Journal of World Prehistory (2023) 36:109–145
https://doi.org/10.1007/s10963-023-09176-4

Agricultural Intensification and the Evidence from Offsite Survey Archaeology

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Accepted: 19 April 2023 / Published online: 26 May 2023

Abstract

The enhancement of crop yields through manuring has been attested since early farming prehistory in many parts of the world. This article reviews the history of research into the potential archaeological evidence for this practice in Europe, the Mediterranean lands and the Near East. The focus is on the interpretation of ceramic data recovered in surface field surveys conducted since 1950 and what sorts of activities may be plausibly inferred from them. The article examines the origins of the model, objections to it, and recent analyses which again strengthen it. A particular case-study analyses the evidence for the protohistoric and early historic periods in Greece. The methodological and empirical arguments tend to strongly reaffirm the importance of artificial manuring in agrarian regimes of all periods, and its significance in furthering understandings of economic and demographic history and prehistory.

Keywords Field survey · Manuring · Agricultural history · Landscape archaeology

Introduction

A consistent feature of the publications of the Boeotia Regional Survey Project, Central Greece, directed by the author and Anthony Snodgrass since 1978, already evident in our first interim report in 1985, is the presentation of a model which identifies a recurrent role for artificial manuring in the creation of widespread off-site potsherd carpets. The identification of this as significant has prompted a major reappraisal of the surface archaeological record in Greece and, as we shall see, it is already widely accepted in other parts of Europe, the Mediterranean and the Near East, as well as even further afield. Nonetheless, a minority of landscape archaeologists reject this interpretation of off-site sherd carpets—a rejection that has meant that some survey projects continue to completely avoid interpreting their offsite

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ceramic finds This is an unfortunate situation, since detecting a specific signal for artificial manuring from surface finds is a unique means for detecting phases of agricultural intensification, whether due to demographic pressure or commercial opportunity, and hence is of considerable historical importance. This article presents a systematic review of recent relevant publications, including an assessment of the pre-2000 background literature, and aims to assist researchers in understanding the model in the context of wider discussions of method and theory in surface survey.

This analysis of the literature provides both a history and an up-to-date review of the interpretation of off-site ceramic 'carpets' as evidence, primarily but never exclusively, for the deliberate spreading of human and animal refuse over the off-site fields to promote their fertility—artificial manuring. The complete model also recognises an intermediate zone of sherd density, lower than that of the site core but higher than the genuinely off-site signal. This zone, immediately surrounding the site, we term the 'site halo'. The site halo, we have argued, is generated by a range of factors including plough-spread from sites, rain-erosion, rubbish dumping, infield gardens, animal stalls and byres, and various activities related to other ancillary buildings and work-areas, graves, shrines, and so on.

Soil Science and Traditional Agriculture

Some introductory comments on the practice of field manuring are in order. In 1991, the soil scientist Rob Shiel pointed out that Medieval sources highlight the superior quality of stored manure, spread and ploughed into farmland, over the casual droppings of grazing livestock. He also noted that historically, urban waste was also recycled ('night soil') to enhance the fields peripheral to towns, where land use was more intense; but added that transport costs necessarily limited such application to a few kilometres from its source (Shiel, 1991). More recently, Shiel (2012) has provided a useful guide as to why manure has been so important to human societies, observing that as soon as human plant exploitation begins and the proportion of plants producing food is augmented, then the amount that can be eaten is increased. Invariably this material is consumed elsewhere; and this depletes the nutrients available at the original source. As a result, soil fertility declines. This decline is most rapidly experienced where cereals are grown as a monoculture. The simplest way to counter this is to abandon over-exploited land and clear new areas; this, however, is not only very labour-intensive, but also assumes that the total human population density is small, so that there is room for expansion. The alternative is to take measures to recycle any available nutrient sources. But even in situations where human and animal waste is assiduously collected and returned to the fields, the decline of soil fertility is merely delayed, as the recycling of nutrients always falls short of what is required. Thus, Shiel suggests, artificial manuring using such natural resources can halt crop decline in the short but not the long term: human depopulation, land abandonment, or a shift to a more extensive land use is likely to result. This is a natural dynamic that was only finally countered through the mass introduction of chemical fertilisers in the late 19th century AD.

Ancient Roman and, to a lesser extent, Greek agronomists, preserved in diverse sources, also preserve plentiful references to artificial manuring of the kind our model envisages, and information and instruction on the theme is then elaborated on in Medieval European and Islamic texts (White, 1970; Wilkinson, 1982; Alcock, Cherry & Davis 1994; R. Jones, 2012b; Forbes, 2013). A famous first mention is found in Homer's *Odyssey*, dating to somewhere around the 7th century BC, where Odysseus' dog Argos is described as lying neglected 'on the heaps of dung from the mules and cattle which lay in profusion at the gate, awaiting removal by Odysseus' servants as manure for his estate' (*Odyssey*, 19, pp. 297–300). Although in the developed Western world, the use of chemical fertilisers had become standard in farming by around AD 1900, in many other places, including the more rural, isolated, or distant parts of Europe, organic midden manuring and spreading of urban night soil continued to be significant, to within living memory; indeed night soil remains today a vital source of nitrogen for farming around urban centres in other parts of the world (see below).

Landscape Archaeology and Sherd Scatters

Let us now turn to a survey of the key publications preceding and following our initial deployment of the artificial manuring model in the Boeotia Survey (most of them before a lively debate over this interpretation in the academic literature, which took place between 1994 and 2002).

During the first half of the twentieth century in Britain, the development of landscape archaeology linked the recording of ancient field systems to sherd scatters. In particular, this was discussed by Rhodes (1950), who observed that the thin but widespread scatter of Romano-British potsherds, which can be picked up from the surface and lynchets of 'Celtic' fields, is a phenomenon which the field-walker soon learns to accept as a matter of course. Even at this early stage, Rhodes investigated the soil context through excavation and was able to establish the important fact that such sherds are incorporated into the field systems and do not represent occupation or other on-site deposits. More than 75% of the Iron Age and Roman field systems examined showed contemporary, period-appropriate manuring scatters.

In the 1970s, a major landscape archaeology project on the German island of Sylt identified three phases of population pressure appearing in marginal areas. These dated to the Iron Age, the Viking to High Medieval era and, finally, to the Early Modern period, and each was associated with the movement of soil (potsherds incorporated) from more fertile contexts, including settlement areas, into the cultivated land (Kossack, 1974). Fields were identified by plough-marks, hay ricks and, latterly, the recorded plans of field boundaries.

In a separate development in the United States, and also during the 1970s, intensive archaeological surface survey was beginning to prevail over earlier, extensive forms of fieldwork, and it was being increasingly recognised that site-focused survey typically ignored the recurrent presence of 'off-site' artefacts, lithic or ceramic, which, when properly observed, were seen often to cover much larger areas of the landscape (albeit at lower densities), than sites (Thomas, 1975). Thus was born

'non-site survey', where the individual surface artefact became the primary unit of observation. In the first season of our Boeotia Project in Central Greece, we recorded off-site data in a qualitative way, but from the second, 1979, season onwards, such data were recorded mechanically and quantitatively. This hastened recognition of the prevalence of off-site finds throughout lowland Greece, and by 1983, John Cherry would describe the Mediterranean surface record as 'likely to consist of a virtually continuous spatial distribution of material over the landscape, but a distribution extremely variable in density' (Cherry, 1983, p. 395).

In the early 1980s, the Vilauba Project in Spain found that its survey was hampered by the intensity of Early Modern manuring over all fields in the region, attested to by very large quantities of rubbish including potsherds (Jones et al., 1982). The Montarrenti Survey, Italy (Barker, 1984; Barker et al., 1986), mapped Roman and Medieval sherds, concentrated mostly within a few hundred metres of village, hamlet and farm sites, whereas post-Medieval scatters were present in almost every field, occurring up to one or two kilometres away from settlements. On the 'manuring interpretation', this implied the expansion of enhanced cultivation over time, showing that the extension of sherd carpets could be a sensitive guide to cycles of land use. This project noted that similar results had been obtained from the Farfa Survey (north-central Italy). In Hampshire, England, a pioneer intensive survey by Shennan (1985) noted that Roman off-site manuring scatters varied according to soil fertility, neglecting heavier soils used for pasture in favour of the lighter-soiled arable sectors.

An edited volume in 1988 broadened the local German coastal study that had been reported on by Kossack (mentioned above) to survey man-made soils over a large part of lowland north-west Europe. Known as 'plaggen soils' (Groenmann-van Waateringe & Robinson, 1988) (see Fig. 1), these label and characterize very extensive regions of poor, sandy soils where permanent farming is only possible through regular manuring, using transported soil from more fertile locations, including domestic and stock enclosures (ceramic inclusions and charcoal are common). Plaggen soils were reviewed more recently by Pears (2012) for the Netherlands, Scotland and Ireland.

A watershed was reached in the early 1980s, when the finest contemporary exponent of Near Eastern geoarchaeology, the late Tony Wilkinson, began to produce a series of landmark papers on off-site pottery scatters, which continued to be published up to his great work of synthesis on the evolution of Near Eastern landscapes in 2003 (Ball et al., 1989; Wilkinson, 1982, 1988, 1989, 1990, 1992, 1994, 1998, 1999, 2003). Wilkinson's achievement rested on several strong, personal factors. First, he had worked in almost every country of the Near East; secondly, he was both a physical geographer and a field archaeologist; and thirdly, his work on off-site ceramics was so thorough that its main conclusions are never now questioned, even by the small group of 'manuring sceptics' in Greece. Wilkinson did, however, face initial resistance from traditional Near Eastern field surveyors, after criticising them for their over-reliance on mounded-sites (tells), and thus for paying little or no attention to flat sites.

Wilkinson's research into off-site manuring 'carpets' involved mapping these in many landscapes, then using his own geomorphic sections to prove that they did not represent sites. At the same time he made another major contribution, by

Fig. 1 Man-made soils in north-western Europe, from van de Westeringhe, 1988, Fig. 2.1

demonstrating that the radial extent of these sherd carpets correlated systematically with the size of their settlement of origin: small rural sites, for instance, would have manure spreads of a few hundred metres' radius, while for towns the radius could extend several kilometres. To the criticism that off-site scatters were due to the recent practice (in Arabic, *sabakh*) whereby modern villagers mine tells for fertile soil to spread on their fields, he argued that this would create multi-period scatters, whereas the dominant manuring carpets that he was able to recognize were confined to one or two periods only, in each landscape, usually coinciding with a peak of local population and hence, in his view, with pressure to increase food production. Thus, importantly, off-site manuring spreads can be described as a 'punctuated equilibrium' phenomenon: in most eras, as well as some landscapes, they are entirely absent. He was also able to identify farmers' tracks, radiating out of prehistoric and ancient settlements ('hollow ways'), which marked access to these manured infields,

and also formed routes into lands further out, with little or no sherd scatters—where, he suggested, lay the primary pastoral land. Importantly, animal manure in these zones would be deposited directly on to fields, so that manuring sherd carpets may signify those areas requiring more intense fertilisation, that is, the primary cereal-growing land for a settlement.

Roughly contemporary with Wilkinson's Near Eastern work was a 1985 Danish report outlining the analysis of a buried Iron Age field in Denmark, using phosphate analysis and soil micromorphology. It showed that around a settlement site the soils had been enriched by animal and human waste (again incorporating potsherds) for manuring purposes; this was a known historical tradition for the infield (the inner zone of land-use around a domestic site) in Denmark, recorded in 19th-century accounts (Liversage, Munro et al. 1985). In the same year, an intensive survey at Maddle Farm, England, focusing on the landscape around a Roman villa, recording a manuring carpet of the same age that covered some 500 ha (Gaffney et al., 1985); the pattern of scatters followed the best arable land, while land more likely to be pasture was neglected. A similar discrimination could be shown for the Medieval era, so that the Maddle Farm results became much cited. In 1991, Peter Hayes wrote that 'sparse scatters of abraded sherds commonly found on fields in Britain have long been interpreted as the product of manure spreading', then went on to describe how his own survey and those of others in England and in Southern France, had succeeded in demonstrating that Roman and Medieval sherd scatters clearly demarcated arable, as opposed to pasture sectors, in the areas of recorded rural settlement (1991, p. 82). In the same year, Rasmussen suggested that increased sherd spreads around Roman sites in the Tuscania Survey in Italy marked manuring areas (Rasmussen, 1991).

In 1992, the Italian Rieti Survey described site-level ceramic density, followed by an area of lesser density bordering site cores (which in Greece we had already christened the site 'halo'), and finally a yet lower level which could be linked to manuring. This last category would provide insight into past land use: thus, Roman farming could be shown to focus on land at higher elevations, with lower levels used as pasture, whereas in the Early Modern era both zones were seen to be intensively cultivated, as evidenced by site numbers and also from the associated off-site scatters (Coccia & Mattingley, 1992). These results echoed those of the Montarrenti Survey cited earlier. In Portugal, around the Bronze Age settlement of Agroal, a publication in the same year combining excavation, survey and soil geochemistry, distinguished between the settlement, middens and manured fields (Lillios, 1992).

The Contribution of the Boeotia Survey

In the following section, our own contribution to the development and use of the 'Manuring Model', from the 1980s to the 2010s, is summarised by reference to the Boeotia Survey evidence for Central Greece.

As noted earlier, like most 'New Wave' surveys in Greece from the 1970s onwards, we rapidly adopted the North American-inspired, artefact-based, non-site approach in the Boeotia Survey from 1979 onwards. 'New Wave' was my term for

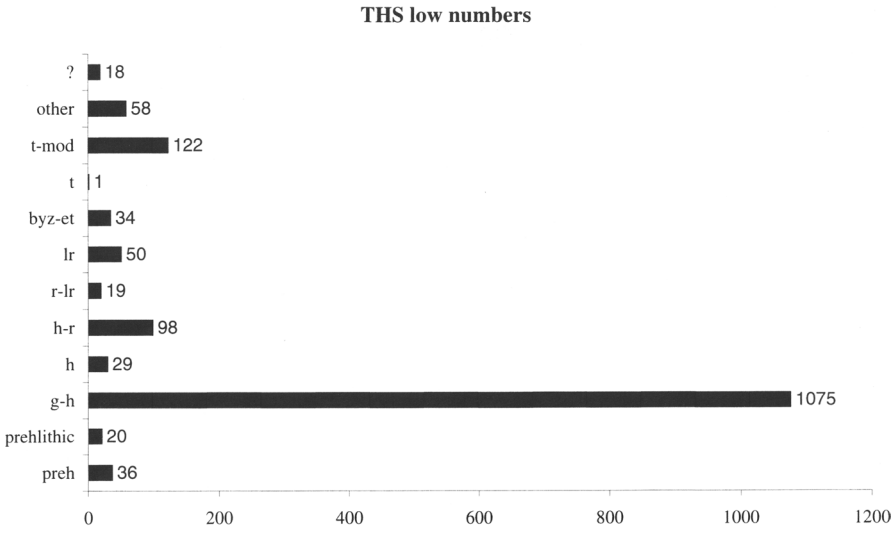
this (borrowed from the innovative Nouvelle Vague cinema of 1960s France)—a label I felt appropriate for the first group of intensive, that is field-by-field, rather than extensive, surveys that started up in the Mediterranean from the beginning of the 1970s, inspired by advances in the USA. The approach not only allowed us to make quantitative evaluations of potential sites, including the strength of their occupation, but also revealed a new, and at the time unexpected, phenomenon: that nearly all the cultivable land in those areas that we field-walked was covered with a carpet of potsherds. Initially we compared the density of such offsite finds with field densities from other Mediterranean, Near Eastern and north-western European surveys: these showed a clear cline in density, from temperate Europe, via the Mediterranean lands, into the more arid areas of the Near East (Bintliff & Snodgrass, 1988). This cline we explained through different post-depositional conditions: soil growth in NW Europe, soil thinning in the Mediterranean and wind deflation in the arid Near East.

As for the origin of these carpets, we summarized the evidence on erosion, plough movement and casual discard, finding them ultimately inadequate to account for the visible parameters of these carpets, which spread uphill, crossed natural barriers, and were mostly continuous. The experimental data for sherd movement, 'sherd lagging' during soil loss, and the nature of slope erosion, all indicated that such landscape-wide carpets could not be produced by unintentional displacement processes. The most likely explanation was deliberate manuring from sites of all sizes, a position matching that of the parallel research being conducted by Wilkinson throughout the Near East. We also drew a distinction, first outlined in 1985 (Bintliff & Snodgrass, 1985), between the site core, and its immediate periphery—the 'halo', with lower than core densities. The halo, we suggested, was generated through a combination of factors: the spreading of site core finds outwards by weather and tillage, the build-up of ancient peripheral rubbish dumps, the existence of infield, intensely-cultivated gardens, sheds and byres, and of burials. The off-site carpet proper, we went on to argue in 1988, was essentially (but not entirely) composed of manuring material of human and animal origin (stall and yard rubbish, including formal middens, animal bone, household waste from meals), all of them likely to include broken artefacts. We also noted, early on, that there existed surface phenomena distant from site cores and their surrounding haloes, but at a density level also lying between that of sites and of the non-site zones: limited clustered finds, which could represent non-residential field bases, vestigial occupation sites, and isolated rural cemeteries.

During this same period, I co-directed an international survey on the island of Hvar, Croatia, in a Greco-Roman lowland landscape, where we again mapped site haloes, as well as off-site manuring spreads, of ancient and Medieval–Early Modern date (Bintliff & Gaffney, 1988). Here, significantly, local informants told us that such a practice had survived into living memory, and they provided us with a very useful additional piece of information, namely that the inclusion of tile and large ceramic was seen as advantageous for aerating the soil.

I can now move to summarize our later work on the off-site, based on a few key publications (Bintliff & Howard, 1999; Snodgrass, 1990) and our two volumes *Testing the Hinterland* (Bintliff, Howard & Snodgrass 2007) and *The City of Thespiai* (Bintliff, Farinetti, Slapsak et al. 2017). An important test of our approach came

with the analysis of the rural hinterland of ancient Thespiai city. The quantified off-site surface-sherd record within the area surveyed could be calculated as 1.37 million elements, a number which can be multiplied several times over in order to take account of the proportion likely to remain in the underlying plough soil. Experiments by Peter Reynolds (1982) at Butser Ancient Farm in Hampshire, England, have suggested that some 16–17% of sherds in the ploughzone can come to the surface during a major cultivation event. This multiplier has been supported from the evidence of soil pits by several researchers, including ourselves in Boeotia, where Peter Reynolds excavated test-pits within the off-site near ancient Hyettos city (Bintliff, 1991). The dated sample of this off-site carpet around Thespiai revealed a surprisingly clear pattern: some 80% of it was Classical Greek to Early Hellenistic in date, with relatively little that could be assigned to earlier or later periods (Fig. 2). Interestingly, although the landscape had housed notable rural settlements in Roman times, we found only site haloes for that era. For the Medieval to Early Modern era, we could map a limited 'infield' halo, but stretching several hundred metres, from the pair of deserted villages of Erimokastro, founded near the edge of now-abandoned ancient Thespiai city. Following textual sources from Medieval north-west Europe (Tinniswood, 1995), we would currently like to suggest that limited village manure scatters for the equivalent era in Greece may represent an infield subject to annual cereal cropping, as opposed to the outfield with far more limited settlement-derived manure and cultivated on an alternate-year fallow regime. The radial diameters of our offsite carpets agreed with the generalisations of Wilkinson, with the manuring carpets from the major (72 ha) ancient city of Thespiai reaching



Histogram for part of the LSE/THS sector (approximately one-third in area), showing the proportion of dated pieces per period making up the surface material. Key: preh=prehistoric pottery, g-h=geometric-classical-Hellenistic, h=Hellenistic, r=Early Roman, lr=LateRoman, byz=Byzantine, t=Tukish, mod=modern

Fig. 2 The date profile for offsite ceramic carpets in the surroundings of ancient Thespiai city, Boeotia, central Greece

two kilometres in radius, and so conforming to Wilkinson's scale for urban-based off-site generation. Phil Howard, using GIS, demonstrated how the friction of distance and slope, for carting manure from the city, could account for variations in off-site density at different distances and altitudes (Howard, 2007). It was noteworthy that this same district revealed several small Classical Greek rural cemeteries, which often became visible in fieldwalking through their being spared from contemporary ancient manuring. One supposed habitation site near the city, LSE 2, however, despite high ceramic surface densities when subjected to intensive gridding, showed no concentric focus, nor sherd density rising to a site core, while its dated sherd density by period was the same as in all the surrounding fields; thus it could be explained as merely part of the most intense area of manuring close to the city walls.

Just as Wilkinson had emphasized the 'punctuated-equilibrium' of large-scale landscape manuring in the Near East (notably present for the Early Bronze Age and Late Roman eras), so we found just a single phase in Boeotia, roughly the 5th–3rd centuries BC, to match this pattern. The more limited Medieval recurrence represented an intensive infield manuring around the villages, with a thinner outfield carpet reaching a further kilometre. We stressed not only that other surveys need not necessarily expect to find comparable evidence for the practice, but that, given the claim that it reflects phases of unusual stress on agrarian productivity, driven by food shortages or commercial pressures, it might never have occurred in other landscapes lacking such historical circumstances. For us, the lack of manuring carpets in other surveys is taken as evidence, not for the failure of the model, but for the absence there of unusual regional pressures stimulating such behaviour. It will also be recalled that pastoral sectors of any exploited landscape should, as Gaffney and Wilkinson had already demonstrated, be expected to lack such manuring carpets.

A further feature to stress is the scalar one: in Boeotia the dominant pattern of sherd carpets could be tied to radial dispersal from city and large village sites. This was most clearly brought out by our survey in the hinterland of the ancient city of Tanagra (Bintliff, 2012, pp. 274–276). Around the town, for a distance of up to two kilometres, we mapped a continuous, low-density scatter of ancient ceramics, crossing streams and other barriers, running uphill and declining with distance from its urban source—thus, a typical zone of intensive cultivation using domestic rubbish (Fig. 3). But survey in the more distant territory of the city, 7 to 8 km away, found merely site haloes on a scale appropriate to the ancient and medieval rural sites that we discovered there. Distance from the massive rubbish resources of the city was clearly the decisive difference. The inner urban fields were farmed by commuting citizens, whereas the distant zone was worked from the rural sites themselves, with much more limited domestic manure resources. It remains quite likely, however, that in the outer territory, largely sherd-empty but still fertile areas lying in between the site haloes, cultivation was still being carried out without the aid of household manure: if some fertilisation was available from flocks kept in this outer part of the territory, it would also be invisible to surface survey (as pointed out by Forbes, 2013). More recently, in a forthcoming monograph on our survey at the ancient city of Hyettos, in north Boeotia, we record that this small ancient city (15.8 ha) has a suitably spatially-limited but very strong manure carpet of Classical Greek date radiating out from its urban

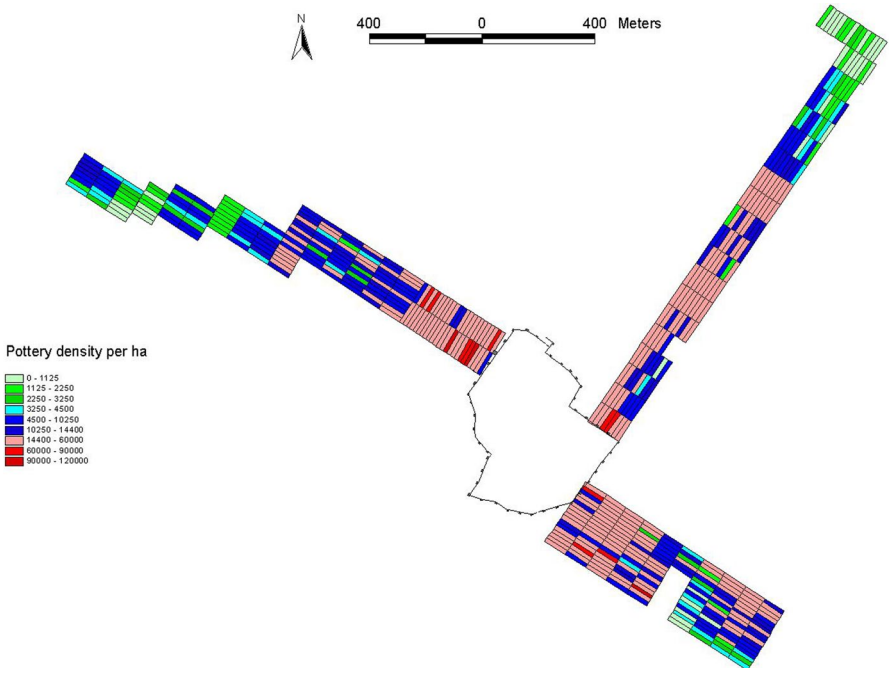


Fig. 3 The offsite carpets radiating from the ancient city of Tanagra, Boeotia

fortifications (Bintliff, Farinetti & Snodgrass, in press) (Fig. 4). We thus recognise a range of surface phenomena ranging from clear high-density occupation sites, low-density manuring carpets and intermediate-density site haloes. Close-detail quantitative mapping of the off-site will identify highs and lows within it, while some high-density localities near cities (as with the same Thespian site, LSE 2) may lie at the top end of manuring density and mimic the numbers for a small independent site. The variations probably reflect overlapping factors such as differential intensity of manure application by individual estate owners, varied soils and crops requiring variable fertilisation treatment, and the friction of distance and slope effects.

Vestigial sites, non-residential or temporary activity locations can display scatters thin enough as to be barely, if at all, distinguishable from the surrounding off-site, where that is unusually dense. Additionally, areas with poor surface visibility will often provide ambiguous sherd cover, preventing their classification. Certain phases with poorly-made ceramics will also be numerically under-represented on the surface and will lack strong apparent densities unless they form part of larger sites: much of Boeotian later prehistory falls into this category. These last three situations have led us to create the concept of 'Hidden Landscapes' as a significant problem for surface survey archaeology (Bintliff, Howard & Snodgrass 1999). For all these reasons, the evaluation of all surface phenomena has to be contextual, ruling out any simple fix based on a numerical threshold, separating a real site from real off-site (*contra* Keay & Millett, 1991, but noted already by Plog et al., 1978—see below).

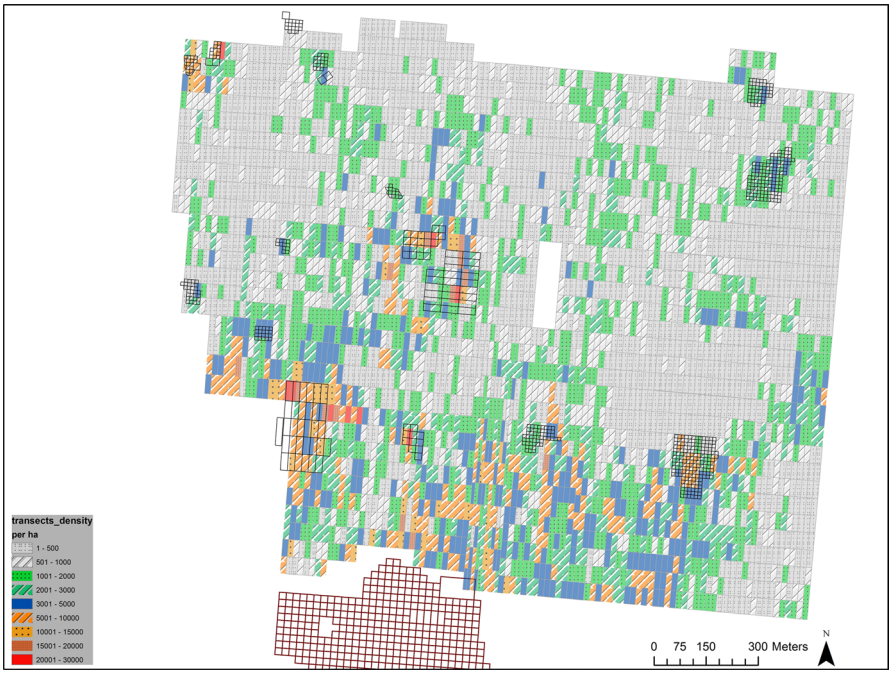


Fig. 4 The offsite carpets surrounding the ancient city of Hyettos, Boeotia

Alternative Explanations and the Response to Them

Let me now move to discuss studies which criticize and reject, in whole or part, the 'manuring model' for widespread, low-density off-site ceramic spreads. Outlining these as fairly as possible, I will then provide summaries of several refutations of these criticisms, which, appear to adequately meet the various objections, reaffirming the validity of the model.

As already intimated, Tony Wilkinson received some criticism from other Near Eastern field surveyors (see especially comments attached to Wilkinson, 1994, and Wilkinson, 2004), for his emphasis on the importance of off-site sherd-scatter recording, plausibly in part as a reaction to his own forthright critique of the many projects which still persisted in extensive, tell-focused research—those that rejected the turn to intensive, non-site survey across this whole region. He refuted the argument that it was the recent mining of tells for manuring soil that produced the observed pattern, with the observation of the single-period off-site carpets (see above). He countered the lack of engagement with the results of his detailed studies of Near Eastern offsite-carpets with the humorous comment: 'It is evidence, however, that manuring and off-site scatters have taken the attention of many, to the point that the commentaries should perhaps have been entitled "No Turd Unstoned" [a pun on the metaphorical phrase 'no stone unturned'] (Wilkinson, 1994, pp. 514–515).

A first negative response to our own adoption of the manuring model appeared with the publication of the Kea Survey (Cherry et al., 1991). It is true that this project acknowledged that the team found 'an almost continuous spatial distribution of cultural materials across the landscape, peaking at places we might call sites'; that 'within off-site some denser spots may well be vestigial activity foci'; and that 'it is a palpable fact that the archaeological landscape of Greece comprises a more or less continuous distribution of artefacts at varying density levels' (Cherry et al., 1991, pp. 45, 48). However, the manuring model is dismissed, because the Kea off-site does not fall off in density from a single source. This overlooks the fact that, with a very small urban site at the periphery of the landscape surveyed, an elongated and narrow territory, and an abundance of Classical farm sites, the bulk of the offsite might well have been spread locally and radially from these numerous estate centres rather than from the city. Regrettably, the data collected for the off-site are admitted to be 'rudimentary' (Cherrys et al., 1991, p. 338); and indeed the off-site ceramics that had been collected were of such a limited range of forms (essentially Classical Greek table-wares and Late Roman amphorae) as to prohibit any analysis. The reader is finally offered the suggestion that the off-site might just represent a number of missed farm sites, although certainly this off-site reflects some degree of intensity of cultivation. It was discouraging for field surveyors to be told that 'there exists no reasoned basis for inference about the nature and origins of differentiated densities of artifacts across the landscape' (Cherry et al., 1991, p. 21).

The same team was in part behind a subsequent challenge to our manuring research (Alcock, Cherry & Davis 1994), although this in turn was critiqued as a topic which some traditionalists considered to be unnecessary (and unpleasant) detail for the noble study of Classical Archaeology. This was clearly expressed by Sarah Morris in a review of Alcock, Cherry & Davis 1994, and the response to that paper in a postscript to the same volume (Snodgrass, 1994), who complained 'making a mountain out of a manure hill will leave many readers with a ludicrous view of survey archaeology' (Morris, 1995, p. 185).

In the Alcock, Cherry & Davis paper, although Wilkinson's studies were largely accepted, our own application of them to Greece was not. The authors pointed out that wider sherd carpets are not universal in Greece, and that the site halo 'reflects the inclusion of the farmyard, courtyard and outbuildings, where dung heaps with cultural refuse would have been, as well as the intensively cultivated vegetable gardens, fruit trees, etc. This is the equivalent of the 'halo' around the actual buildings on the site' (Alcock, Cherry & Davis 1994, pp. 160–161). These points had already, as I have earlier stated, been made by us in our own preceding papers. The solid meat of the article is, rather, a complex series of calculations of how much manure, and how much incorporated pottery within it, can have been produced on a Classical farm; far too little, the authors conclude, to account for the massive offsite sherd carpets. But from this point on, the argument becomes less focussed: they admit that ancient and medieval to early modern sources testify to widespread field manuring, and that this would be particularly likely to have been carried out around ancient urban centres, and that ceramics would have been included in it. They contest, however, the interpretation by Ault (for detail see his later paper, Ault, 1999, and monograph, Ault, 2005), of what he identified as manure collection pits (*koprones*) at the

ancient city of Halieis in southern mainland Greece. And in the end, while allowing that some of this carpet could be manuring, they insist that there have to be many other mechanisms to account for the phenomenon. About these they do not enter into detail, pointing out however that their intensive Nemea Survey in the northern Peloponnese of mainland Greece, had not detected manuring carpets. (For more recent contradictory data on this survey see further below.)

By 1997, members of the same team (Davis et al., 1997) made further pronouncements on the manure hypothesis in the reports from the Pylos Survey in the southwestern Peloponnese, also in mainland Greece: 'monocausal explanations for light artefact scatters found in Mediterranean landscapes are often inappropriate and can too narrowly confine the range of mechanisms that may result in the deposition of cultural material offsite' (Davis et al., 1997, p. 414). This somewhat vague statement then leads them to limit specific comment on their recorded off-site, merely noting that there were altitude differences by period in its distribution. A promise was made (Davis et al., 1997, p. 485) for the future, to explain the creation of low-density artefact distributions, but by 2005 the report of the Pylos Survey abandoned the analysis of the offsite altogether (Alcock et al., 2005).

Thus this group of 'manuring sceptics', at one and the same time, have allowed and approved of Wilkinson's explanation of Near Eastern off-site carpets in terms of ancient manuring, and then disputed its recognition in Greek landscapes. Those involved pronounced on the sheer complexity of likely contributory processes, but have since neglected to provide the promised attempts to explain sherd carpets. Their later surveys note the presence of offsite carpets and either refer to them vaguely as 'indications of land use intensity' (which most of us would be happy to interpret as manuring), or ignore them. Thus Jack Davis in 2004, describing the Dyrrachium Survey results in Albania, reports that in the hinterland of this major ancient city 'an almost continuous litter of artifacts was detected and documented by survey teams'; but we are given no interpretation of its significance (Davis, 2004). Again in 2007, reporting on his Apollonia Survey in Albania, Davis records that concentrations of artefacts extend more than 1 km west of the ancient city walls, but he then moves quickly on to discuss only the sites (Davis, 2007). Alcock and her colleagues in her recent Petra Project (Knodell et al., 2017, p. 640) likewise record spikes of high density ceramics near known sites, while the off-site spreads were nearly continuous; this her team interprets as 'widespread patterns of activity throughout the landscape'. The most widespread of these ceramics are Early–Middle Roman, and mark 'intensification of land use' (Knodell, Alcock et al., 2017, p. 669), whereas the scarcer Late Roman off-site is more localised, but still 'suggesting ongoing use of terrace systems' (Knodell, Alcock et al., 2017, p. 670). An all-but acknowledgement of the manuring interpretation?

In 2001 Pettegrew took up the neglected challenge to come up with alternative explanations for the off-site phenomenon in Greece, in a debate with Foxhall and Osborne (Pettegrew et al., 2001). Pettegrew covers some of the same ground, as recognised by Wilkinson and our team in Boeotia, in repeating scholars' suggestions that smaller and less diverse artefact clusters represent non-residential buildings and activity areas, such as storage sheds, field buildings, animal pens, beehives, and gardens; while post-depositional processes, such as erosion, or the 'smearing' of

artefact clusters through ploughing, might be responsible for some low-density scatters in the countryside. However he expands on this uncontroversial view, to provide an original explanation for the extensive sherd carpets as whole. While rejecting their association with land use intensification, he opts instead for a revised demographic argument, that they represent a previously invisible underclass. In his argument he deploys another of our Boeotia-based models, that of the prehistoric 'hidden landscape' (Bintliff et al., 1999, introduced earlier in our discussion), to provide a radical new explanation for the historical Greco-Roman off-site carpets. Our thesis had been that some periods of the past have typical ceramics rendered almost invisible to survey, through coarse fabrics and long-term attrition in the plough-soil, causing their small and short-lived rural sites to be under-represented in the recorded site maps. Pettegrew uses this same model to suggest that Greco-Roman off-site carpets are primarily created by a vast spread of shacks built by the poor, their location shifting so frequently that they eventually form a continuous surface around ancient cities. The artefactual poverty of such sites then causes them to be unrecognised as genuine occupation sites, rather than off-site.

Lin Foxhall in her response, although conceding that perhaps some farms were so poor as to resemble off-site, comments that the survey of a varied landscape such as Methana revealed a lowland zone with dense sites and off-site, but also an upland with simple farm sites only and no off-site carpet. This neatly parallels our own experience in the inner and outer territory of ancient Tanagra, already cited. Just as the Classical upland sites at Methana were by no means wealthy farmers' homes, so we were able to find the smallest scale of Classical farm in the deeper Tanagra hinterland. If the supposed shacks of the poor in both survey areas are clearly absent in the remoter landscape, whilst we do find poor but recognisable small farms instead, this still leaves it open for them to have clustered in shanty-towns around walled cities; but precisely in the land closest to ancient Tanagra city, small farms *were* discovered, with indications of relative poverty in their assemblages, yet clearly standing out from the offsite carpets all around them (V. Stissi, *pers.com.*). Foxhall adds that ancient farm sites in her experience are indeed often far from wealthy estate centres, often evidencing reused tiles, which were unlikely to have been removed when a farm was abandoned. Actually traditional houses in Corinthia show that old and broken tiles are not removed: instead, additional layers are placed to manage the potential leaks (P. Lock *pers.com.*)

In 2002 we also responded to this discussion (Bintliff, Farinetti, Howard et al., 2002). Surveys, including ours, have in fact distinguished sites where the limited range of pottery types, or the predominance of tile or agricultural processing equipment, have encouraged belief in a partially or entirely non-residential function. It is precisely the degree of build-up of refuse around the site core (the 'halo'), and the range of activity indicators (storage, processing and table-wares, lamps, weaving equipment), that mark distinctive levels of residential activity. Secondly, identified surface 'farms' can often be small enough for no more than one or two roofed structures: we cannot imagine a smaller 'poor' farm, yet Classical off-site scatters have a similar proportion of tile to that found on the recognised farm sites. If we were to imagine our continuous off-site carpet as comprising the traces of farms, we would have to assume that a large proportion of the prime agricultural fields within the

first 2 to 3 km radius from these Boeotian cities was occupied, within the period c. 500–300 BC, by a continuous and dense mass of farms. If residential farms typically survived several generations, there would remain very little land to be cultivated, given that the location of the main suburban carpets occupies the best and closest cereal-producing land to the town. Such a city hinterland would then be typified by an unbroken spread of farm sites, each some 0.2–0.3 ha in area; so leaving (worse still) no nearby land for urban residents (most of whom were active farmers, it is now generally accepted, in the typical Greek city-state) to cultivate. Finally, if the offsite carpets of Thespiai city were part of an extramural town, its total size would be 12.6 square kilometres—the size of Imperial Rome.

We can certainly point to simple non-residential Classical sites, and to occupied farms without any sign of wealth or sophistication (in a forthcoming volume we document both types around Hyettos: Bintliff, Farinetti & Snodgrass, in press), while there are no findings that support the vision of an almost seamless shanty-town round cities, none of which ever appear as concentrations of tile or ceramic. Our own test-pits moreover match those made by Wilkinson, in showing no evidence for structures underlying such 'peri-urban' off-site carpets.

Surprisingly, even though one of the first critics of the 'manuring hypothesis' had conceded that the Mediterranean surface record 'is likely to consist of a virtually continuous spatial distribution of material over the landscape, but a distribution extremely variable in density' (Cherry, 1983, p. 395), one of the achievements of this critique has been to induce many projects to abandon altogether the further investigation of the off-site. Let me illustrate this from one of the finest recent Italian surveys, the Potenza Valley Project, which reported, as recently as 2017, that owing to 'prevailing uncertainties about the genesis of [off-site pottery]' (Vermeulen et al., 2017, p. 112), it had been decided just to focus research effort on the sites. Likewise, the Homs Project in Syria (Philip & Bradbury, 2010) records, without further investigation, that Roman and Late Roman pottery form a low-level background noise across much of the basalt landscape.

These are not the only projects which, when confronted by off-site carpets, avoid trying to analyse them, or offer only non-committal comments. David Pettegrew and his colleagues, as with other manuring sceptics, also express indeterminacy when commenting on off-site carpets in recent projects. Thus, in discussing the Eastern Corinthia Survey in Greece, Pettegrew begins encouragingly: 'Studying the landscape in terms of artifacts rather than sites is among the most important developments of the trend in Mediterranean survey towards refining and intensifying data collection'; while 'returning to more extensive approaches ... now seem(s) inconsistent with the complexity of the artifactual record' (in Caraher, Nakassis & Pettegrew 2006, pp. 7–8). Yet later in the same study, we read that site densities allow of just one Archaic site, while for the same period the off-site shows much low-level, contextless activity that would have been missed by an approach focussed merely on peak-density sites. This and later off-site patterns, down to the Late Roman era, are not however attributed to any specific human behaviour. Likewise, in a following paper, the same author and colleagues note that much of this Eastern Corinthia Project study area is covered by a near-continuous carpet of Late Antique artefacts of fluctuating, but high, densities which they attribute to intensive agriculture and land

use, however without further explanation (Pettegrew, 2007). Again, members of the same group, in the Pyla-Koutsopetra Survey on Cyprus, explain prominent Late Roman sherd carpets either as the remains of agricultural activity, or as small-scale buildings, without additional elucidation (Caraher, Scott Moore & Pettegrew 2014). Finally, the more recent Western Argolid Survey, Greece, has mapped an extensive Classical Greek off-site scatter across the arable land of the ancient town of Orneai. This was compared to the off-site scatter we had described for the land surrounding the city of Thespiai but, probably because of the 'manuring debate', team members were content merely to leave it to future study to refine its function (Gallimore et al., 2016).

Responses to these various criticisms or sidestepping of the manuring model began with Anthony Snodgrass commenting on the 1994 paper by Alcock, Cherry and Davis, at the end of the volume in which it appeared (Snodgrass, 1994). Snodgrass pointed out that the calculations by Alcock, Cherry and Davis of sherd quantities in manure, based on ethnoarchaeological parallels, had failed to acknowledge that far greater quantities of ceramics were used in everyday life by pre-modern Mediterranean communities, than have been since (based on their partial to eventually almost complete substitution by metal and eventually plastic containers). He was able to cite the numbers of sherds recovered in the manure pits (*koprones*) claimed for ancient Halieis (at that time published only in a brief summary form: Ault, 1993; cf. Ault, 1999, 2005), and made some appropriate calculations. Although Alcock, Cherry and Davis (1994, pp. 169–70) had contested Ault's interpretation of these koprones (stone-lined vats), they have since accepted Ault's interpretation (as reported in Ault, 1999).

Next, we can highlight the most recent detailed discussion articles on the 'manuring debate', significantly emanating from two leading ethnoarchaeologists of Greece. Hamish Forbes' 2012 and 2013 papers review, directly and at length, the evidence from historical sources, archaeology, and ethnography for manuring practices in Greece (Forbes, 2012, 2013). Forbes concludes that, as quantified models demonstrate, the high levels of 'background' found in many survey projects are best interpreted as the result of artefacts, at low levels, being inadvertently incorporated in manure. He criticizes much of the relevant literature on Greek survey for failing to distinguish between what we have termed the 'site halo' and the genuine off-site, which were generated by different processes. On Pettegrew's theory that the wider, landscape-scale off-site carpets are simply traces of innumerable peasant shacks, Forbes comments that even the smallest regularly inhabited settlements were likely to leave a footprint of artefacts that, in most situations, would be recognizable using normal surface survey methods. The further claim by Pettegrew, that some farmsteads might have lasted only one or two decades, fails to recognize the complex use-lives documented for those few ancient farms that have been excavated—here, we can indeed confirm that very few ancient Boeotian rural sites did not have multiple periods of use, including phases of non-residential or 'taskscape' function (we give examples of several sites in the Hyettos countryside in the forthcoming volume cited earlier). The idea that an even carpet of sherds originated from numerous low-level artefact clusters, generated by short-lived habitations, depends in part on post-abandonment agricultural practices evening out the original peaks and troughs of

artefact deposits across the landscape. Such a process would require very substantial degrees of lateral displacement of sherds across agricultural land, presumably over several tens of metres, via the action of ploughing, but all the experimental evidence demonstrates far more restricted spatial dispersion. As for soil erosion having the same effect, the Methana geomorphological study (James et al., 1994), focusing on this aspect of 'site smearing', had found that erosion there was unlikely to be a factor affecting sherd distributions—even less so in other survey areas with more moderate slopes by comparison with those on Methana.

After a renewed calculation of the ethnographic evidence for domestic waste in manure middens, Forbes was able to conclude that exceptional levels of background artefacts, reported for off-site carpets, do indeed seem to reflect increased levels of artefact inclusion in manure. Yet these high levels turn out to be credible, even in terms of relatively low levels of artefact inclusion in the organic waste used as compost or manure for intensive manuring. We should add here, however, that Forbes specifically excludes consideration of the impact of urban manuring in Antiquity, since his modern parallels only relate to villages and farms—although these latter contexts can already generate sufficient artefactual input for typical manure carpet densities. The vast majority of waste objects, Forbes argues, remained on the site or were disposed of around its periphery. This we can again confirm from Boeotia, from the remarkably high levels of surface ceramic densities still remaining within our ancient cities and medieval villages, that also formed the source for the extensive off-site carpets.

A second expert ethnoarchaeologist of Greece, Paul Halstead, covered much of the same ground as Forbes in a paper entitled 'The Sh** that you find on the surface: Manuring and field survey in the Mediterranean countryside' (Halstead, 2018). Interestingly for our assumption of a Boeotian urban manure radius of up to 2 km, Halstead writes that, in recent Greek practice, draught or pack animals often carried manure just a few hundred metres, and rarely more than 2–3 km. We can add to Halstead's comments, that Bogaard (2012) cites ethnographic evidence from Spain for a pair of draught cattle hauling 250 kg manure to the fields, in contrast to the 30-kg basket-loads carried by women in Nepal.

Re-examining the calculations of Alcock, Cherry and Davis (1994), as Forbes had done, he finds their results too pessimistic in respect of the productive manuring of estates, identifying no argument to question the widespread and routine use of field manuring in Antiquity, even if distance and density were limited by logistical costs: 'There thus seems no reason to doubt that the widespread off-site scatters in Boeotia result primarily from middening and thus support Snodgrass' interpretation of most Classical–Early Hellenistic rural sites in that region as farmsteads from which land was cultivated fairly intensively over a radius of up to 250 m or so' (2018, p. 159). Halstead reiterates some key points made in his earlier papers on traditional Mediterranean farming (e.g. Halstead, 1987). As these will take our discussion in innovative directions, I shall return to them in a later section of this paper covering contrasted modes of farming the landscape connected to social class.

What we shall call the 'Halstead model' contrasts two farming systems: one is the 'traditional' Greek farming system, with cereals plus vines and olives as the main crops, complemented by transhumant pastoralism. This has a low potential

for village-based field manuring using animal midden material, is under-productive and depends on a two-year fallow system. The second system is one of rotation of grain with pulses and with livestock in small local herds, so that farm-based manure is available: this is more intensive and needs more labour, but is more productive. The nucleated traditional village pattern suits the former model, while the spread of ancient farms, even if only seasonal, suits the second one, and can explain their associated off-site scatters (Halstead, 1987). As with Forbes' models, however, Halstead's do not add the specific additional scenario of ancient towns dominated by commuting farmers, which we can observe are an even more potent source of field scatters than rural sites.

Reassessment is also having an effect on weakening the sceptical position in the 'ancient manuring debate'. In the original assessment of their Nemea Survey, Alcock, Cherry & Davis (1994, pp. 157–65) claimed that off-site carpets were all-but absent; those that were observed were explained as due to ploughing, weather-related factors, and the amount of pottery discarded during ancient work in the fields. The offsite finds were said to be only Classical rather than Roman or Medieval; in only rare locations they might have been the result of intentional manuring, and even there other explanations could be invoked. Subsequent work now calls this into question: Christian Cloke's doctoral dissertation and a recent paper deriving from it (Cloke, 2016, 2021) focussed on the rural survey data from Nemea, and presented an exhaustive analysis of the ceramic finds and their locational properties. For the Greco-Roman periods that most concern us, Cloke concludes that Classical Greek finds are indeed notably confined to sites and their immediate surroundings. Artefact clusters here thus appear mainly to be associated with places of habitual or intensive activity—sites—but of smaller size than carpets: in other words, he identified farm sites and their associated haloes. By comparison, land use had by the Late Roman period expanded considerably, with signs of activity no longer constrained to defined sites and their immediate outskirts, but spreading over wider tracts of the landscape; this trend had already begun in Early to Mid Roman times. A spike in offsite sherd finds of Late Roman date, and the conclusion that scatters of such material seem to be the product of manuring, now places the advent of truly intensive agricultural exploitation of the land towards the end of the timespan under consideration—namely, in the 4th to 7th centuries AD. Then, we do witness off-site manure carpets at Nemea. He links this inferred intensification of farming to an expansion in the size of the associated town of Phlius, which has its own peripheral manuring zone, and to the spread of rural commercial villa estates, each with its own manuring sector around it.

Further Considerations

I must, in way of commentary at this point, note that there are still central research issues that remain to be addressed. One relates to the implications of the recognition, shared by all Mediterranean survey specialists, that we never find all the sites in any district. This essentially relates to small and not very long-lived rural sites, particularly in remoter periods of the past. Much of this seems due to archaeological

filters, such as sites obscured by vegetation, buried by slope wash, or under alluvium, or surface loss through erosion on steep and over-cultivated terrain, other seasonal and year to year changes in forms of agricultural use, and finally (relevant to some phases) the issue of assemblages with easily fragmenting ceramics. Revisits of any surveyed landscape in later years invariably reveal that some previously-recorded sites have been obscured or destroyed in this way, while new small sites have appeared. In so far as this concerns the off-site, the implication is that it may contain sites which are 'invisible', either permanently or temporarily, at the time of first recording (as was also pointed out in the Mesopotamian context by Jason Ur: Ur, 2009). Yet although this process of obscuring is certainly general, there are overwhelming reasons to limit the contribution of such factors to the creation of the off-site carpet, especially in the phases when such carpets were mainly created in the Greek landscape. Sites of the Greco-Roman and High Medieval eras used considerable quantities of tile in their rural buildings, and their ceramics are well-fired and plentiful, so that even small rural sites, when regularly cultivated, will produce a distinctive surface signal. Since recognition of sites is achieved through ceramic density contrasts, but more particularly through spotting freshly-broken, larger potsherds brought up recently from sub-surface occupation levels, it is unlikely that, in areas of good visibility and constant soil disturbance, most or even very many small sites escape detection. It is rather in those survey sectors with low visibility, or forms of land management likely to obscure or even destroy the surface record (e.g. vineyards), where we find the frequent situation, as Graeme Barker described it for Italy, of sites that go on and off 'like traffic-lights' (Barker & Lloyd, 1991, p. 5). Nonetheless in full-cover landscape survey (as opposed to the selective survey of open cultivated fields), poor visibility transects or those with negative geomorphological history can easily constitute a significant percentage of the terrain covered, while Barker's cyclical appearance and disappearance of sites following variations in land use are also characteristic of the Mediterranean landscape. In *Testing the Hinterland* for example (Bintliff, Howard & Snodgrass 2007, p.147), we suggested that perhaps as many as one half of small sites were missed in our single sweeps of the countryside. However the surface area of such minor rural sites takes up a tiny proportion of the ancient settled landscape.

Equally important is a critical and often neglected point, made in both Wilkinson's and our own work, that the dominant form of the sherd carpets is that associated with urban centres, covering several square kilometres of continuous landscape immediately around them—a feature, as we have just noted, impossible to reconstruct as a virtually unbroken surface of missed rural sites. The fact that these carpets blanket the most important fertile land, closest to the town, merely increases the implausibility of the view that they represent settlements, rather than intensively-fertilised 'bread-baskets' for the city's inhabitants.

In this survey of the 'manuring debate', we have seen that early research, well before our own work in Boeotia, had already laid a firm evidential basis for interpreting widespread, low-density sherd carpets as primarily created by artificial rubbish disposal for manuring purposes. The work of Wilkinson gave such a thorough documentation of this, and refutation of alternative explanations, that the recent debate in Greece has never called his research into question. The continuation of

Wilkinson's heritage in Boeotia has merely enhanced the range of case-studies and added detail to the interpretation. The attempt to show that, even though field manuring was practised in Antiquity—which has never been in question—the quantities of artefacts likely to become incorporated in this fertiliser could never achieve the levels found in the off-site carpets, has been comprehensively refuted by Ault, Snodgrass, Forbes and Halstead. Finally the key case-study cited by the anti-manure lobby, the Nemea Survey, now appears to document systematic, large-scale manuring in Late Roman times.

Midden Creation Past and Present

Let us now introduce case-studies which document the process of midden-creation, since the dispersal of such resources in the field demands a necessary phase in which rubbish settles and is converted into useful manure, before being applied to the cultivated land (Jones, 2004).

Haselgrove's survey in the Aisne Valley in France showed that prehistoric and ancient communities were removing their rubbish to the settlement periphery – what we call the 'site halo' zone (Haselgrove, 1985). The Laconia Survey, Greece, used phosphate analysis to clarify human impact at its Greco-Roman surface sites (Cavanagh et al., 1988). It found that geochemical traces of anthropogenic soil enhancement spread well beyond the site core defined by high artefact counts. This was attributed to such phenomena as open animal pens, rubbish tips, manure heaps, and other non-structural concentrations, stated as a local parallel to what we had defined in Boeotia as the 'site halo'. In Normandy, manure pits of Iron Age date, full of animal bone and ceramic waste, were excavated and their form and contents found to be similar to what can be deduced from Early Modern descriptions of farmyard manure; they thus could be linked to wider evidence such as extensive offsite scatters around Iron Age settlements, indicating that manuring played a fundamental role in the Gallic agrarian system (van den Bossche & Marcigny, 2010). Study of refuse disposal at the Czech Neolithic settlement of Bylany built on the recognition that 'in pre-industrialized, agricultural populations, refuse consists mainly of kitchen scraps, human and animal waste, ashes, discarded work items and everyday tools, and abandoned dwelling, working and storage structures or parts thereof.' (Kvetina, 2010, p. 339). The Bylany data documented how refuse tended to be deposited on the periphery of the occupation zone. The author noted that this accorded well with ethnographic data which demonstrates the widespread application of a principle of least effort, with people discarding rubbish nearest to their areas of residence and activity; in phases of lower population, however, refuse was deposited in empty house lots, as also attested in ethnographic sources (cited in Kvetina, 2010).

De Haas (2012) cites excavations (e.g. the Villa Regina near Pompeii) for the discovery of middens, enclosures and vineyards of Roman age, where assemblages match refuse deposits from the sites themselves, indicating that kitchen rubbish was spread as fertiliser. Excavations outside the Roman town of Corinium in England revealed a large rubbish dump outside its walls during the Imperial period (Holbrook et al., 2013). The excavated Medieval village of Diepensee near Berlin provided new

insights into variations in rural disposal practices (Civis, 2013): here, organic waste such as animal bone was seen as undesirable and carefully removed to the surrounding ditch, whereas broken ceramic was (unusually) considered of no interest for further disposal and left to lie in the soil of the house areas, where it was ground ever smaller by the passage of people and animals. Theune (2015) provides further insights from a Central European perspective, observing that a family in pre-Modern times needed just two to three years to create a cubic metre of rubbish, including faeces: when excavations reveal vast amounts of rubbish, we see how easily this accumulated over generations. In 14th-century Nürnberg much of the rubbish was being thrown over the city wall and Zürich also offers archaeological confirmation of this practice. Whereas metal and bone saw regular recycling, repairs to ceramics were rare and, once broken, these made up masses of waste debris, some of which was used in construction work. Theune (2015) finally notes that the small, abraded sherds found in Central European rural expanses can be attributed to manuring.

Emmerson (2020) has found that piles of garbage lay outside the city walls amid tombs on Pompeii's outskirts, some of these waste piles being several metres high, stacked along almost the entire external wall on the city's northern side. She argues that this was not just simple refuse-disposal, but the creation of recycling foci for reusable materials. Structural foundations in the town included tiles, broken pottery and other recycled materials plastered-over to create a clean uniform surface: these contained the same sandy soil found in the rubbish piles outside the city, implying that trash was sorted regularly and resold to be used inside the city walls. Nevertheless, garbage was also ubiquitous in the city centre, contradicting the assumption that rubbish lay outside the wall because it was intolerable within the town. Considering differences between deposits found across the city, Emmerson argues that the material represents refuse at various points in Pompeii's waste stream, in which rubbish first accumulated within properties or on the streets just outside them, before being moved to larger spaces such as abandoned lots or, in the greatest quantity, open areas in the city's suburbs. Yet these extramural deposits were not, like modern landfills, located in neglected places just to remove waste from the living space of the city. Instead, the garbage accumulated in active zones that served as staging grounds for cycles of use and reuse. The suburban setting was ideal, where rubbish could be sorted, stored, and gathered in sufficient quantities to become valuable, with easy access to roads and highways. So, one individual might have paid to have human waste removed from her cess-pit, while another could have bought it to fertilize a farm or garden.

The accumulation of rubbish within house-lots, left unoccupied when parts of a town are abandoned was also noted by Fentress in her study of the 'failed town' of Cosa in Italy (Fentress, 1994); while Johnson (2010) maps the increasing penetration of urban waste into abandoned urban spaces in the Late Antique townscapes of Rome and Milan.

A detailed examination of the marketing of urban human waste in Early Modern Edo/Tokyo was published by Tajima (2007). City dwellers sold this resource ('night soil') as agricultural fertiliser to farmers or their agents (indeed, a similar practice is known from ancient Greece: Ault, 1999), being one of the key sources for villages on the urban fringe, which in turn were vital to the provision of food for the city. In a

parallel study, Ishigami (unpublished conference presentation) notes that pits where other waste products were dumped (household rubbish including ceramics and tile), either for recycling or for manuring in the countryside, have been documented and excavated in every part of Edo.

In Western Europe, we might consider waste disposal to the fields as a past practice, but it still plays a major role in other parts of Europe and on other continents, as discussed by Pearce (2008, 2013). Each of us produces on average 500 litres of urine and 500 kg of faeces per year, containing enough nitrogen, phosphorus and potassium nutrient for 200 kg of cereals. Since the 1890s, for example, most of the sewage from Mexico City has been piped to the fields of Tula valley, more than 100,000 ha in extent. Many other global cities without sewage systems still have human waste collected: for example in Bangalore, sewage goes first into drying pits to concentrate the nutrients, assist spreading, and kill off pathogens, before direct field use in the dry season. About half the fields in urban vicinities in developing countries are irrigated with raw sewage, while an estimated 20% of the world's food is grown in such peri-urban areas.

Recent Survey Data Supporting Manuring

It remains to offer a more general review of how survey projects in other parts of Europe and the Near East have dealt with their off-site finds, since the Greek debate took off in the 1990s. Did the controversy close down all meaningful study of off-site finds, as we saw in the case of the Potenza Valley or Homs projects? Or has the literature rejected the Wilkinson-Boeotia model since 2000, even while its opponents have come up with nothing conclusive to replace it?

In this section we shall introduce additional studies, published within the same period as our own published applications of the 'manuring model', and the subsequent associated debate on the validity of our model. Some of these specifically respond to those discussions between 1994 and 2002.

The Alto-Medio Polesine survey project near Venice (Balista et al., 1990) found that, outside settlement areas, there were constant low-level ceramic finds, which could represent manure mixed with rubbish, a technique used till recently locally. The Gubbio Survey in Italy (Stoddart & Whitbread, 1991; Malone & Stoddart, 1994) mapped an intensively-farmed, manured landscape around the Roman town of Gubbio, with an absence of manure scatters in the pastoral zone of the uplands, while in the wider lowland the off-site varied in correlation with rural estate centres, indicating the practice of variable forms of land use. Medieval manuring scatters were also recorded around the contemporary town. In the Czech Republic, the well-made Medieval and Post-Medieval ceramics survived well in surface soils, allowing surveyors to record both rubbish dumps and manuring scatters throughout the region (Kuna et al., 1993). The Ager Tarraconensis Survey in Spain interpreted its Roman off-site scatters as most likely created by manuring (Carreté et al., 1995). On Cyprus, the Akamas Survey (Hayes, 1995) reported that a seemingly interminable scatter of sherds covered almost the whole survey area of 36 km^2. It was argued that the principal process behind this had been the spreading of midden material and

animal manure on the former fields. Analysis of ancient terraced fields, with their sherd content, pointed to phases of expansion and contraction of intensive land use over the last 2500 years. Soil pits showed that erosion and other factors could be ruled out.

The Alisar Survey, Turkey, found a zone of scatters around the eponymous tell, supporting Wilkinson's manure model (Branting, 1996). In Greece, the Berbati Survey mapped Late Bronze Age off-site scatters, suggesting that manuring of the fields closest to settlements could account for this. The High Medieval era also saw a general background scatter across almost the whole survey area (Wells & Runnels, 1996). In the very course of the survey, they also found contemporary evidence: piles of sheep manure containing household debris, including sherds. The Methana Survey (Mee & Forbes, 1997), as noted earlier, contrasted the high off-site densities in the lowlands, created by manuring out of numerous ancient farmsteads, with the uplands where thinner populations managed large-scale numbers of stock and had sufficient animal manure to remove the need to use domestic waste in the fields.

Bakels (1997) reviewed evidence for the prehistory of manuring in the Netherlands. An early example from the Late Neolithic was a buried field with ard-marks, covered with domestic waste including ceramics. Bronze Age case-studies included settlement ditches used as middens, associated with buried ploughed fields, both including domestic refuse. Parallels were drawn with the Neolithic Swiss lakeside village of Weier, where it had been shown that domestic human and animal waste was transported to terraced fields. Bakels returned to this topic recently with additional evidence (2018). Stable isotope analysis of Bronze Age cereals in the Netherlands revealed high values of $\delta^{15}N$. Cultivation of the same cereal species under controlled circumstances indicated that this showed that the prehistoric cereal fields must have been manured. Reconstruction of the size of the arable fields and of livestock numbers suggests that animal dung cannot have been the only source of fertiliser: application of household waste and mud from ditches is proposed (sherds, bone and charcoal are found in sealed Bronze Age arable fields, a feature of the north-western Netherlands). Large-scale mapping of such fields, now below peat, confirmed that they did not overlie settlements; and the even spread of the debris evidenced the careful dispersal of household waste. A further test of the isotope signature for manured fields was carried out in the Czech Republic, and has found identical results to those of Bakels for the maintenance of soil fertility in prehistoric and Medieval times (Dreslerova et al., in press); however, owing to the poor survival-rate of prehistoric as opposed to Medieval ceramics, the ceramic manuring carpets survive only for the latter period in this landscape (as was noted earlier in Kuna, 2000).

In Early Modern Scotland, abandoned rural settlements have been studied using geoarchaeological and soil science approaches. As population grew, additional soil fertility was needed and this was met through manuring, using a wide range of organic materials, as well as human and animal waste products from the settlements themselves (Entwistle, Abrahams & Dodgshon 1998, 2000; Entwistle, Dodgshon & Abrahams 2000; Davidson et al., 2007; Wilson et al., 2009). Such manure began in the byres or houses, was then moved to yards and gardens, and was finally spread on to the arable land. Each of these stages created a detectable geochemical soil signature, with enhancement values declining at each stage, down to the unmanured

parts of the outfield. In Southern Italy, the Basentello Survey (Small et al., 1998) revealed Iron Age manuring from the site of San Felice. Mattingly (1999) disputed the proposal by Alcock, Cherry & Davis (1994) that off-site carpets were not the sole or obvious product of manuring, finding wide support for a correlation between higher levels of background noise and the most intensively cultivated parts of the landscape. On the Riu Mannu Project, Sardinia (van de Velde, 2001), sherd mapping of Punic and Roman date could identify farmyard or garden areas, then beyond them an almost continuous carpet, which could represent manuring. These carpets could not be due to smearing in later land use, as they were period-specific. In the environs of the Minoan Bronze Age settlement of Pseira on Crete, prehistoric terracing was in use throughout this era, attested by excavation and embedded ceramics. Lipid and carbon analysis confirmed that a highly-structured pattern of manuring had taken place on these terraces during this period, utilising human excrement and domestic waste from Pseira village (Bull et al., 2001; Bull & Evershed, 2012).

One of the most thorough investigations of ancient manuring appeared in the doctoral thesis of Laure Nuninger (2002) on the settlement and land use history of Languedoc. We quote:

> However, one field remains little exploited: the study of 'off-site' surface data. These data, sherds with abraded edges, relatively sparse, can be interpreted as the remains of the scattering of domestic rubbish and agrarian manuring. [*Cependant, une piste demeure peu exploitée: l'étude des indices 'hors-site' repérés en surface. Ces indices, des tessons aux bords émoussés, relativement épars, peuvent être interprétés comme des vestiges d'épandage de déchets domestiques et de fumures agraires*.] (Nuninger, 2002, p. 159).

Nuninger dismisses erosion as a significant factor, noting the even spread over vast surfaces and the association with recorded sites. Palaeosol studies showed that manuring began as early as the Early Iron Age, whilst environmental analysis supported artificial soil enhancement. Mapping these sherd carpets by period brought additional insights. The Early Iron Age carpets are patchy and follow the dispersal pattern of sites, then the Middle Iron Age marks a slight decline in the off-site, followed by a Late Iron Age to Early Roman re-expansion of both indicators. She matched ethnographic models to the spatial analysis of the off-site carpets, linking their formation to manuring, with radii that reflected the respective sizes of their originating settlements. Interestingly the largest pre-Roman sites are given an impact radius of 1500–2000 m, recalling the scale of Boeotian Classical urban manure haloes at Thespiai, Tanagra and Hyettos. This work in Languedoc has been furthered by Ouriachi and Favory (2020), who have mapped areas of scattered, very broken, eroded and worn material, as the record over time of the most intensely manured areas fertilized by organic matter. The spatial connection with the networks of habitats is noted as highly significant.

In Turkish Thrace, manuring scatters were identified through intensive survey for the Early Bronze Age and Roman eras, distinct from site haloes (Erdoğu, 2003). The Sydney Cyprus Survey in its final monograph (Given & Knapp, 2003; cf. Given, 2004) recorded a very early example of areal manuring, again from the Early Bronze Age, then recurrent widespread manuring carpets for the Classical and Roman eras.

Instances of Roman date were up to 3 km across and essentially covered the best arable land, while their contexts ruled out dispersal by erosion or ploughing. The haloes around Medieval to Modern villages were however more confined, and were taken as evidence for a major focus of manuring in the infield zone only (as we found for the villages of Medieval Thespiai and Medieval Hyettos in Boeotia). Also in Cyprus, the Palaipaphos Survey produced a mostly continuous background scatter from the Roman era around that urban site, attributing it to probable manuring and waste disposal from this town (Rupp, 2004). Away from the coastal plain, there were usually no such scatters. The Konya Plain Survey in Turkey (Baird, 2004) identified dense rural settlement during Late Antiquity, associated with surrounding artefact scatters, once more interpreted as manuring.

One of the most penetrating and innovative studies of off-site manuring appeared in 2004, and dealt with Medieval archaeological and textual evidence from the English Midlands (Jones, 2004). The aim here was to go beyond the recognised site and manure zonation from surface sherd densities (presented so far in this review), so as to reveal subtle changes in medieval manuring strategies not just over time but also between different arable farming regimes. These systems, such as infield/outfield cultivation, open-field farming, demesne blocks, and assarts, can all be characterized by the manuring strategies that they deployed, and identified from the signatures these have left in the ground. The plotting of ceramic manuring scatters thus permits a detailed mapping of each component of the medieval arable zone, leading to a more comprehensive reconstruction of the medieval rural landscape than has previously been attempted. Thus, as we have seen commonly elsewhere, changes in the distribution of domestic pottery mapped outside the villages showed an increasing extension of the arable land across the High Medieval era, while the scale of each community could be correlated with the density and scale of manuring. But additionally, shifts from distinct plots, one per family, marked by light manure cover, to denser carpets could be correlated with the creation of blocks of open field strips manured by many families. Interestingly, it was argued that élite landowners possessed large flocks and thus did not need to accumulate domestic waste for manuring their own fields.

Jones returned to these themes in his edited volume *Manure Matters* (Jones, 2012a, 2012b, 2012c). The separating out of different types of waste is most visible on high-status Medieval rural sites, related to the quantities of organic waste produced by such households, to where it was generated (separate buildings for people and animals, separate food preparation areas) and to the space available to store it. Waste was very differently generated on peasant holdings, invariably leading to an immediate integration of household and farmyard materials into a single composite mix. The typical peasant manure mixture was an amalgamation of all available materials, hence discarded domestic vessels became incorporated within it. This is a crucial understanding, since pottery survives in the fields and is easily detected in archaeological survey. By contrast, seigneurial manuring, as a result of the different pathways of dispersal, did not need to include such fragments. The identification of the two manures—peasant and seigneurial—the first of which commonly contains pottery, while the other which tends not to, tells us that when the diagnostic medieval pottery scatters are encountered, this is evidence not for the full extent of

cultivation at any one time, but rather for the manuring activities of the medieval peasantry.

The Moncayao Survey in Spain (Wilkinson & Gerrard, 2005) recorded a halo of manuring debris around existing settlements, beginning in the late Medieval period and continuing into the Early Modern era. The South Picenum Survey (Menchelli, 2008) noted that, around Roman villas, vast offsite pottery scatters were usually found, produced by manuring and other agricultural activities. The Sagalassos Survey investigated the landscape in the close environs of that ancient city (Martens et al., 2008), linking olive presses and manuring scatters to indicate intensively cultivated gardens and orchards. Chemical analysis of animal bones from the city suggested that, in the Early Roman period, flocks were pastured in the more distant landscape; whereas in Late Antiquity, high levels of pollution in the archaeologically recovered bones pointed to animals being brought to graze in the same urban periphery, which was enriched with city waste. More recent results from the Sagalassos Rural Survey (Vandam et al., 2019) record its outer territory: marginal land in the Taurus Mountains, which was taken into cultivation in Late Antiquity. Ancient terraces here, rich in ceramics, charcoal, bone and human waste indicators from geochemical analysis, are seen as probable manuring indicators.

In Israel, the survey between Sepphoris and Nazareth (Dark, 2008) identified Roman and Late Antique settlements with spreads of material surrounding them, especially on ancient built terraces, that were presumed to represent fields manured with domestic waste. Kaptijn's survey in the Jordan Valley identified manuring episodes for the Early Bronze Age, the Late Roman and Mamluk (Medieval) periods (Kaptijn, 2009). She also recorded site haloes which she attributed to plough smearing and the intense manuring of infield gardens, significantly noting that Early Modern villages lacked haloes since they lacked peripheral garden zones. The recent mining of tells for fertiliser (Arabic *sabakh*) had occurred, but could be detected through the multi-period off-site deposits around these tells: these were distinct from landscape carpets of a single phase which represented genuine outfield manuring with contemporary settlement waste (as Wilkinson, 2003, had also noted). Ethnohistorical records support the latter practice. Parallels were drawn with the Wadi Feynan survey, also in Jordan, which had documented extensive off-site manuring in the Early Bronze Age, the Iron Age and the Late Roman period. Interestingly, the combination of intensive surface recording with historical air photos enabled Kaptijn to tie small, dispersed clusters of Modern material culture to transitory Bedouin camps.

Poirier et al. (2010) summarised the archaeological evidence for manuring from various regions of France. A review of several study areas showed that the spread of such intensification increased from the Iron Age to the Modern era, and its mapping allowed the important inference that regions were out of step in the degree to which they were intensively farmed. Poirier returned to this topic more recently in relation to survey in the Garonne region (Poirier, 2018). Alongside the ancient authors, medieval Carolingian sources also advised manuring, which included all household rubbish. The close association of yards and byres with residences explains the incorporation of the inorganic waste. 'Considering all these arguments, we can conclude that the off-site material collected during field-walking surveys may indeed reflect

the location of intensively cultivated areas' (Poirier, 2018, p. 42). Also in France, Trément presented an analysis of surveys in the Auvergne (Trément, 2011). Elevated off-site scatters of worn fragments, continuous and covering vast areas without foci, were seen as clearly due to ancient manuring, especially during late Iron Age and Roman times. Some notable peaks around sites were probably gardens, found also for Medieval–Modern villages, and confirmed by palaeobotanical findings. A GIS study showed a close association of sites with manured areas.

The Nepi Survey in central Italy mapped an off-site urban halo, fluctuating in density and extent from later Republican times to Late Antiquity (Mills & Rajala, 2011). The Guadiana Survey in Spain (Herrera et al., 2011; Mayoral Herrera et al., 2012), explained low-density Roman off-site scatters as in part created by manuring in an intensively-cultivated landscape. In many areas, there was a carpet of very homogeneous surface finds, 90% of it being made up of roof tiles and traditional pottery dating from the last 100 years: this was the residue of manuring. The oldest living farmers explained this practice, which only ceased in the 1970s when industrial chemicals took over the role. The Pontine Survey in Italy (de Haas, 2011, 2012), revealed haloes around Roman sites, interpreted as rubbish dumps and manured garden plots; then beyond, lower-density off-site scatters were primarily attributed due to manuring. Within these latter, interestingly, small peaks with more varied finds and larger fragments were considered to mark foci such as sheds or local middens, as well as eroded sites. The extent of the wider carpets ruled out erosion or ploughing as causes. Variations in time indicated that some areas were only manured in Republican times, while with others it continued into the Imperial era. The Pathways to Complexity Project surveyed three different regions of South and Central Italy, including the Pontine region, to trace the rise of the Roman Empire, arguing for a general intensification of agricultural production over time, based on their off-site manuring scatters (Attema & Burgers, 2010). The Dzarylgac Survey Project in the Crimea (Bilde et al., 2012) found that Classical Greek sites possessed haloes, beyond which a consistent off-site scatter showed land use attributed to manuring and other forms of discard. In the light of Pettegrew's theory (cited earlier), we can note that this project's discovered Greek farm sites were generally poor in material culture. Early Modern off-site material was also found to be ubiquitous and could be shown to emanate from the recent settlement nuclei. The Troodos Foothills survey in Cyprus identified Iron Age to Greco-Roman manuring off-site, punctuated by likely rural sites (Fall et al., 2012). On the Northern Plateau in Spain (Garcia-Sanchez & Cisneros, 2012), off-site studies over 10 km^2 showed the low quality of the sherds, with distance decay from settlements conforming to the manure model. Land use intensification under Roman rule formed a first wave, followed by a second wave in Medieval to Modern times, when the landscape was recolonised after the Christian Reconquest.

In 2013 there appeared an exhaustive, long-term study of the archaeology of the English village of Shapwick, in south-west England (Aston & Gerrard, 2013). The spreads of Roman off-site pottery were remarkably even, implying control over land use and refuse disposal—thus not marking the infield halo, but from the open outfield. This was also concentrated at a certain altitude, pinpointing the main arable zone, while absence of pottery suggested pastureland. From Early into Late

Medieval times, off-site scatters demonstrated that a first system, of household-manured arable infield and pastoral outfield, was transformed later into a wider, intensively-cultivated arable landscape, as population rose (compare our discussion of Jones, 2004, above). Massive quantities of Early Modern pot, brick, tile and slates showed the continuation of this practice into later times: the sequence was confirmed by textual sources and toponyms. One of the techniques used in this project was widespread test-pitting, both within traditional villages and in the rural zone. Other applications of medieval village research, in various regions of England, had already demonstrated that the types of pottery, sherd size and degree of abrasion could distinguish areas of elite and peasant settlement or manuring (Catling, 2010; Jones, 2004).

Meanwhile, for purposes of wider geographical comparison, we should cite the Erbil Plain Survey in northern Iraq, which recorded high off-site densities, conforming to the reported generalisation that, all across northern Mesopotamia, the terrain between sites is covered with a scatter of artefacts, best interpreted as the result of manuring (Ur et al., 2013). So too, even further afield, we should introduce the remarkable evidence for land-use intensification in the pre-Columbian Amazon forest, a region with naturally poor soils (Golinska, 2013). Here anthrosols have been recognised and mapped, called ADE (Amazon Dark Earths), containing large numbers of pottery sherds and concentrated organic matter. They can cover 6–18 km^2 of forest and were located by past or recent traditional settlements. In the 1960s, in this vast tropical landscape, Sombroek identified two zones around prehistoric settlements, one with dark earths containing large numbers of sherds and organic matter (*terra pretas*), in settlement-rich areas. The settlements were kept clean and their discarded waste products went into peripheral middens and then gardens and orchards, and other forms of intensive cultivation. The second was a purely ancient cultivation anthrosol (*terra mulata*). This was found further out in the community outfield cultivation zone, and had far less household rubbish in it. Kawa (2016) calculates that an area of 40 ha of such 'anthrosols', 1m deep, could feed 5000 people. It seems that from the 1st mill BC onwards there occurred a major expansion of population in the Amazon based on farming, but the formation of the ADE soils occurred later, presumably as a result of this increasing population pressure on less than ideal soils.

The Alcoi Valley Project, in Iberia (Grau Mira, 2014), studied the Late Iron Age landscape, finding that there was a close relationship between the fields susceptible to intensive farming practices and the dispersed artifact scatters, and that manuring should be considered the cause of this pattern, as erosion and other natural mechanisms were tested and ruled out as causes. Moreover, manuring had till recently been a common traditional practice in orchards, irrigated fields, and other small plots within the study area, as ethnohistorical studies had indicated. It was proposed that the stimulus for Iron Age agricultural intensification was that farmers were forced to satisfy tribute demands, in the framework of a new patron-client relationship in Iberian society. Meanwhile, a Danish field system was being investigated, archaeologically and through phosphate and trace element analysis (Nielsen & Kristiansen, 2014). This could be dated to the Late Bronze and Early Iron Ages through its incorporation of ceramics, along with animal bone and hearth debris.

Study confirmed that the fields had been manured with domestic waste and animal manure. The Vardar Valley Survey in Macedonia (Donev, 2015) identified possible Iron Age and High Medieval, and confirmed Roman and Ottoman-to-Early Modern manuring scatters, with support for the latter period from local ethnographic accounts. Occupation sites possessed radial offsite zones, while in some other areas, instead of off-site scatters, there were small satellite sites around larger foci. The scale of manuring impact, just as predicted by Wilkinson, varied with site size. The Politiko-Troullia Survey on Cyprus (Ridder et al., 2016) enlarged our concept of the 'site halo' around this Bronze Age village. The site and its halo covered 18ha, with the latter stretching a couple of hundred metres around the village and providing evidence of metal-working installations, agricultural processing and perhaps social activities.

In the volume *The Rural Economy of Roman Britain* (Allen et al., 2017) it was stated that Roman sherd scatters in Britain showed substantial investment in fertilising the land, most likely linked to a perceived decrease in soil fertility due to over-exploitation in the Early Imperial period. In several cases, Roman field systems with embedded sherd scatters could be demonstrated. Presenting survey results from Essex, England, Medlycott (2018) discussed Medieval and Early Modern evidence for manuring based on the dispersal of ceramic and tile, commenting on its usefulness for delineating changes in the extent of agricultural areas over time. In Spain, the Segisamo Survey supported the manuring interpretation for the Roman urban centre and surrounding rural sites. Although there were other factors behind the generation of the off-site, the case for manuring was judged to be the dominant one (Garcia-Sanchez, 2018).

It is an important part of the argument for the manuring case, that these off-site carpets can reflect atypical periods in the history of certain regions of agricultural intensification; and this can find support in the complementary cases where the phenomenon did not occur (e.g. the Diepensee village study cited earlier). The San Giovanni Survey in Italy discussed the potential models to explain off-site finds, but no homogeneous carpets to indicate manuring were detected in this area. Instead, localised variations in the off-site marked farm and burial sites (Waagen, 2014). So too, in a survey of mountain uplands in south-eastern Spain, Reyero et al. (2018) contrasted the widespread evidence for manuring practices in late Iron Age lowland Spain, with this more marginal zone where such scatters are absent, arguing for extensive rather than intensive farming, and with livestock-raising focused on mere subsistence needs.

Conclusion

Artificial field manuring in archaeological contexts has been attested since the early 20th century, but it was the large-scale landscape work of Tony Wilkinson in the 1970s and 1980s that brought a new scientific rigour to its recording, as well as a solid theoretical basis for its significance for economic and social prehistory and history. My own application around several ancient cities in Central Greece since the 1970s has seen some critique, but sceptics can be seen to have increasingly

recognized the general validity of the model, and have still to provide convincing alternatives for these offsite phenomena. In contrast, this review has made abundantly clear that landscape archaeology throughout Europe and further afield, has provided a very extensive body of case studies for land-use intensification employing household waste as field manure, detected through surface ceramics and geochemistry as well as ethnohistoric records. Most recently anthropologists and historians have suggested further insights into manuring, which allow us to infer social class contrasts and variations in settlement economics behind different patterns in the surface archaeological record.

Acknowledgements The Boeotia Regional Survey Project, co-directed by the author and Professor Anthony Snodgrass, has benefitted from long-term support from the universities of Bradford, Cambridge, Durham and Leiden, the Leverhulme Trust, the ERC, the British Academy and the Institute for Aegean Prehistory. The author thanks Timothy Taylor as editor of *JWP* for his helpful criticisms which much improved the text's coherence and arguments.

References

Alcock, S. E., Berlin, A.M., Harrison, A. B., Heath, S., & Stone, D. L. (2005). Pylos regional archaeological project, part VII. Historical Messenia, Geometric through Late Roman. *Hesperia, 74*, 147–209.

Alcock, S. E., Cherry, J. F., & Davis, J. L. (1994). Intensive survey, agricultural practice and the classical landscape of Greece. In I. Morris (Ed.), *Classical Greece: Ancient histories and modern archaeologies* (pp. 137–170). Cambridge University Press.

Allen, M. J., Lodwick, L., Brindle, T., Fulford, M., & Smith, A. (Eds.) (2017). *The rural economy of Roman Britain.* The Society for the Promotion of Roman Studies.

Aston, M., & Gerrard, C. (2013). *Interpreting the English village*. Oxbow.

Attema, P., Burgers, G.-J., & van Leusen, M. (2010). *Regional pathways to complexity*. Amsterdam University Press.

Ault, B. A. (1993). Koprones and oil presses: Domestic installations related to agricultural productivity and processing at Classical Halieis. *American Journal of Archaeology, 97*, 324–325.

Ault, B. A. (1999). Koprones and oil presses at Halieis: Interactions of town and country and the integration of domestic and regional economies. *Hesperia, 68*, 549–573.

Ault, B. A. (2005). *The excavations at Ancient Halieis: Vol. 2. The houses. The organization and use of domestic space*. Indiana University Press.

Baird, D. (2004). Settlement expansion on the Konya Plain, Anatolia 5th–7th centuries AD. In W. Bowden, L. Lavan & C. Machado (Eds.), *Late Antique archaeology: Vol. 2. The Late Antique countryside* (pp. 219–246). Brill.

Bakels, C. (1997). The beginnings of manuring in western Europe. *Antiquity, 71*, 442–445.

Bakels, C. (2018). Maintaining fertility of Bronze Age arable land in the northwest Netherlands. In C. C. Bakels, Q. P. J. Bourgeois, D. R. Fontijn, & R. Jansen (Eds.), *Local communities in the big world of prehistoric northwest Europe* (pp. 65–76). Sidestone Press.

Balista, C., De Guio, A., Edwards, M., Ferri, R., Herring, E., Davis, C., Howard, P., Peretto, R., Vanzetti, A., Whitehouse, R., & Wilkins, J. (1990). Alto-Medio polesine project: Second report. *Accordia Research Papers, 1*, 153–187.

Ball, W., Tucker, D., Wilkinson, T. J., & Black, J. A. (1989). The Tell al-Hawa project. *Iraq, 51*, 1–45.

Barker, G. (1984). The Montarrenti Survey, 1982–83. *Archeologia Medievale*, 278–289.

Barker, G., Bartoloni, V., Coccia, S., Francovich, R., Hodges, R., Jones, D., Parenti, R., Roncaglia, G. & Sitzia, J. (1986). The Montarrenti Survey 1985. *Archeologia Medievale*, 291–320.

Barker, G., & Lloyd, J. (Eds.) (1991). *Roman landscapes. Archaeological survey in the Mediterranean Region.* British School at Rome.

Bilde, P. G., Attema, P., & Winther-Jacobsen, K. (Eds.) (2012). *The Dzarylgac Survey Project: Vol. 1*. Aarhus University Press.

Bintliff, J. (1991). The Boeotia Project: Field survey 1990. *University of Durham & University of Newcastle upon Tyne Archaeological Reports*, 13–16.

Bintliff, J. L. (2012). *The complete archaeology of Greece, from hunter-gatherers to the twentieth century AD*. Blackwell-Wiley.

Bintliff, J., Farinetti, E., Howard, P., Sarri, K., & Sbonias, K. (2002). Classical farms, hidden prehistoric landscapes and Greek rural survey: A response and an update. *Journal of Mediterranean Archaeology, 15*, 259–265.

Bintliff, J. L., Farinetti, E., Slapsak, B., & Snodgrass, A. M. (Eds.) (2017). *Boeotia Project: Vol. 2. The city of Thespiai: Survey at a complex urban site*. Cambridge, McDonald Institute Monographs.

Bintliff, J. L., Farinetti, E., & Snodgrass, A. (Eds.) (In press). *The Greek city state on a small scale: Hyettos in Boeotia and its territory*. Cambridge: McDonald Institute.

Bintliff, J. L., & Gaffney, V. L. (1988). The Ager Pharensis/Hvar Project. In J. Chapman, J. L. Bintliff, V. Gaffney & B. Slapšak (Eds.), *Recent developments in Yugoslav archaeology*. *British Archaeological Reports Int. Ser.* 431, 151–175.

Bintliff, J., & Howard, P. (1999). Studying needles in haystacks: Surface survey and the rural landscape of Central Greece in Roman times. *Pharos, 7*, 51–91.

Bintliff, J. L., Howard, P., & Snodgrass, A. M. (1999). The hidden landscape of prehistoric Greece. *Journal of Mediterranean Archaeology, 12*(2), 139–168.

Bintliff, J. L., Howard, P., & Snodgrass, A. M. (Eds.) (2007). *Testing the hinterland: The work of the Boeotia Survey (1989–1991) in the southern approaches to the city of Thespiai.* MacDonald Institute Monographs.

Bintliff, J. L., & Snodgrass, A. M. (1985). The Cambridge/Bradford Boeotian Expedition: The first four years. *Journal of Field Archaeology, 12*, 123–161.

Bintliff, J. L., & Snodgrass, A. M. (1988). Off-site pottery distributions: A regional and interregional perspective. *Current Anthropology, 29*, 506–513.

Bogaard, A. (2012). Middening and manuring in Neolithic Europe. In R. Jones (Ed.), *Manure matters* (pp. 25–40). Ashgate.

Branting, S. A. (1996). The Alisar Regional Survey 1993–1994. *Anatolica, 22*, 145–158.

Bull, I. D., Betancourt, P. P., & Evershed, R. P. (2001). An organic geochemical investigation of the practice of manuring at a Minoan Site on Pseira Island, Crete. *Geoarchaeology, 16*, 223–242.

Bull, I., & Evershed, R. (2012). Organic geochemical signatures of ancient manure use. In R. Jones (Ed.), *Manure matters* (pp. 61–78). Ashgate.

Caraher, W. R., Nakassis, D., & Pettegrew, D. K. (2006). Siteless survey and intensive data collection in an artifact-rich environment: Case studies from the Eastern Corinthia, Greece. *Journal of Mediterranean Studies, 19*, 7–43.

Caraher, W., Scott Moore, R., & Pettegrew, D. K. (2014). *Pyla-Koutsopetria I: Archaeological survey of an ancient coastal town*. The American Schools of Oriental Research.

Carreté, J. M., Keay, S., Millett, M., Burès, L., Evans, J., Taylor, J., Williams, D., & Winter, C. (1995). A Roman provincial capital and its hinterland: The Survey of the Territory of Tarragona, Spain. *Journal of Roman Archaeology*, Supplement 15.

Catling, C. (2010). Test pits and teaching. *Current Archaeology,* February, 30–35.

Cavanagh, W. G., Hirst, S., & Litton, C. D. (1988). Soil phosphate, site boundaries, and change point analysis. *Journal of Field Archaeology, 15*, 67–83.

Cherry, J. F. (1983). Frogs round the pond: Perspectives on current archaeological survey projects in the Mediterranean region. In D. R. Keller & D. W. Rupp (Eds.), *Archaeological survey in the Mediterranean area* (pp. 375–416). British Archaeological Reports.

Cherry, J. F., Davis, J. C., & Mantzourani, E. (Eds.) (1991). *Landscape archaeology as long-term history*. Institute of Archaeology, University of California Los Angeles.

Civis, G. (2013). Wertnetze und Wertverschiebungen im mittelalterlichen Dorf Diepensee. In F. X. Eder, O. Kuhschelm, B. Schmidt-Lauber, C. Theune, & P. Ther (Eds.), *Kulturen des Ökonomischen. Historisch-kulturwissenschaftliche Beiträge* (pp. 167–197). Vienna: Verlag des Instituts für Europäische Ethnologie.

Cloke, C. F. (2016). The landscape of the lion: Economies of religion and politics in the Nemean countryside (800 BC to AD 700). Unpublished PhD thesis, Department of Classics, University of Cincinnati.

Cloke, C. F. (2021). Farming on the fringe: Diachronic changes in land-use patterns and agricultural strategies in ancient Nemea. *Journal of Greek Archaeology, 6*, 1–25.

Coccia, S., & Mattingley, D. (1992). Settlement history, environment and human exploitation of an intermontane basin the Central Apennines: The Rieti Survey 1988–1991, Part I. *Papers of the British School at Rome, 60*, 213–289.

Dark, K. R. (2008). Roman period and Byzantine landscapes between Sepphoris and Nazareth. *Palestine Exploration Quarterly, 140*, 87–102.

Davidson, D. A., Wilson, C. A., Meharg, A. A., Deacon, C., & Edwards, K. J. (2007). The legacy of past manuring practices on soil contamination in remote rural areas. *Environment international, 33*, 78–83.

Davis, J. L. (2004). Are the landscapes of Greek Prehistory hidden? A comparative approach. In S. E. Alcock & J. F. Cherry (Eds.), *Side-by-side survey: Comparative regional studies in the Mediterranean world* (pp. 22–35). Oxbow Books.

Davis, J. L. (2007). The hinterlands of Apollonia. In V. Dimo, P. Lenhardt, & F. Quantin (Eds.), *Apollonia d'Illyrie* 1(pp. 13–22). Paris: École française d'Athènes.

Davis, J. L., Alcock, S. E., Bennet, J., Lolos, Y. G., & Shelmerdine, C. W. (1997). The Pylos regional archaeological project part I: Overview and the archaeological survey. *Hesperia: The Journal of the American School of Classical Studies at Athens, 66*(3), 391–494. https://doi.org/10.2307/148395

de Haas, T. (2011). Fields, farms and colonists: Intensive survey and Early Roman colonization in the Pontine region, central Italy. Doctoral Thesis, Institute of Archaeology, Groningen University.

de Haas, T. (2012). Beyond dots on the map: Intensive survey data and the interpretation of small sites and off-site distributions. In P. Attema & S. G. Portsmouth (Eds.), *Comparative Issues in the Archaeology of the Roman Rural Landscape*. Journal of Roman Archaeology Suppl. Ser. 88, 55–79.

Donev, D. (2015). *Rural landscapes along the Vardar valley: Two site-less surveys near Veles and Skopje, Republic of Macedonia*. Archaeopress.

Dreslerova, D., Hajnalová, M., Trubač, J., Chuman, T., Kočár, P., Kunzová, E., & Šefrna, L. (2021). Maintaining soil productivity as the key factor in European prehistoric and Medieval farming. *Journal of Archaeological Science: Reports*. https://doi.org/10.1016/j.jasrep.2020.102633

Emmerson, A. (2020). *Life and death in the Roman suburb*. Oxford University Press.

Entwistle, J. A., Abrahams, P. W., & Dodgshon, R. A. (2000). The geoarchaeological significance and spatial variability of a range of physical and chemical soil properties from a former habitation site, Isle of Skye. *Journal of Archaeological Science, 27*, 287–303.

Entwistle, J. A., Abrahams, P. W., & Dodgshon, R. A. (1998). Multi-element analysis of soils from Scottish historical sites. Interpreting land-use history through the physical and geochemical analysis of soil. *Journal of Archaeological Science, 25*, 53–68.

Entwistle, J. A., Dodgshon, R. A., & Abrahams, P. W. (2000). An investigation of former land-use activity through the physical and chemical analysis of soils from the Isle of Lewis, Outer Hebrides. *Archaeological Prospection, 7*, 171–188.

Erdoğu, B. (2003). Off-site artefact distribution and land-use intensity in Turkish Thrace. *Proceedings of the Prehistoric Society, 69*, 183–200.

Fall, P. L., Falconer, S. E., Galletti, C. S., Shirmang, T., Ridder, E., & Klinge, J. (2012). Long-term agrarian landscapes in the Troodos foothills, Cyprus. *Journal of Archaeological Science, 30*, 1–13.

Fentress, E. (1994). Cosa in the Empire: The unmaking of a Roman town. *Journal of Roman Archaeology, 7*, 209–222.

Forbes, H. (2012). Lost souls: Ethnographic observations on manuring practices in a Mediterranean community. In R. Jones (Ed.), *Manure matters* (pp. 159–172). Ashgate.

Forbes, H. (2013). Offsite-scatters and the manuring hypothesis in Greek survey archaeology: An ethnographic approach. *Hesperia, 82*, 551–594.

Gaffney, C., Gaffney, V., & Tingle, M. (1985). Settlement, economy of behaviour? Micro-regional land use models and the interpretation of surface artefact patterns. In C. Haselgrove, M. Millett, & I. M. Smith (Eds.), *Archaeology from the ploughsoil* (pp. 95–107). University of Sheffield.

Gallimore, S., James, S., & Nakassis, D. (2016). To Argos: Archaeological survey in the western Argolid, 2014–2016. In D. W. Rupp & J. Tomlinson (Eds.), *From maple to olive: A colloquium to celebrate the 40th anniversary of the Canadian Institute in Greece* (pp. 421–438). Athens: Publications of the Canadian Institute. in Greece.

Garcia-Sanchez, J. (2018). The hinterland of Segisamo (Sasamon, Spain). In C. Wohlfahrt & C. Keller (Eds.), *Funde in der Landschaft* (pp. 181–191). Bonn: LVR-Amt für Bodendenkmalpflege im Rheinland.

Garcia-Sanchez, J., & Cisneros, M. (2012). An off-site approach to Late Iron Age and Roman landscapes on the Northern Plateau, Spain. *Journal of European Archaeology*, 1–26.

Given, M. (2004). From density counts to ideational landscapes: Intensive survey, phenomenology, and the Sydney Cyprus Survey Project. In E. F. Athanassopoulos & L. A. Wandsnider (Eds.), *Mediterranean archaeological landscapes: Current issues* (pp. 165–182). University of Pennsylvania Press.

Given, M., & Knapp, A. B. (2003). *The Sydney Cyprus Survey Project*. Los Angeles: Cotsen Institute of Archaeology.

Golinska, B. (2013). The role of environmental studies in understanding Amazonian prehistory: Terra Preta as an example. In S. Kadrow & P. Wlodarczak (Eds.), *Environment and subsistence—forty years after Janusz Kruk's 'Settlement studies'* (pp. 381–393). Bonn: Rudolf Habelt.

Grau Mira, I. (2014). The Iron Age landscape of Alcoi Valley, eastern Iberia: Agricultural intensification and sociopolitical dynamics. *Journal of Field Archaeology, 39*, 124–133.

Groenmann-van Waateringe, W., & Robinson, M. (Eds.) (1988). *Man-made soils.* British Archaeological Reports.

Halstead, P. (1987). Traditional and ancient rural economy in Mediterranean Europe: Plus ça change? *Journal of Hellenic Studies, 107*, 77–87.

Halstead, P. (2018). The sh** that you find on the surface: Manuring and field survey in the Mediterranean countryside. In L. Nevett & J. Whitley (Eds.), *An age of experiment: Classical archaeology transformed (1976–2014)* (pp. 151–160). McDonald Institute.

Haselgrove, C. (1985). Inference from ploughsoil artefact samples. In C. Haselgrove, M. Millett, & I. Smith (Eds.), *Archaeology from the ploughsoil* (pp. 7–29). Department of Archaeology University of Sheffield.

Hayes, P. P. (1991). Models for the distribution of pottery around former agricultural settlements. In A. J. Schofield (Ed.), *Interpreting artefact scatters. Contributions to ploughzone archaeology* (pp. 81–92). Oxbow.

Hayes, P. (1995). The field survey: Its role and methodology. In J. Fejfer (Ed.), *Ancient Akamas, Part I: Settlement and environment* (pp. 171–188). Aarhus University Press.

Herrera, V. M., UriarteII, A., Chapa Brunet, M. T., Vicent García, J. M., & Cabrera Díez, A. (2011). 'Background noise' and landscape exploitation in the Late Iron Age Andalusian countryside. In M. van Leusen, G. Pizziolo, & L. Sarti (Eds.), *Hidden landscapes of Mediterranean Europe* (pp. 265–270). Archaeopress.

Holbrook, N., McSloy, E., & Geber, J. (2013). Corinium's dead. *Current Archaeology, 281*, 28–34.

Howard, P. (2007). Spatial analysis of Boeotia field-walking survey data: Testing the Hinterland. In J. Bintliff, P. Howard & A. Snodgrass (Eds.), *The work of the Boeotia Survey (1989–1991) in the southern approaches to the city of Thespiai* (pp. 111–127). Cambridge: McDonald Institute Monographs.

Ishigami, H. n.d. An archaeological analysis of waste management system in Edo, the main Early Modern city in Japan. (unpublished conference paper).

James, P. A., Mee, C. B., & Taylor, G. J. (1994). Soil erosion and the archaeological landscape of Methana, Greece. *Journal of Field Archaeology, 21*, 395–416.

Johnson, P. S. (2010). Investigating urban change in Late Antique Italy through waste disposal practices. In D. Sami & G. Speed (Eds.), *Debating urbanism within and beyond the walls, AD 300–700* (pp. 167–193). Leicester University Press.

Jones, R. (2004). Signatures in the soil: The use of pottery in manure scatters in the identification of Medieval arable farming regimes. *Archaeological Journal, 161*, 159–188.

Jones, R. (Ed.) (2012a). *Manure matters.* Ashgate.
Jones, R. (2012b). Why manure matters. In R. Jones (Ed.), *Manure matters* (pp. 1–12). Ashgate.
Jones, R. (2012c). Understanding medieval manure. In R. Jones (Ed.), *Manure matters* (pp. 145–158). Ashgate.
Jones, R. F. J., Keay, S. J., Nolla, J. M., & Tarrús, J. (1982). The late Roman Villa of Vilauba and its context. A first report on field-work and excavation in Catalunya, North-East Spain, 1978–81. *The Antiquaries Journal, 62*, 245–282.
Kaptijn, E. (2009). *Life on the watershed. Reconstructing subsistence in a steppe region using archaeological survey: A diachronic perspective on habitation in the Jordan Valley*. Sidestone.
Kawa, N. C. (2016). *Amazonia in the Anthropocene*. University of Texas Press.
Keay, S., & Millett, M. (1991). Surface survey and site recognition in Spain: The Ager Tarraconensis Survey and its background. In A. J. Schofield (Ed.), *Interpreting artefact scatters: Contributions to ploughzone archaeology* (pp. 129–139). Oxbow.
Knodell, A. R., Alcock, S. E., Tuttle, C. A., Cloke, C. F., Erickson-Gini, T., Feldman, C., Rollefson, G. O., Sinibaldi, M., Urban, T. M., & Vella, C. (2017). The Brown University Petra Archaeological Project: Landscape archaeology in the northern hinterland of Petra, Jordan. *American Journal of Archaeology, 121*, 621–683. https://doi.org/10.3764/aja.121.4.0621
Kossack, G. (1974). *Zehn Jahre Siedlungsforschung in Archsum auf Sylt*. de Gruyter.
Kuna, M. (2000). Surface artefact studies in the Czech Republic. In J. Bintliff, M. Kuna, & N. Venclova (Eds.), *The future of archaeological field survey in Europe* (pp. 29–44). Sheffield Academic Press.
Kuna, M., Zvelebil, M., Foster, P. J., & Dreslerová, D. (1993). Field survey and landscape archaeology research design methodology of a regional field survey in Bohemia. *Památky Archeologické, 84*, 110–130.
Kvetina, P. (2010). The spatial analysis of non-ceramic refuse from the Neolithic site at Bylany, Czech Republic. *European Journal of Archaeology, 13*, 336–367.
Lillios, K. T. (1992). Phosphate fractionation of soils at Agroal, Portugal. *American Antiquity, 57*, 495–506.
Liversage, D., Munro, M. R., Courty, M. A., & Nornberg, P. (1985). Studies of a buried Early Iron Age field. *Acta Archaeologica, 56*, 55–84.
Malone, C., & Stoddart, S. (Eds.) (1994). *Territory, time and state.* Cambridge University Press.
Martens, F., Vanhaverbeke, H., & Waelkens, M. (2008). Town and suburbium at Sagalassos: An interaction investigated through survey. In H. Vanhaverbeke, J. Poblome, M. Waelkens, F. Vermeulen, & R. Brulet (Eds.), *Thinking about space: The potential of surface survey and contextual analysis in the analysis of space in Roman times* (pp. 127–149). Turnhout: Brepols.
Mattingly, D. (1999). Methods of collection, recording and quantification. In D. Mattingly, H. Patterson, & R. Francovich (Eds.), *Extracting meaning from ploughsoil assemblages* (pp. 5–15). Oxbow.
Mayoral Herrera, V., Barrera, C. B., Ángel, J., del Pozo, M., & de Tena, M. (2012). The evolution of an agrarian landscape. In S. J. Kluiving & E. Guttmann-Bond (Eds.), *Landscape archaeology between art and science* (pp. 97–114). Amsterdam University Press.
Medlycott, M. (2018). Archäologische Feldbegehungen in Essex 1986–2005. In C. Wohlfahrt & C. Keller (Eds.), *Funde in der Landschaft* (pp. 69–80). Bonn: LVR-Amt für Bodendenkmalpflege im Rheinland.
Mee, C., & Forbes, H. (Eds.) (1997). *A rough and rocky place: The landscape and settlement history of the Methana peninsula.* Liverpool University Press.
Menchelli, S. (2008). Surface material, sites and landscapes in South Picenum (Marche, Italy). In H. Vanhaverbeke, J. Poblome , M. Waelkens & F. Vermeulen (Eds.), *Dialogue with sites: The definition of the space at the macro and micro level in Imperial times* (pp. 31–43). Turnhout: Brepols.
Mills, N., & Rajala, U. (2011). Interpreting a ceramiscene landscape. *Proceedings of the 20th Annual TRAC Conference* (pp. 1–17). Oxbow.
Morris, S. (1995). From modernism to manure: Perspectives on Classical archaeology. *Antiquity, 69*, 182–185.
Nielsen, N. H., & Kristiansen, S. M. (2014). Identifying ancient manuring: Traditional phosphate vs. multi-element analysis of archaeological soil. *Journal of Archaeological Science, 42*, 390–398.
Nuninger, L. (2002). Peuplement et territoires protohistoriques du VIII^{e} au I^{er} s. av. J.-C. en Languedoc oriental (Gard-Hérault). Doctoral Thesis. Sciences de l'Homme et Société. Université de Franche-Comté.

Ouriachi, M.-J., & Favory, F. (2020). Applications of inter-site spatial archaeology in eastern Languedoc (France) to cast light on the history of the system of settlement from the Iron Age to the Middle Ages. Online. halshs-02546530.
Pearce, F. (2008). Sewage that's too precious to waste. *New Scientist*, 23 August, 14.
Pearce, F. (2013). Flushed with success. *New Scientist*, 16 February, 48–51.
Pears, B. (2012). The formation of anthropogenic soils across three marginal landscapes. In R. Jones (Ed.), *Manure matters* (pp. 109–128). Farnham: Ashgate.
Pettegrew, D. K. (2007). The busy countryside of Late Roman Corinth: Interpreting ceramic data produced by regional archaeological surveys. *Hesperia, 76*, 743–784.
Pettegrew, D. K., Osborne, R. and Foxhall, L. (2001). Chasing the family farmstead: Assessing the formation and signature of rural settlement in Greek landscape archaeology. *Journal of Mediterranean Archaeology, 14*, 189–209.
Philip, G., & Bradbury, J. (2010). Pre-Classical activity in the basalt landscape of the Homs region, Syria. *Levant, 42*, 136–169.
Plog, S., Plog, F., & Wait, W. (1978). Decision making in modern surveys. In M. B. Schiffer (Ed.), *Advances in archaeological method and theory* (Vol. 1) (pp. 383–421). Academic Press.
Poirier, N. (2018). From archaeological evidence for manuring to an understanding of settlement and landscape dynamics. In C. Wohlfahrt & C. Keller (Eds.), *Funde in der Landschaft* (pp. 41–54). Bonn: LVR-Amt für Bodendenkmalpflege im Rheinland.
Poirier, N., Fovet, E., & Georges-Leroy, M. (2010). The time-space dynamics of agricultural areas from Antiquity to Modern times. In C. Gandini, F. Favory, & L. Nuninger (Eds.), *Archaedyn: 7 Millennia of territorial dynamics* (pp. 81–94). University of Franche-Comté.
Rasmussen, T. (1991). Tuscania and its territory. In G. Barker & J. Lloyd (Eds.), *Roman landscapes* (pp. 106–114). British School at Rome.
Reynolds, P. (1982). The ploughzone. In *Festschrift zum 100jährigen Jubiläum der Abteilung Vorgeschichte der Naturhistorischen Gesellschaft Nürnberg* (pp. 315–340). Nürnberg.
Reyero, S. G., Palencia, F. J. S., Saez, J. A. L., Diaz, S. P. , Alonso, M. R., Perona, D. R., Iriso, J. V., & Ayuso, E. A. (2018). Agrarian landscapes in the Iberian Iron Age: Mountain communities and land use in southeastern Iberia. *Geoarchaeology*, 1–20.
Rhodes, P. P. (1950). The Celtic field-systems on the Berkshire Downs. *Oxoniensia, 15*, 1–28.
Ridder, E., Galletti, C. S., Fall, P. L.. & Falconer, S. E. (2016). Economic and social activities on ancient Cypriot terraced landscapes. *Journal of Environmental Management, 30*, 1–10.
Rupp, D. W. (2004). Evolving strategies for investigating an extensive terra incognita in the Paphos district by the Canadian Palaipaphos Survey Project and the Western Cyprus Project. In M. Iacovou (Ed.), *Archaeological field survey in Cyprus: Past history, future potentials* (pp. 63–76). British School at Athens.
Shennan, S. (1985). *Experiments in the collection and analysis of archaeological survey data*. Sheffield University.
Shiel, R. (1991). Improving soil productivity in the pre-fertiliser era. In B. M. S. Campbell & M. Overton (Eds.), *Land, labour and livestock* (pp. 51–77). Manchester University Press.
Shiel, R. (2012). Science and practice. In R. Jones (Ed.), *Manure matters* (pp. 13–24). Ashgate.
Small, A., Small, C., Campbell, I., MacKinnon, M., Prowse, T., & Sipe, C. (1998). Field survey in the Basentello valley on the Basilicata-Puglia border. *Echos du monde classique/Classical views, 42*(2), 337–371.
Snodgrass, A. M. (1990). Survey archaeology and the rural landscape of the Greek city. In O. Murray & S. Price (Eds.), *The Greek city from Homer to Alexandria* (pp. 113–136). Oxford University Press.
Snodgrass, A. (1994). Response: The archaeological aspect. In I. Morris (Ed.), *Classical Greece: Ancient histories and modern archaeologies* (pp. 197–200). Cambridge University Press.
Stoddart, S., & Whitbread, N. (1991). Cleaning the Iguvine stables. In A. J. Schofield (Ed.), *Interpreting artefact scatters: Contributions to ploughzone archaeology* (pp. 141–148). Oxbow.
Tajima, K. (2007). The marketing of urban human waste in the Early Modern Edo/Tokyo metropolitan area. *Environnement urbain/Urban Environment* [En ligne] http://journals.openedition.org/eue/1039.
Theune, C. (2015). Perspektiven auf Entsorgungspraktiken im Mittelalter. *Beiträge zur Mittelalterarchäologie in Österreich, 31*, 99–110.

Thomas, D. H. (1975). Non-site sampling: Up the creek without a site? In J. Mueller (Ed.), *Sampling in archaeology* (pp. 61–81). University of Arizona Press.

Tinniswood, A. (1995). *Life in the English country cottage*. Weidenfeld & Nicolson.

Trément, F. (Ed.) (2011). *Les Arvernes et leurs voisins du Massif Central à l'époque romaine*. Clermont-Ferrand: Revue d'Auvergne.

Ur, J. (2009). Pastoral nomads of the 2nd and 3rd millennia AD on the Upper Tigris river. *Journal of Field Archaeology, 34*, 37–56.

Ur, J., De Jong, L., Giraud, J., Osborne, J. F., & MacGinnis, J. (2013). Ancient cities and landscapes in the Kurdistan Region of Iraq: The Erbil Plain Archaeological Survey 2012 season1. *Iraq, 75*, 89–117.

Vandam, R., Kaptijn, E., Broothaerts, N., De Cupere, B., Marinova, E., Van Loo, M., Verstraeten, G., & Poblome, J. (2019). 'Marginal' landscapes: Human activity, vulnerability, and resilience in the Western Taurus Mountains (Southwest Turkey). *Journal of Eastern Mediterranean Archaeology & Heritage Studies, 7*(4), 432–450.

van den Bossche, B., & Marcigny, C. (2010). Changing settlement patterns in the Normandy countryside. In C. Gandini, F. Favory & L. Nuninger. (Eds.), *Archaedyn: 7 millennia of territorial dynamics* (pp. 175–186). University of Franche-Comté.

van de Velde, P. (2001). An extensive alternative to intensive survey: Point sampling in the Riu Mannu Survey Project, Sardinia. *Journal of Mediterranean Archaeology, 14*, 24–52.

van de Westeringhe, W. (1988). Man-made soils in the Netherlands, especially in sandy areas ('Plaggen Soils'). In W. Groenmann-van Waateringe & M. Robinson (Eds.), *Man-made soils* (pp. 5–19). British Archaeological Reports.

Vermeulen, F., Van Limbergen, D., Monsieur, P., & Taelman, D. (Eds.) (2017). *The Potenza Valley Survey (Marche, Italy): Settlement dynamics and changing material culture in an Adriatic valley between Iron Age and Late Antiquity.* Rome, Academia Belgica. Studia Archaeologica I.

Waagen, J. (2014). Evaluating background noise: Assessing off-site data from field surveys around the Italic sanctuary of S. Giovanni in Galdo, Molise, Italy. *Journal of Field Archaeology, 39*, 417–429.

Wells, B., & C. Runnels, Eds. (1996). *The Berbati-Limnes Archaeological Survey 1988–1990*. Jonsered: Paul Astroms Forlag.

White, K. D. (1970). *Roman farming*. Thames & Hudson.

Wilkinson, T. J. (1982). The definition of ancient manured zones by means of extensive sherd-sampling techniques. *Journal of Field Archaeology, 9*, 323–333.

Wilkinson, T. J. (1988). The archaeological component of agricultural soils in the Middle East: The effects of manuring in antiquity. In W. Groenmann-van Waateringe & M. Robinson (Eds.), *Man-made soils* (pp. 93–114). British Archaeological Reports.

Wilkinson, T. J. (1989). Extensive sherd scatters and land-use intensity: Some recent results. *The Journal of Field Archaeology, 16*, 31–46.

Wilkinson, T. J. (1990). Soil development and early land use in the Jazira region, Upper Mesopotamia. *World Archaeology, 2*, 87–103.

Wilkinson, T. J. (1992). Off-site archaeology. *National Geographic Research and Exploration, 8*, 197–207.

Wilkinson, T. J. (1994). The structure and dynamics of dry-farming states in Upper Mesopotamia. *Current Anthropology, 35*, 483–520.

Wilkinson, T. J. (1998). Water and human settlement in the Balikh valley, Syria. *Journal of Field Archaeology, 25*, 63–87.

Wilkinson, T. J. (1999). Demographic trends from archaeological survey: Case studies from the Levant and Near East. In J. Bintliff & K. Sbonias (Eds.), *Reconstructing past population trends in Mediterranean Europe* (pp. 45–640). Oxbow.

Wilkinson, T. J. (2003). *Archaeological landscapes of the Near East*. University of Arizona Press.

Wilkinson, T. J. (2004). The disjunction between Mediterranean and Near Eastern survey: Is it real? In E. F. Athanassopoulos & L. A. Wandsnider (Eds.), *Mediterranean archaeological landscapes: Current issues* (pp. 55–67). University of Pennsylvania Press.

Wilson, C. A., Davidson, D. A., & Cresser, M. S. (2009). An evaluation of the site specificity of soil elemental signatures for identifying and interpreting former functional areas. *Journal of Archaeological Science, 36*, 2327–2334.

Wilkinson, K., Gerrard, C., Aguilera, I., Bailiff, I., & Pope, R. (2005). Prehistoric and historic landscape change in Aragon, Spain. *Journal of Mediterranean Archaeology, 18*, 31–54.