PAUL HALSTEAD*

Agropastoral land use and landscape in later prehistoric Greece

The nature and scale of agropastoral land use in Neolithic Greece are problems of considerable significance to the understanding of early farming society and economy. Relevant archaeological and palaeoecological evidence is sparse and often ambiguous, however, and is interpreted, either implicitly or explicitly, by comparison with alternative models based on recent agropastoral practice. This paper explores the relevance to prehistory, and compatibility with the available evidence, of three such models: floodwater farming; extensive agriculture coupled with specialised transhumant pastoralism; and small-scale, intensive, mixed farming. It is argued that the last of these models is the most relevant to the Neolithic and is also compatible with the limited archaeological and palaeoecological data, while the need is highlighted for further research into the nature and scale of Neolithic animal husbandry.

Key word: *Neolithic. Greece. Land use. Farming.*

INTRODUCTION

The bioarchaeological record from Neolithic sites in Greece is overwhelmingly dominated by the remains of domestic plants and animals. On the basis of present evidence for the size, spacing and permanence of Neolithic settlements, it has been argued elsewhere (Halstead, 1981; 1989) that most of the human population must have been largely dependent for subsistence, most of the time, on cultivated cereal and pulse grain crops. It is assumed here that this model of *consumption* is broadly correct, as the basis for a discussion of the patterns of *production,* or land use, which underpinned it.

The nature and scale of land use are of interest, *inter alia,* for their relevance to the short-term economic viability and long-term economic stability of Neolithic communities, for the potential social implications of competition for land, movement of livestock, etc., and for their role in shaping the cultural landscape. There is little direct evidence, however, for Neolithic land use: on-site bioarchaeological evidence is largely a record of consumption rather than production; off-site archaeological evidence (surface scatters of artefacts) largely dates from later periods (and this may reflect taphonomic processes rather than changing patterns of land use - cf. Bintliff *et alii,* 1999); and the existing off-site palaeoecological record is coarse-grained in terms of both temporal and spatial resolution and in terms of our ability to infer causality (e.g. Bottema, 1982; Endfield, 1997). Because of the scarcity of direct evidence, all attempts at reconstructing Neolithic land use have, in practice, argued that the available data are consistent with one or other model of land use based, explicitly or implicitly, on recent practice in the Mediterranean or elsewhere. This paper explores some alternative models of recent land use in terms of, first, their likely relevance to prehistoric Greece and, secondly, their compatibility with the available archaeological and palaeoecological data. Although the aim of this exercise is to shed light on the nature of *Neolithic* land use and landscape, the temporal frame of discussion is extended to include both the Neolithic and Bronze Age because of the heuristic benefits of a longerterm, comparative perspective.

* Department of Archaeology and Prehistory. University of Sheffield, Northgate House. West St. Sheffield S1 4ET, UK.
e-mail: p.halstead@sheffield.ac.uk

IMPLICATIONS AND WEAKNESSES OF THE FLOODWATER FARMING MODEL

Van Andel and Runnels (1995) have followed Sherratt (1980) in arguing that the Neolithic inhabitants of Greece practised a form of floodwater farming, loosely analogous with recent farming practice in the Nile valley and Mesopotamia. This model was held to be consistent with evidence of site location in active floodplains and, more specifically, with evidence for alluvial deposition contemporary with Neolithic occupation at Zarko in Thessaly (van Andel *et alii*, 1995). The broader significance of this model is that, by linking Neolithic cultivation to very restricted patches of seasonally inundated land, it perhaps lends plausibility to arguments that the spread of farming in southeast Europe was effected by the demographic expansion of early farmers (e.g., Ammerman and Cavalli-Sforza, 1973; 1979). Of more immediate concern here is the related inference that Neolithic settlements such as Zarko were occupied seasonally, as this might well undermine the argument advanced above that the size, spacing and *permanence* of Neolithic settlements enforced subsistence dependence on staple grain crops. Moreover, the biggest floods of Thessalian rivers tend to occur in late winter-early spring, after the snow melts in the high mountains (Sivignon, 1975), and so rather late in the growing season for reliable harvests of winter cereals and pulses. These late floods also tend to be unpredictable in terms of both timing and extent: for example, in neighbouring central Macedonia, prior to modern drainage and canalisation work, villagers report that late floods of the Aliakmon periodically destroyed even summer crops such as New World beans (Halstead fieldnotes, Aiginio). Under a floodwater farming regime, therefore, grain crops would probably have been an insecure basis for Neolithic subsistence, thus further undermining the model of consumption adopted here.

For this reason, it is essential to note some basic flaws in the van Andel and Runnels model before proceeding further with discussion of Neolithic land use. First, as Wilkie and Savina (1997) have emphasised, the floodwater farming model is irrelevant to large numbers of Greek Neolithic sites (and, indeed, to large areas of the settled Neolithic landscape) located well above, and well away from, active floodplains. Secondly, geoarchaeological evidence from Zarko does not demonstrate that flooding took place annually rather than, say, once per generation or even less frequently (van Andel *et alii*, 1995). The floodplain location of sites thus does not necessarily indicate seasonal occupation. Thirdly, faunal evidence from Platia Magoula Zarko implies occupation at least in late winter-early spring (Becker, 1999), precisely at the time of year when the site should have been abandoned according to the van Andel and Runnels model. The available evidence from this and other Neolithic settlements in Thessaly, though patchy and inconclusive, is at least consistent with year-round occupation (Halstead, 1999a). Neolithic farmers may have cultivated seasonally inundated land *opportunistically*, as in recent times in Thessaly (e.g. Leake, 1967: 424), and may have used the more predictable waters of perennial springs in drought years when rain-fed cultivation was unreliable. On present evidence, however, floodwater farming seems unlikely to have been either the normal form of land use or the basis of subsistence in Neolithic Greece.

LEARNING FROM TRADITIONAL MEDITERRANEAN LAND USE

Recent, non-mechanised farming in the Mediterranean is perhaps more relevant ecologically, and has been more widely favoured, as a model for early agro-pastoral land use in Greece. The extensive cultivation of cereals, in alternation with bare fallow, and large-scale management of sheep, involving transhumance between winter pastures in the lowlands and summer pastures in the mountains, have been regarded as particularly characteristic of such 'traditional' mediterranean farming (e.g. Grigg, 1974). That these strategies are not *necessary* responses to mediterranean climate and topography, however, is made clear by the parallel existence in the recent past of small-scale mixed farming, typically involving crop rotation (e.g. of cereals and pulses), rather than fallowing, and small-scale, sedentary herding, usually of a mixture of livestock species (e.g., Forbes, 1982; Halstead and Jones, 1989). While extensive arable farmers have relied on plough-oxen to till large areas, both for sowing and fallowing, with minimal human labour, small-scale mixed farmers have often tilled by hand and have typically invested human labour more intensively in practices such as weeding, manuring and watering. Similarly, while seasonal movement between pastures has enabled transhumant herders to run large flocks with limited human labour, small-scale mixed farmers have tended to expend human labour more intensively on the growing or collection of fodder and on the supervision of small groups of grazing animals.

Large-scale, extensive, specialised farming and small-scale, intensive, diversified farming should perhaps be regarded as opposite ends of a spectrum of land use regimes, rather than as strict alternatives, but this opposition has heuristic value as a source of possible models of prehistoric land

use (e.g. Halstead, 1987a; 2000; Cherry, 1988). The approach adopted here is twofold: first, to explore the contexts in which these two strategies of land use have existed in the recent past as a means of assessing their potential relevance to prehistory; and, secondly, to assess the compatibility with either strategy of the limited evidence for later prehistoric land use.

Recent extensive cultivation and transhumant herding have largely been geared to surplus production for the market (Karavidas, 1931; Vergopoulos, 1975). Conversely, intensive cultivation and sedentary herding, often supplemented by part-time wage labour or small-scale production for market, have tended to characterise production primarily for domestic consumption. Moreover, extensive cultivation has been practised by large landowners and intensive cultivation by smallholders, while transhumant herders were also traditionally dependent on the fallow fields of large landowners for winter pasture. Large landowners have not only relied on oxen for tillage, but also on gangs of landless reapers at harvest time (Halstead, 1995). Thus both land use regimes have existed within the context of marked inequality in access to land and of the existence of a market economy, conditions which have obtained from the Late Bronze Age and historical era, respectively, but not demonstrably from an earlier date. In addition, recent smallholders have widely been dependent in the southern Greek lowlands on viticulture (Psikhogios, 1987), for which there is scant Neolithic evidence, and in the mountains (McNeill, 1992) on the growing, in rotation with Old World winter cereals, of New World summer crops (maize, potatoes, *Phaseolus* spp. beans), which were not available in Europe in prehistory.

Both the extensive and intensive poles of recent mediterranean land use were historically contingent and, as such, cannot be extrapolated wholesale to prehistory. Arguably, however, the dependence of recent small-holders on wage labour and on vines or New World crops was a response to scarcity of land (e.g., Psikhogios, 1987), and so the intensive, diversified regime might plausibly be a model for early farming in a relatively egalitarian social environment with less constrained access to land. Conversely, it is doubtful that specialised extensive cultivation or transhumant pastoralism would be viable without salient inequality in control over land and labour. On this basis, evidence for extensive patterns of land use might not be expected before the later Bronze Age, when marked social stratification, entailing unequal access to basic resources of land and labour, is first unambiguously apparent. Neither the linkage between social (in)equality and land use nor the evidence for prehistoric social change is sufficiently robust, however, to obviate the need for empirical investigation of patterns of land use.

EARLY CROP HUSBANDRY

Evidence for the nature of early arable farming is sparse and somewhat indirect, but reasonably consistent. The impact of early farming is only unambiguous in the palynological record from the second millennium BC onwards (Bottema, 1982; Willis and Bennett, 1994). The absence of clear Neolithic traces may partly reflect the insensitivity of cores from large-catchment basins to small-scale clearance, while analysis of the on-site charcoal record from two Neolithic settlements is also consistent with clearance on a limited scale (Ntinou and Badal, 2000). Conversely, the visibility of later Bronze Age cultivation partly reflects the adoption of palynologically distinctive tree-crops, such as the olive, walnut and chestnut, and may also partly reflect an increase in human population numbers and so in the *aggregate extent* of land use, without any attendant change in the *type* of land use. On the other hand, there are numerous reasons why extensive, specialised agriculture should have more impact on the landscape, and should be more apparent in the palaeoecological record, than an intensive, diversified regime (Halstead, 2000). The palynological record is thus compatible with, but by no means indicative of, intensive cultivation during the Neolithic and earlier Bronze Age, giving way to more extensive cultivation from the later Bronze Age.

The most striking feature of the sparse archaeobotanical record for Neolithic and Bronze Age Greece is perhaps the diversity of grain crops grown and, more particularly, the relatively even representation of cereals and pulses (Halstead, 1994: 204-5, table 1). In both respects, the archaeobotanical record of crops grown is more typical of intensive, diversified 'horticulture' than of extensive, specialised agriculture, but such circumstantial evidence is not conclusive. More direct evidence for husbandry practices may be derived from ecological analysis of the weed seeds contaminating grain samples (e.g. Jones *et alii*, 1999; Bogaard *et alii*, 2000). The only such study available suggests an element of intensive cultivation at Late Bronze Age Assiros Toumba, a possible grain storage centre in northern Greece (Jones, 1987; 1992; also Andreou and Kotsakis, 1986). Another form of indirect evidence is that pertaining to plough animals. Artistic representations of yoked cattle are first known from the third millennium BC (Pullen, 1992), but may have little relationship to actual farming practices. Archaeozoological evidence from prehistoric sites in Thessaly indicates a marked improvement in survivorship of male cattle in the Bronze Age (Halstead, 1987b), but male cattle are not necessarily used for ploughing, nor is ploughing necessarily entrusted to oxen, and anyway the modest sample from these few sites is an inadequate

basis for extrapolating to the whole of Greece. On the other hand, the Linear B records from the Late Bronze Age palaces of southern Greece clearly indicate central involvement in large-scale cereal growing, with the palaces providing plough-oxen (Killen, 1993a) and local communities probably providing human labour, particularly for harvesting (Halstead, 1999b). Moreover, comparison of the textual and archaeobotanical records suggests that such plough-based agriculture was paralleled by more diversified (and so perhaps smaller-scale and more intensive) cultivation outside of central control (Halstead, 1992). Overall, therefore, the sparse and often circumstantial evidence for the nature of early crop husbandry is at least consistent with the predominance of an intensive horticultural regime, supplemented during the later Bronze Age by elite-sponsored, extensive agriculture.

This suggested predominance of intensive horticulture has a number of wider implications. First, intensive cultivation is, by virtue of its diversity, a more resilient and reliable basis for subsistence than extensive agriculture, with its tendency towards specialisation (cf. Forbes, 1976). Secondly, the reliability of diversified, intensive farming arguably promotes social equality, whereas extensive practices are in large part dependent on the existence of marked social inequality. Thirdly, and of most importance in this present context, intensive cultivation is likely to have exercised a relatively modest transforming effect on the landscape.

EARLY STOCK HUSBANDRY AND FORAGING

Even if early farmers were primarily dependent on crop growing, and even if the latter largely took the form of small-scale, intensive horticulture, stock rearing and foraging may have involved spatially more extensive use of the landscape. Direct evidence for foraging of wild animals and plants, although relatively abundant on some Bronze Age sites, is remarkably rare on Early-Middle Neolithic and, to a lesser extent, Late-Final Neolithic sites (e.g. von den Driesch, 1987; Halstead, 1999a). It is possible, however, that the rarity of wild animal and plant remains on early sites reflects not the avoidance of foraging but a preference for consumption of wild foods off-site, perhaps because of cultural rules on sharing (Halstead, 1999a). Equally, the possibility cannot be excluded that small, mobile groups of foragers existed alongside the archaeologically more obtrusive early farming communities. Foragers, or foraging expeditions by farmers, may have been of great cultural significance in forging connections between scattered sedentary communities and may be reflected archaeologically in the long-distance movement of, for example, lithic raw materials (e.g. Perlès, 1990). Nonetheless, gathering and hunting activities, whether by largely sedentary farmers or by more mobile foragers, are unlikely either to have made a significant overall contribution to subsistence or to have had much impact on the landscape.

A possible role in long-distance interaction also arises in the case of stock husbandry (e.g. Jacobsen, 1984), for which concrete evidence is much more abundant and the potential for a significant contribution to both subsistence and landscape change is significantly greater. The scale and importance of stock rearing cannot be inferred directly from archaeozoological evidence, because of the complexities of bone discard, survival and recovery, but it has been argued elsewhere that these questions can be addressed indirectly (Halstead, 1996). Recent Greek pastoralists have typically been dependent on keeping large numbers of animals and on specialised production, especially of cheese, for the market; cereals were acquired in exchange as dietary staples. Specialisation in milk products yields more calories per animal than carnivorous pastoralism (e.g. Legge, 1981) and so would arguably be essential if herders were directly dependent on their livestock, rather than on purchased crop staples, for subsistence. Moreover, the low market value of cereals relative to animal products effectively subsidises pastoralists, allowing them to subsist on smaller herds than would be possible in the absence of such exchange. In archaeozoological terms, the slaughter of infant males would have maximised demographic potential for intensive dairying (Payne, 1973; Halstead, 1998), while specialisation in one particular species would have facilitated the herding of large numbers of animals. By contrast, archaeozoological assemblages from Neolithic and Bronze Age open settlements exhibit a more or less balanced mixture of species, with mortality patterns suggesting management according to a mixed-purpose 'meat' strategy (Halstead, 1996).

The archaeozoological record from *open* settlements is thus more reminiscent of recent small-scale mixed farming than of large-scale pastoralism. During the later Neolithic and Early Bronze Age, there is also widespread occupation of caves and of tiny open sites, often located in rough terrain with more obvious potential for grazing than cultivation (e.g. Sampson, 1992; Johnson, 1996; Dousougli, 1996; Cavanagh, 1999). Available archaeozoological evidence from these sites too (i.e., Kalythies, Skoteini and Zas caves), however, is compatible with mixed-purpose 'meat' management of the predominant sheep and goats, suggesting that livestock indeed played a secondary role in prehistoric subsistence (Halstead, 1996).

Even among recent mixed farmers dependent on crop staples for subsistence, however, there was considerable variation in the numbers of animals kept. Although of subsidiary dietary importance, livestock were highly valued: as sources of milk, meat, leather, wool, manure and labour; as vehicles for the recycling of agricultural and kitchen waste and for the 'indirect storage' of surplus grain (Halstead, 1990); and as a means of creating social alliances and obligations through feasting (e.g., Vardaki in press). As a result, the possession of large herds was also a very visible index of wealth and prestige (e.g., Karakasidou, 1997). For similar reasons, the same may well have been the case in prehistory and animal figurines, interpreted as representing domesticates, perhaps confirm that livestock was culturally significant in Neolithic society (Toufexis, 1994).

For Late Bronze Age southern Greece, Linear B written documents record that the palace at Knossos harvested wool from tens of thousands of sheep (Killen, 1993b), while demographic considerations suggest that even larger numbers of sheep may have been in 'private' ownership, with several hundred individuals in rural communities controlling substantial flocks (Halstead, 1999c). The Linear B texts also reveal palatial mobilisation of large numbers of livestock for sacrifices and feasts and again it can be argued that ceremonial consumption was also taking place on a very large scale in local communities (Killen, 1994; Halstead in press).

The task of estimating the scale of animal keeping during the Neolithic, without the assistance of written records, is much harder. At the Late Neolithic 'extended' site of Makrigialos, in northern Greece, remains of several hundred sheep, goats, cattle and pigs were deposited in a single pit complex, apparently over a relatively short period of time, implying *consumption* of meat on a very substantial scale indeed (Collins and Halstead, 1999). On the other hand, the animals consumed at this feast or series of feasts (and likewise those participating in their consumption) may have been drawn from numerous communities scattered over a large region and so do not necessarily indicate local stock *rearing* on a large scale. A pilot analysis of dental microwear on sheep and goat mandibles from Late Neolithic Makrigialos (Mainland pers. comm.) revealed a pattern of attrition suggestive of heavy grazing, but microwear is continuously overwritten (Mainland, 1998) and so this evidence might simply reflect a period, shortly before slaughter, when these animals were confined within the ditch and bank which enclose the site. Bone chemistry provides a more cumulative record of diet. A pilot analysis of bone isotopic composition (Triantaphyllou, 1999) suggests that the diet of domestic pigs at Makrigialos was intermediate between that of wild boar and humans, implying that this species of livestock was at least partly tethered to human settlement, rather than ranging freely in the landscape, and so was perhaps kept in limited numbers.

A similar inference can be drawn, on different grounds and with wider relevance, for both pigs and cattle. During the course of the Neolithic and Bronze Age in Greece, bones of domestic cattle and pigs become increasingly distinct metrically from their larger wild counterparts (e.g. von den Driesch, 1987). An important selective pressure in favour of large body size in the wild populations will have been competition between males, as a result of which large males dominate mating. In the case of the domesticates, archaeozoological evidence for selective culling of young males (e.g., Halstead, 1987b) indicates that this selective pressure will have been relaxed - provided wild males did not have ready access to domestic females. The steeply declining body size of domestic cattle and pigs thus suggests that these livestock species were herded closely enough to inhibit mating with wild males and so, arguably, that stock were kept in modest numbers.

While these rather indirect arguments tentatively suggest limited numbers of early livestock, the Late Neolithic-Early Bronze Age colonisation of agriculturally marginal parts of the Greek landscape would arguably have favoured increasing reliance on livestock, at least as an alternative source of subsistence following crop failures, and there are possible indications that the scale of stock rearing increased through the Neolithic. While the density and structure of lowland vegetation in seventh millennium BC Greece cannot, on present evidence, be reconstructed in detail, there is no reason to doubt that the landscape around the earliest farming settlements offered suitable niches, in varying proportions, for each of the principal livestock species: cattle, sheep, goats and pigs. In this light, it has been argued that the predominance on earlier Neolithic sites of sheep (ideally suited to grazing stubble and fallow fields, as well as sprouting cereals) reflects an initially close integration of livestock with the cultivated landscape (Halstead, 1981). In later Neolithic-Early Bronze Age faunal assemblages, a contrast is apparent between open sites in fertile lowland basins, on the one hand, and cave sites and a few open sites in more marginal locations, on the other hand. At the former, sheep are still far more abundant than goats, although pigs and cattle may also be more or less well represented. Conversely, at the latter, sheep and goats predominate in fairly even proportions (Halstead, 1996). This apparently increased sensitivity to the local natural en-

vironment perhaps indicates that livestock made greater use of uncultivated parts of the landscape, and so were kept in larger numbers, than in the earlier Neolithic.

Such an expansion of herding would be compatible with widespread geoarchaeological evidence for erosion and alluviation, roughly dated to the later Neolithic and Early Bronze Age (van Andel *et alii*, 1990; Zangger, 1991; Krahtopoulou, 2000; Whitelaw, 2000). Modern herders are sensitive to overgrazing, because this has an immediate, negative impact on the productivity of livestock in terms of milk yields, fertility and meat weights, and so have widely adopted measures to limit livestock numbers and the potential for degradation of the landscape (Forbes, 1997; 2000; Koster, 1997). The possibility must be entertained, however, that prehistoric herders had different priorities, for example being more concerned to maintain large herds as a symbol of wealth and status than to maximise the productivity of their livestock. Herding also tends to be more spatially extensive than cultivation and so might be favoured as a cause of early anthropogenic impact on the landscape, but there is as yet no secure evidence that the alluviation episodes in question resulted from human activity (Endfield, 1997; Krahtopoulou, 2000).

Studies of recent herders underline the importance of the *quality*, as well as quantity, of grazing. Seasonal flushes of nutritionally rich pasture, such as the ruderal plants which spring up in stubble fields after the harvest, are sought after for their ability to fatten animals, improve milk yields, or enhance reproductive success and so may play a major role in shaping both local and long-distance movements of livestock in the landscape. Such nutritious flushes are often not the lushest patches of vegetation, being found instead on disturbed or even barren ground which supports young growth. The small and perhaps short-lived sites of later Neolithic-Early Bronze Age date, found in barren locations in several southern Greek surveys (e.g. Johnson, 1996; Cavanagh, 1999) may thus be indicative of such seasonal grazing to fatten modest numbers of livestock, rather than of herding on a large scale. Recent herders have also often sought to extend the availability in time or space of valued patches of pasture by measures such as burning or cutting. Prehistoric herders may have done the same and, in steep or barren areas, such activities even on a small scale may well have caused changes to vegetation or erosion severe enough to be registered in the palaeoecological record. The relationship between numbers of livestock, on the one hand, and the spatial scale of herding and the impact of grazing on the landscape, on the other hand, is thus complex. An understanding of the movement of livestock in space, however, would illuminate not only patterns of land use in prehistory and their possible role in shaping the cultural landscape, but also the possible role of herding movements in regional social intercourse.

CONCLUSIONS

Many questions remain concerning the nature of prehistoric land use in Greece and much of this survey has been devoted to exposing the often flimsy basis on which existing interpretations are founded. It has been argued that Neolithic land use was essentially small-scale and intensive, with arable farming in many respects resembling horticulture rather than agriculture. The scale of animal husbandry is probably the most contentious and also complex issue. Domestic animals were probably subsidiary to crops in their contribution to normal subsistence, but were on occasions consumed in large numbers and may well have been herded at some distance from the 'home' settlement, whether in search of preferred patches of pasture or because such movements served as a vehicle for social intercourse. There are also reasons to expect that the scale and economic significance of stock husbandry will have increased during the course of the Neolithic and there is possible empirical support for this expectation, but the evidence is far from conclusive.

Perhaps the most significant conclusions from this survey are methodological. First, there is an evident need both for more and better palaeoecological and palaeoeconomic data and for further actualistic studies of contemporary land use as a basis for interpreting such data. For example, in the light of ecological studies of modern weed floras, archaeobotanical evidence could clarify the intensity of cultivation practices or the likelihood of floodwater farming. Analyses of bone isotopic composition, of dental microwear and, where available, of animal dung could shed complementary light on the movement of livestock in the landscape. Finer dating of palaeoecological sequences and further studies of modern vegetation and landforms would facilitate the recognition and interpretation of human impact on the landscape. Secondly, the pervasive and inevitable role of models, derived from recent practice, in shaping reconstruction of prehistoric land use must be acknowledged explicitly, so that the relevance of these models can be critically evaluated and the heuristic potential of their application can be enhanced.

ACKNOWLEDGEMENTS

I am grateful to Tina Badal and colleagues, for the invitation to take part in a stimulating and most enjoyable meet-

ing in Valencia; to Tina Badal, Valasia Isaakidou and Maria Ntinou, for comments on an earlier draft of this paper; and to Geerd-Jaap van Klinken, Ingrid Mainland and Sevi Triantaphyllou, for permission to refer to unpublished work.

BIBLIOGRAPHY

AMMERMAN, A. J. and CAVALLI-SFORZA, L. (1973): A population model for the diffusion of early farming in Europe. In C. Renfrew (ed.), *The Explanation of Culture Change*. Duckworth. London: 343-357.

AMMERMAN, A. J. and CAVALLI-SFORZA, L. (1979): The wave of advance model for the spread of agriculture in Europe. In C. Renfrew and K. L. Cooke (eds.), *Transformations: Mathematical Approaches to Culture Change*. Academic Press. New York: 275-293.

VAN ANDEL, TJ.; GALLIS, K. and TOUFEXIS, G. (1995): Early neolithic farming in a Thessalian river landscape, Greece. In J. Lewin, M. G. Macklin and J. C. Woodward (eds.), *Mediterranean Quaternary River Environments*. Balkema. Rotterdam: 131-143.

VAN ANDEL, Tj. and RUNNELS, C. (1995): The earliest farmers in Europe. *Antiquity*, 69: 481-500.

VAN ANDEL, Tj.; ZANGGER, E. and DEMITRACK, A. (1990): Land use and soil erosion in prehistoric and historical Greece. *Journal of Field Archaeology*, 17: 379-396.

ANDREOU, S. and KOTSAKIS, K. (1986): Diastasis tou khorou stin kendriki Makedonia: apotiposi tis endokoinotikis kai diakoinotikis khoroorganosis. In *Amitos* (Festschrift to M. Andronikos). University of Thessaloniki, Thessaloniki: 57-88.

BECKER, C. (1999): The Middle Neolithic and the Platia Magoula Zarkou - a review of current archaeozoological research in Thessaly (Greece). *Anthropozoologica*, 30: 3-22.

BINTLIFF, J.; HOWARD, P. and SNODGRASS, A. (1999): The hidden landscape of prehistoric Greece. *Journal of Mediterranean Archaeology*, 12 (2): 139-168.

BOGAARD, A.; CHARLES, M.; HALSTEAD, P. and JONES, G. (2000): The scale and intensity of cultivation: evidence from weed ecology. In C. Frederick and P. Halstead (eds.), *Landscape and Land Use in Postglacial Greece*. Sheffield Academic Press, Sheffield: 129-134.

BOTTEMA, S. (1982): Palynological investigations in Greece with special reference to pollen as an indicator of human activity. *Palaeohistoria*, 24: 257-289.

CAVANAGH, W. (1999): Revenons à nos moutons: surface survey and the Peloponnese in the Late and Final Neolithic. In J. Renard (ed.), *Le Péloponnèse: archéologie et histoire*. Presses Universitaires Rennes, Rennes: 31-65.

CHERRY, J. F. (1988): Pastoralism and the role of animals in the pre- and proto-historic economies of the Aegean. In C.R. Whittaker (ed.), Pastoral economies in classical antiquity. *Cambridge Philological Society Supplementary Volume*, 14: 6-34.

COLLINS, P. and HALSTEAD, P. (1999): Faunal remains and animal exploitation at LN Makrigialos: preliminary results. In P. Halstead (ed.), *Neolithic Society in Greece*. Sheffield Academic Press. Sheffield: 139-141.

DOUSOUGLI, A. (1996): Epirus - the Ionian Islands. In G.A. Papathanassopoulos (ed.), *Neolithic Culture in Greece*. Goulandris Foundation. Athens: 46-48.

VON DEN DRIESCH, A. (1987): Haus- und Jagdtiere im vorgeschichtlichen Thessalien. *Prähistorische Zeitschrift*, 62: 1-21.

ENDFIELD, G. H. (1997): Myth, manipulation and myopia in the study of Mediterranean soil erosion. In A. Sinclair, E. Slater and J. Gowlett (eds.), *Archaeological Sciences 1995*. Oxbow Monographs 64. Oxbow. Oxford: 241-248.

FORBES, H. (1976): 'We have a little of everything': the ecological basis of some agricultural practices in Methana, Trizinia. *Annals of the New York Academy of Sciences*, 268: 236-250.

FORBES, H. (1982): *Strategies and Soils: Technology, Production and Environment in the Peninsula of Methana, Greece*. PhD dissertation, University of Pennsylvania.

FORBES, H. (1997): A 'waste' of resources: aspects of landscape exploitation in lowland Greek agriculture. In P. N. Kardulias and M. T. Shutes (eds.), *Aegean Strategies: Studies of Culture and Environment on the European Fringe*. Rowman and Littlefield. Lanham: 187-213.

FORBES, H. (2000): Landscape exploitation via pastoralism: examining the 'landscape degradation' vs sustainable economy debate in the post-medieval Southern Argolid. In P. Halstead and C. Frederick (eds.), *Landscape and Land Use in Postglacial Greece*. Sheffield Academic Press. Sheffield: 95-109.

GRIGG, D. B. (1974): *The Agricultural Systems of the World: an Evolutionary Approach*. Cambridge University Press. Cambridge.

HALSTEAD, P. (1981): Counting sheep in Neolithic and Bronze Age Greece. In I. Hodder, G. Isaac and N. Hammond (eds.), *Pattern of the Past: Studies in Honour of David Clarke*. Cambridge University Press. Cambridge: 307-339.

HALSTEAD, P. (1987a): Traditional and ancient rural economy in Mediterranean Europe: plus ça change? *Journal of Hellenic Studies*, 107: 77-87.

HALSTEAD, P. (1987b): Man and other animals in later Greek prehistory. *Annual of the British School at Athens*, 82: 71-83.

HALSTEAD, P. (1989): Like rising damp? An ecological approach to the spread of farming in southeast and central Europe. In

A. Milles, D. Williams and N. Gardner (eds.), *The Beginnings of Agriculture*. BAR International Series 496. British Archaeological Reports. Oxford: 23-53.

HALSTEAD, P. (1990): Waste not, want not: traditional responses to crop failure in Greece. *Rural History,* 1: 147-164.

HALSTEAD, P. (1992): Agriculture in the Bronze Age Aegean: towards a model of palatial economy. In B. Wells (ed.), *Agriculture in Ancient Greece*. Swedish Institute at Athens. Stockholm: 105-116.

HALSTEAD, P. (1994): The North-South divide: regional paths to complexity in prehistoric Greece. In C. Mathers and S. Stoddart (eds.), *Development and Decline in the Mediterranean Bronze Age*. JR Collis. Sheffield: 195-219.

HALSTEAD, P. (1995): Plough and power: the economic and social significance of cultivation with the ox-drawn ard in the Mediterranean. *Bulletin on Sumerian Agriculture,* 8: 11-22.

HALSTEAD, P. (1996): Pastoralism or household herding? Problems of scale and specialization in early Greek animal husbandry. *World Archaeology,* 28: 20-42.

HALSTEAD, P. (1998): Mortality models and milking: problems of uniformitarianism, optimality and equifinality reconsidered. *Anthropozoologica,* 27: 3-20.

HALSTEAD, P. (1999a): Neighbours from hell: the household in Neolithic Greece. In P. Halstead (ed.), *Neolithic Society in Greece*. Sheffield Academic Press. Sheffield: 77-95.

HALSTEAD, P. (1999b): Surplus and share-croppers: the grain production strategies of mycenaean palaces. In P. Betancourt, V. Karageorghis, R. Laffineur and W.-D. Niemeier (eds.), *MELETHMATA. Studies Presented to Malcolm H. Wiener as he Enters his 65th Year.* Aegaeum 20. University of Liège. Liège: 319-326.

HALSTEAD, P. (1999c): Missing sheep: on the meaning and wider significance of *o* in Knossos SHEEP records. *Annual of the British School at Athens,* 94: 145-166.

HALSTEAD, P. (2000): Land Use in Postglacial Greece: Cultural Causes and Environmental Effects. In P. Halstead and C. Frederick (eds.), *Landscape and Land Use in Postglacial Greece*. Sheffield Academic Press. Sheffield: 110-128.

HALSTEAD, P., in press: Texts, bones and herders: approaches to animal husbandry in Late Bronze Age Greece. *Minos 33-34.*

HALSTEAD, P. and JONES, G. (1989): Agrarian ecology in the Greek islands: time stress, scale and risk. *Journal of Hellenic Studies,* 109: 41-55.

JACOBSEN, T.W. (1984): Seasonal pastoralism in southern Greece: a consideration of the ecology of neolithic urfirnis pottery. In P. M. Rice, *Pots and Potters: Current Approaches in Ceramic Archaeology*. UCLA Institute of Archaeology. Los Angeles: 27-43

JOHNSON, M. (1996): The Berbati-Limnes archaeological survey: the Neolithic period. In B. Wells (ed.), *The Berbati-Limnes Archaeological Survey 1988-1990.* Swedish Institute at Athens. Stockholm: 37-73.

JONES, G. (1987): Agricultural practice in Greek prehistory. *Annual of the British School at Athens,* 82: 115-123.

JONES, G. (1992): Weed phytosociology and crop husbandry: identifying a contrast between ancient and modern practice. *Review of Palaeobotany and Palynology,* 73: 133-143.

JONES, G.; BOGAARD, A.; HALSTEAD, P.; CHARLES, M. and SMITH, H. (1999): Identifying the intensity of crop husbandry practices on the basis of weed floras: *Annual of the British School at Athens,* 94: 167-189.

KARAKASIDOU, A. N. (1997): *Fields of Wheat, Hills of Blood.* Chicago University Press. Chicago.

KARAVIDAS, K. D. (1931): *Agrotika: Meleti Sigkritiki*. Athens.

KILLEN, J. T. (1993a): The oxen's names on the Knossos Ch tablets. *Minos* 27-28: 101-107.

KILLEN, J. T. (1993b): Records of sheep and goats at mycenaean Knossos and Pylos. *Bulletin on Sumerian Agriculture,* 7: 209-218.

KILLEN, J. T. (1994): Thebes sealings, Knossos tablets and mycenaean state banquets. *Bulletin of the Institute of Classical Studies,* 1994: 67-84.

KOSTER, H. A. (1997): Yours, mine and ours: private and public pasture in Greece. In P.N. Kardulias and M.T. Shutes (eds.), *Aegean Strategies: Studies of Culture and Environment on the European Fringe.* Rowman and Littlefield, Lanham: 141-186.

KRAHTOPOULOU, A. (2000): Holocene alluvial history of northern Pieria, Macedonia, Greece. In P. Halstead and C. Frederick (eds.), *Landscape and Land Use in Postglacial Greece.* Sheffield Academic Press. Sheffield: 15-27.

LEAKE, W. M. (1967): *Travels in Northern Greece, 4.* Hakkert. Amsterdam.

LEGGE, A. J. (1981): The agricultural economy. In R. J. Mercer (ed.), *Grimes Graves Excavations 1971-72.* Her Majesty's Stationery Office. London: 79-103.

MCNEILL, J. R. (1992): *The Mountains of the Mediterranean World.* Cambridge University Press. Cambridge.

MAINLAND, I. L. (1998): The lamb's last supper: the role of dental microwear analysis in reconstructing livestock diet in the past. *Environmental Archaeology,* 1: 55-62.

NTINOU, M. and BADAL, E. (2000): Local vegetation and charcoal analysis: an example from two Late Neolithic sites in northern Greece. In P. Halstead and C. Frederick (eds.), *Landscape and Land Use in Postglacial Greece*. Sheffield Academic Press. Sheffield: 38-51.

PAYNE, S. (1973): Kill-off patterns in sheep and goats: the mandibles from Asvan Kalé. *Anatolian Studies,* 23: 281-303.

PERLÈS, C. (1990): L' outillage de pierre taillée néolithique en Grèce: approvisionnement et exploitation des matières premières. *Bulletin de Correspondance Hellénique,* 114: 1-42.

PSIKHOGIOS, D. K. (1987): *Proikes, Foroi, Stafida kai Psomi: Oikonomia kai Oikogenia stin Agrotiki Ellada tou 19 Aiona.* Ethniko Kentro Koinonikon Erevnon. Athens.

PULLEN, D. J. (1992): Ox and plough in the Early Bronze Age Aegean. *American Journal of Archaeology,* 96: 45-54.

SAMPSON, A. (1992): Late Neolithic remains at Tharounia, Euboea: a model for the seasonal use of settlements and caves. *Annual of the British School at Athens,* 87: 61-101.

SHERRATT, A.G. (1980): Water, soil and seasonality in early cereal cultivation. *World Archaeology,* 11: 313-330.

SIVIGNON, M. (1975): *La Thessalie: analyse géographique d' une province grecque.* Memoires et Documents 17. Institut des Études Rhodaniennes. Lyon.

TOUFEXIS, G. (1994): Neolithic animal figurines from Thessaly. In *La Thessalie: quinze années de recherches archéologiques, 1975-1990.* Ministry of Culture. Athens: 163-168.

TRIANTAPHYLLOU, S. (1999): *A Bioarchaeological Approach to Prehistoric Cemetery Populations from Western and Central Greek Macedonia.* PhD Dissertation. University of Sheffield.

VARDAKI, E., in press: Consumption strategies in a highland village of central Crete: the case of marriage banquets. In E. Kotjabopoulou, Y. Hamilakis, P. Halstead, C. Gamble and P. Elefanti (eds.), *Zooarchaeology in Greece.* British School at Athens, London.

VERGOPOULOS, K. (1975): *To Agrotiko Zitima stin Ellada, i Koinoniki Ensomatosi tis Georgias.* Exandas. Athens.

WHITELAW, T. (2000): Settlement instability and landscape degradation in the southern Aegean in the third millennium BC. In P. Halstead and C. Frederick (eds.), *Landscape and Land Use in Postglacial Greece.* Sheffield Academic Press. Sheffield: 135-161.

WILKIE, N. C. and SAVINA, M. E. (1997): The earliest farmers in Macedonia. *Antiquity,* 71: 201-207.

WILLIS, K. J. and BENNETT, K. D. (1994): The neolithic transition fact or fiction? Palaeoecological evidence from the Balkans. *The Holocene,* 4: 326-330.

ZANGGER, E. (1991): Prehistoric coastal environments in Greece: the vanished landscapes of Dimini bay and Lake Lerna. *Journal of Field Archaeology,* 18: 1-16.