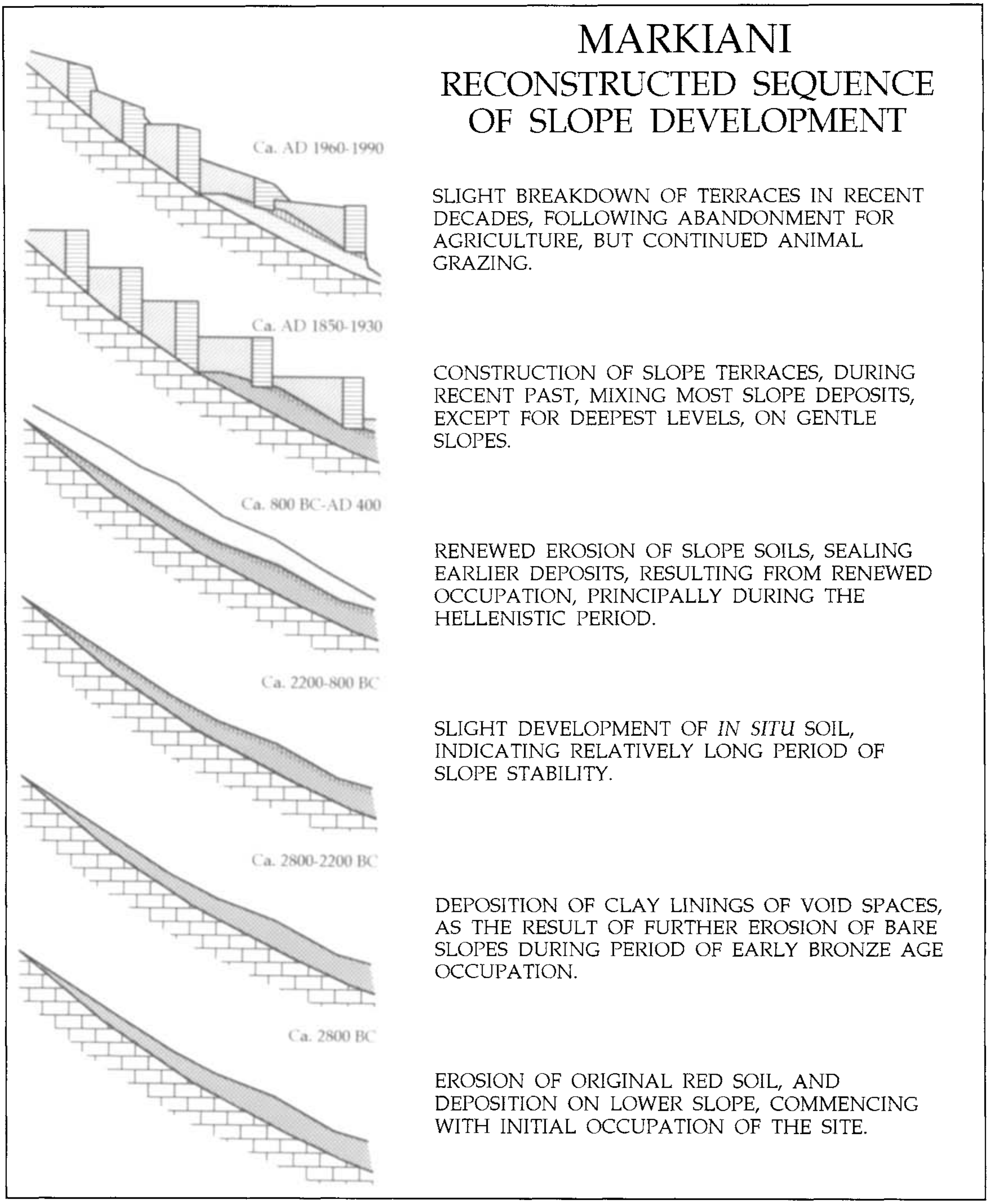


Figure 10.13 **Reconstructed sequence of slope development at Markiani, Amorgos.**

immediate vicinity of the site, but even so, even a small-scale occupation can be seen to have had a very significant impact on vegetation and slope stability in its vicinity.

Indeed, given the amount of erosion documented, it is worth exploring this linkage reflexively—just as the occupation sequence can be held to be responsible for the pattern of slope erosion around the site, erosion on such a scale is, in turn, likely to have been a major factor in the periodic abandonment of the site. While soils would not have redeveloped fast enough to account for the reoccupation of the site, it seems likely that, as other nearby areas were also over-exploited, areas previously somewhat degraded were returned to and exploited further.

While this is only a single case, it does establish a direct linkage between settlement history and landscape degradation which has been hypothesized but not demonstrated, elsewhere in the southern Aegean. While methodologically showing that such linkages can be established, substantively, it also indicates the severe environmental impact that even small-scale and short-lived settlement could have on marginal slopes in southern Aegean environments.

Landscape Degradation, Settlement Instability and Inter-Community Competition

It is now worth returning to our environmental and cultural sequences, to see how the potential linkages between them can be developed more explicitly. It was argued above that we have a significant problem linking these different sequences in any causal fashion, which is not helped by simply assuming that different local sequences, whether cultural or environmental, fit a single process during one chronological horizon. We are likely to develop a better understanding of the different processes involved by paying more attention to local differences, and by considering in their own right the implications of different variables, such as overall population levels, the relative sizes of individual sites, the relative distribution of population among sites of different sizes, and the location of different types of sites within the landscape.

Any move toward explanation of the changes in either settlement or environment, will also require a more subtle sense of the dynamics behind the settlement transformations documented throughout the southern Aegean near the end of the third millennium BC. For this, we need to be clearer on what is similar and different in the settlement trajectories of different regions, and therefore, what changes and transformations need to be explained at the local scale, and which require explanation in terms of more inclusive, regional and inter-regional processes. With the hints at diversity outlined above, no single model is likely to be relevant to understanding settlement pattern changes throughout the southern Aegean. In this case, it seems worthwhile to try to pull together observations on some of the different phenomena involved, which may point toward productive areas for future research.

Given the short life span which can be inferred for most small Early Bronze Age sites in the southern Aegean, all of our chronological distribution maps are likely to be extreme palimpsests, which do not allow us to appreciate the degree of instability of settlement. Even in south-central Crete, where many of the round tombs reveal evidence of use for over a millennium, we are not necessarily dealing with particularly stable communities. Some of the tombs may have been used continuously, but that need not imply stability of settlement. In the intensively surveyed Ayiopharango valley (Blackman and Branigan

1977; Vasilakis 1989–90), the existence of several occupation sites for each tomb has been used to argue that each tomb served several hamlets or farmsteads. However, the occupation sites rarely demonstrate long-term occupation, and are more likely to represent a sequence of occupation sites shifting location through time, tethered to a tomb serving as a territorial focus and legitimation of control over productive resources in its vicinity. Similarly, while the ceramics published from any tomb other than Ayia Kyriaki (Blackman and Branigan 1982) represent tiny and unreliable samples of the ceramics originally deposited, the chronological gaps in the documented use of many tombs may indicate episodic rather than continuous use. On this reading, the evidence for clearing out and burning inside many tombs may represent, not part of the funerary ritual (Branigan 1992: 119-27), but rather cleaning out for re-use by a new kin-group, after a period of abandonment.

Such small-scale, unstable occupations—predominantly farmsteads and small hamlets—characterize much of the Final Neolithic and Early Bronze Age throughout the southern Aegean, and it is their disappearance toward the end of the period which can be seen as a broadly synchronous pattern across the region. They appear to represent small-scale colonization of the most marginal environments, an extreme manifestation of the progressive colonization of marginal environments which characterizes much of the Aegean during the fourth and third millennia BC. Their development, and their eclipse, as an Aegean-wide phenomenon, would appear to require explanation at a broad, inter-regional, rather than local, level.

There is a much more variable distribution of larger, more demographically stable communities, whose viability will have been linked directly to the agricultural resources available in their vicinity. With generally deeper soils and better water resources, agriculture in their vicinity would generally have been more productive and more reliable. Where they appear, they can be seen as part of a longer-term pattern of expansion of population through successful development of Neolithic agricultural strategies, supplemented and made more resilient through diversification with new species, the development of complementary pastoral resources, and the parallel development of new social strategies buffering local communities against risk and uncertainty (Halstead 1981; 1989; 1994).

While it was opportune and effective, in trying to develop a social perspective on the Aegean Early Bronze Age, for Renfrew to emphasize similarities and draw upon different types of evidence from different areas to develop a common outline of 'proto-urban' societies throughout the southern Aegean (1972a), subsequent research has only served to further differentiate the cultures at the broad regional level (e.g. Davis 1992; Rutter 1993; Watrous 1994), and we are increasingly able to pick up finer distinctions within regions (e.g. Whitelaw 1983; 1999; Broodbank 1989; Wiencke 1989). The presence and nature of nucleated settlements, and the degree to which they may have acted as local centres, appears to vary significantly within and between different areas of the Aegean. Therefore, such sites are not necessarily a unitary phenomenon, and their pattern of development needs to be considered in terms of different patterns of inter-play between broad inter-regional and local level variables.

The nucleation of population at large lowland, often coastal sites, at the end of the Early Bronze Age and in the Middle Bronze Age, in some cases develops a pattern seen already in particularly favoured locations in the Early Bronze Age. In such regions, relatively large sites already existed in the Early Bronze Age, and 'nucleation' only appears to be a later

Early Bronze Age phenomenon because of the loss of the smaller, more ephemeral dispersed sites in the uplands. In other areas, such as the Cyclades, such sites appear to represent a completely new social formation, with a real aggregation of formerly dispersed populations. That these communities did not have their roots in the few large sites of the mid Early Bronze Age, such as Dhaskaleio and Ayia Irini, is suggested by the abandonment of the latter. These early centres developed in a different social and economic context, owing less to local agricultural resources and more to their location on communication routes, given enhanced importance precisely because of the need for inter-island interaction in such marginal environments.[2]

The concentration of population in a small number of large, lowland communities during the Middle Bronze Age, was likely to have been a variable phenomenon, in some areas part of a longer-term process of development from the Neolithic, but in others, responsive to short-term, local ecological dynamics. Perhaps not completely fortuitous in the more marginal areas, the erosion of upland soils is likely to have benefited agricultural exploitation of the lowlands, where such soils were redeposited. The widespread, near complete nucleation of population into such communities, while undoubtedly contributing to the new social contexts out of which developed more politically-centralized societies in the Middle Bronze Age, is unlikely to be explained as the result of a single process throughout the southern Aegean.

Closer consideration of settlement patterns should involve not just the individual communities and their relations with each other, but also their specific locations within the environment. Site locations in prehistory throughout the southern Aegean, as can be documented in detail for Melos and northwest Keos (Fig. 10.14), but assessed more superficially for other published surveys, clearly favoured low-slope land, which could be cultivated without requiring slope terracing for soil conservation. While agricultural terraces, or at least gully check-dams, of later Bronze Age date have been investigated on Pseira (Betancourt and Hope Simpson 1992) and in the western Mesara (Watrous *et al.* 1993; Gifford and Reese 1995), and more recently suggested for Kythera (Broodbank in Blackman 2000: 27), no survey anywhere in the Aegean has yet revealed a distribution of prehistoric sites relative to slope which would suggest that terraces were used in soil conservation on any scale. If farmers were avoiding the most unstable slopes, this would seem, on the face of it, to limit the potential impact of slope erosion on cultivated areas. However, there is no absolute cut-off such that fields above a certain angle of slope are at risk and those below are not—the situation is one of degrees of risk, which will also be affected by local conditions such as the nature of the soil, the cultivation techniques, the vegetation, the aspect and exposure. Even fields on gentle slopes and in valley bottoms would be affected by increased water run-off from higher slopes, deforested or denuded through clearance and grazing. Similarly, the re-deposition of the quantity of soil moved downslope, documented in areas such as the Argolid, will have had short-term catastrophic impacts on fields and crops.

Regardless of the local details, the instability of small sites and their widespread disappearance late in the Early Bronze Age, appears to represent more than demographic processes alone; without effective soil conservation measures, Early Bronze Age populations in marginal areas were literally eating their way through the landscape, denuding slopes as catastrophic soil erosion eventually followed clearance for cultivation and, particularly, local grazing. Ironically, it may have been an

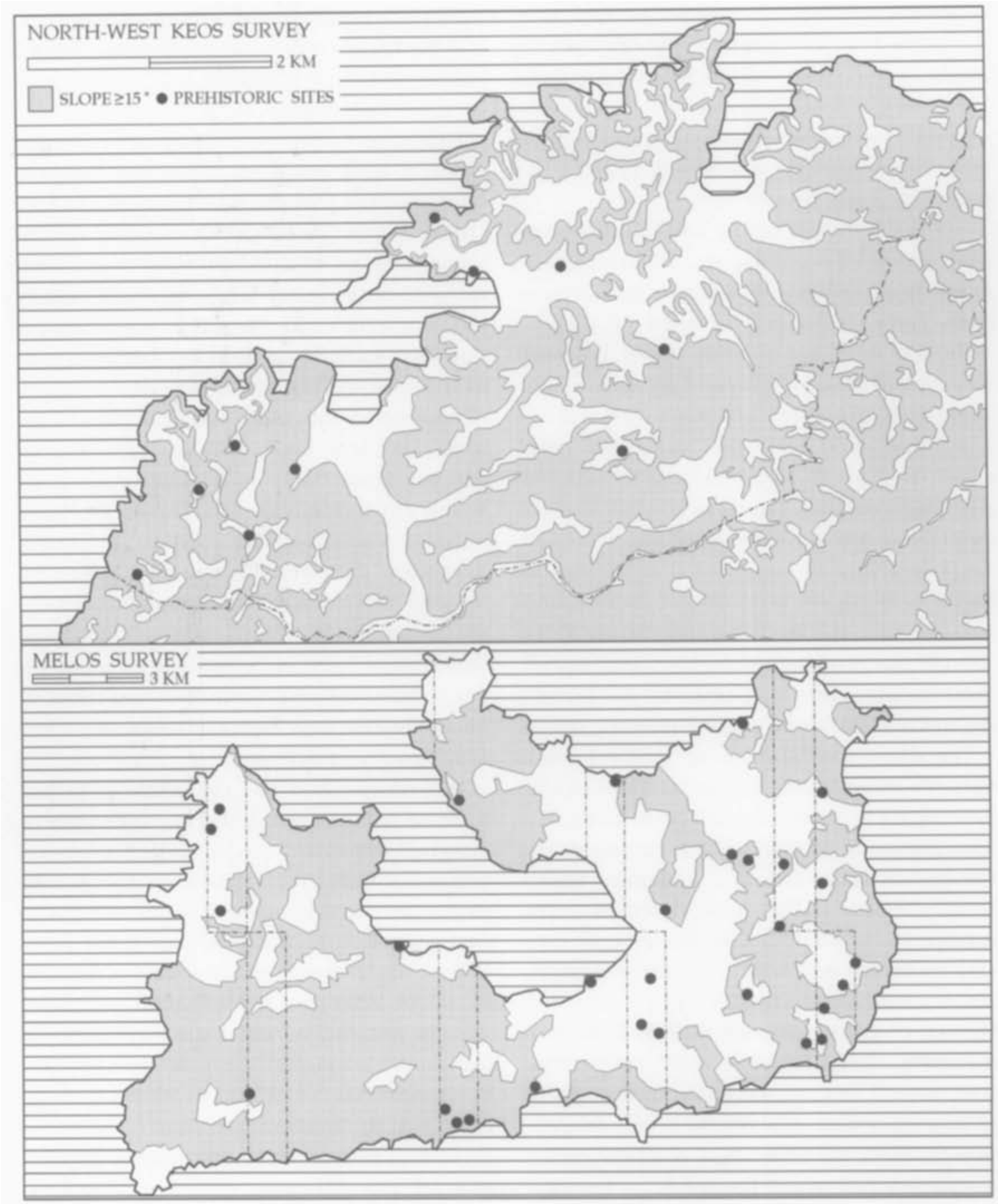


Figure 10.14 Slope angle and distribution of prehistoric sites: (a) Northwest Keos survey; (b) Melos survey. Slopes greater than 15° shaded.

increasing reliance on animals as part of a diversified agro-pastoral strategy—which made colonization of such environments viable in the first place—which caused erosion and large-scale abandonment of upland areas throughout the southern Aegean by the end of the Early Bronze Age.

Given the impact on the local landscape of even small-scale occupation, as documented at Markiani, settlement instability would have been particularly acute in areas of shallow soils, and steep and unstable slopes. Ignoring local details of soil quality and access to water, these areas are also those most marginal for agriculture, and were the landscapes colonized latest—both regionally and locally. The denudation of the uplands would have been a cumulative process, since slope soils were lost far faster than they could develop. We should therefore anticipate increasing pressure on land as a resource during the course of the Early Bronze Age, and an increasing frequency of local resource crises, as traditional risk-buffering mechanisms came under increasing stress.

The distinctive horizon of fortified sites, variably dated in different areas, but broadly developing in the second half of the third millennium BC, is puzzling when considered in the context of distinct local settlement trajectories. Traditionally, such defences were assumed to be a response to threats from outside each local region, but no intrusive populations have been convincingly identified (Forsen 1992; Sotirakopoulou 1993). Defensive measures, documented at small and remote sites as well as large lowland centres, would fit in a context of increasingly acute competition for land, far better than competition for metalwork and other elite goods, as has usually been suggested to date, since the evidence for the latter is far more variable inter-regionally (Cosmopoulos 1991). Just as the process of colonization of marginal landscapes is relevant to the entire region, though the timing varies as a result of local settlement history, so are the consequences, as landscapes became subject to similar pressures and were affected by similar processes.

Finally, social inequality, defined as unequal access to basic productive resources, needs to be considered, not simply as a trend through the period, but as an element in the dynamics which worked in different ways in different areas of the Aegean. This was not obviously an issue in the earlier Neolithic, when occupation was focused on lowland basins. However, expansion of at least some of the regional population onto more marginal areas of the landscape, with lower and less reliable agricultural productivity, will have engendered significant inequalities in access to the basic means of production (Halstead 1995). Increasing instability and unreliability in production through the third millennium, differentially concentrated in such marginal contexts, would only have exacerbated such inequalities, within and particularly between communities, creating new forms of stress and intercommunity competition.

This contribution has not intended to put forward population expansion, cultivation of marginal slopes and environmental degradation as a universal process, or the prime-mover in the settlement pattern and social changes which marked the end of the Early Bronze Age throughout the southern Aegean. However, it has tried to bring another element into the arguments, which mediates between the purely social, and largely deterministic environmental perspectives developed to date. That the expansion of small-scale settlement into upland areas does appear to be a general phenomenon within a long-term process, its long-term consequence—the over-exploitation and degradation of marginal and upland areas—may provide a common ingredient which links otherwise more divergent local settlement trajectories.

Prospects: Integrating Settlement and Environmental Sequences in Landscape Archaeology

The development of intensive survey has dramatically affected the way Aegean prehistory is approached, emphasizing long-term processes, regional scale patterns, and comparative perspectives. While this has led to an increasing convergence both in questions and data resolution, to date, archaeological and environmental investigations in the Aegean region have progressed largely in parallel, even where the practitioners have worked together on specific site-based or regional projects. Fully integrated research, which would allow ecologically sophisticated exploration of social and demographic development within dynamic environmental contexts, is difficult to achieve.

Methodologically, we have tended to compare parallel sequences, only broadly correlated chronologically, and have simply asserted causal connections which cannot be demonstrated because of the coarseness or uncertainty of our respective chronologies. More direct linkages, however, can be developed, if relevant investigation contexts are sought, and appropriate investigative strategies are pursued. Similarly, more integrated approaches to research design are required to ensure that environmental research is fully integrated from the start, rather than running in parallel to the archaeological project (or even being an afterthought), and being reported as a background chapter or relegated to an appendix. The research that has been undertaken to date demonstrates that the potential is there, but 25 years after the initiation of multi-disciplinary research in the Aegean (McDonald and Rapp 1972; Renfrew and Wagstaff 1982; Jameson *et al.* 1994), full and effective integration is still in the future.

Acknowledgments

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Notes

1. Locations where environmental investigations have documented later prehistoric vegetation and landscape change in the southern Aegean, numbered as in Figure 10.10.

   Vegetation changes in the fourth and third millennia BC

   Copais (1): Turner and Greig 1975; Greig and Turner 1974; Rackham 1983; Allen 1990
   Kitsos (3): Renault-Miskovsky 1981
   Lerna (7): Jahns 1990; Jahns 1993

Naxos (14): Renault-Miskovsky 1983; Dalongeville and Renault-Miskovsky 1993
Tersana (18): Moody *et al.* 1996

Vegetation changes with broader chronological limits
Koiladha (11): Bottema 1990
Thermisia (12): Whitehead and Sheehan 1981
Amorgos (16): French and Whitelaw 1999
Aghia Galini (19): Bottema 1980; 1996

Vegetation changes in the second millennium BC
Messenia: Wright 1972; Zangger *et al.* 1997

Major erosion events in the fourth and third millennia BC
Copais (1): Allen 1990
Southern Argolid (10): Pope and van Andel 1984; van Andel *et al.* 1990; van Andel and Zangger 1990; van Andel *et al.* 1986
Tiryns (8): Zangger 1991a; 1993; 1994a
Lerna (7): Zangger 1991b; 1993;
Asine (9): Zangger 1994b
Naxos (14): Dalongeville and Renault-Miskovsky 1993
Amorgos (16): French and Whitelaw 1999
Kythera (13): Broodbank, in Blackman 2000: 27
West Mesara (20): Watrous *et al.* 1993

Major erosion events with broader chronological limits
Ayiofarango (22): Doe and Holmes 1977
Berbati (6) (not directly dated): Wells *et al.* 1990; Zangger 1992

Major erosion events in the second millennium BC
Thorikos (2): Paepe and Deraymaeker 1973
Melos (15): Davidson *et al.* 1976; Davidson and Tasker 1982
Thera (17): Davidson 1978; Limbrey 1990
Kommos (21): Gifford and Reese 1995; Parsons and Gifford 1995

Possible minor erosion events within broad limits
Methana (5): James *et al.* 1994; 1997

Soil and vegetation changes at Nemea (4) are dated earlier in the Neolithic
Demitrack 1990; Atherden *et al.* 1993; Atherden and Hall 1994

2. Relatively large Early Cycladic sites such as Skarkos on Ios (Marthari 1997) and Chalandriani on Syros (Marthari 1998) may have closer parallels with the large lowland Early Helladic sites, than with contemporary sites such as Dhaskaleio and Ayia Irini in the islands.

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11

Soils and Site Function: The Laconia Rural Sites Project

Christopher Mee and Peter James

Introduction

The focus of this paper is palaeoenvironmental research at the level of the individual site but in the context of a project which has a regional perspective. We hope to show how soil studies can help us to understand the function of the most common type of site encountered by recent intensive surveys, namely small rural sites. The Laconia Rural Sites Project (Cavanagh and Mee 1999) has been set up specifically to investigate such sites. It has evolved from the Laconia Survey which identified over 400 sites east of the River Eurotas (Cavanagh *et al.* 1996a). Phosphate analysis of soil samples from a number of these sites was undertaken (Buck *et al.* 1988; Cavanagh *et al.* 1996b).

Rural Sites

Intensive surveys have identified hundreds of rural sites. Although more common in some periods than others, they have been a feature of the Greek landscape at least since the end of the Neolithic. Characteristically they are 5000 m^2 or less in size. Often their period of use was relatively brief. Most consist of a dense scatter of sherds and tile. There may be stone implements, more substantial items such as press beds, or traces of walls. The assumption is that these sites were isolated farmsteads (Cherry *et al.* 1991: 336-37; Jameson *et al.* 1994: 249-50; Snodgrass 1990: 125-26) but can we be certain that they were in fact occupied and were not simply storehouses or shelters? Were they occupied continuously or only when the agricultural cycle made residence in the countryside more convenient? Were they occupied by their owners, by tenants or by slaves (see *inter alia* Alcock 1993: 60-62; Alcock *et al.* 1994: 163; Cavanagh 1991: 113-14; Osborne 1992: 25; Snodgrass 1987: 117-18)?

Texts and inscriptions provide some information about the function of rural sites in the Classical, Hellenistic and Roman periods, although most Greek writers were more interested in the city than the countryside and their comments can be ambiguous or even contradictory (Osborne 1985: 119). Ethnographic evidence has also been utilized, in particular by Whitelaw (1991; 1994) who has undertaken a detailed analysis of recent rural settlement and land use on Keos, based on documentary and statistical data, interviews and study of the field systems and structures. Nevertheless, we felt that it would be useful to investigate the surface characteristics of rural sites as rigorously as possible and thereby resolve, or at least redefine, some of the questions about their function.

The Laconia Rural Sites Project

In the first phase of the project, we revisited approximately 60 of the sites identified by the Laconia Survey. These were single period sites, in most cases less than 2500 m^2. We then selected 20 (Fig. 11.1) which seemed suitable for intensive survey and analysis. The range of periods represented is: Early Helladic (2), Middle/Late Helladic (2), Archaic (1), Classical (4), Hellenistic (3), Roman (6) and Byzantine (2). The sites were examined in 1993–94 and there was a study season in 1995.

The procedure adopted on each of the sites was as follows. A 5 m × 5 m grid of squares was laid out across the whole of the site. The members of the survey team counted the number of artefacts and recorded surface visibility along transects which crossed the site and its periphery. This enabled us to identify peaks in artefact density and to decide how we would sample the site. Then every artefact was collected from each of the squares. Tile was sorted by type of decoration and thickness, the different categories were weighed and recorded, and the tile was then discarded on site. Sherds, stone artefacts and other finds were taken away to be cleaned, marked, drawn and recorded on our database. This enables us to generate density maps for the different types of artefact on each site, so that we can see whether there is a correlation in the distribution of sherd and tile for instance.

In order to identify possible sub-surface features, Neil Brodie undertook a geophysical survey of every site. A gradiometer was used to detect local variations in the magnetic field. Readings were taken at 1 m intervals in a series of 20 m × 20 m grids. Soil resistivity was measured on a resistance meter with a twin probe array. The high temperatures did affect the instruments and the fact that the soil was so dry impeded the use of the resistivity meter in our second season. However, we took advantage of the much wetter conditions in the spring of 1995 to complete the programme of geophysical prospection. The results are still being processed but features have been identified on over half of the sites.

The third element in the analysis of each site has involved detailed soil studies. The aim has been to assess the likely impact of past soil erosion and deposition, and soils have been sampled for analysis of selected chemical and mineral magnetic properties. The purpose of the analyses is to determine any spatial relationships between soil properties and artefacts, and to consider whether the present soil properties may reflect past human activities associated with each site, such as the discard of organic waste, the use of a hearth/kiln, or metallurgy. Residues can accumulate in the soil from a great range of organic and inorganic materials in food, textiles, household utensils, building material such as mudbrick, agricultural and industrial implements, processes such as tanning, as well as the faeces, urine and bodies of humans and animals. Manure, wood ash and other waste products were used to improve soils for intensive crop growth. Many soils, particularly base-rich soils in non-humid environments, are capable of retaining a portion of the chemical elements derived from these materials in a relatively immobile form. The smelting and working of metals are also likely to leave marked chemical signatures. Soil mineral magnetic properties are altered when oxidation/reduction processes caused by intense burning transform iron oxides, for example around hearths where magnetic susceptibility tends to be enhanced.

The elements chosen for analysis were phosphorus (P), lead (Pb), copper (Cu) and zinc (Zn). These, and a number of other elements, have been shown to occur in archaeological soils in both the Old and New Worlds at concentrations above those off-site (Griffith 1980;

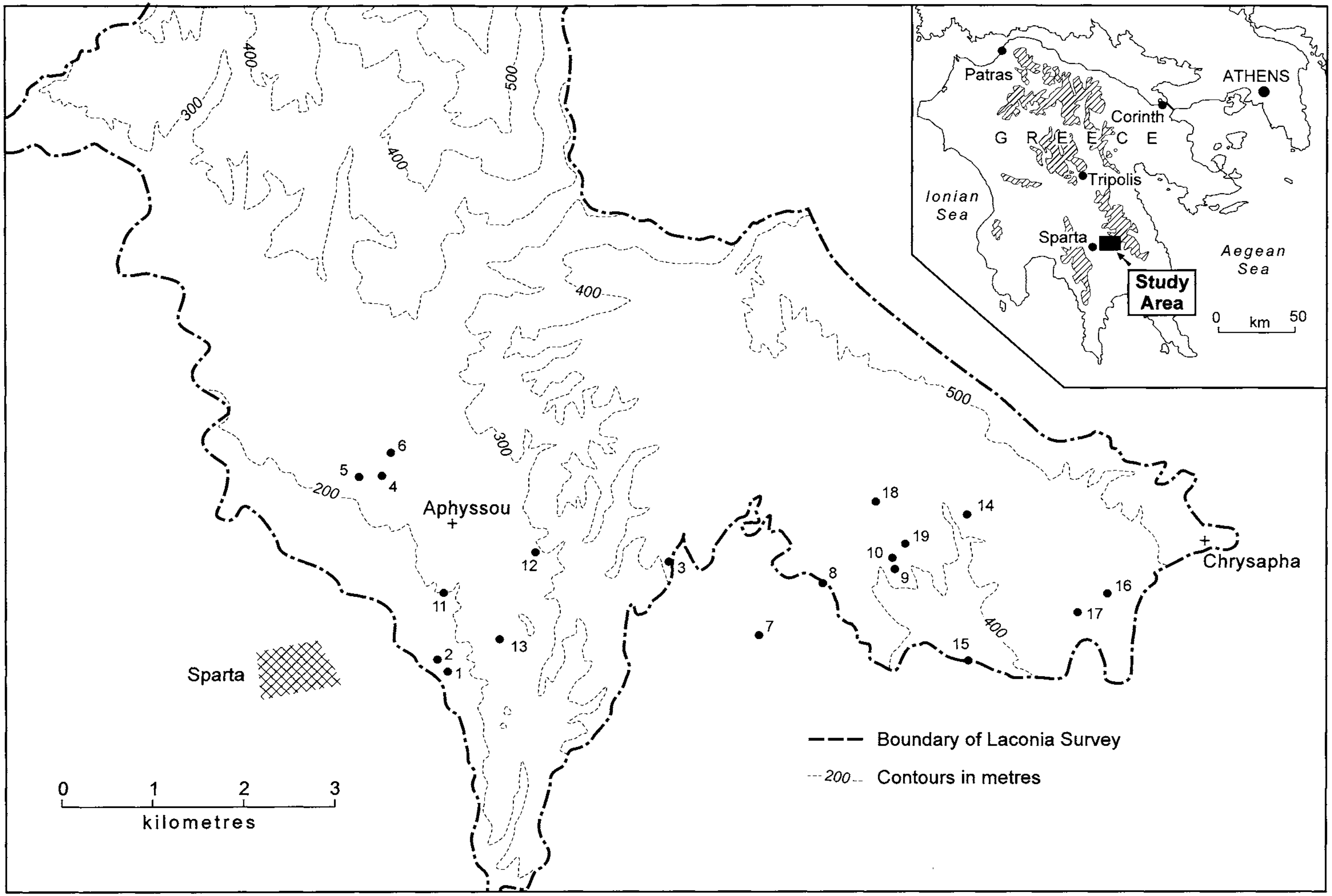

Figure 11.1 The location of the 20 sites selected for the Laconia Rural Sites Project.

1981; Konrad *et al.* 1983; Buck *et al.* 1988; Moore and Denton 1988; Bintliff *et al.* 1990; Lewis *et al.* 1993; Aston *et al.* 1998). Total nickel (Ni) and manganese (Mn) were determined for more than half of the sites. Nickel was selected as an element which is not associated with pre-industrial activity, manganese as an element with a distribution expected to be dominated by its abundance in soil minerals, though both elements are excreted by humans (Snyder *et al.* 1975). In the case of site LP1, which is discussed in more detail below, total iron (Fe), calcium (Ca), magnesium (Mg), potassium (K), organic carbon (C), soil particle size distribution, percentage $CaCO_3$ and secondary iron oxides were also analysed. In addition to analysis of mineral magnetic properties in the laboratory (following Thompson and Oldfield 1986), volume susceptibility was measured along selected transects in the field by F-probe at 20 cm depth and on the ground surface.

Soil samples were taken at a depth of 20 cm from the centre of each grid square or from the boundaries between grid lines. A note was made of the soil texture and colour, consistency, stone and root content, and the number of artefacts in the topsoil was counted. In each of the grid squares sampled, the gradient and aspect of slope, surface soil characteristics and vegetation were also recorded. In addition, off-site samples were taken, although in some cases the soil conditions were markedly different from those on the site.

In the laboratory the samples were thoroughly air-dried, once pH had been determined. The analyses were undertaken on <2 mm material, subsamples for the different analyses being sieved through brass, stainless steel or nylon sieves. The total amount of each element was determined by nitric and perchloric acid digestion and atomic absorption spectrophotometry. In addition to total iron (Fe_t), dithionite extractable Fe (Fe_d)(Mehra and Jackson 1960)—chiefly that in fine crystalline iron oxides formed within the soil—was measured for LP1 because, together with Fe in primary minerals inherited from the soil parent material, it is a major determinant of mineral magnetic properties. Iron oxyhydroxides also adsorb heavy metals. Secondary amorphous or paracrystalline Fe, extracted with ammonium oxalate (Fe_0)(McKeague and Day 1966), was also determined for LP1 as, in relation to other fractions of Fe, it is used to interpret the pathway and extent of soil development. Organic matter in the soil, measured as organic carbon (Walkley and Black 1934), may carry significant amounts of all the elements determined and may itself be a residue from material deposited when the site was in use. Secondary Fe and magnetic susceptibility (X_{lf}) tend to be associated mainly with the clay fraction. The three size fractions, sand (63–2000 mm), silt (2–63 mm) and clay (<2 mm), and the full particle-size curve for the <2 mm soil were determined.

Spatial relationships between the soil attributes and between these and the ground-surface artefact weights have been examined first by subjective comparison of plots which show the distribution of each variable (simplified into five classes of values) across the grid, and secondly by examining (again subjectively) data for selected grid cells. In addition data from some of the sites have been examined by correlation, principal components, and cluster analysis. Particular attention has been paid to variables which appear to be related at some spatial scale, as it is found that such relationships are of interest, whether or not there is evidence of clear on-site/off-site differences in soil attributes.

It is through the integration of these different approaches that we hope to understand how these rural sites functioned. As the analysis of the data is still in progress this is obviously not the moment for definitive statements but we can offer some comments based on the results from LP1, a Late Roman site, and more briefly from four further sites.

LP 1

The site is in an olive grove on a terrace above the river Eurotas, approximately 1 km east of Sparta (Figs. 11.2–11.3). The west margin of the site is cut by the edge of the terrace, an 85° bluff which falls 6 m to the modern Eurotas flood plain. The south-east margin of the site has been eroded by a 3.5 m deep gully. Now stabilized, the gully forms part of one of the large gully systems which drain the Neogene gravels on the east side of the Eurotas valley. Erosion of the east side of the site is attested by the exposure of a Roman tile grave in the gully wall to the south of grid square E11. It is likely, however, that the gully has followed approximately its present course at least since Late Roman times. The surface of the river terrace in the area of the grid has also remained stable. Because of the gentle slope (<2° to the south) only the finer fractions of the soil would be transported by overland flow and the terrace is protected by the gully from deposition of sediment eroded off the hill-slope to the east. The southern limit of the site, which has not been located, lies in the dense vegetation of an irrigated *Citrus* grove. To the north, site LP2 lies at a distance of 150 m.

We sampled 99 squares *in toto* and so this was one of the largest sites surveyed (Fig. 11.4). Artefact density peaks at three points (Fig. 11.7). Square A10 stands out in a cluster which also includes A9, B9–10 and C9– 10. B2–4 and C3 represent a second cluster, while the third occupies squares E8–11. It is in these clusters that the highest numbers of sherds were recorded, and there is a close, although not exact, correlation between the pottery and tile distributions. It is possible that sherds, potentially the most mobile of the artefacts on the ground surface, have been displaced from where they were originally discarded. The roof tile was unpainted and weighed 181.85 kg. There were also 47.85 kg of brick and floor tile, concentrated in squares B2, B10, C3, C10 and E8.

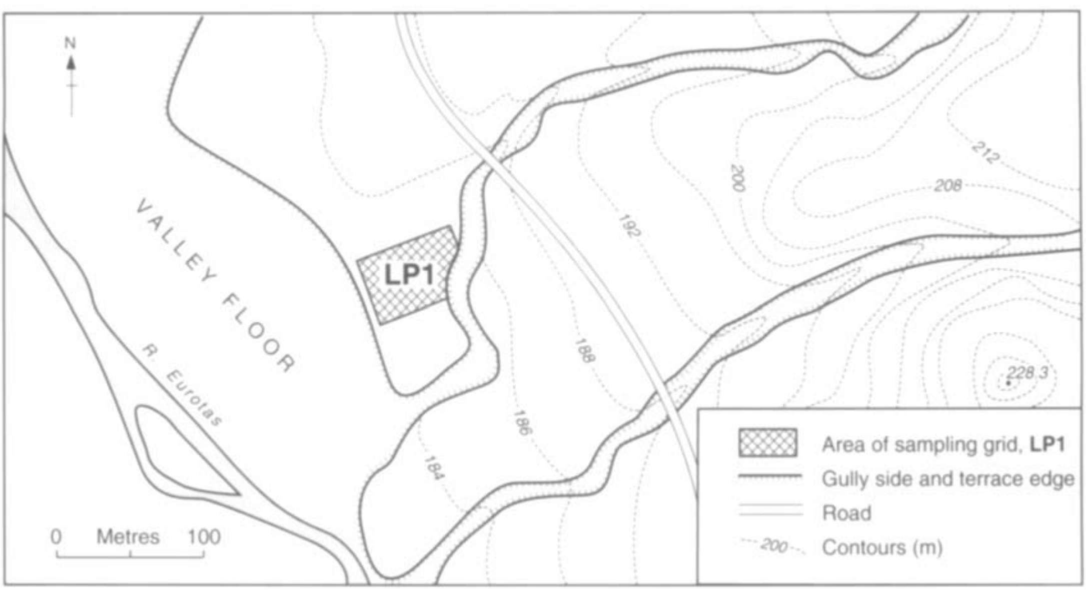

Figure 11.2 Location of LP1.

Figure 11.3 LP1: view of the site from the north-east.

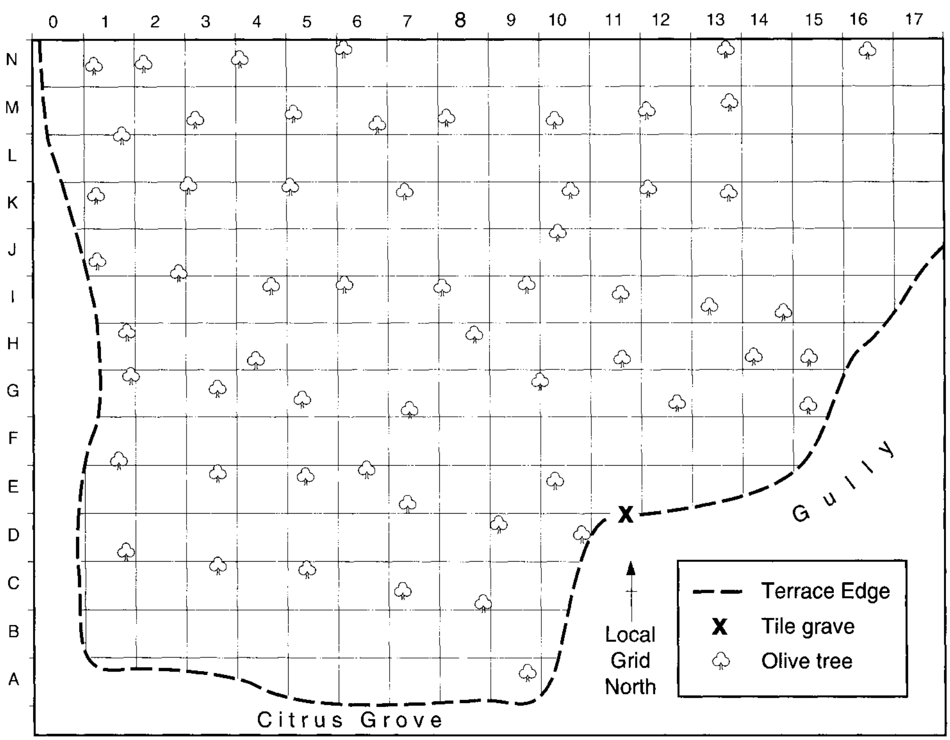

Figure 11.4 LP1: site plan.

A high proportion of the pottery from LP1, possibly as much as 90%, is closed. There were pithos sherds, especially in the squares defined as clusters 1 and 3, a range of amphorae, also jars, jugs and a lid. Open shapes include bowls, basins and dishes. A number of sherds preserve traces of black glaze decoration and a Hellenistic date is likely but not certain. Most of the pottery should be Roman or Late Roman and there were also nine mediaeval sherds. A bronze coin, which was in square D9, has been identified as a follis of the emperor Maurice Tiberius which was struck in AD 590/591.

Geophysical prospection on LP1 indicated a large magnetic anomaly in squares A8 and A9, which continues into square A10 and covers an area of about 50 m^2 (Fig. 11.5). The maximum intensity recorded was in excess of 100 nT and suggests the presence of a fired structure, such as an oven or kiln. There is a linear magnetic anomaly traversing the site from square H2 to square D10, which is also visible as a diffuse, high resistance feature (Fig. 11.6). This may mark the path of an old wall or track.

The soil studies revealed that the artefacts in the topsoil were concentrated in the same areas of the site, the south-west and south-east corners of the grid, as those on the surface (Fig. 11.7). This suggestion of the 'reliability' of the ground surface artefacts as an archaeological indicator is supported by the geomorphological stability of the river terrace upon which LP1 is situated. Associated with the high artefact concentrations in the southern part of the grid are relatively high magnetic susceptibility (Ms) values, total phosphorus (P), lead (Pb), copper (Cu), zinc (Zn), potassium (K), organic carbon and clay content, low pH and darker soil colour (Figs. 11.7–11.8). The spatial association is particularly marked for phosphorus, copper and magnetic susceptibility which highlight the two centres defined by the artefacts. The values for lead are high in relation to other sites. The maximum for copper, 259.2 mg kg^{-1} in D9, is one of the highest recorded in the survey and exceeds the concentration recommended as safe for food production (Baker 1990). Calcium concentration is high in the area of high tile and sherd weights, but an extreme value of 14,555 mg kg^{-1} occurs at I/J16. The organic carbon and the dark colour of the soil may well have survived from the use of manure in intensive food production when the site was inhabited. Organic carbon can reside in the soil for many thousands of years, particularly in relatively dry climates and where organic matter is stabilized by interaction with clay minerals (Huang and Schnitzer 1986; Wang and Amundsen 1996). Dark soil colours, such as those in the south of the grid, may form under intensive cultivation and persist for long periods after cultivation ceases (Smith 1980). Illuviation of humus, clay and silt results in darkening of subsurface horizons during long-term cultivation in Mediterranean environments (Soil Survey Staff 1997: 10) and may have occurred in the soil at LP1. Relatively high values for clay content occur throughout the grid, but the highest are in rows B, C and D. The clay might have been brought in when floors were being laid or could derive from mudbricks. The possibility that the soil in square E6 has been modified by intense heat is suggested by a 'hard' mineral magnetic remanence (frequency dependent and low frequency susceptibility are low), characteristic of haematite (Oldfield and Richardson 1990). One of the processes by which haematite forms within soil is by intense heating. The 'hard' remanence in square E6 is appreciably higher than elsewhere in the grid.

It would seem that there were two, or possibly three, structures on LP1, which were certainly in use in the Roman/Late Roman period.

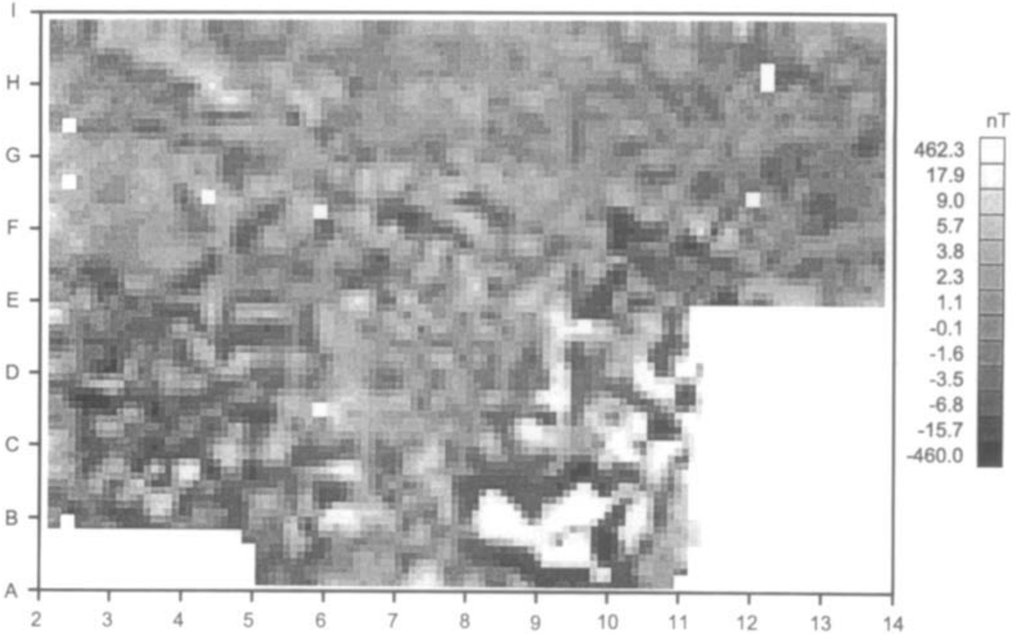

Figure 11.5 LP1: gradiometer plot.

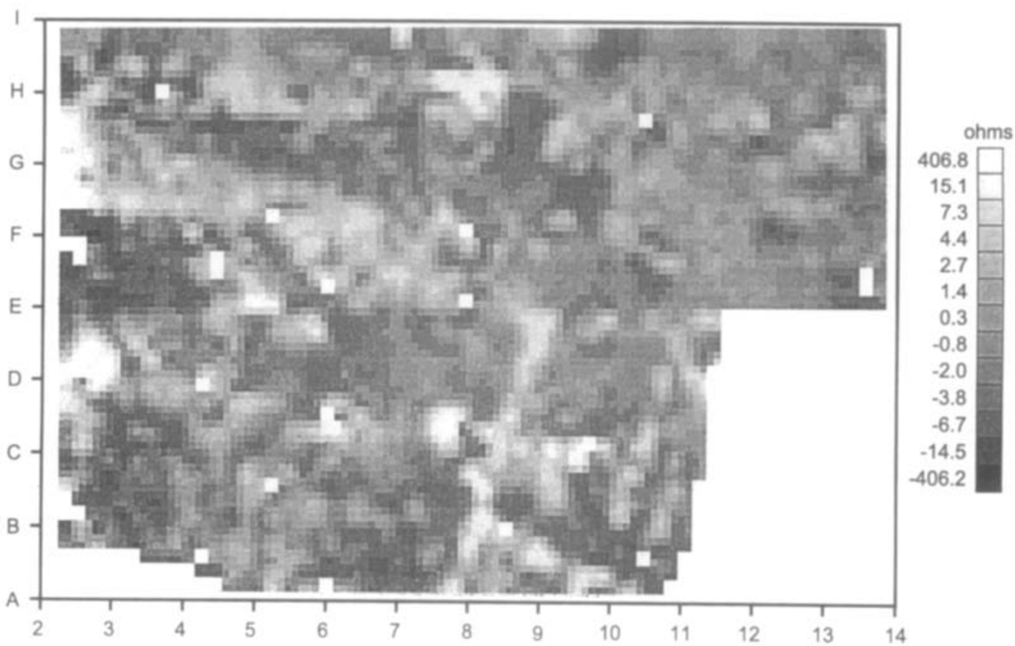

Figure 11.6 LP1: resistivity plot.

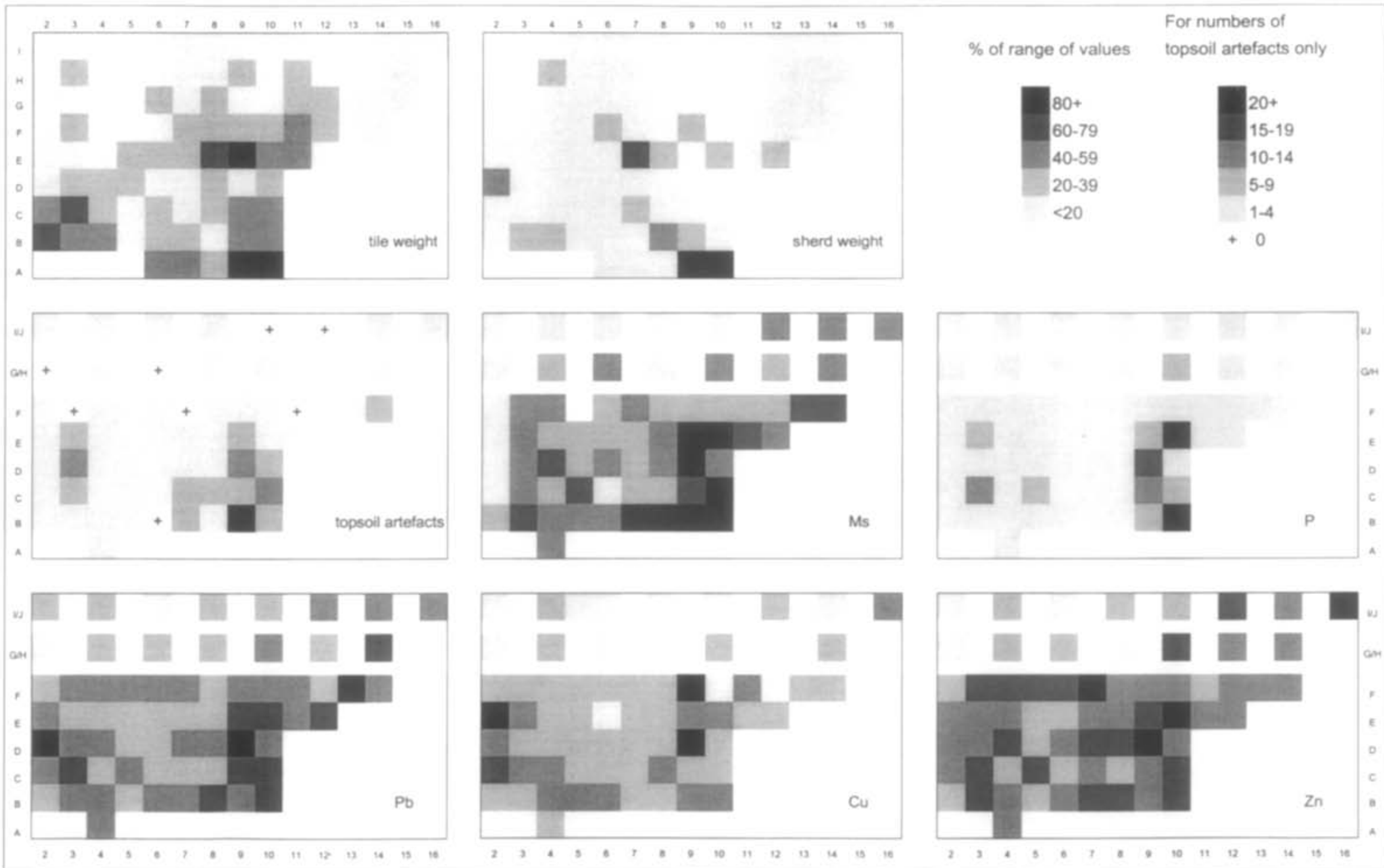

Figure 11.7 LP1: tile weight, sherd weight, topsoil artefacts, magnetic susceptibility, phosphorus, lead, copper and zinc.

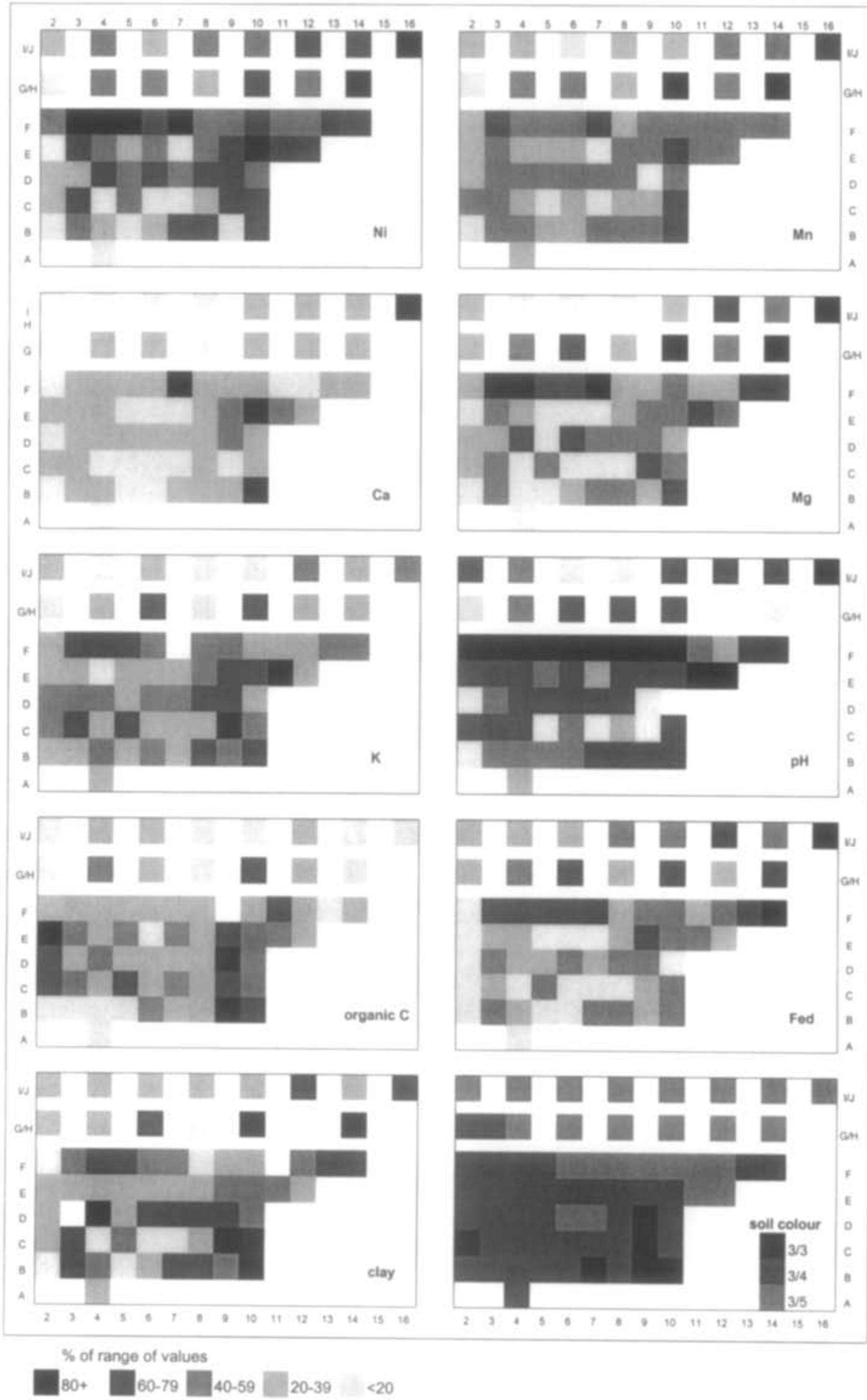

Figure 11.8 LP1: nickel, manganese, calcium, magnesium, potassium, pH, organic carbon, secondary crystalline iron, clay and soil colour. For each soil colour the Munsell value and chroma are given.

The lack of domestic pottery and the high proportion of storage vessels suggest that this was not primarily a residential site but a complex of storehouses in which agricultural produce was kept and processed. The relatively high organic carbon, phosphorus and other element concentrations indicate that the land around these storehouses was intensively cultivated and there may have been middens. The magnetic anomaly could reflect associated 'industrial' activity.

Other Sites

A brief account of the results from four more sites will illustrate the way in which the soil analyses both complement and extend the inferences drawn from the artefact data. LP3 is a Hellenistic site of the third or second century BC. Most of the artefacts—pottery and tile—were concentrated in four squares in the centre of the site. Our impression is that there was a single structure, most likely a farmstead, which was occupied at least on a seasonal if not a permanent basis. There were high values for magnetic susceptibility, copper, lead, zinc and phosphorus in the squares in which the artefact density was high, and additionally for nickel, manganese and cobalt in squares adjacent to these. The peaks in these variables are consistent with the use of fire and of a range of materials at the site centre. The maximum for phosphorus (50.1 mg kg^{-1}) is high for the LRSP soils and could result from a midden located near the site centre. At the southern end of the site, high phosphorus, lead, manganese, copper and zinc suggest a second focus of more restricted activity. The situation on LP13, a Roman site on a single agricultural terrace, is rather similar. An area of five squares in which the pottery and tile were clustered also yielded high values for magnetic susceptibility, organic carbon, phosphorus and lead. However, the squares in the north of the grid were the most distinctive in terms of their soil chemistry, with high values for trace metals, magnetic susceptibility and organic carbon. The soil data for LP13 indicate a range of activities and support the conclusion, based on the presence of domestic pottery, that this was a residential site.

Multivariate analyses of the data from LP1 (see also James 1999) and LP13 usefully highlight differences between the two sites. Selected results from principal components analysis are shown in Table 11.1. For both sites there is a 'mineral' component with naturally inter-related soil variables showing relatively high loadings (>4.0), and an 'archaeological' component in which artefacts, organic carbon, phosphorus and lead are among those variables with higher loadings. The 'archaeological' component is the first component for LP13 and the second for LP1. There is a significant difference in the role of copper between the sites: in LP1 it has the highest loading on the 'archaeological' component, but the lowest on this component in LP13. In the latter, manganese has a loading of 0.57 and zinc plays a greater part than in LP1, with a loading of 0.36. The results of the principal components analyses suggest a stronger—or simpler—archaeological signal in the soil of LP13 and differences in materials used between the two sites, with copper being important in LP1.

Two Mycenaean sites provide an insight into the variable effects of post-depositional processes. LP10 occupies the summit of a ridge that slopes up to the north and south. Most of the artefacts were at the north and south ends of the site rather than in the centre. The mineral magnetic, lead, copper and zinc values have a similar distribution. Phosphorus has particularly high values in two squares in the south (73.3 mg kg^{-1} and 98.3 mg kg^{-1}). It seems likely that soil has been eroded

Table 11.1 Principal components analysis (unrotated) of data from LP1 and LP13. Selected variable loadings on the first two components. Soil art = number of artefacts recorded in topsoil. Percentage figures are for variance. For LP1, extreme values for Mg and Ca at location I/J16 are excluded. For LP13, X_{lf}, pH, particle-size data and topsoil artefacts are not included.

LP1				LP13			
Component 1 (Mineral) 34.4%		Component 2 (Archaeological) 15.6%		Component 1 (Archaeological) 31.8%		Component 2 (Mineral) 23.9%	
Zn	0.90	Cu	0.74	Org C	0.77	Zn	0.79
Mg	0.83	Org C	0.65	Pb	0.75	Ni	0.78
Sand	-0.82	P	0.56	Tile wt	0.70	Cu	0.70
Clay	0.82	Soil art	0.51	P	0.67	$CaCO_3$	0.46
X_{lf}	0.81	Pb	0.44	Mn	0.57	Mn	0.42
K	0.78	pH	-0.43	Sherd wt	0.54		
Ni	0.77	Tile wt	0.41	Zn	0.36		
Ca	0.76	Sherd wt	0.33	$CaCO_3$	-0.61		
Fe_d	0.73	X_{lf}	0.28	Cu	0.16		
Mn	0.72						
Pb	0.66						
P	0.59						
pH	0.49						
Soil art	0.31						
Cu	0.19						
Org C	0.16						

downslope from the squares in the south of the grid. The removal of the brown topsoil by a combination of cultivation and overland flow has left the sherds exposed there and buried the artefacts in the centre of the site. Where topsoil has been removed the soil is redder but still carries the magnetic and chemical traces of activities associated with the site. On LP20, the settlement associated with the Mycenaean chamber tomb cemetery at Melathria (Cavanagh and Crouwel 1992), there is a derelict house. The sherd and tile on the south side of the site evidently derive from this. Most of the Mycenaean pottery was concentrated on the east side of the grid where the mineral magnetic and phosphorus levels were also high.

Conclusions

We thought at first that analysis of *total* amounts of chemical elements in the soil would be too blunt an instrument for defining pedochemical signals of former activity at the sites, but it has proved not to be. The chemical patterns derived correspond quite closely with those both of artefact density and of a range of magnetic, mechanical and physical properties on 18 of the 20 sites examined. There occur clear associations between artefact distribution and organic carbon, certain mineral magnetic properties, soil colour and total phosphorus, copper, zinc, lead, calcium and potassium. It is encouraging that these traces of activity have survived *in situ*, together with the artefacts, for a period of up to 5000 years, commonly in sloping terrain at considerable potential erosion risk. One inevitable conclusion is that actual erosion has been limited throughout this period.

Acknowledgments

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