# New Perspectives on the Medieval 'Agricultural Revolution'

## *Crop, Stock and Furrow*

Edited by Mark McKerracher
and Helena Hamerow

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# Abbreviations

| | |
|---|---|
| ALUSS | agricultural land use signal strength |
| AMS | accelerator mass spectrometry |
| API | arable/pastoral index |
| BBCH | Biologische Bundesanstalt, Bundessortenamt und Chemische Industrie |
| EngLaId | English Landscapes and Identities |
| EPD | European Pollen Database |
| FeedSax | ‘Feeding Anglo-Saxon England: The Bioarchaeology of an Agricultural Revolution’ |
| FTIR | Fourier-transform infrared spectroscopy |
| HLNUG | Hessisches Landesamt für Natuschutz, Umwelt und Geologie |
| IMBE | Institut Méditerranéen d’Écologie et de la Biodiversité |
| LALIA | Late Antique Little Ice Age |
| MCA | medieval climate anomaly |
| MNI | minimum number of individuals |
| mPI | modified pathological index |
| OD | ordnance datum |
| PAST | PAleontological STatistics [software package] |
| RSRB | *Rural Settlement of Roman Britain* |
| SHARP | Sedgeford Historical and Archaeological Research Project |
| SPSS | Statistical Package for the Social Sciences |
| TLP | total land pollen sum |

# Preface

This volume represents the proceedings of a conference held in December 2020 on the theme of 'New Perspectives on the Medieval "Agricultural Revolution"'. The idea for the conference grew out of a project funded by the European Research Council, based at the Universities of Oxford and Leicester, called 'Feeding Anglo-Saxon England: The Bioarchaeology of an Agricultural Revolution' (FeedSax).[1] Both project and volume focus on a long-standing debate about the role and timing of the technological improvements in farming that occurred between *c.*800 and 1300, which – aided by a warming climate – fuelled population growth, urban expansion, and a proliferation of markets not only in England, but across much of Europe. The origins of the project lie in the conviction that our understanding of these developments, which has relied on indirect evidence for early medieval farming – such as charters, post-medieval maps, manuring scatters, and place-names – could be significantly advanced by generating direct evidence for the conditions in which medieval crops were grown, using scientific methods to analyse the remains of plants and livestock from archaeological contexts.

The FeedSax project began in 2017 and by the end of 2020 had generated enough results to warrant presenting these to a wider audience. The conference also provided an opportunity to consider our results within the context of innovative research into early medieval (and Roman) farming being carried out by colleagues in the UK and elsewhere in Europe. We had originally planned to hold the conference in Oxford with around 50 attendees, but the pandemic led to a radical altering of these plans, and the conference – like so much else – took place online. While much was undoubtedly lost,

1 The FeedSax project is supported by the European Union's Horizon 2020 research and innovation programme under grant agreement no. 741751.

above all face-to-face discussions with friends and colleagues, there were also clear gains: the conference was attended by over 400 people from more than 20 countries, giving it an incomparably wider reach than we could ever have imagined. We are enormously grateful to the speakers, session chairs, and all those who attended and offered valuable insights, despite the limitations and frustrations of online 'Q&A'.

In addition to the present volume, the results of the FeedSax project are being published in a series of journal articles (including Hamerow et al., 2020; Holmes et al., 2021b), but primarily in a project monograph (Hamerow et al., in prep.), which integrates results from a wider range of case studies with insights from national datasets and builds upon the selected initial results presented in this collection. The monograph will be accompanied by an open-access data archive held by the Archaeology Data Service (McKerracher et al., forthcoming).

The chapters in Part I of this volume present early results from the FeedSax project and should be regarded as interim statements of work in progress. Entitled 'Unpacking the "Mouldboard Plough Package"', it shows how the medieval 'agricultural revolution' can be broken down into functional elements – such as crop rotation and use of the heavy plough – and addressed using a range of science-based methods. Part II, 'Revolutions Revisited', presents the work of colleagues whose diverse approaches and perspectives – encompassing experimental archaeology, farming in Roman Britain and the Frankish world, the novel paradigm of syntironomy, a unique case study in eastern England and a critical review of 'revolutions' in English agricultural history – contextualize and enrich the findings generated by FeedSax.

While this collection is not intended to present any unified conclusions, certain key themes emerge from the papers. For instance, the importance of a practical and integrated perspective on crop and animal husbandry is demonstrated repeatedly (e.g., in papers by Stroud, Forster and Charles, Kropp, and Williamson): crop, stock and furrow prove ultimately to be inseparable. Equally, the powerful influence of environmental conditions – topography, geology, soils – upon agricultural practices becomes apparent time and time again (e.g., in papers by Bogaard et al., Holmes, McKerracher, and Williamson); but wider socio-economic and cultural factors should not be underestimated (e.g., papers by Lodwick, Faulkner, and Caroe). Meanwhile, crop diversity seems increasingly important, with oats, rye and spelt playing significant roles alongside bread wheat and barley in different parts of north-west Europe; the contrast with the restricted crop repertoire of the Roman period is striking (see papers by Forster and Charles, Lodwick, and Schroeder).

Above all, every paper demonstrates how monolithic perspectives of an 'agricultural revolution' are increasingly moribund. Only by unpacking and disentangling the constituent parts of medieval farming – such as heavy ploughing, livestock management, crop diversity, rotation, extensification and settlement structure – can we apply new methods and concepts, and so break the impasse (see Hamerow, this volume).

The editors are grateful to the anonymous reviewers for their invaluable and insightful feedback, and to Clare Litt of Liverpool University Press for her enthusiasm and efficiency in seeing this project through to publication. Archaeological investigation, as represented in this volume, is an inherently collaborative endeavour, and individual authors have provided more specific and detailed acknowledgements within their papers.

As this volume neared publication, we learned with sadness that one of our contributors, Dr Neil Faulkner, had passed away. Members of the FeedSax project benefited greatly from collaboration with Neil, and we will miss his generosity, enthusiasm and intellectual energy. In an email exchange after the conference, passionately setting out his perspective on the Mid Saxon economy, Neil declared: 'I just love debate. It makes life worth living.' In that spirit, we hope that this volume will help to energize and propel the medieval 'agricultural revolution' debate for many years to come.

# I Unpacking the 'Mouldboard Plough Package': The Feeding Anglo-Saxon England Project

# 1 The 'FeedSax' Project: Rural Settlements and Farming in Early Medieval England

*Helena Hamerow*

**Introduction to 'FeedSax': cereal farming, population growth and wealth disparities in early medieval England**

During the early Middle Ages, England's population, like that of much of Europe, grew steeply, from around 1.7 million in 1086[1] to around 4.8 million in *c.*1290 (Broadberry et al., 2015). How medieval farmers managed to produce enough cereals to sustain this remarkable growth – which fuelled a major expansion of towns and markets – and the impact of this 'cerealization' on the landscape, settlement patterns and communities of England, have been debated for many decades (Williamson, 2018). The overall aim of the project 'Feeding Anglo-Saxon England: The Bioarchaeology of an "Agricultural Revolution"' (hereafter, FeedSax) is to generate new evidence that can be brought to bear on these debates.

The period in question saw the advent of new forms of cereal farming capable of yielding regular, large surpluses, ultimately enabling landowners to amass wealth by exploiting the labour of

I am grateful to Debby Banham, John Blair, Ros Faith and the anonymous reviewers for their comments and insights on an early draft of this paper.

1 This figure is itself likely to represent significant growth since the fifth to seventh centuries, although population estimates for these earlier centuries are notoriously unreliable, and even population figures based on the Domesday Book are contested. One recent calculation undertaken for the Netherlands – based on a range of archaeological proxies – estimates that the region saw an overall population decline of between 70 per cent and 80 per cent during the fifth to ninth centuries (Groenewoudt and van Lanen, 2018).

others.[2] By 1066, there were thousands of such landowners with their own estates, prospering from the cereal surpluses produced by peasant labour. Indeed, cereals possess certain qualities that make them particularly attractive to the rent-collector: they are harvested at predictable times of year and are easily stored, transported, measured and divided up (Scott, 2017, 129–30). A link thus existed in medieval Europe, as in prehistory, between the expansion of cereal cultivation and the growth of wealth inequalities (Kohler et al., 2017; Bogaard et al., 2019). Furthermore, not only are cereals readily taxable, but a unit of land sown with cereals will feed many more mouths than the same land unit used to graze livestock (Spedding et al., 1981, 355).

Early medieval farmers appear to have expanded cereal production largely by adopting increasingly extensive, low-input forms of farming. This involved increasing the area of land under cultivation while decreasing the amount of 'input' – manure and human labour – per land unit.[3] Expanding the amount of land under cultivation allowed overall yields to increase even while productivity per land unit decreased. In many regions of Europe, including around a third of England, this 'extensification' of cereal farming culminated in a variety of regular and irregular open-field systems, 'in which the arable land of different proprietors lay intermingled, as unhedged strips' (Williamson, 2018, 5). While the establishment of open fields was undoubtedly one of the transformative changes of the Middle Ages, they were only one element of what has often been referred to as an 'agricultural revolution', not its inevitable outcome (cf. Banham and Faith, 2014).

The idea that the changes in farming seen in this period amounted to an 'agricultural revolution' is widely regarded as problematic, not only because it implies rapid change catalysed by innovation – which is difficult to demonstrate from the available evidence – but also for its technological determinism (Sawyer and Hilton, 1963). The term can, nevertheless, be useful 'when a number of improvements in separate areas of the farming system co-occur as a complex' and when their

2 This need not imply, however, that these new ways of farming were initiated by landowners, and it is important to recall that most production would have been peasant production (Banham and Faith, 2014). The material analysed by FeedSax derives from a range of settlement types from royal centres to peasant farms; much comes from land that was in monastic hands, but some comes from settlements whose status is uncertain.

3 The term 'low-input' refers to the ecological conditions in arable fields. Thus 'extensive' systems were low-input from the perspective of the crops and weeds that grew in those fields, not of the people who laboured in them.

impact on society is of sufficient magnitude (van der Veen, 2010, 1). It is best understood in an early medieval context not to refer to a 'great leap forward' impelled by technology, but rather to the cumulative impact of a series of innovations and changes, including incremental developments, or what van der Veen (2010) has called 'micro-innovations'. Some of these may have had a long gestation. The mouldboard plough, for example, was a key element in the transformation of early medieval farming. Its presence in seventh-century England has been demonstrated by the discovery of a distinctive type of coulter at the royal site of Lyminge in Kent (Thomas et al., 2016), but it is unlikely to have come into widespread use until the tenth or eleventh century, when a 'tipping point' appears to have been reached and large numbers of farmers decided the time had come to invest in this technology (see below).[4]

There can be little doubt that the expansion of early medieval cereal farming fuelled the rise of lordship as well as the growth of towns and markets, but no consensus has been reached regarding several key questions. Was there a period of 'revolutionary' change, or instead a more gradual, piecemeal process of cerealization? Was the 'extensification' of cereal farming primarily a response to top-down pressure from lords demanding ever larger surpluses, or was it bottom-up, originating in peasant households? To what extent were key innovations such as the mouldboard plough and systematic crop rotation linked with each other and with field and settlement form? After more than a century of research, we have arguably reached an impasse regarding these questions. A major obstacle to progress is the lack of direct, closely dated evidence for early medieval fields and for the conditions in which crops were grown, especially for the period prior to 1000. The evidence that is available – manorial accounts, scatters of pottery sherds associated with manuring, place names, post-medieval maps, etc. – is indirect and can be interpreted in different ways. Much of the written evidence, furthermore, post-dates the key period of change and presents farming practices as seen through the eyes of officials who administered open-field cultivation on behalf of landowners. The data generated by FeedSax, on the other hand, derive from the remains of early medieval crops, arable weeds, pollen and livestock, and therefore provide direct – if not always straightforward – evidence of the conditions in which early medieval

4 Over 80,000 plough teams are recorded in the Domesday survey, although it is impossible to know whether this represented a similar number of ploughs or was primarily a convenient way of counting plough beasts (Darby, 1977, 336).

crops were grown and livestock raised, enabling us to address these questions from a different perspective.

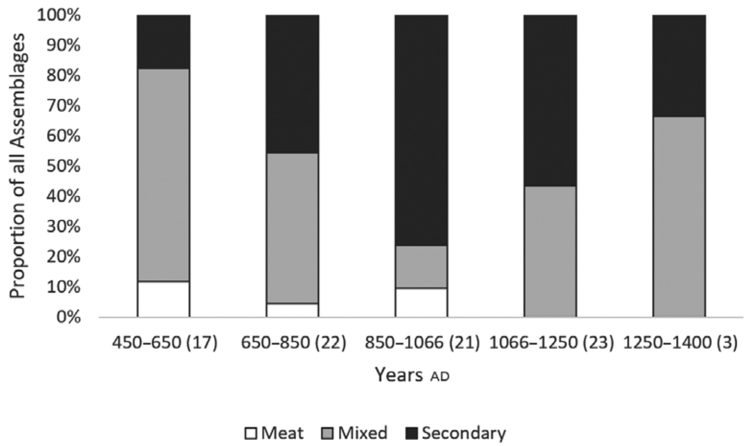
## Reconstructing medieval cultivation regimes from bioarchaeological remains

The FeedSax project uses a multi-proxy approach, comparing results from several different forms of primary evidence to enable a more robust reconstruction of farming regimes than would be possible from a quantitative study of cereal grains alone.[5] Grains preserved by accidental charring provide quantitative data that allow changes in the range and ratios of crop species to be traced and chronological and regional patterns in crop preferences to be identified (McKerracher, this volume). The molecular signatures of these grains, namely ratios of stable carbon and nitrogen isotopes, can be analysed to establish whether and how intensively crops were manured, if they were grown in rotation in the same fields, and whether they grew in wetter or drier soils (Stroud, this volume). The crop stable isotope results can be compared with the evidence provided by arable weeds which grew amongst the crops and whose seeds were accidentally harvested and preserved together with them. Weed floras also vary according to soil fertility, sowing time and tillage methods and, when used in combination with crop stable isotope results, provide a powerful tool for reconstructing cultivation regimes (see Bogaard et al., this volume).

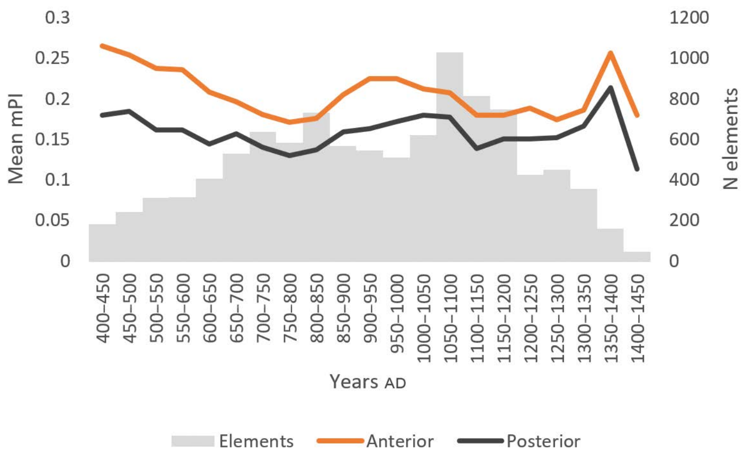
Excavated assemblages of animal bones have also been analysed. Cattle bones can serve as a proxy for developments in the use of traction, such as the spread of the heavy mouldboard plough (Holmes, this volume). Cattle that pulled a heavy plough, especially on heavy soils, were more likely to develop distinctive pathological and sub-pathological changes that are visible on their bones (Thomas et al., 2021). These changes can be studied in conjunction with age-at-death data and sex profiles, which provide important information regarding the importance of traction relative to meat and dairy production (Figure 1). Taken together, this evidence reflects the changing emphasis on traction over time (Figure 2; see also Holmes, this volume).[6] The increasing proportion in animal

5 See Hamerow et al., 2020 for a 'worked example' of this multi-proxy approach applied to the early medieval town of Stafford.

6 Figure 2 provides aoristic values based on the likely modified pathological indices (mPIs) derived from sites within each 50-year category. This incorporates data provided in Chapter 5, Figure 19, which illustrates the




1 Simplified mortality profiles for cattle, based on FeedSax mortality data, showing relative significance of meat production versus secondary products (milk, traction) over time. After Holmes et al., 2021a.

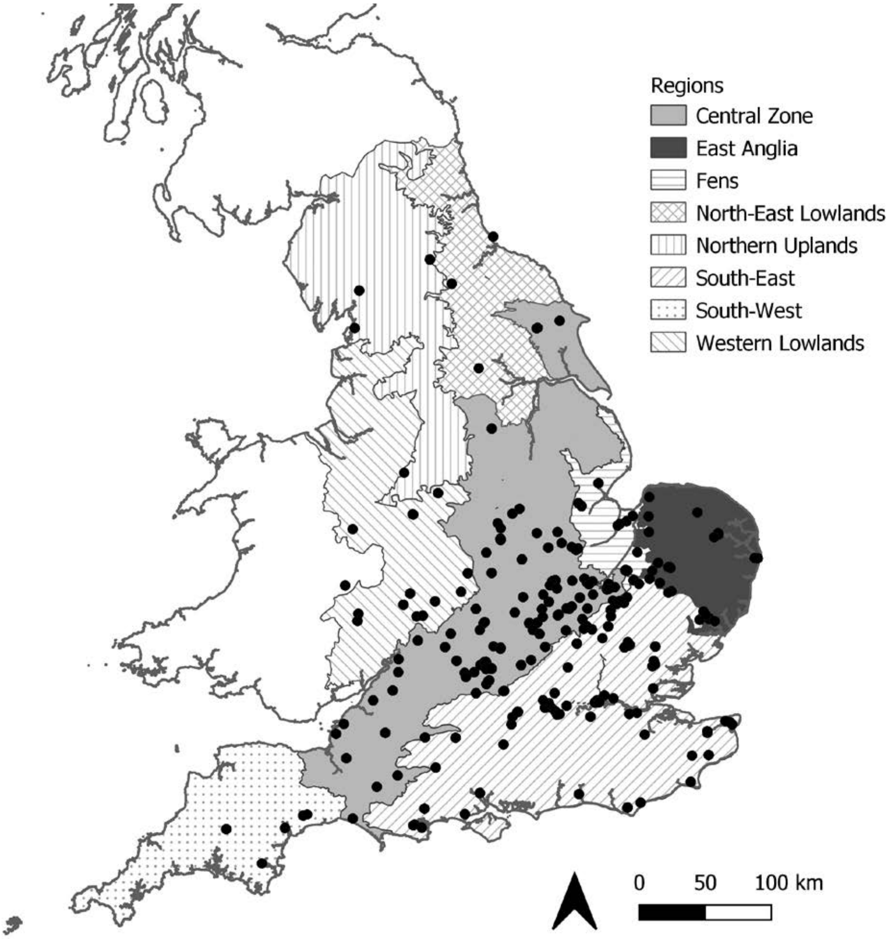



2 Aoristic model of the mean modified pathological index (mPI) for forelimbs (anterior) and hind limbs (posterior) from all targeted sites (N = 40), superimposed on numbers of elements analysed per period. Hindlimb pathologies provide a better proxy for traction use than do forelimbs, which tend to exhibit higher values, as they bear most of the animals' weight (M. Holmes in Hamerow et al., in prep).

bone assemblages of sheep – 'walking dung machines' that, unlike cattle, do not compete with crops for richer soils – provides a useful proxy for the expansion of arable relative to pasture over time (Campbell, 2000, 154; Holmes et al., forthcoming).

Pollen data collated from existing sources and supplemented by new analyses of pollen cores by FeedSax provide the 'big picture' of land use. Pollen studies spanning this period in England have previously been undertaken, most recently and significantly as part of the *Fields of Britannia* project (Rippon et al., 2015). These have shown that much of England had already been cleared of woodland by the late Roman period and, with a few exceptions, that the post-Roman

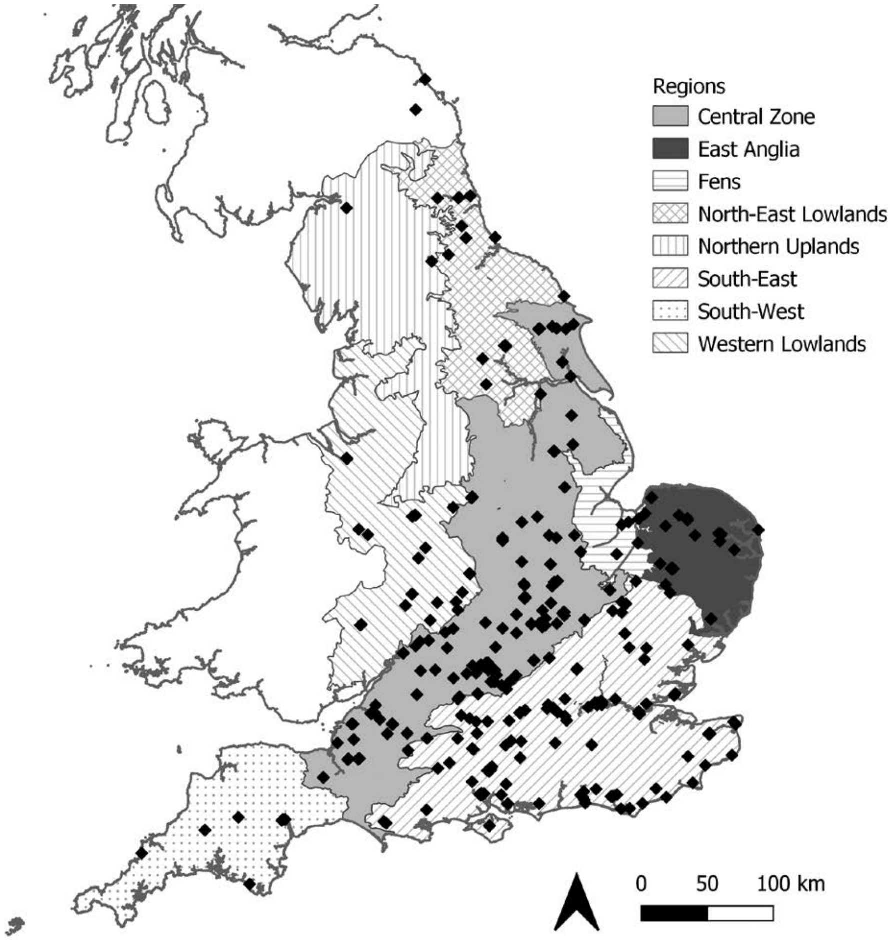
posterior mPI data from each site, and Figure 20, which provides metacarpal data included in the anterior values described here.




**3a–c** (a) Distribution of FeedSax archaeobotanical samples; (b) distribution of FeedSax zooarchaeological samples; (c) distribution of FeedSax pollen samples. Regional divisions after Rippon et al. (2015). Map created with QGIS (www.qgis.org; accessed 08/03/2022).

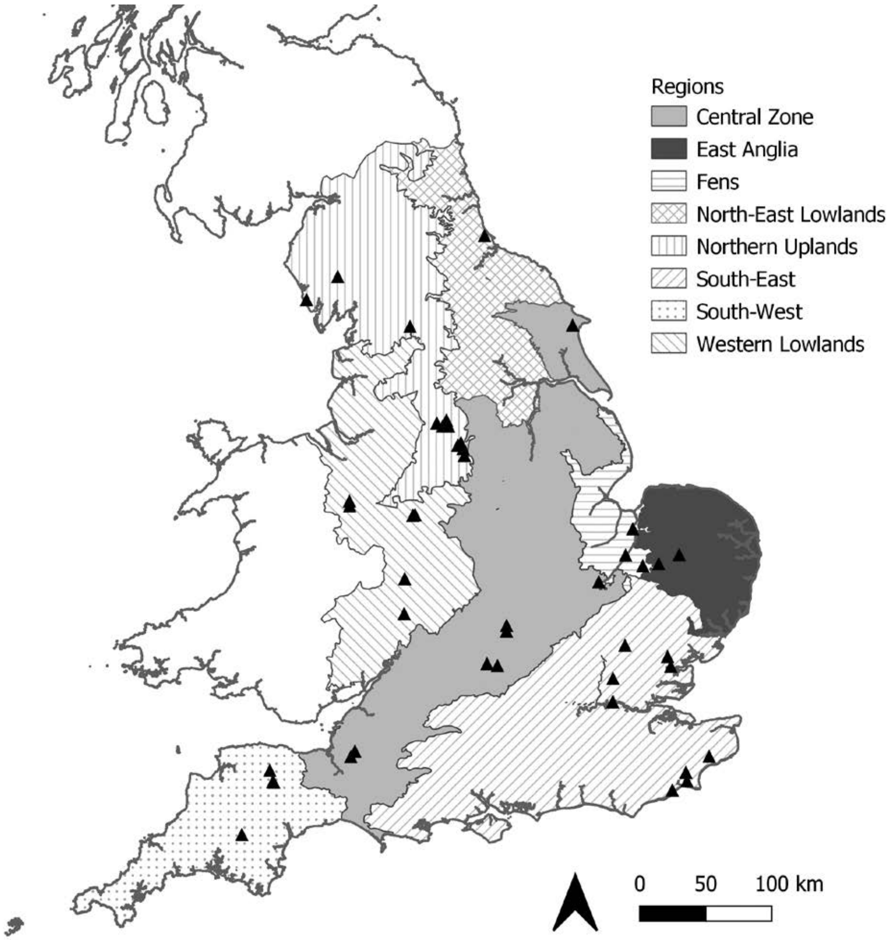
centuries saw relatively little woodland regeneration (Rippon et al., 2015; Figure 3c). It is unsurprising, therefore, that FeedSax has found evidence for largely open landscapes in most regions. Its main aim, however, has been to develop a method that allows for a more focused investigation within these open landscapes of the expansion or reduction of arable relative to pasture and heath (Forster and Charles, this volume).

While FeedSax's reliance on organic materials has presented certain constraints due to the imperfect and variable preservation of samples, a great advantage of using such materials is that they can be dated with considerable precision. Almost 200 radiocarbon dates provided by the Oxford Radiocarbon Accelerator Unit form the basis of a uniform chronological framework that allows results



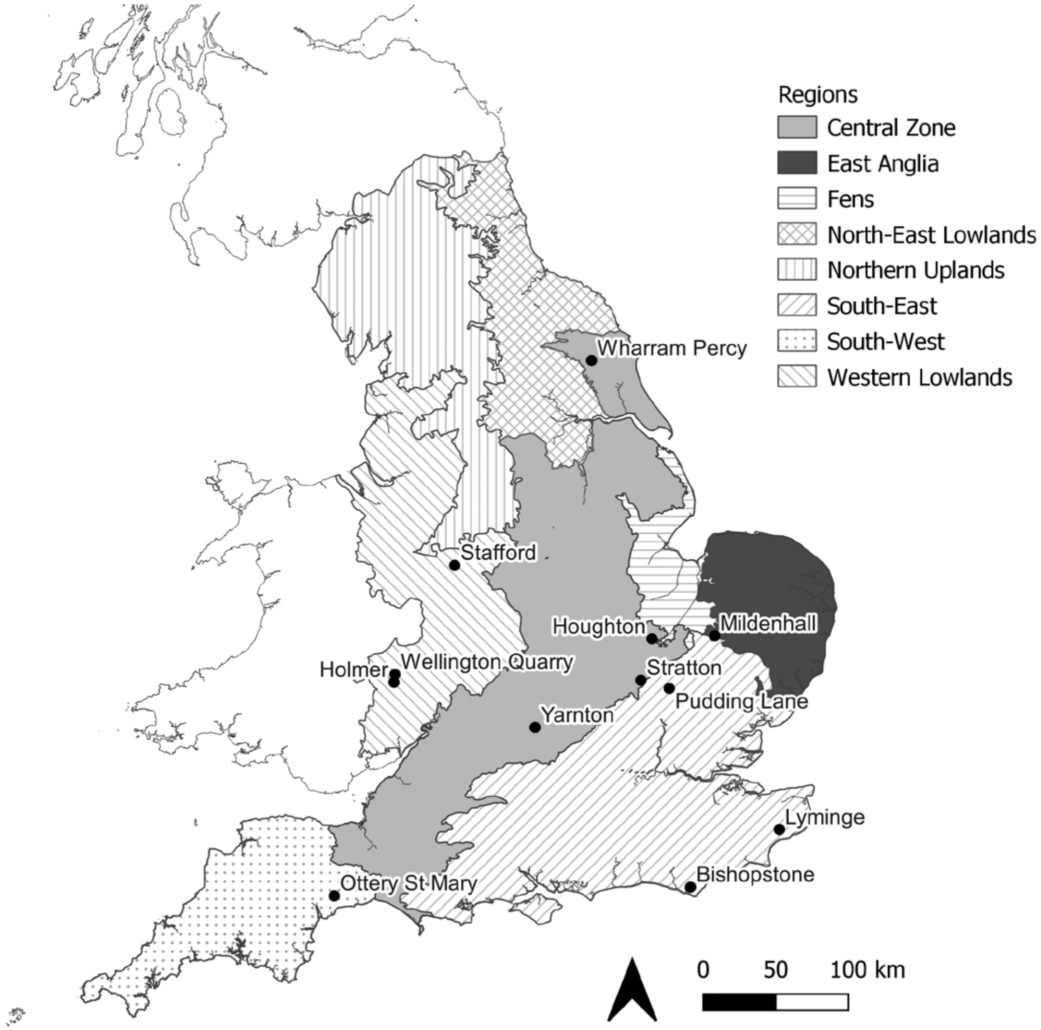

(**b**)

from many different sites to be compared directly in a way that is rarely possible with conventional, ceramics-based dating. Supported by this framework, analysis has taken place at two scales: the national picture is provided by a database containing some 700 zooarchaeological assemblages from 454 excavations, over 4,000 archaeobotanical samples from nearly 300 sites and pollen data from over 50 cores (Figure 3a–c). This database provides the basis for large-scale, inter-regional comparisons and has been complemented by detailed analyses of bones, weed seeds, cereal grains and pollen cores from selected case study sites with sufficiently abundant material, ideally spanning at least two centuries (Figure 4). In practice, few sites proved to have sufficient quantities of more than one or two categories of evidence due to poor preservation, a problem




(c)

that significantly limited opportunities for crop stable isotope analysis in particular. Furthermore, different soil conditions are conducive to the preservation of pollen, bone and charred plant remains, making it difficult to find sites where all three are equally well preserved. The best pollen sequences, for example, are found primarily in the western uplands, where the relatively acidic geology is inimical to the preservation of animal bones. The large assemblages of animal bones needed to provide statistically robust results are more likely to be found in urban contexts, whereas high-density deposits of charred cereals are more likely to be recovered from rural sites. Some settlements originally thought to span several centuries were revealed by targeted radiocarbon dates to be primarily single-phase, and so on. As a result, despite the project's aim to consider the whole of early




4 Distribution of FeedSax case study sites, and other sites mentioned in the text. Regional divisions after Rippon et al. (2015). Map created with QGIS (www.qgis.org; accessed 08/03/2022).

medieval England, some regions contain only one case study site or none, a problem that particularly affects the Northern Uplands and North-East Lowlands.[7]

## The 'mouldboard plough package'

The approach taken by FeedSax disaggregates three elements of early medieval farming traditionally assumed to be inextricably linked:

7 The regions used by FeedSax (Figure 4) are based on those developed by Rippon et al. (2015) for the *Fields of Britannia* project.

(i) systematic crop rotation, (ii) low-input, 'extensive' cultivation regimes and (iii) widespread use of the mouldboard plough. We have dubbed this the 'mouldboard plough package' and adopted it as a convenient framing device. It should not be assumed, however, that these practices were invariably linked, either with each other or with field and settlement form, nor that there was a transformative moment when all three came together. Similarly, the idea of a 'great re-planning' of fields and settlements around the tenth century has given way to interpretations that envisage a more gradual process of change, with less emphasis on the open-field 'Midland System' as the driver of increased production and a greater awareness of regional variation within an overall trend towards 'cerealization' (Williamson, 2018, and this volume; Banham and Faith, 2014; Rippon et al., 2015).

The first element of the 'mouldboard plough package' to be considered here is crop rotation. In its most systematic, fully developed form, this involved dividing most or all of a village's arable into two or three 'courses', often (though not necessarily) equating to two or three fields. In a two-field system, half the arable would lie fallow in a given year while in a three-field system, only one-third of the arable was given over to fallow. One of the other 'courses' would consist of an autumn-sown crop (often wheat, which benefits from a longer growing season) and the third a spring-sown crop (usually barley or oats, which are ready to harvest after a few months). A regular short fallow period – one year out of every two or three – enabled more land to be brought under the plough. In a three-field system, a field would be sown with winter corn by the end of October; following the harvest, it would be ploughed and sown with spring corn around March. After the second harvest, the field would be left fallow and used for communally regulated grazing until the autumn of the following year when it would again be sown with winter corn (Orwin and Orwin, 1938, 49–52; Hall, 2014; cf. Schroeder, this volume).[8] By analysing weed flora and crop stable isotope data in conjunction, it has been possible to confirm the evidence for seasonal sowing indicated by weed flora and to identify systematic crop rotation where stable isotope values for two or more cereals are sufficiently similar to indicate that they were grown in similar soil conditions and so – especially where seasonal sowing is indicated – probably in the same fields (as at Stafford: see Hamerow et al., 2020). For other sites, it has been possible to rule out crop rotation, at least during certain phases. In a few cases, it

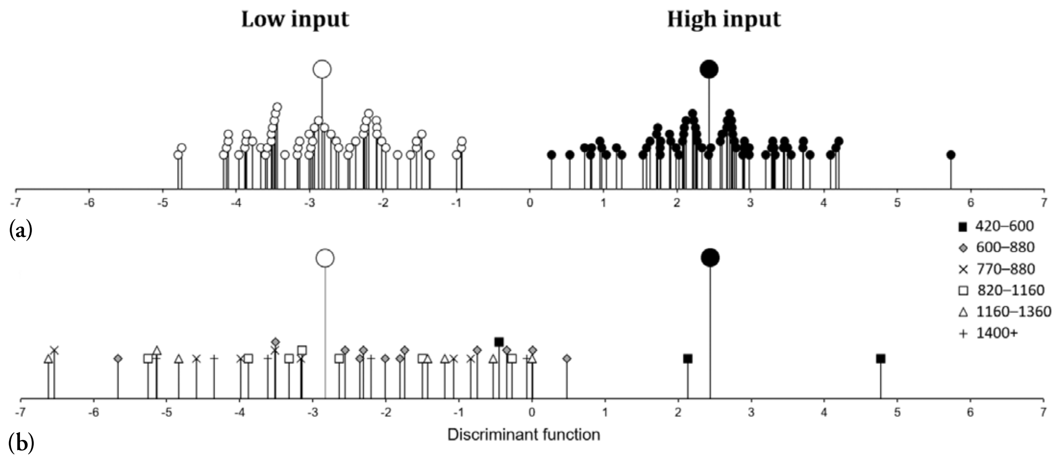
8 More complex rotations are also documented (Stone, 2005).

appears that two cereals were grown in rotation while a third was grown elsewhere, in different soil conditions.

The second element of the 'package' is low-input, extensive cultivation. This involves increasing overall cereal production by cultivating more land while investing less manure and human labour (e.g., weeding and tilling) per land unit. Intensive, high-input agricultural systems therefore tend to be associated with small-scale farming, where labour input is the key limiting factor of production; extensive agricultural systems are, by contrast, land-limited rather than labour-limited and tend to be larger in scale. Extensive systems also tend to be associated with increased wealth inequalities, as land is more readily owned and inherited than labour (Kohler et al., 2017; Bogaard et al., 2019). The intensity of farming regimes – in particular, the degree to which fertility was boosted by manuring – is also reflected in stable isotope values and weed flora (see papers by Bogaard et al. and Stroud, this volume). While it is not possible to identify a distinctive open-field 'signature' based on stable isotope values and weed ecology alone, all forms of open-field farming are by definition low-input, even those on poorer soils where, for example, close-folding of sheep was used to maintain fertility (Williamson, 2018, 6). Using the 'intensity model' discussed by Bogaard et al. (this volume), the arable weed seed assemblages of eighth-century and later date examined by FeedSax have all been shown to reflect broadly low-input, 'extensive' cultivation regimes, albeit with a tail of around 10 per cent to 20 per cent of samples reflecting higher-input conditions. It is possible, of course, that most of these samples derive from open fields, which would explain the dominance of weeds reflecting 'low-input' conditions.

The weed flora from a number of sites also reflect a subtle but clear shift over time towards increasingly low-input conditions, as seen, for example, at Stafford (Hamerow et al., 2020). In a few cases, including Stratton, near Biggleswade (Bedfordshire), earlier samples dating to the fifth to seventh centuries were available (Shotliff and Ingham, 2022). In these instances, it has been possible to detect a shift from relatively intensive and presumably smaller-scale farming regimes in this early period, to extensive, low-input and larger-scale regimes by the eighth to ninth centuries (Figure 5; Bogaard et al., this volume).[9] Even weed assemblages dating to the tenth to thirteenth centuries display some variability, however, and most include a few

9 An exception to this trend is Lyminge (Kent), where low-input conditions are indicated even for the sixth- to seventh-century samples (see below and Bogaard et al., this volume).




**5a–b** (a) The relationship of modern low-input fields (to the left) and high-input fields (to the right) to a discriminant function extracted to distinguish weed floras growing under different cultivation conditions; (b) the relationship of archaeobotanical samples from Stratton to this discriminant function. The larger symbols represent 'centroids' (average scores) for the modern groups of fields. See Bogaard et al., this volume, for further details.

samples reflecting more intensively managed conditions (Bogaard et al., this volume; Hamerow et al., in prep.). Such variability is unsurprising given that some small-scale, more intensive practices are likely to have continued alongside the overall trend towards low-input cultivation (Banham and Faith, 2014, 41–42).

Despite the relatively small number of samples from northern regions, some regional variability is hinted at. Ninth- to thirteenth-century samples from Wharram Percy (North Yorkshire), for example, which lies at the northern extremity of the Central Zone, were somewhat less 'extensive' than those from other Central Zone sites (Hamerow et al., in prep.). Regional variability is also evident when considering the overall ratio of sheep to cattle: the Northern and Central Zones, as well as East Anglia, saw the ratio of sheep to cattle increase to reach parity by the eighth century, significantly earlier than in other regions, suggesting that the emphasis on arable production in these regions extends back into the Mid Saxon period (Holmes et al., forthcoming).[10]

Finally, widespread adoption of the mouldboard plough famously enabled farmers to expand from light, easily cultivated soils onto heavier, more fertile soils and to plough more land in a day. As already noted, the mouldboard plough was present in England, at least in Kent, in the seventh century. It is unclear, however, when and how it changed from a rarefied, high-status implement used at royal sites like Lyminge, to a widely used technology (Bogaard et al.,

10 Whereas cattle would be in competition with arable farming for the richest soils, sheep can thrive on those poorer soils less favoured for arable and are also well-suited to close-folding and muckspreading on fallow.

this volume). It should be noted that the ard continued to be used throughout the medieval period and on some terrains could have been the main cultivation implement (Banham and Faith, 2014, 50; see also Kropp, this volume). It is equally possible that, in some circumstances, a mouldboard plough was used in enclosed fields, as appears to have been the case at Pendock, Worcestershire; the adoption of the mouldboard plough was thus not invariably linked to a reorganization of arable (Dyer, 1990, fig. 4).

Zooarchaeological investigations by FeedSax have shed new light on the uptake of mouldboard ploughing technology in early medieval England: cattle bone assemblages from several settlements have been found to display significantly elevated proportions of pathological and sub-pathological changes in foot bones, or evidence of individual animals with unusually severe pathologies – i.e., indications of draught work. A clear correlation has emerged between heavy soils and a predominance of draught cattle, although half of sites in East Anglia also produced a high proportion of draught animals, despite its lighter soils (Holmes, this volume). The growing emphasis on traction and, by implication, increasing use of the mouldboard plough, is also manifest in the increasing proportion of male cattle (Holmes et al., forthcoming). The use of functional weed ecology to assess changing levels of soil disturbance as set out by Bogaard et al. (this volume) is another means by which use of the mouldboard plough can be traced.

According to convention, crop rotation, low-input regimes involving regular, short fallow periods, and the mouldboard plough were closely linked, not only with each other but also with the reorganization of arable and the establishment of open fields. The earliest written sources describing such systems in England date to the twelfth and thirteenth centuries and indicate that a feature of the three-field system was communal management of arable. This involved collective decision-making, particularly around fallow grazing. For this system to work, farmers had to agree to follow a scheme of crop rotation. They also shared expensive resources, namely the mouldboard plough and the team of oxen needed to pull it. It has long been argued that, in some regions of England, this sharing of the plough and plough team encouraged households that had previously lived in small, scattered settlements, to live in close proximity, i.e., in 'nucleated' villages.[11] To what extent the systems described in these

11 This 'nucleation hypothesis' has been convincingly challenged by Williamson, who argues that it applies primarily to settlements on clay soils where the window available for ploughing was particularly brief, due to the risk of 'puddling' (Williamson, 2018, 19; and this volume). He also notes that

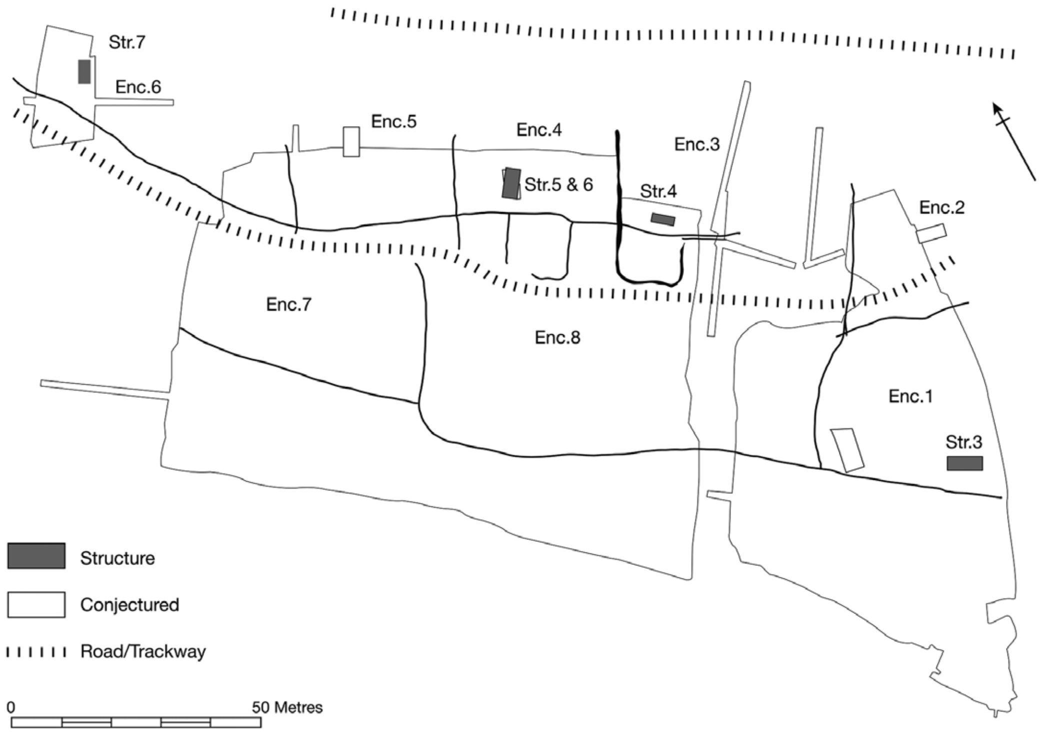
sources existed in the pre-Conquest period is a question that has never been satisfactorily resolved. The data generated by FeedSax cannot, of course, tell us whether fields were enclosed or open, farmed in strips, or associated with a particular form of landholding. It can, however, help to establish the relative intensity and scale of arable farming, whether systematic crop rotation was practised, if and when there was an expansion onto heavier soils, how the ratio of arable to pasture varied regionally and over time, and the relative importance of traction at different periods.

## Farming and settlement archaeology

The relationship between rural settlement and farming is usually considered in terms of the link between field systems and 'nucleated' versus 'dispersed' settlement patterns. Consideration should also be given, however, to the link between farming practices and settlement form. An examination of excavated settlements allows us to consider how, if at all, changes in farming regimes identified by FeedSax are reflected in the composition and layout of farms themselves. It must be recognized, however, that the distribution of excavated settlements from the pre-Conquest period is heavily biased towards eastern and southern England. This uneven distribution appears to be primarily the result of different 'building cultures', one of which is relatively easy to recognize and recover archaeologically, while the other is virtually invisible (Blair, 2018, 27 and fig. 4). Large assemblages of charred cereal remains are mostly found within a triangular zone 'pointing southwestwards from the Wash and Humber' identified by John Blair as containing the greatest concentration of fifth- to ninth-century settlements (Figure 3a; Blair, 2018, 27). It includes much of the Central Zone and East Anglia as well as parts of the South-East. It is possible that communities that adopted the 'Anglo-Saxon building culture' so evident in this zone also processed cereals in a way and on a scale that was more likely to result in substantial deposits of charred crops.

Returning to settlements themselves, three episodes of change in their form and composition are particularly relevant. The first took place during the so-called 'long eighth century', *c.* AD 680–830 (Hansen and Wickham, 2000). This period saw a number of 'firsts', including the first post-Roman complexes of ditched enclosures that appear to have served as pens, paddocks and corrals for livestock (Hamerow, 2012; McKerracher, 2018, figs 26–34). In a few cases, the

cooperative ploughing (co-aration) was sometimes practised in areas of dispersed settlement (Williamson, 2013, 196).




**6** Schematic plan of the main enclosures and trackways at West Fen Road, Ely, Cambridgeshire (after Mortimer et al., 2005).

buildings associated with them are relatively substantial, for example the barns and other structures found at the tribute-collecting centre at Higham Ferrers (Northamptonshire) (Hardy et al., 2007). More often, however, the associated structures were small, lightly built and ephemeral, as seen at West Fen Road, Ely (Cambridgeshire) (Figure 6; Mortimer et al., 2005; Mudd and Webster, 2011). Indeed, it is often difficult to determine which, if any, of the structures found at such sites served as dwellings (McKerracher, 2018, 36).

The appearance of substantial livestock enclosures and droveways in the landscape after more than two centuries during which farmers had no need of them has two major implications. First, it suggests that livestock were being managed in new ways that required their movement to be controlled to avoid animals straying into farmsteads and fields, perhaps because they were now kept close to settlements for part of the year. Second, it indicates that farmers were cooperating in the construction and maintenance of these extensive systems of enclosures, and perhaps in the management of livestock.[12]

12 A similar arrangement appears to have existed amongst eighteenth-century farming communities on the Swedish island of Öland (Blair, 2018, 300–1).

Those of the kind found at Ely and Cottenham in Cambridgeshire, for example, must have been large-scale communal undertakings, involving the digging of many hundreds of metres of ditches, re-cut and modified over several centuries (Mortimer et al., 2005; Mortimer, 2000). Early medieval farmers would, of course, always have cooperated at key stages in the farming year, for example during haymaking (Banham and Faith, 2014, 124). The appearance of these ditched complexes, however, represents cooperation and the pooling of labour on a new scale (cf. Faulkner, this volume).

The mid-seventh to ninth centuries also saw investment in the first centralized crop processing and storage facilities since the end of the Roman period. These include a small number of grain drying and malting kilns, watermills, granaries and barns (see Caroe, this volume; Hamerow, 2012, 151–55; McKerracher, 2018, 121–22). Such constructions can reasonably be described as 'capital projects' associated with high-status establishments, both royal and monastic, built with the wealth generated by the increasing cereal surpluses they were designed to process and store. Agricultural infrastructure of this kind not only served a practical function, but also signalled that the owners were the proprietors of a highly productive agricultural estate. As Mark McKerracher (2018) has observed, taken together, these additions to the repertoire of settlement features provide a compelling, if circumstantial, case for a transformation of farming in at least some regions. This circumstantial evidence can now be compared with the direct evidence for cultivation regimes generated by FeedSax.

It should first be noted that the earliest 'high-density' post-Roman archaeobotanical assemblages of charred grains (i.e., those yielding at least 30 grains per litre of soil) date to the second half of the seventh century (McKerracher, 2018, 90–92). Indeed, with few exceptions, it has not been possible to extend weed or stable isotope analysis back into the fifth to seventh centuries, simply because sufficiently well-preserved, high-density samples are lacking. A pilot study found that sites producing such high-density archaeobotanical assemblages become more common in the archaeological record from the eighth and ninth centuries onwards, especially in the Central Zone and East Anglia (McKerracher, 2016a). As already noted, such assemblages are themselves likely to be the product of increasingly large harvests being stored and processed in new ways and they may therefore serve as prima facie evidence for an increasing emphasis on surplus production (as in the Roman period; see van der Veen, 2016). Their appearance in the archaeological record at around the same time as grain drying kilns, barns and watermills strengthens the case for a link between the scale of arable production and the density of grain assemblages. The case is further supported by the weed data which, as already observed, suggest that the shift to low-input, larger-scale regimes had occurred by 800. Pollen evidence and an increase in the proportion of male cattle from around 7 per cent during the fifth to seventh centuries to around 23 per cent by 750 also indicate that the eighth century saw an increasing emphasis on arable production, at least in some regions (Forster and Charles, and Holmes, this volume), while the growing emphasis on sheep (and on collecting their droppings) must at least in part explain the complexes of droveways and ditched enclosures that first appeared around the same time.

The second key change took place during the tenth century, when the first distinctive aristocratic or 'proto-manorial' settlement complexes appear. Some of these were the residences of local lords who had been granted land and who extracted and mobilized the surpluses it generated to fund lifestyles of 'elegance, comfort and richness of possessions' (Blair, 2015, 192; see also Fleming, 2011). Others could have been built by 'upwardly mobile' *ceorls*, prosperous independent peasants who had acquired enough land and wealth to attain thegnly status, perhaps thanks to innovative farming regimes. Examples of this kind of complex have been identified in several regions and include Goltho (Lincolnshire), Faccombe Netherton (Hampshire), Bicester (Oxfordshire), Bishopstone (Sussex) and Raunds (Northamptonshire) (Beresford, 1987; Fairbrother, 1990; Harding and Andrews, 2003; Thomas, 2010; Audouy and Chapman, 2009). They are characterized by distinctive architectural forms, namely 'angle-sided' and aisled halls, often set within a 'long range' that included a number of separate, presumably functionally distinct, chambers (Blair, 2015, 192). Such sites often included special-purpose structures such as kitchens and latrines, and some had private churches or free-standing timber towers (Figure 7). Apart from these distinctive thegnly sites, however, the essential form of rural settlements remained unchanged; the widely spaced, loosely articulated compounds of buildings, ditched enclosures and trackways that first appeared in the 'long eighth century' – recently dubbed 'semi-nucleations' (Blair, 2018, 294–301) – were still being constructed in the tenth, as seen, for example, at Yarnton (Oxfordshire), Stratton, Houghton (Cambridgeshire), Raunds and Ely (Hey, 2004; Shotliff and Ingham, 2022; James, 2018; Audouy and Chapman, 2009; Mortimer et al., 2005). It has been suggested that some of the enclosures within ditched complexes of this kind could have been the focus of 'high intensity cultivation', their fertility maintained by the manure collected from livestock penned within the same complexes (Blair, 2018, 299). As already observed, however,

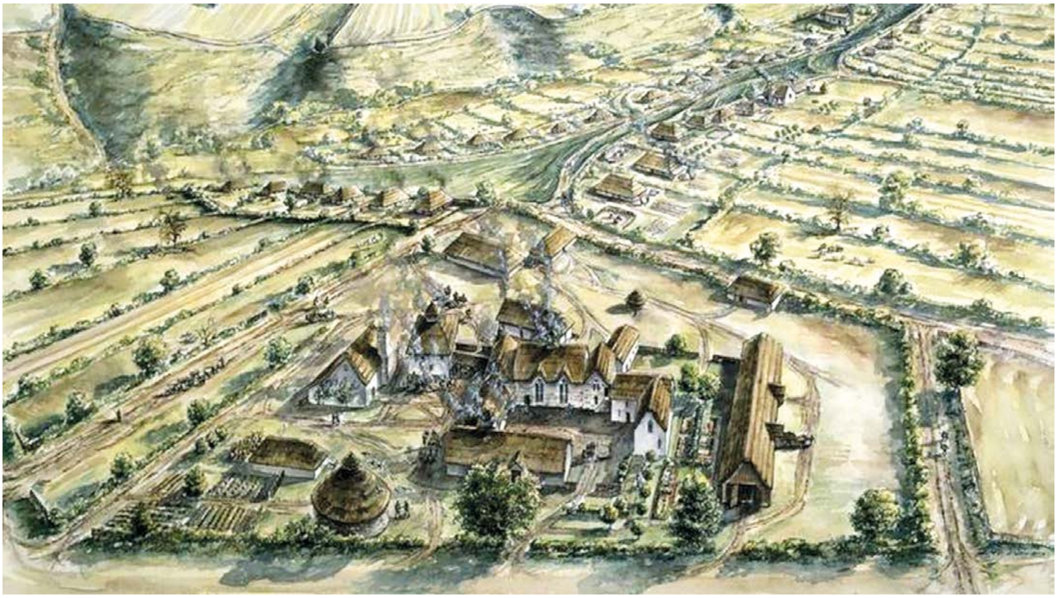
7 Conjectural reconstruction of the tenth-century courtyard range at Bishopstone, Sussex, by Mark Gridley. Reproduced with kind permission of Gabor Thomas, University of Reading.

FeedSax's analysis of arable weeds shows that the great majority of the tenth- to thirteenth-century cereals examined had been grown in low-input conditions and that the shift to low-input regimes took place well before the tenth century. It is possible that some of these enclosures were used for small-scale, intensive cultivation of specialist crops such as flax and hemp, but this must remain conjecture.

Evidence for systematic crop rotation first becomes relatively widespread in the tenth century.[13] Cereal grains and weeds from the *burh* at Stafford, for example, indicate that wheat, oat and rye were grown in rotation but that barley – found in much smaller quantities – was grown separately (Hamerow et al., 2020). Regional patterning also emerges more clearly in this period, with oat, for example, being particularly prominent in Devon and Cornwall (Hamerow et al., in prep.).

The next major development in rural settlement form took place in the later eleventh to thirteenth centuries when nucleated villages – as distinct from the earlier 'semi-nucleations' described above – began to appear, of the kind still seen in parts of the landscape today, with planned arrangements of contiguous, clearly defined house plots whose form and position 'reflected the status and obligations of their inhabitants' – as seen, for instance, at Wharram

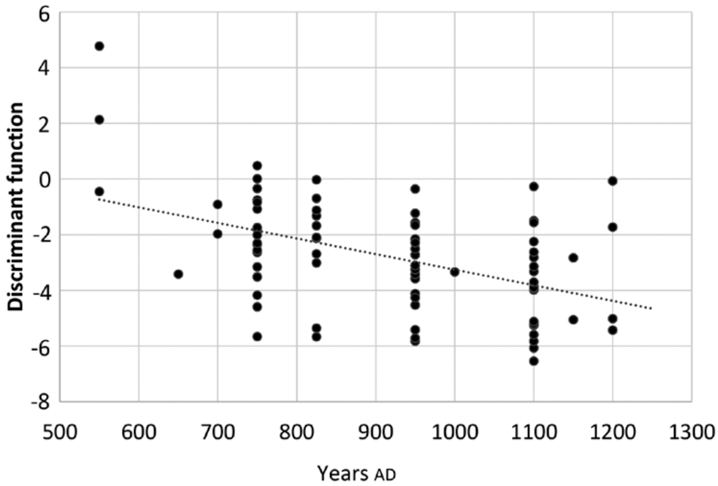
13 Earlier evidence for the systematic rotation of rye and barley, dating to between 770 and 880, has been identified at Holmer, Herefordshire (Elizabeth Stroud, pers. comm.).



8 Artist’s impression of the village of Wharram Percy, North Yorkshire, in the twelfth century. Reproduced with kind permission of Historic England.

Percy (Figure 8; Blair, 2018, 383; see also Creighton and Rippon, 2017). What, if any, direct link existed between the establishment of such villages and the laying out of open fields is still far from clear. The setting out of planned tofts and crofts could, for example, represent a secondary stage of development that followed on from the creation of a village’s field system (Faith, 1997, 235). Indeed, while nucleated villages emerged during a relatively well-defined ‘window’, open fields appear to have developed over a much longer period of ‘extensification’ lasting several centuries.

There is nothing in the bioarchaeological record for this period to suggest major innovations in farming. In terms of charred crop deposits, however, the average density of plant remains per litre of soil increases sharply for the eleventh to thirteenth centuries, implying a significant scaling up of production, as does the increasing investment in the processing and storage of cereals, reflected in growing numbers of watermills, barns and granaries (McKerracher, this volume; Gardiner, 2013). A marked shift to wheat cultivation is also apparent in several regions, perhaps reflecting an increasing emphasis on cash rents and hence cash crops, while weed flora, especially from the Central Zone, reflect more consistent and thorough tillage from around the twelfth century onwards. This presumably reflects more systematic use of the mouldboard plough within two- and three-field systems and perhaps a greater investment of labour in activities such as hand-weeding and harrowing (see papers in this volume by Bogaard et al., McKerracher, and Williamson). The overall frequency




Linear regression with random site effects:
$R^2 = 0.21$
$P < 0.000$

**9** Linear regression analysis of weed flora from sites in the Central Zone, showing declining fertility over time (A. Bogaard in Hamerow et al., in prep).

of pathological and sub-pathological changes in cattle feet at most of the sites examined also indicates a marked increase in the use of cattle for traction around 1000 (Holmes, this volume).

Finally, written sources and manuring scatters indicate that, by the twelfth and thirteenth centuries, landowners were going to considerable lengths to boost soil fertility by manuring and marling (Jones, 2004; Faith, 1997, 237), although whether this was driven primarily by a desire to maximize outputs or by concern over declining fertility – the long-term net effect of extensification – is far from clear.[14] The weed ecology of those fields demonstrates, however, that these efforts were insufficient to halt a subtle but clear trend towards diminishing levels of fertility (Figure 9; see Hamerow et al. in prep.). The findings of FeedSax thus support a recent assessment of the eleventh and twelfth centuries as seeing 'broad continuities in agricultural regimes, technologies and husbandry practices' against the backdrop of an overall increase in the scale of arable farming and a proliferation of formal markets where cereals were bought and sold (Creighton and Rippon, 2017, 60; Britnell, 1981).

14 Marl contains limited nitrogen, so marling is unlikely to have affected the $\delta^{15}N$ values in cereal grains as measured by crop stable isotope analysis. It does, however, contain potassium, lime, phosphorus and magnesium, all of which would have boosted plant growth (Elizabeth Stroud, pers. comm.).

## Conclusion

This provisional comparison between bioarchaeological trends and developments in settlement archaeology raises a number of difficulties. Data of the kind provided by weed flora, for example, are most readily modelled and represented as a linear regression; the nature of the evidence – with many more samples from some phases than others – makes it difficult to discern potential 'step changes', for example in soil fertility. Settlement archaeology, by contrast, is punctuated by moments of change, such as the appearance of the first ditched livestock enclosures, the first 'thegnly' compounds or the first nucleated villages. Single-phase case studies, such as the fourteenth-century granary at Ottery St Mary (Devon) and the harvest it contained, provide useful but static snapshots of what was undoubtedly a dynamic situation (Mudd et al., 2018). The animal bones, crop remains and weeds from a single settlement, furthermore, reflect local and potentially unique developments relating to a particular community. This is illustrated by the royal site at Lyminge, where low-input, relatively high-disturbance conditions appeared at an exceptionally early date (Bogaard et al., this volume). While this is likely in part to reflect the settlement's position on lighter soils, the possibility that it was precocious in adopting the mouldboard plough, as suggested by the seventh-century coulter mentioned at the beginning of this paper, should not be discounted.

Such problems beset any attempt to weave together diverse strands of evidence, yet working in this way has allowed us to address the broad questions outlined at the start of this paper from a new perspective and to offer several key observations. First, no one period can be singled out as having undergone 'revolutionary' change, although the mid-seventh to ninth centuries were characterized by significant innovations in both crop and animal husbandry, evidenced in the appearance of livestock enclosures, watermills and grain ovens, as well as in the remains of crops, weeds and livestock. Second, if the extensification of cereal farming, systematic crop rotation and use of the mouldboard plough had been initiated by local lords – the occupants of the 'proto-manors' described above – one would not expect to find evidence of these practices prior to the tenth century. Analysis of weed flora clearly shows, however, that the shift to low-input cultivation took place well before the tenth century, presumably driven partly by population growth but also by royal and monastic innovation and regional markets for grain (cf. Hamerow, 2007; Yorke, 2008, 80; Naylor, 2016, fig. 2). The tenth century did, however, see an increase in systematic crop rotation, a trend that became more marked in the eleventh; animal bones point to the increased use of cattle for traction – and, presumably, of the mouldboard plough – from the later tenth and eleventh centuries. The same period saw a decrease in crop diversity, as farmers fine-tuned cropping regimes according to local conditions; the timing of these developments is consistent with a degree of 'top-down' pressure to increase productivity. The work undertaken by FeedSax thus indicates that the different elements of the mouldboard plough package did not come together in a 'revolutionary' moment or follow a single shared trajectory. Instead, the 'cerealization' of England emerges as a regionally variegated process lasting several centuries, punctuated by periods of innovation and rapid change.

# 2 Lessons from Laxton, Highgrove and Lorsch: Building Arable Weed-Based Models for the Investigation of Early Medieval Agriculture in England

*Amy Bogaard, John Hodgson, Claus Kropp, Mark McKerracher and Elizabeth Stroud*

## Introduction

Arable weed ecology provides a means of comparing farming systems in terms of crop growing conditions. A useful 'short-cut' to summarizing key ecological characteristics of arable weeds is to measure their functional ecological traits. These are morphological or behavioural characteristics that have been shown experimentally to predict weed species' potential in relation to major habitat variables. Thus, for example, specific leaf area (the ratio of leaf area to leaf dry weight) and related traits reflect growth rate, and hence species' potential to flourish in fertile soil conditions (Díaz et al., 2004; 2016; Wright et al., 2004; Reich, 2014).

The approach of estimating species' potential by measuring functional traits, known as functional ecology, also lends itself to framing comparisons between present and past farming systems. The weed floras of present-day crop fields can be recorded through survey, while those from past agricultural systems are attested through archaeobotanical assemblages of crops and their associated weeds. The advantage of using functional ecology as the basis of comparison between weed floras is twofold: it enables comparison of weed floras (e.g., modern and ancient) that have few or no species in common;

We would like to extend our thanks to Gabor Thomas (University of Reading) for the opportunity to analyse the archaeobotanical remains from Lyminge; to Alison Nicholls (Gladstone Pottery Museum) and Joseph Perry (Potteries Museum) for providing access to and permission to analyse archaeobotanical material from Stafford; to Joy and Dik Allison, Mary and Robert Haigh, Stuart Rose and the Laxton History Group, for their knowledge and hospitality in Laxton; and to David Wilson of Duchy Home Farm for sharing his expertise and permitting our survey at Highgrove.

and the 'functional' nature of the traits means that similarity or difference in weed floras can be assessed in terms of underlying ecological processes. In other words, use of functional ecology makes it possible to set up a 'relational analogy' (Wylie, 1985) between modern and ancient weed communities: assessments of similarity (or difference) are based on an understanding of relevant causal (here, ecological) mechanisms. The aim of such comparisons is therefore *not* to stumble upon an exact modern 'match' for ancient weed floras and farming systems, but rather to identify meaningful ecological *contrasts*, as a means of reconstructing past land use systems that may have no close modern analogue (Charles et al., 2002; Jones, 2002; Bogaard, 2004, 8).

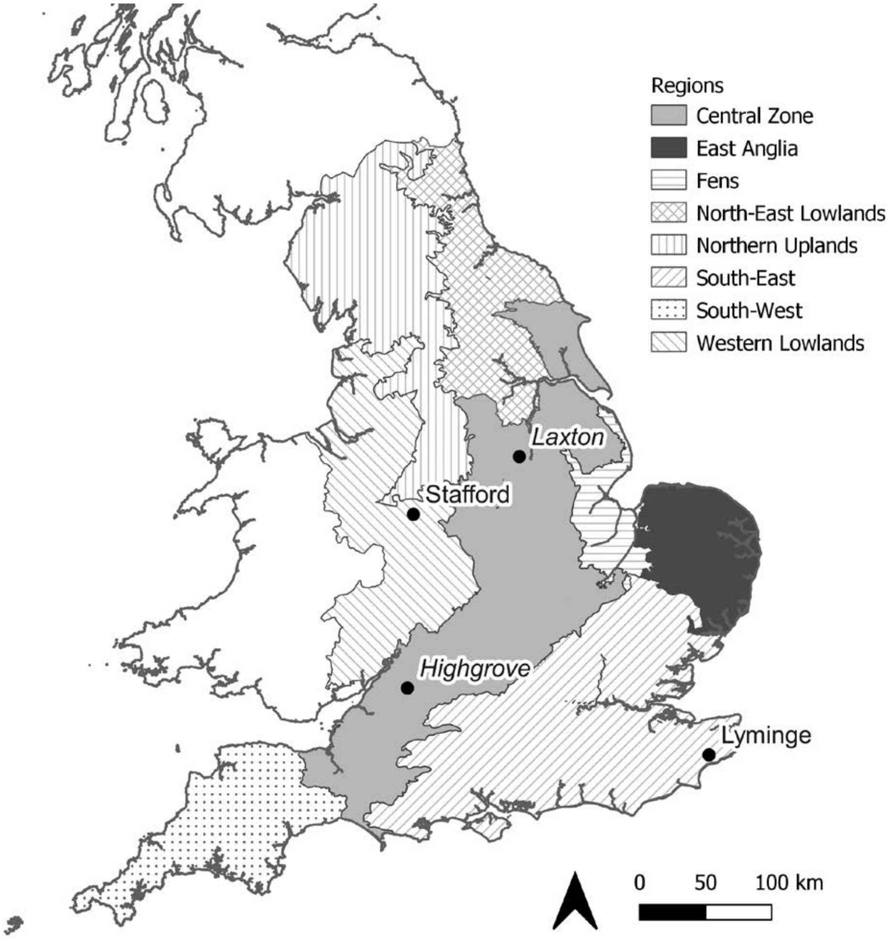
In this paper we consider the usefulness of functional weed ecology to shed light on early medieval agriculture in England by framing comparisons between archaeobotanical weed assemblages and present-day farming systems. We do this in two steps.

First, we consider a previously published weed ecological model for distinguishing 'low-input' and 'high-input' cereal production systems on the basis of a set of functional ecological traits that reflect species' potential in relation to fertility and disturbance (Bogaard et al., 2016). 'Disturbance' in plant ecology refers to the destruction of plant biomass, for example by mechanical perturbation of the soil, which in arable fields is effected through tillage and weeding (Grime et al., 1988). The weed ecological model was derived to discriminate between low-input production of cereals in present-day Haute Provence, south-eastern France (e.g., little/no manuring or hand-weeding) and high-input cultivation in Asturias, northern Spain (e.g., intensive manuring and hand-weeding) on the basis of such traits (Bogaard et al., 2016). The model provides an axis of combined fertility and disturbance to assess the labour intensity of past farming systems. We review a worked example of the application of this model to an early medieval archaeobotanical assemblage, from Stafford in the West Midlands of England (Hamerow et al., 2020), dating primarily from the late ninth to mid-twelfth centuries, and then consider a second case study, that of sixth- to twelfth-century Lyminge, Kent (Thomas, 2013; Thomas and Knox, 2013). We use these assemblages to illustrate how application of the Provence/Asturias 'intensity model' relates to the general hypothesis of extensification in early medieval England: that is, expanding cereal production with diminishing inputs per unit area (Hamerow, this volume).

While the 'intensity model' provides a means of situating early medieval arable weed assemblages on an input/intensity spectrum, it combines traits relating to fertility *and* disturbance, since this combination achieved the best discrimination of low-input cereal production in Haute Provence from high-input cultivation in Asturias. For the purposes of understanding developments in early medieval farming, however, it is desirable also to consider soil disturbance separately. The hypothesized nature of early medieval husbandry is that it achieved 'extensification' in part through use of the mouldboard plough, which enabled expansion onto heavier soils and promoted effective tillage by turning over the soil (Fussell, 1966; Hamerow, this volume). The tillage regime in Haute Provence incorporated spring harrowing, and the disturbance contrast between the Haute Provence and Asturias regimes was not sufficiently strong to construct a model on the basis of disturbance traits alone (Bogaard et al., 2016). The second step in our functional weed analysis, therefore, was to construct a new model on the basis of two regimes that differed *primarily* in terms of disturbance, in order to monitor disturbance levels in early medieval fields. We did this using relevant ecological traits of weed floras surveyed in two present-day English cereal production systems: the persisting open-field system at Laxton, Nottinghamshire, and organic cereal fields at Highgrove's Duchy Home Farm, Gloucestershire (Figure 10; Plate I).

The well-known open-field system at Laxton (Orwin and Orwin, 1938) as it exists today is a conventional farming system incorporating herbicides and thus lacking a fully expressed arable weed flora. Alongside arable fields, however, the open-field landscape incorporates substantial meadow verges, known locally as 'sykes', that have remained unploughed for centuries, and are not sprayed with herbicides (Plate Ia). While the 'sykes' are thus outside the arable regime per se, they offer valuable evidence of the flora that develops in the absence of substantial disturbance from ploughing. The 'sykes' can be contrasted with the arable weed floras that persist in unsprayed arable field edges at Laxton (Hamerow et al., 2020). Highgrove's Duchy Home Farm established organic cereal production near Tetbury, Gloucestershire in 1985. The farm offers a good sample of cereal field weed floras developed under moderate management intensity (Plate Ib), supplementing the fragmentary arable field weed flora at Laxton. Here we combine the botanical survey and ecological trait data for the Laxton 'sykes' and fields with data from the Highgrove fields to produce a new model for discriminating between low- and high-disturbance conditions.

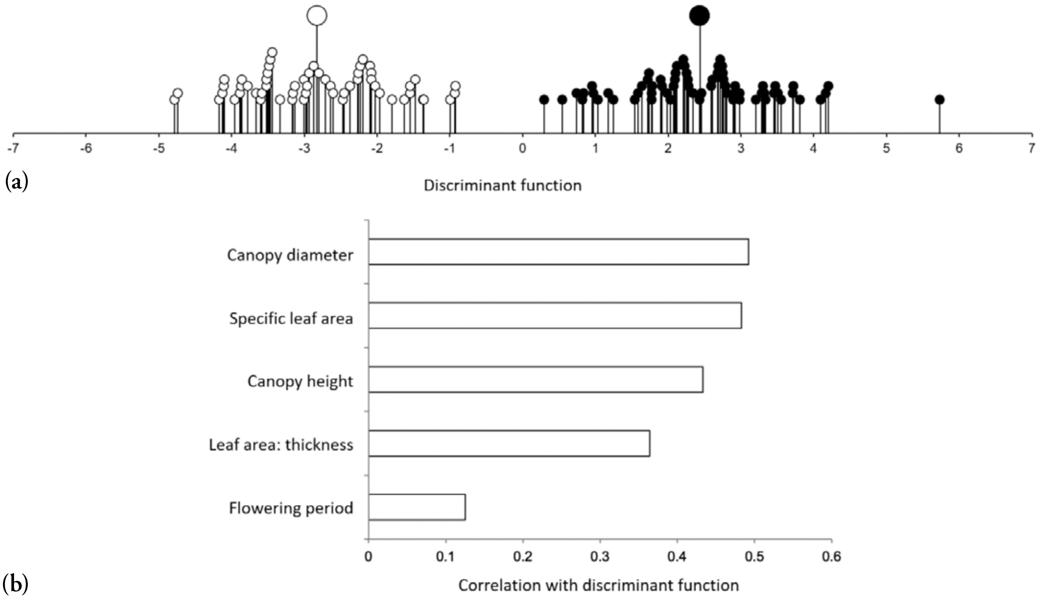
Before applying the Laxton-Highgrove model to archaeobotanical data, we take the additional step of introducing a comparison with a unique weed dataset from experimental mouldboard ploughing at the Lauresham Open-Air Laboratory for Experimental Archaeology




**10** Map showing the locations of the two present-day English cereal production systems considered here (italics), and the two archaeological case studies. Regional divisions by Rippon et al. (2015). Map created with QGIS (http://www.qgis.org; accessed 08/03/2022).

in Lorsch (Kropp, this volume). In recent years, the Lauresham team has established a three-field rotation system (an autumn cereal followed by a spring cereal and then a fallow year) using (re) constructed early medieval mouldboard tillage powered by oxen. Surveys of the weed floras growing on three main experimental ridge-and-furrow fields (north-east, south and north-west) at Lorsch in 2019 and 2020 (Sonnberger, 2020; see also Kropp, this volume) provide a key opportunity to assess disturbance levels achieved with the mouldboard plough.

Finally, using the archaeobotanical examples of Stafford and Lyminge, we assess arable disturbance levels and consider to what extent use of the mouldboard plough successfully maintained – or even enhanced – disturbance levels as part of early medieval 'cerealization'.



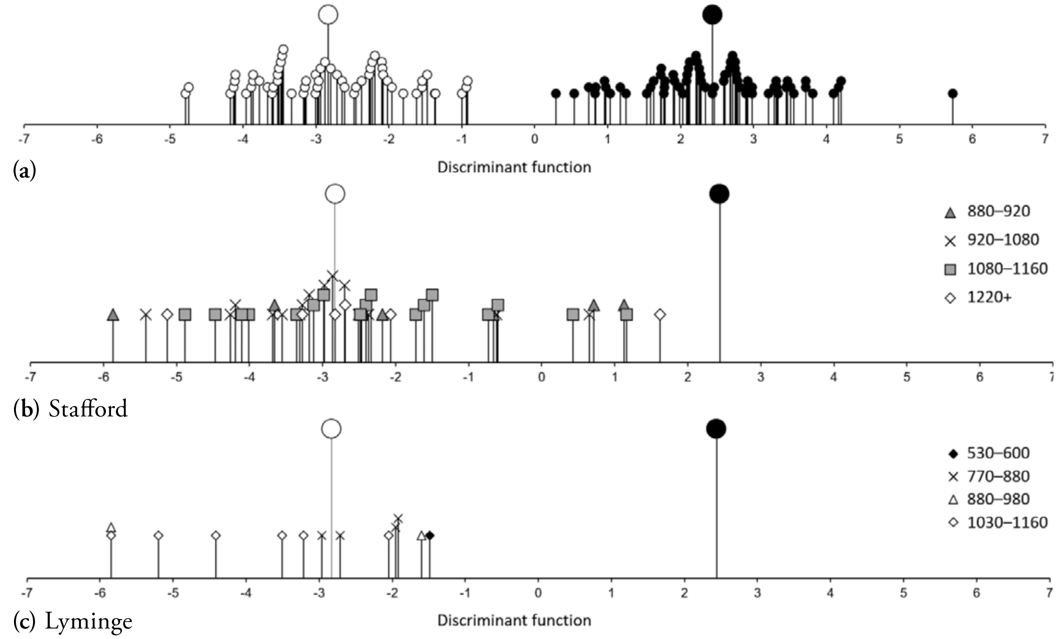

**11a–b** (a) The relationship of Haute Provence fields (open circles) and Asturias fields (filled circles) to the discriminant function extracted to distinguish these two groups (larger symbols indicate group centroids); (b) correlations between the functional attribute scores used as discriminating variables and the discriminant function.

## A model for assessing the labour-intensity of cultivation: Haute Provence and Asturias

A functional ecological study of weed floras developed under traditional agricultural regimes in Asturias and Haute Provence successfully discriminated between high- and low-input farming methods, respectively (Bogaard et al., 2016). This separation was achieved using discriminant analysis on the basis of five functional traits of weed species that predict their response to soil fertility (e.g., manuring) or disturbance (tillage and weeding): specific leaf area (leaf area/leaf dry weight), canopy height and diameter, the ratio of leaf area per node to fresh leaf thickness, and flowering duration. Figure 11 shows the separation of surveyed fields in Asturias and Provence along the discriminant function, and the functional traits of weed species used as discriminating variables. This analysis was conducted on the basis of species' presence/absence per field (rather than frequency in quadrats), making the model applicable to archaeobotanical weed data (Bogaard et al., 2016).

## Application of the intensity model: Stafford and Lyminge

In order to assess similarity to the modern high- versus low-input regimes, the 'intensity model' was applied to archaeobotanical weed data from Stafford, as set out by Hamerow et al. (2020). Stafford, in




**12a–c** (a) The relationship of the modern fields in Haute Provence and Asturias to the discriminant function; the relationship of archaeobotanical samples from (b) Stafford and (c) Lyminge to the discriminant function (larger symbols indicate centroids for the modern groups).

the West Midlands of England, was established as a *burh* (fortified settlement) in 913, and later developed as a town at the intersection of land- and river-based transport routes; its hinterland, at the interface of lighter river terrace soils and heavier clays, provided a setting well suited to crop production (Figure 10; Carver, 2010; Hamerow et al., 2020, 587).

Archaeobotanical samples from Stafford containing at least ten seeds of weed taxa identified to species level were entered into the classification phase of the discriminant analysis, as unknown cases. The results (Figure 12b) show that late ninth- to early tenth-century samples have variable scores on the discriminant function, but from the early tenth century onwards, the Stafford samples increasingly conform to 'low-input' growing conditions. Thus, the great majority of cereals benefited from little to no manuring or hand-weeding from the early tenth century. These results, combined with palynological evidence for largely open, arable landscapes around Stafford through this period (Hamerow et al., 2020), suggest that cereal cultivation featured low-input management within an extensive, large-scale system.

A second case study, that of Lyminge, opens another 'window' onto the extensification process, in a very different setting. Lyminge lies in south-east Kent (Figure 10), on chalk bedrock overlain in places by silts, clays, sands and gravels (McKerracher, 2017, 130). The archaeobotanical assemblage from Lyminge dates from the sixth through to the twelfth century, offering a sequence that begins much earlier than that at Stafford (McKerracher, 2017). Following the establishment of a royal centre/hall complex at Lyminge in the sixth to early seventh century, a royal monastery existed from the mid-seventh to late ninth century (Thomas, 2013). Lyminge was subsequently an archepiscopal possession of Canterbury through the tenth to twelfth centuries (Thomas and Knox, 2013). A seventh-century plough coulter excavated at Lyminge – the earliest known example from Anglo-Saxon England – raises the possibility of precocious adoption of mouldboard plough technology in a high-status context under Frankish influence (Thomas et al., 2016). The actual implication of this find for agricultural practice, however, has as yet remained unclear.

The assemblage of 'weed-rich' archaeobotanical samples at Lyminge (containing at least ten weed seeds identified to species level) is smaller than that at Stafford, but their distribution along the discriminant function (Figure 12c) has interesting implications. First, *all* of the Lyminge samples fall at the low-input end of the spectrum, from the sixth century onwards, in contrast to Stafford, where a 'tail' of high-input samples persists throughout the sequence. Second, the chronological distribution of Lyminge samples on the discriminant function suggests progressively lower input conditions through time: the single sixth-century sample has the highest score, while the later eighth- to ninth-century samples mostly have higher scores than those of eleventh- to twelfth-century date. In sum, the results from Lyminge suggest that its farming system already 'began' as a low-input regime, but underwent further extensification through time, paralleling developments at Stafford.

### A model for assessing soil disturbance levels: Laxton and Highgrove

A second weed-based model, focused on contrasting mechanical soil disturbance levels, enables us to factor out the influence of soil fertility and to build a complementary perspective on tillage regimes, especially the use of the mouldboard plough. This model is based on a combination of two modern botanical survey datasets: from Laxton and Highgrove's Duchy Home Farm (Figure 10; Plate I).

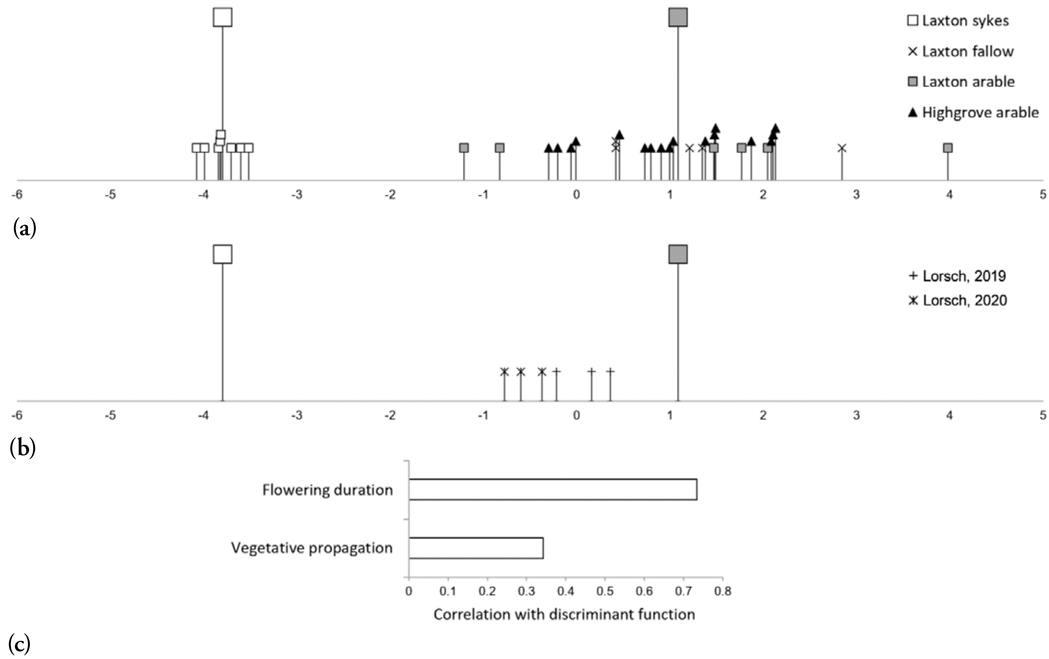
Botanical survey at Laxton in June 2018 encompassed three types of site/habitat: (a) eight unploughed but periodically grazed and annually cut 'sykes' (hay meadow areas, unsprayed by herbicides, between or on the edges of the open fields); (b) unsprayed six-metre edge strips of six cereal fields; and (c) five fallow fields – i.e., in the third, fallow year of the rotation scheme – that had not recently been sprayed.

At Highgrove in June 2019 we surveyed 17 organic cereal fields managed as part of a rotation system: typically two to three years of ley (grass/clover) followed by one year each of bread wheat, oats, barley and rye. The cereals notably included tall, locally adapted populations of 'heritage' rye and wheat developed by John Letts that have been grown at Highgrove for over ten years; and a similarly unimproved, 'traditional' landrace of barley.[1]

In each field, the weed species present were recorded in each of five one-metre-square quadrats distributed along a transect from one end of the field to the other, as in other recent studies (Bogaard et al., 2018). For the purposes of archaeobotanical application, the data were converted to a semi-quantitative form of weed species' presence/absence per field. The average score of each functional trait per field was calculated as the sum of attribute values for the species in the cultivated field divided by the number of species in each field. IBM® SPSS® (Statistical Package for the Social Sciences) version 27 was used to perform discriminant analysis, using the 'leave one out' option. The success of the discriminant analysis was measured in terms of the percentage of fields correctly reclassified as 'low-disturbance' or 'high-disturbance', using the discriminant function extracted in the analysis.

Discriminant analysis was used to separate the Laxton 'sykes', on the one hand, from the Laxton and Highgrove arable fields (including those under fallow at Laxton), on the other (Figure 13a). This successful discrimination (94 per cent correctly reclassified) was achieved on the basis of two functional attributes relating to species' tolerance of mechanical disturbance: flowering duration (which patterns with germination time, and hence the ability of seeds to germinate following a disturbance event) and (for perennials only) vegetative propagation, i.e., the ability to regenerate from fragments of root/stolon/rhizome following disturbance (Figure 13a, c). This model is similar to that described by Hamerow et al. (2020) but is more robust in that it incorporates a larger set of fields, including those at Highgrove.

1 A landrace is a crop population adapted to a specific local environment. The terms 'heritage', 'traditional' and 'unimproved' highlight the contrast between these crops and modern commercial monocultures which do not adapt to local environmental conditions.



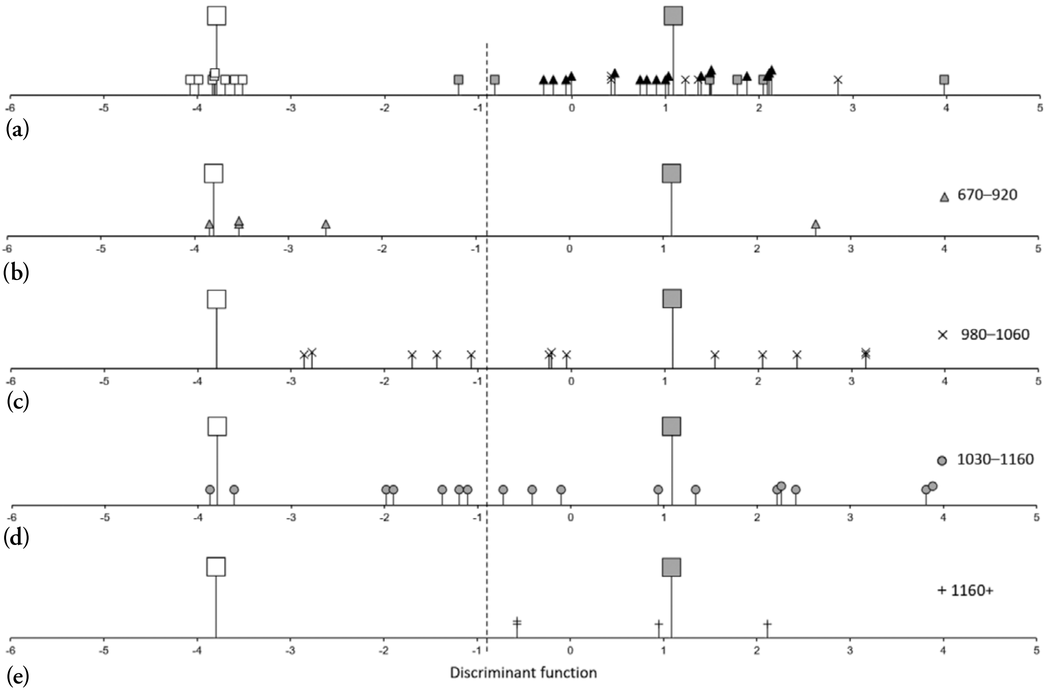

**13a–c** (a) The relationship of the Laxton sykes (open squares) and arable fields at Laxton and Highgrove (other symbols) to the discriminant function extracted to distinguish these two groups (larger symbols indicate group centroids); (b) the relationship of the Lorsch mouldboard-ploughed fields to the discriminant function; (c) correlations between the functional traits used as discriminating variables and the discriminant function.

## Application of the disturbance model: experimental mouldboard ploughing at Lorsch

Botanical survey of three experimental ridge-and-furrow fields was conducted at Lorsch in June 2019 and June 2020 (Sonnberger, 2020; see also Kropp, in this volume). The lists of weed species present in each field at survey time were entered into the classification phase of the discriminant analysis, as unknown cases. The discriminant scores of the Lorsch plots (Figure 13b) place them within the arable field range. Relative to the tractor-ploughed fields at Laxton and Highgrove, the Lorsch fields fall at the lower end of the arable group. Lorsch therefore offers a plausible baseline of disturbance levels to be expected under effective mouldboard ploughing.

## Application of the disturbance model: Stafford and Lyminge

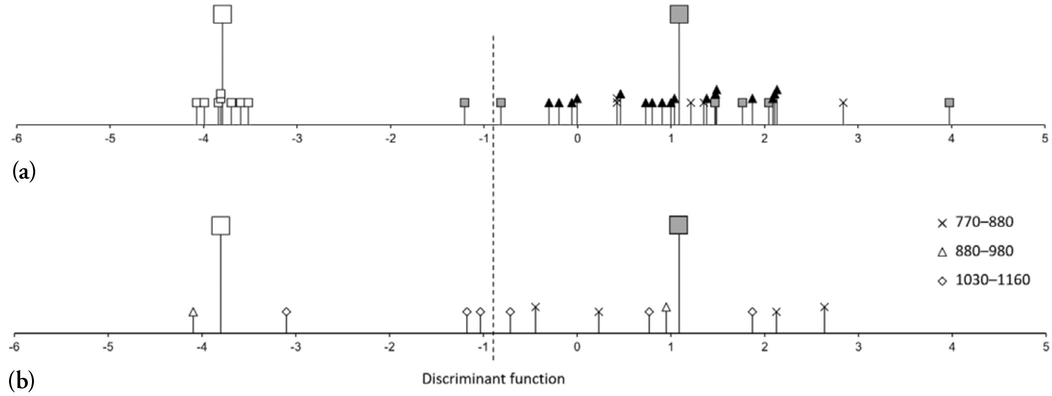
Archaeobotanical samples from Stafford containing at least ten seeds of weed taxa identified to species level were entered into the classification phase of the discriminant analysis, as unknown cases. As observed in a previous application of the Laxton-only disturbance model to the Stafford data (Hamerow et al., 2020), the discriminant scores of the Stafford samples, organized by phase (Figure 14a–e), show an increasing tendency through time towards more disturbed




**14a–e** (a) The relationship of Laxton sykes versus Laxton and Highgrove arable fields to the discriminant function; (b–e) the relationship of archaeobotanical samples from Stafford to the discriminant function (larger symbols indicate centroids for the modern groups). The dotted line represents the 'Lorsch baseline', the minimum discriminant score to be expected under effective mouldboard ploughing.

conditions resembling the modern arable fields. None of the samples dating to the twelfth century or later resembles the undisturbed grassland of the 'sykes', whereas in earlier phases some samples were more similar to the sykes, perhaps because they represent the intermittent cultivation of land normally used for pasture (see Hooke, 1981, 207) or the interface of arable and grassland. The implication is that, *within* the extensification process, arable fields at Stafford were more consistently and comprehensively disturbed from the twelfth century onwards than in earlier periods. This observation is consistent with a more systematic use of the mouldboard plough in this final phase, when all cereal farming apparently took place in heavily disturbed conditions. The plausibility of this interpretation is supported by the 'Lorsch baseline' (the dotted line in Figure 14), which suggests the minimal discriminant scores and disturbance levels to be expected under effective mouldboard ploughing.

Archaeobotanical samples from Lyminge containing at least ten seeds of weed taxa identified to species level were similarly entered into the classification phase of the discriminant analysis, as unknown cases. In addition, samples lacking seeds of perennial weeds were excluded, since one of the functional traits used as a discriminating variable – vegetative propagation – only applies to




**15a–b** (a) The relationship of Laxton sykes versus Laxton and Highgrove arable fields to the discriminant function; (b) the relationship of archaeobotanical samples from Lyminge to the discriminant function (larger symbols indicate centroids for the modern groups). The dotted line represents the 'Lorsch baseline', the minimum discriminant score to be expected under effective mouldboard ploughing.

perennials.[2] The results (Figure 15) show that the earliest eligible samples (of late eighth- to late ninth-century date) all fall at the arable/high-disturbance end of the spectrum, and above the 'Lorsch baseline'. In disturbance terms, this phase at Lyminge, contemporary with the royal monastery, resembles the samples of twelfth-century and later date at Stafford, and is consistent with mouldboard ploughing. Later phases at Lyminge, when it was an archepiscopal possession of Canterbury, are more variable in terms of disturbance, though most are more or less comparable with disturbance levels under mouldboard ploughing. We consider the implications of these findings further below.

## Discussion: interpreting the results from Stafford and Lyminge

The application of weed-based models, one focused on intensity (high versus low inputs, combining fertility and disturbance) and one on disturbance levels only (contrasting unploughed meadow with annually tilled arable), to medieval archaeobotanical assemblages from Stafford and Lyminge has revealed similarities as well as differences between the two archaeological case studies. Taking the similarities first, application of the intensity model suggests that cereal production at both Stafford and Lyminge reflects a general process of 'cerealization' through increasingly extensive farming, with low inputs per unit area. Within this trend, there is subtle differentiation between the two sites: whereas the Stafford results include a minor proportion of relatively high-input (presumably infield) cereal production throughout the late ninth- to twelfth-century and later

2 At Stafford, this step did not exclude any samples since all contained some perennials.

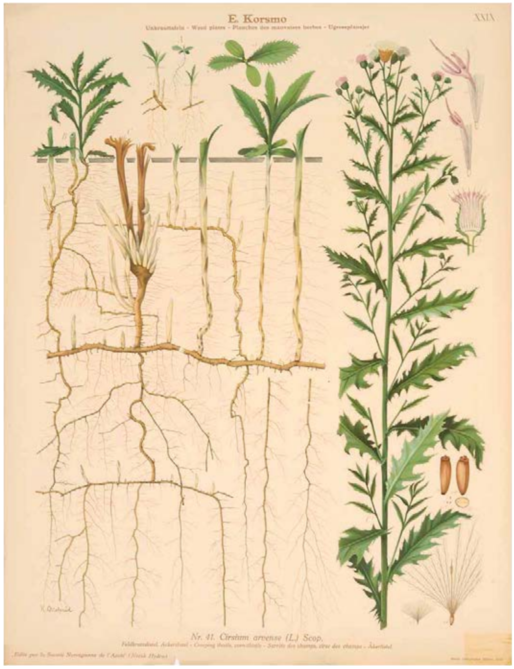
sequence, at Lyminge the weed signal is distinctively 'low-input' from the sixth century onwards, without a 'tail' of higher-input samples.

Application of the disturbance model also reveals some divergence between the two sites. The heavier clay soils at Stafford were effectively disturbed to levels comparable with modern arable fields from the twelfth century onwards, probably reflecting pervasive use of the mouldboard plough at this time. At Lyminge, by contrast, high disturbance comparable with modern annually cultivated arable and mouldboard ploughing is apparent much earlier, from the late eighth century.

The seventh-century coulter discovered at Lyminge (Thomas et al., 2016) indicates that the mouldboard plough could have been in use here from the beginning of the sequence reflected in the archaeobotanical samples classified by the disturbance model. The results of the application of the disturbance model to experimental mouldboard-ploughed fields at Lorsch, on the one hand, and to the Lyminge archaeobotanical samples, on the other, support the inference that the coulter was a powerfully symbolic object in part because it reflected actual agricultural practice (Holmes, this volume).

It appears that early medieval farmers achieved levels of mechanical soil disturbance comparable to the modern tractor-ploughed arable fields at Laxton and Highgrove, and above the 'mouldboard baseline' provided by Lorsch. This similarity, however, may obscure differences in soil conditions and agricultural practice. Laxton is surrounded by heavy clay soils, while those at Highgrove are more variable but include very heavy clays; the soils around Lyminge were chalk-based and hence lighter to work. Another difference between modern and ancient practice may be how many times fallow fields in the rotation were ploughed. Nowadays the fallow in Laxton is ploughed only once, in March, for ground-nesting birds, in accordance with Natural England's Higher Level Stewardship scheme. In the early twentieth century, in the absence of herbicides, the fallow was ploughed up to six times in summer to control weeds (Haigh, 2016, 16). Repeated ploughing discouraged some weeds but not others; one Laxton farmer recalled that the roots (rhizomes) of twitch or couch grass (*Elymus repens* (L.) Gould; Figure 16a) were particularly troublesome, being 'propagated rather than killed by ploughing' (Allison et al., 2017, 109). This capability of certain perennial weeds to regenerate from fragments of root/rhizome/stolon is exactly what we seek to capture by including that functional trait in the disturbance model (Figure 13).

It is possible that early medieval farmers at Stafford and Lyminge ploughed multiple times in the fallow year to control weeds, maintaining high levels of disturbance. Experimental farming at


**16a–b** (a) Couch grass (*Elymus repens* (L.) Gould) and (b) creeping thistle (*Cirsium arvense* (L.) Scop.), showing in each case rhizomes that readily regenerate when fragmented by ploughing. Illustrations from Korsmo, 1934, obtained from www.plantillustrations.org (accessed 26/07/21). Images are in public domain, reproduced under Creative Commons Licence. https://creativecommons.org (accessed 26/07/2021).

Lorsch includes mouldboard ploughing a minimum of two times in the fallow year, using a reduced furrow depth. That medieval farmers did seek to plough fallow multiple times to control weed levels is suggested by Walter of Henley's 'Husbandry', written 1276–90. In a section headed, 'To free lands from too much water', he recommended that the fallow field be ploughed twice, in April and again after midsummer (St John's Day) and justified the timing of the second ploughing as follows: 'Let your land be cleaned and weeded after St John's Day; before that is not a good time. If you cut thistles fifteen days or eight before St John's Day, for each one will come up two or three' (Cunningham and Lamond, 1890).

The timing of ploughing after midsummer echoes early twentieth-century practice in Laxton of ploughing multiple times through July (Haigh, 2016, 14), as does a particular concern with thistles (Allison et al., 2017, 106). Like twitch or couch grass mentioned above, creeping thistle (*Cirsium arvense* (L.) Scop.) has rhizomes that readily regenerate when fragmented by ploughing (Figure 16b). The instruction to plough after St John's Day, the driest part of the summer, suggests an attempt to minimize the probability of any rhizome fragment detached by the plough producing roots and subsequently establishing into a new plant.

A further possible contrast between ancient and modern practice is two- versus three-course rotation. Evaluation of these two rotation scenarios is beyond the scope of this paper (Schroeder, this volume; Hamerow et al., in prep.), but it stands to reason that a two-course rotation, with repeatedly ploughed fallow every *second* year (rather than every third), would result in more frequent ploughing events (cf. Campbell and Robinson, 2010). Two-course rotation may help to explain how early medieval farmers achieved high levels of disturbance comparable to annual cultivation with modern tractor ploughing and exceeding the Lorsch baseline.

A more general inference, stemming from application of both intensity and disturbance models to Stafford and Lyminge is that, within the process of 'cerealization through extensification', high disturbance levels were frequently maintained. This finding underlines the distinctiveness of early medieval farming, which, on the one hand, suffered from diminishing inputs in terms of fertility while, on the other, achieving remarkable levels of weed control through mouldboard tillage. This 'decoupling' of trends in inputs (predominantly fertility) and disturbance in some sense paved the way for later developments in cereal farming in England – and more widely across western Europe – which variously promoted intensive approaches to restoring fertility *despite* expanding scales of cultivation (Bloch, 1931; Bayliss-Smith, 1982; Williamson, 1998 and this volume). This stands in contrast to the kind of extensification apparent in Romano-British farming. As shown by Lodwick (this volume), there are signs of low-input crop husbandry in Roman Britain, but no definitive evidence for a mouldboard plough: extensive farming in the Roman period may therefore have entailed both low fertility *and* low disturbance, with their decoupling coming only when the mouldboard plough came into more widespread use in the early medieval period. Hence, while there may be a consistent trend towards extensification through the Roman and medieval periods – as also seen in the Rhineland (Hamerow et al., forthcoming) – the particular means and mechanisms of extensive farming may have been different in each era.

## Conclusions

The arable weed-based models considered here provide complementary means of assessing the overall intensity of arable land management and growing conditions, and the specific role of mechanical soil disturbance. Application of these models to two contrasting case studies – Stafford in the lowlands of the West Midlands, and Lyminge among the chalk downs of Kent – illustrates some of the variety we might expect across England (see McKerracher, this volume, for another archaeobotanical application of the disturbance model). On the one hand, the ecological setting, chronology and social geography of each site clearly shape its uptake and deployment of innovations such as the mouldboard plough. On the other hand, even in two such distinct cases it is possible to discern variations on similar agroecological themes: the cerealization of local landscapes through extensive management, and effective tillage through the mouldboard plough and bare fallow. The wider emerging picture suggests that these processes played out through the early medieval period, resulting in a tendency towards diminishing fertility alongside consistent levels of disturbance comparable to mouldboard ploughing, at least in the Central Zone where most available archaeobotanical data are concentrated (Hamerow, this volume; Hamerow et al., in prep.). Given this bias, the western and south-eastern case studies considered here are instructive in suggesting the wider relevance of these trends.

# 3 Understanding Early Medieval Crop and Animal Husbandry through Isotopic Analysis

*Elizabeth Stroud*

## Introduction

The early medieval period saw changes in both animal and crop husbandry methods in some regions, from the introduction of crop rotation and the mouldboard plough to the possible reduction in animal pasture (Hamerow, this volume). This paper explores the nature of animal and crop husbandry during this period using stable carbon and nitrogen isotope analysis. The stable isotopes of carbon and nitrogen provide direct information relating to the diet of animals and the soil conditions in which crops were cultivated. For the first time, the isotopic values of early medieval English crop remains are used to investigate whether cereals could have been regularly consumed by domestic animals: for example, through grazing on stubble or fallow fields. Two case study sites – Lyminge in Kent and Stratton in Bedfordshire (Figure 4) – had both plant and animal remains available for isotopic sampling, providing the unique opportunity to explore changes in crop and animal husbandry over time and between different species.

As crop and animal husbandry are interlinked, understanding one can provide information regarding the other. Arable expansion could have reduced the availability of pasture, thus restricting the grazing locations of animals. Conversely, grazing on stubble or fallow fields may have increased as arable cultivation expanded. Grazing of the fallow by livestock is thought to be a method of increasing the fertility of the soil, with sheep manure and urine providing nitrogen and phosphate (O'Connor, 2011, 372). It has been suggested that the expansion of arable farming in the early medieval period is linked to a widespread increase in sheep rearing (Holmes et al., forthcoming), potentially associated with the use of sheep to manure stubble and fallow fields (Campbell, 2000, 154).

Historical documents pertaining to fully developed open-field systems indicate that sheep spent significant amounts of time on fallow fields. In fourteenth-century France, for example, textual evidence indicates that sheep grazed on fallow fields for four months of the year (Carroll and Wilson, 2012). In seventeenth-century Laxton in Nottinghamshire, sheep could spend most of their lives grazing on stubble and fallow: grazing the autumn field after the harvest until October, when that field was ploughed in preparation for the sowing of the spring crop (Haigh, 2016, 80). The sheep would then be moved to the newly harvested spring field and could graze there until the following October (Haigh, 2016, 81). Other livestock, such as cattle and horses, would be removed from the fields by 23 November and kept inside for winter (Haigh, 2016, 81). The reliance on fallow grazing is thought to have increased over time – with the Laxton example probably a consequence of rigid regulations and the lack of alternative grazing locations – but exactly what occurred during the early medieval period is unclear. Isotopic analysis of animal and plant remains offers one way of understanding developments in the consumption patterns of livestock during this poorly documented period.

While zooarchaeological studies have provided crucial information regarding the relative proportions and regional variations of domestic animals (e.g., Holmes, 2014; 2016; Sykes, 2007), understanding the animals' diet is more difficult and requires the use of other methods. Some studies have used tooth wear and related pathologies to investigate dietary inputs (Wilkie et al., 2007; Holmes et al., 2021b), but stable isotope analysis offers a more direct method of investigating diet: as demonstrated, for example, by isotopic research on medieval pigs (Hamilton and Thomas, 2012; Hammond and O'Connor, 2013) and herbivores (Evans et al., 2007; Müldner et al., 2014).

## Background to the sites

### *Lyminge*

Lyminge is located on chalk bedrock at the head of the Nailbourne river valley, eight kilometres from the Kent coast (Figure 4). The site has access to different soils: while it is surrounded by silty soils, areas of deep loam and clay, as well as seasonally wet deep clay, are accessible to the south and east of the site. Palaeoenvironmental reconstruction as well as historical records indicate wooded areas in the vicinity during the early medieval period (Maslin, 2017).

Excavations by the University of Reading (2007–14) have revealed a long occupation sequence including a seventh-century hall complex, a mid-seventh- to late ninth-century monastic centre, and a tenth- to twelfth-century archepiscopal estate (Thomas and Knox, 2012; Thomas, 2013). A seventh-century plough coulter excavated here represents the earliest archaeological evidence for the mouldboard plough in early medieval England, making this a key site in the history of early medieval farming (Thomas et al., 2016; Bogaard et al. and Hamerow, this volume).

Bioarchaeological research into early medieval agriculture at Lyminge has been extensive. Archaeobotanical research indicates that a range of crops was cultivated throughout the occupation sequence, with a particularly diverse range of crops and weeds represented in the eighth- to ninth-century phase (McKerracher, 2017; Bogaard et al., this volume). Zooarchaeological and isotopic research has also been conducted at the site (Knapp, 2018). Zooarchaeological analysis reveals that cattle, the dominant animal between the fifth and seventh centuries, was superseded by sheep in the eighth- to ninth-century phase. This shift could indicate a change in the provisioning of the site or in the wider animal economy, or perhaps an increase in the importance of arable agriculture, given the mobility of sheep and their potential use in grazing and manuring the fallow (Knapp, 2018).

***Stratton***

Stratton lies in the Ivel valley in east Bedfordshire (Figure 4). The soils surrounding the site comprise easily worked, free-draining loams; deep clays which are prone to waterlogging; and seasonally wet alluvium. Local pollen evidence indicates that the area was a relatively cleared landscape throughout the early to late medieval periods, with some wooded areas available for use by the inhabitants (Shotliff and Ingham, 2022).

Large-scale excavations by Albion Archaeology (1990–2003) revealed an occupation sequence spanning the fifth to seventeenth centuries, with extensive, formal settlement planning evident from the seventh to ninth centuries onwards – perhaps indicating some ecclesiastical oversight (Blair, 2013, 33). Research into the agricultural activities at the site has indicated that a wide range of crops were consumed throughout its occupation history, including both bread and rivet wheat, barley, oat and rye (Moffett and Smith in Shotliff and Ingham, 2022). Documentary evidence suggests that Stratton may not have produced its own barley, but rather received it from Biggleswade, the manorial centre of the parish, at least by the thirteenth century: the local rolls of assess from 1297 indicate that barley was cultivated at Biggleswade but not at Stratton (Shotliff and Ingham, 2022). Zooarchaeological research highlights a heavy reliance on cattle, supplemented by sheep and pigs, to provide meat for consumption. Cattle appear to have been slaughtered at an older age over time, and a rise in the proportion of female cattle indicates a possible increase in the importance of secondary products such as milk (Maltby in Shotliff and Ingham, 2022; Holmes in McKerracher et al., forthcoming).

**Stable carbon and nitrogen isotopes**

The analysis of cereal grains' stable carbon isotopic ratio ($\delta^{13}C$) allows information about the growing conditions of the plant to be gained, particularly how wet or dry the environment was during cultivation. This is due to the fact that wheat, barley, oat and rye use the $C_3$ photosynthetic pathway which preferentially selects the lighter isotope of carbon over the heavier one. The plant, when absorbing the $CO_2$ required for photosynthesis, can also lose water via its stomata. Thus, there is a trade-off between the absorbance of $CO_2$ and the conservation of water. In times of water limitation, that plant will close its pores to reduce water loss; the plant has to use any of the intercellular $CO_2$ present, including the heavier isotope of carbon, and therefore the ratio changes in a more positive direction.

The isotopic ratio of the absorbed $CO_2$ also has an impact on the $\delta^{13}C$ value of the plant. In locations where the $CO_2$ stable carbon isotopic ratio has been depleted – i.e., closed canopy forest and woodlands – the plant's isotopic value will also be depleted. Consequently, plants within closed environments will have a more negative $\delta^{13}C$ value compared with those in open environments (Bonafini et al., 2013). The consumption of plants from such environments by animals will be reflected in their isotopic values which will be more depleted in $^{13}C$.

There is, however, a fractionation which occurs between diet and consumer. A 4.8‰ difference between the consumed plant matter and the animal's collagen carbon isotopic value has been found (Fernandes et al., 2012). There are also differences in isotopic values between stems, seeds and leaves in both carbon and nitrogen. Experiments indicate that there is a difference between cereal grains and chaff (rachis): –2.4‰ for $\delta^{15}N$ (Fraser et al., 2011) and –2‰ for $\delta^{13}C$ (Wallace et al., 2013).

The ratio of the stable isotopes of nitrogen ($\delta^{15}N$) provides information regarding the soil $^{15}N$ enrichment. The proportion of the heavier isotope ($^{15}N$) within the soil, compared to the lighter isotope ($^{14}N$), provides information about the modes by which nitrogen found its way into the soil, and the processes which may have changed the nitrogen into different compounds in the soil. Different environmental processes affect soil $^{15}$N enrichment. Factors such as seasonal wetting and drying, salinity, waterlogging and aridity can all change the ratio of $^{14}$N to $^{15}$N in the soil (Handley et al., 1999; Hartman and Danin, 2010; Heaton, 1986; Yousfi et al., 2010). The addition of manure to the soil also changes its isotopic ratio (Senbayram et al., 2008; Fraser et al., 2011). Manuring in agriculture to increase the fertility of the soil enriches the soil in $^{15}$N as a large proportion of the lighter isotope ($^{14}$N) is released as ammonia gas. The remaining nitrogen in the soil (in the form of ammonium) is therefore enriched in $^{15}$N.

Stable nitrogen isotopes can also provide information regarding the trophic position of a species. As plants absorb their nitrogen from the soil, their $^{15}$N values are some of the lowest in the food web. Herbivores consume, and thus take their nitrogen from, the plants. It is believed that the fractionation of that nitrogen occurs during amino acid synthesis, with the heavier $^{15}$N retained and the light $^{14}$N excreted (DeNiro and Epstein, 1981). There is about a 3–5‰ increase between each trophic level, with researchers commonly using an average as an estimate of the diet-to-tissue discrimination factor (Minawaga and Wada, 1984; Steele and Daniel, 1978). Thus, it is possible to infer the relative position of different animals within a food web, understanding the different dietary positions of herbivores, omnivores and carnivores. The $\delta^{13}$C values of consumed plants vary, according to different ecosystems and photosynthetic pathways (Chisholm et al., 1982; Schoeninger et al., 1983; van der Merwe and Vogel, 1978). Due to dietary routing, there is about a 4.8‰ difference between the $\delta^{13}$C value of the consumed food compared to the consumer (Fernandes et al., 2012).

### *Methods*

The plant material from Lyminge and Stratton derived predominantly from mixed archaeological deposits where it is possible that the grains originated from multiple depositional events; grains were therefore analysed individually, rather than as bulk samples. Grains from mixed deposits are more likely to be from different years/harvests, so bulk samples, which average those grain together, would have been providing an average of multiple years' harvests and thus obscuring any variations between harvests. In total, 50 charred grains from Lyminge were analysed, representing four species – free-threshing wheat (*Triticum* L. free-threshing type), rye (*Secale cereale* L.), oat (*Avena* L.) and hulled barley (*Hordeum vulgare* L.). The grains came from four different periods (sixth-century, eighth- to ninth-century, ninth- to tenth-century, and eleventh- to twelfth-century), with the majority coming from the well-preserved eighth- to ninth-century phase. For Stratton, the plant material suitable for isotopic analysis was limited because of the high temperatures at which most of the grains had been charred. In total, thirteen grains of rye and barley were analysed from two phases: the eighth to ninth centuries, and the fifteenth to sixteenth centuries.

The selected grains were those whose internal and external morphology indicated a charring temperature in the range of 230–300°C. This was necessary because an understanding of the offset between charred and uncharred material would be required to reconstruct diet, with current research only conducted up to 300°C (Nitsch et al., 2015; Stroud et al., in prep.). Three grains per site were analysed using FTIR (Fourier-transform infrared spectroscopy) to determine the presence of contaminants (as per Vaiglova et al., 2014). No peaks associated with carbonate, humics or nitrates were detected in the Stratton material and so no pre-treatment was conducted. However, the Lyminge FTIR analysis detected a large peak at 870 $cm^{-1}$, with a second smaller peak at 720 $cm^{-1}$. These peaks correlate with carbonate contamination and so the samples were pre-treated. The grains were placed in 0.5M HCL, which was heated at 70°C for 40 minutes or until any effervescence stopped. The acid was decanted and the samples washed in water until they reached a neutral pH. The samples were then frozen, then freeze-dried.

The collagen samples from animal bones were selected so as to prevent multiple measurements of the same individual: elements determined to be from only one specific side of the body were used. Forty-three bone samples from sheep, pig and cattle were chosen from Stratton covering four phases: fifth- to sixth-century, seventh- to ninth-century, tenth- to twelfth-century, and thirteenth- to fourteenth-century. Thirteen bone samples from two species (cattle and sheep) were selected from Lyminge, most samples dating to the later phases of the site. The bones were cleaned of adhering soil using a sandblaster and *c.*300 milligrams of bone was removed. The material was crushed and then demineralized in 0.5 M HCL for 24–48 hours, until the mineral phase of the bone had dissolved. The acid was decanted and the samples rinsed three times before being heated in acidic water (pH 3) at around 70°C for 48 hours. The solution was filtered using Ezee Filters, the liquid then frozen, and then freeze-dried for 48 hours.

The samples from Stratton, both plant and collagen, and the collagen samples from Lyminge, were analysed at the Research Laboratory for Archaeology and the History of Art at the University of Oxford on a SerCon EA-GSL mass spectrometer. The plant samples from Lyminge were sent to Iso-Analytical Ltd for simultaneous carbon and nitrogen determination using a Europa Scientific 20-20 IRMS.

The samples analysed at Oxford used a combination of internal standards of Cow ($\delta^{13}C$ −24.28‰, $\delta^{15}N$ 7.76‰), Seal ($\delta^{13}C$ −12.6‰, $\delta^{15}N$ 16.3‰), Alanine ($\delta^{13}C$ −26.91‰, $\delta^{15}N$ −1.57‰) and Leucine ($\delta^{13}C$ −28.23 ± 0.07‰, $\delta^{15}N$ 6.35 ± 0.19‰), in addition to EMA-P2 ($\delta^{13}C$ −28.19 ± 0.14‰, $\delta^{15}N$ −1.57 ± 0.19‰) (see project archive for full details: McKerracher et al., forthcoming). Every tenth sample was duplicated to understand precision. For the plant samples analysed at Iso-Analytical, four IAEA standards (N1, N2, CH6 and CH7) were included, along with EMA-P2. Iso-Analytical also included their in-house standards of IA-R045, IA-R045, IA-R046, IA-R005, and IA-R006. In total, four standards were used for calibration per isotope (CH6, CH7, IA-R005 and IA-R006 for carbon and N1, N2, IA-R045 and IA-R046 for nitrogen), while P2 and IA-R001 were used as check standards.

Precision, accuracy and overall uncertainty were calculated as per Szpak et al. (2017) and are recorded in the project database for the different sites and materials (McKerracher et al., forthcoming). All plant results were adjusted by 0.16‰ for $\delta^{13}C$ values and 0.34‰ for $\delta^{15}N$ values to account for charring and to allow comparison with uncharred materials (as per Stroud et al., in prep.). Reliability of the plant isotope values was assessed on the basis of correlation between %N and $\delta^{15}N$ values or %C and $\delta^{13}C$ values; if any strong correlation was found, the specific samples were removed.[1] The C:N ratio of the collagen samples was used to determine if they fell within the acceptable ranges of 2.9 and 3.6 (DeNiro, 1985; Ambrose, 1990).

In addition to the new isotopic measurements of animal collagen, the isotopic values of 85 previously analysed samples were included from Knapp (2018). The additional 13 samples analysed in the FeedSax project extended the overall temporal range of the samples into the later phases (spanning the tenth to twelfth centuries). All published and new data from Lyminge's sheep, cattle and pig samples were combined for this publication (original data in Knapp, 2018 and McKerracher et al., forthcoming). Sheep and sheep/goat data have been considered together as sheep. Although sheep and goat are seldom zooarchaeologically distinguishable, it is assumed that most of the samples analysed here represent sheep, since previous research has indicated that goats are genuinely rare in medieval bone assemblages in England (Salvagno and Albarella, 2019).

1 One sample from Stratton and two from Lyminge were removed due to a correlation between high $\delta^{15}N$ values and high %N.

Diet reconstruction was modelled on Styring et al. (2017), using ellipses to understand the theoretical isotopic signature of different dietary inputs. The theoretical isotope range of an animal consuming 100 per cent cereal grain was calculated as the mean of the cereal values for the phase in question plus 4‰ for $\delta^{15}N$ trophic offset, and plus 4.8‰ for the $\delta^{13}C$ dietary offset. The theoretical isotope range of an animal consuming 100 per cent cereal rachis was calculated as cereal grain minus the offset between grain and chaff (–2.4‰ for $\delta^{15}N$, as per Fraser et al., 2011; –2‰ for $\delta^{13}C$, as per Wallace et al., 2013), with the result then adjusted to account for the dietary offsets. The isotopic ratio of wild vegetation is difficult to calculate because of the lack of wild herbivores within the early medieval assemblages: wild herbivore collagen values minus the dietary offsets are commonly used as a proxy for wild vegetation (e.g., Styring et al., 2017). Roman deer values from Kent were used as a potential 'natural' vegetation baseline for the site of Lyminge (data from Madgwick et al., 2013) as they will have occupied geologically similar landscapes. The use of deer data from the Roman period assumes that the fallow deer were not consuming agricultural products, an assumption which in other periods would be questionable, given the propensity of fallow deer to graze in agricultural fields. However, research by Madgwick et al. (2013) indicates that, in Roman Britain, the deer were most likely enclosed in an area for display, preventing them from grazing within the agricultural fields. The use of deer isotope values from Kent provides an estimation of the 'natural' vegetation's $\delta^{15}N$ and $\delta^{13}C$ values for the region and can be applied, with some caveats relating to different time periods and differing locations, to the Lyminge data. For Stratton, no isotopic results from wild herbivores in the region (or local geology) exist, making it difficult to estimate the isotopic value of 'natural' vegetation. The use of the deer values from Kent would be highly problematic in this case because of the geological difference between the two regions; consequently, the interpretation of the Stratton dataset has been conducted without an understanding of the 'natural' vegetation's isotopic value.

## *Results*

### *Lyminge: plants*

The results of the isotopic analysis of plant remains from Lyminge show variable ranges in $\delta^{13}C$ and $\delta^{15}N$ values depending on the crop examined. The overall mean $\delta^{13}C$ values of the crops reflect the physiological differences expected if the crops were cultivated in similar soil moisture availability: barley (–23 ± 1‰) and oat (–23.9 ± 1‰) are lower than wheat (–22.2 ± 0.8‰) and rye (–21.5 ±

0.85‰) (Plate IIa). However, when separated into phases (Plate IIb), the physiological separation of the species is not as consistent. The sixth-century samples show no statistical difference between the mean barley and free-threshing wheat values (−23.5 ± 1.3‰ and −23 ± 0.6‰). The eighth- to ninth-century phase has samples of all four crop species, and the means of the samples reflect some of the physiological differences expected if the crops were cultivated in the same soil moisture availability. As expected, oat (−23.9 ± 1‰) is significantly lower than the other crops, though barley and wheat are highly variable, with barley's mean (−22.7 ± 0.8‰) not 1–2‰ lower than wheat's (−22 ± 0.9‰). Rye's mean (−21.5 ± 0.85‰) is higher than the wheat and barley mean. Statistically, oat's mean is different from wheat and rye ($p < 0.001$ Tukey post hoc), while the other three species are not statistically different from each other; such results are expected of oat, wheat and rye when grown in the same soil moisture, but the similarity of barley to wheat and rye is not as expected, with less than a 1‰ difference between them. The high variability seen in wheat and barley is most likely the reason for the lack of statistical difference; the rye and oat values are less variable. The lack of multiple species in the other two phases limits any interspecies comparison.

The $\delta^{15}N$ values, like the $\delta^{13}C$ values, show high variability, especially in the barley and wheat values. Overall, the means of the four species are within 2.5‰ of each other, with oat the lowest (2.3 ± 0.9‰); wheat (3.9 ± 2.1‰), barley (4.2 ± 2.2‰) and rye (4.6 ± 0.3‰) are within 1‰ of each other (Plate IIc). The highly variable ranges of wheat and barley are noticeable, having standard deviations of greater than ± 2‰. Comparison of the samples by phase shows a similarity in means for the sixth-century samples; the difference between means is ~1‰. The eighth- to ninth-century phase has similar values for oat and free-threshing wheat (2.4 ± 0.9‰ and 2.3 ± 2.1‰), and similar means for rye and barley (4.6 ± 0.3‰ and 4.9 ± 2.2‰). Statistically, oat's mean is different from those of barley ($p = 0.01$) and rye ($p = 0.007$), while wheat's mean is different from that of rye ($p = 0.02$)[2] (Plate IId).

*Lyminge: animals*

The $\delta^{13}C$ values of sheep, cattle and pig, regardless of phase, range from −23.1 to −20.4‰ (Plate III). Cattle and sheep means are similar (−21.8 ± 0.4‰, −21.7 ± 0.5‰) while pig is more positive (−21.1 ± 0.4‰) and statistically different from both cattle and sheep ($p < 0.001$)[3].

2 Kruskal Wallis rank sum test with post hoc Dunn test.

3 Anova with a Tukey post hoc test.

Within the fifth- to seventh-century phase, pig (−21.1 ± 0.5‰) has a more positive $\delta^{13}C$ mean value than cattle (−21.8 ± 0.5‰) and sheep (−21.5 ± 0.4‰). Post-hoc testing shows that the pig mean is different from cattle ($p < 0.001$) and to a lesser extent, sheep ($p = 0.055$), while the sheep and cattle means also differ from each other ($p = 0.056$)[4] (Plate IIIa). Similar trends are seen in the eighth- to ninth-century phase, with pig (−21.2 ± 0.3‰) significantly different from both sheep (−21.9 ± 0.5‰) and cattle (−21.7 ± 0.3‰) in terms of $\delta^{13}C$ values, due to a more positive mean $\delta^{13}C$ value (Plate IIIc) ($p < 0.001$ and $p = 0.008$ respectively). In the tenth- to twelfth-century phase, only cattle and sheep were sampled, with no significant difference between their mean $\delta^{13}C$ values (−21.5 ± 0.4‰ and −22.1 ± 0.6‰) (Plate IIIe).

Examining each species through time reveals limited changes in $\delta^{13}C$ values. Cattle show no significant differences between phases, with the means from each phase falling within 0.4‰ of each other (Plate III). Sheep display rather more change over time: there is a slight trend towards more negative $\delta^{13}C$ values, with a decrease from the more positive mean of -21.2 ± 0.5‰ in the fifth to seventh centuries, to a low of −22.1 ± 0.6‰ in the tenth to twelfth centuries (Plate III). However, statistical testing suggests no significant difference between the phase means ($p = 0.07$). Pig samples are only available from the first two phases, and the means for these phases show limited differences.

The $\delta^{15}N$ values of the animals examined range from 1.3 to 11.8‰. The mean values of sheep (5.9 ± 1.3‰), cattle (5.7 ± 1.5‰) and pig (5.9 ± 1.3‰) are very similar. In the fifth- to seventh-century phase, the same trends are seen with sheep (6 ± 1.1‰), cattle (5.8 ± 1.6‰) and pig (6.2 ± 1.6‰) falling within 0.4‰ of each other. The eighth- to ninth-century and tenth- to twelfth-century phases follow very similar patterns, with the species means not significantly different from each other (Plate III).

Comparing the species through time shows limited differences between phases. Pigs are only represented in the first two phases and, while their $\delta^{15}N$ means are lower in the second phase than in the first, the difference is not significant. Cattle means are relatively consistent over time, with a slight enrichment in $^{15}N$ during the tenth- to twelfth-century phase. Sheep $\delta^{15}N$ means are also consistent over time with just a slight depletion in the eighth- to ninth-century phase.

4 Anova with a Tukey post hoc test. Note that sheep vs cattle is just insignificant at the arbitrary 0.05 level with a p-value of 0.056. Sheep compared to pig also has a similar p-value of 0.055.

The potential diet of the animals can be investigated using the plant values from the site. Plotting the animal data against the theoretical isotopic range of an animal consuming 100 per cent cereal rachis or 100 per cent cereal grain indicates that the animals could have been consuming cereal rachis/straw in both the sixth-century and the eighth- to ninth-century phases, and/or stubble and fallow vegetation (there appears to be limited offset between leaf and rachis) (Plate IV). Evidence that the cattle, sheep or pigs were consuming a high proportion of cereal grain is limited. The lack of wild herbivore remains from the site prevents us from using their data as a proxy for natural vegetation, but there are isotopic values for Roman fallow deer from Kent which provide a general impression of the natural vegetation (see Methods section above for justification and caveats). The overlap between the hypothetical range of animals consuming 'natural' vegetation and that of animals grazing on arable fields indicates that the livestock at Lyminge were possibly consuming a combination of the two vegetation types, and that manuring levels were low.

*Stratton: plants*

Barley and rye samples from Stratton have similar overall mean $\delta^{13}C$ values (barley: −24 ± 1.3‰, rye: −23.7 ± 1.7‰); there is no evidence of the species-specific offset expected if they were grown in the same water availability conditions (Plate Va). Comparing samples from the eighth- to ninth-century phase reveals a similar pattern. There is a ~1‰ difference in the expected direction between the means (barley: −24 ± 1.3‰, rye: −23 ± 1.1‰), but the high variability means that there is no statistical difference between the two groups. Looking at rye over time indicates that there is a difference in means, but statistical testing does not indicate a significant difference between the means, most likely because of the wide standard deviation (−23 ± 1.1‰ in the eighth to ninth centuries, and −25 ± 2.2‰ in the fifteenth to sixteenth centuries) (Plate Vb).

A student t-test indicates that there is a difference between the two species' $\delta^{15}N$ means (barley: 8.2 ± 0.7‰, rye: 6.3 ± 1.7‰) ($p = 0.03$) (Plate Vc). The eighth- to ninth-century data also indicate a difference of ~2‰ between the two species' means (t-test $p = 0.04$) (Plate Vd). Statistical comparison of the rye samples by phase shows no significant difference between the means, even though the means differ by over 1‰ (5.8 ± 1.79‰ for the eighth to ninth centuries, 7.1 ± 1.5‰ for the fifteenth to sixteenth centuries).

*Stratton: animals*

The $\delta^{13}C$ values from the Stratton animal collagen, examined without regard to phase, range from −21.2 to −19.7‰. Cattle and sheep have similar $\delta^{13}C$ values (−21.6 ± 0.4‰ and −21.9 ± 0.5‰ respectively), while the pigs' values are more positive (−20.9 ± 0.7‰). Post hoc testing[5] indicates a difference between the pig and sheep means ($p < 0.001$) and pig and cattle means ($p = 0.01$).

Dividing the samples by phase shows that cattle and sheep have similar $\delta^{13}C$ values in the fifth to sixth centuries (Plate VIa–b). By the seventh- to ninth-century phase, the number of pig samples allows comparison between the three species; there is limited difference in $\delta^{13}C$ values but the trend for pig to have more positive $\delta^{13}C$ values is apparent (Plate VIc–d). During the tenth- to twelfth-century phase there is a more species-specific separation in carbon values; the sheep $\delta^{13}C$ mean is more negative (−22.3 ± 0.3‰) than that of pig (−21.2 ± 0.6‰) and cattle (−21.5 ± 0.6‰), with post hoc testing indicating a difference between sheep and pig means ($p = 0.023$) (Plate VIe–f). In the thirteenth- to fourteenth-century phase, due to limited cattle samples, only sheep and pig can be compared; there is limited difference between their means because in this phase the sheep have more positive values than in the other phases (−21.5 ± 0.5‰) (Plate VIg–h).

Comparison of the species' $\delta^{13}C$ values through time is possible, although limited samples in some phases prevent all phases being included for all species. Sheep means stay within 1‰ of each phase, but during the tenth- to twelfth-century phase sheep are at their most negative and further from the means of other phases. Statistically, however, there is limited difference between sheep means over the four phases. Cattle only have enough samples in the first three phases to allow for comparison and have very similar means (within 0.5‰) with no statistical difference between them. Pigs can only be examined for the final three phases and have limited differences between them.

The mean $\delta^{15}N$ values of the three species are similar (sheep 7.1 ± 1.2‰, cattle 6.6 ± 0.8‰ and pig 6.9 ± 0.7‰) and, when phasing is disregarded, statistically there is limited difference between the means of the three species (Plate VI). Examining the data by phase shows a consistency in mean $\delta^{15}N$ values, with all species having similar mean values within each phase. One notable detail is the small range of the pig $\delta^{15}N$ values in the thirteenth- to fourteenth-century phase.

5 Anova with a Tukey post hoc test.

While this is only based on three individuals, the pig $\delta^{15}N$ values are very similar but their $\delta^{13}C$ values are variable, especially compared to the tenth- to twelfth-century data which sees the opposite trend. Consideration of the individual species through time also reveals no difference between the phases in either $\delta^{13}C$ or $\delta^{15}N$ mean values.

The diet of the animals at Stratton was investigated by projecting the theoretical isotopic values of animals consuming 100 per cent cereal grain and 100 per cent cereal rachis (Plate VII). The limited number of plant samples suitable for isotopic analysis from multiple phases of the site restricts our ability to trace change over time. However, the high variability in the cereal grain isotopic values is consistent with the animals consuming cereal chaff in the seventh- to ninth-century phase, and this trend is also seen when all data are combined irrespective of phase. Interpreting the diet of the animals further via the plant isotope data is difficult because we have limited understanding of the isotopic value of the natural vegetation at Stratton: it is possible that the natural vegetation and arable fields had indistinguishable isotopic signatures.

## Discussion

### *Crop husbandry: rotation and fertility*

The crop isotope results from Lyminge and Stratton provide an indication of cultivation conditions and support an assessment of the likelihood that crops were cultivated in rotation. At Stratton, the nitrogen isotope results indicate that some crops were cultivated in slightly different soil conditions, with a statistical difference between rye and barley. The lack of difference between the rye and barley $\delta^{13}C$ values also suggests that the two crops were cultivated in slightly different conditions: either a difference in annual precipitation or cultivation on different soils resulted in different water availability. Such evidence correlates with historical documents which record, by the thirteenth century, the cultivation of barley at Biggleswade – the centre of the parish – and the cultivation of rye at Stratton (Shotliff and Ingham, 2022). This in turn suggests that Biggleswade provided barley for the smaller settlement of Stratton, and the isotopic evidence now indicates that this may already have been the case prior to the thirteenth century. Whether the difference between the $\delta^{15}N$ values is due to different crop husbandry methods, such as the addition of manure to the soil, is difficult to ascertain because of our lack of information about the natural soil $^{15}N$ enrichment at Stratton. The functional ecology of weed species from the site indicates that a trend towards low fertility and extensive cultivation had begun by the eighth to ninth centuries, which suggests that, if manuring was occurring, it was having a limited effect on overall fertility (Hamerow et al., in prep.).

At Lyminge, the cultivation conditions of the four crops varied. During the sixth century, the $\delta^{15}N$ values of wheat and barley are similar, with a ~1‰ difference between them indicating similar levels of $^{15}N$ enrichment. However, the similarity between barley and wheat $\delta^{13}C$ values may indicate either a difference in soil moisture between the two species or differing annual precipitation. The eighth- to ninth-century samples provide an opportunity to look at all crop species and show some differences due to high variability in wheat and barley. There are some similarities in water availability, suggesting similar soil moisture conditions, with oat offset from the other crops as expected. However, the highly variable barley values produce a mean value similar to those of wheat and oat, something which would not be expected if the crops had been grown in the same soil moisture conditions. Again, theoretically, the difference could be due to differing annual precipitation amounts, or to cultivation in different soils – i.e., free-draining chalk compared to heavier clays which occur around the site. The $\delta^{15}N$ values confirm that differences in soil conditions are a contributory factor, with the barley and rye from this phase cultivated in a more enriched location than oat. The high variability seen in wheat and barley (in both $\delta^{13}C$ and $\delta^{15}N$) compared to the other crops could indicate that these crops were cultivated across a variable landscape of different soil types and water retention, or else were imported from different locations. The different $^{15}N$ enrichments of the soils could be due to different natural properties of the soil, or to the variable addition of manure in different fields. However, natural variability seems more likely for two reasons. The first is that a study of functional weed ecology at the site indicates low fertility, which implies that manuring was either limited or ineffectual (see Bogaard et al., this volume). Second, when the $\delta^{15}N$ values of the crops are compared to the adjusted values of the Kent deer (which act as a proxy for the natural $^{15}N$ enrichment), there are strong similarities. This suggests that the arable fields have similar $^{15}N$ enrichment to the 'natural' vegetation, indicating limited manuring.

The plant isotope results highlight the variability of the arable landscape in terms of $^{15}N$ enrichment and water availability. The two sites examined do not reveal evidence that species were systematically cultivated in rotation; similar $\delta^{15}N$ means and the expected $\delta^{13}C$ offsets are not present. The lack of additional species, especially at Stratton, limits our conclusions. If barley was cultivated elsewhere, it is possible that a different crop such as wheat or oat (both present in the archaeobotanical record at the site) was grown in rotation with rye. It is also possible that the high plant isotopic variability seen for some species, for example barley and wheat at Lyminge, may suggest different growing conditions were being maintained by different farmers. Hence, it is possible that no *systematic* rotation occurred during the phases with isotopic data from multiple species, but this does not rule out *individual* farmers cultivating crops in rotation, or the use of two-course rotation (the weed ecological data from Lyminge are plausibly consistent with two-course rotation: see Bogaard et al., this volume).

***Animal husbandry: grazing locations and diet***

One of the main aims of this research is to investigate whether the grazing of stubble and/or fallow fields can be detected isotopically. The impact that such grazing would have on the isotopic ratio of animal collagen is dependent on two things: the proportion of the animal's diet provided by stubble and/or fallow field grazing, and how different the isotopic ratio of such a diet is compared to the consumption of other vegetation – i.e., pasture or 'natural' grazing. It is hypothesized that a change in the isotopic ratio of animals over time might indicate a change in diet. It is thought that the grazing of stubble may have increased as the availability of pasture declined over the course of the early medieval period; if so, changes in animal diet indicated isotopically may reflect an increased dependence on stubble grazing. It is possible that such a change would be represented by an increase in $\delta^{15}N$ values, as stubble contributed increasingly to the animals' diet – provided that there is an isotopic difference between the arable fields and pasture/natural vegetation due to a higher input of manure on the arable fields.

Looking for the two possible indicators of increased stubble grazing in the Lyminge data is facilitated by both the high number of samples compared to Stratton and the use of the Kent fallow deer values as a proxy for 'natural' vegetation. While caution is required when using the fallow deer values – minus dietary offsets – as a representation of the natural vegetation, this approach provides a possible guide as to what the isotopic value of natural vegetation might be. It is possible that the animals at Lyminge consumed cereal rachis, since the animal values fall within the cereal rachis ellipse (Plate IV); but the limited difference between the 'natural' vegetation and the cereal rachis ellipses indicates there is high similarity between these two environments' isotopic signatures, making it extremely difficult to distinguish between them. The lack of any statistically significant change within the Lyminge animals' isotopic values over time (in either $\delta^{13}C$ or $\delta^{15}N$) suggests four possibilities: (i) that there was no switch to stubble grazing over time, (ii) that stubble grazing was part of the animal husbandry regime from the beginning, (iii) that consumption of stubble was occurring, but is 'masked' by similar isotopic values representing the surrounding pasture, or (iv) that stubble constituted only a small proportion of the animals' diet.

Turning to the two possible indicators of increased stubble grazing at Stratton, it can be seen that there is no change over time in either $\delta^{13}C$ nor $\delta^{15}N$ values. The reconstructed ellipses of animals consuming cereal grain or rachis at Stratton have very large ranges, due to the high variability seen in the crop plant isotopic values, and the limited number of plant isotopic samples (compare Plate VII with Styring et al., 2017, Appendix 6). Due to the limited quantity of cereal remains available from this site, only the seventh- to ninth-century phase can be examined in this way; this restriction precludes any investigation of trends through time, something which would be crucial for identifying a general increase in stubble grazing. The dietary reconstructions do not rule out animals consuming cereal rachis – and therefore stubble – as the animal values do fall within the potential rachis consumption ellipse (Plate VII). However, the highly variable nature of the plant isotope values suggests a landscape with variable $^{15}N$ enrichment, which results in the ellipses encompassing the majority of possible isotopic values. If the theory that barley was cultivated elsewhere than Stratton is correct, then this species must be removed from the ellipse calculation. Removing barley has a limited effect on reducing the resultant ellipse, however. Until another way of understanding the isotopic value of pasture/natural grazing is developed which does not rely on wild herbivore isotopic values, it is difficult to determine whether stubble and natural pasture had similar isotopic values at this site.

There is evidence of an environmental difference in nitrogen enrichment between the two sites, with Stratton significantly more enriched than Lyminge (Stratton averaging around 8‰, Lyminge 6‰). The elevated nature of the Stratton samples in terms of $^{15}N$ is also noticeable when the values are compared to other early medieval data (Mallet, 2016; Mallet and Stansbie, 2021). These results could suggest that the land surrounding Stratton had a higher $\delta^{15}N$ baseline than other locations. Given the difference between the sites' local geologies – Lyminge located on chalk, Stratton in a valley with deep clays which are prone to waterlogging – it is unsurprising that there is a difference between the results from the two sites, and this highlights the importance of using baseline data from the same geology/environment. The lack of wild herbivores from Stratton precludes a detailed understanding of the whole landscape enrichment in $^{15}N$, although locations within the landscape which experienced seasonal flooding, waterlogging, salinity or high amounts of animal/human waste could explain the trend towards higher enrichment at Stratton.

It is possible to use the animal isotope results to understand similarities and differences in diet between the different species. The sheep and cattle from the two sites show limited statistical differences, which potentially suggests that they consumed similar diets. At Stratton, however, the more negative sheep $\delta^{13}C$ values in the tenth to twelfth centuries, although they are not significant within the broader sheep values, potentially indicate that the sheep during this phase consumed plants from wetter or more closed canopy environments within the landscape in comparison with Stratton's cattle. The sheep and cattle from Lyminge also show limited differences from one another isotopically, especially in the eighth- to ninth-century phase where the isotopic values are very similar, thus suggesting very similar diets. There is some difference in the sheep values in the tenth- to twelfth-century phase and, as at Stratton, more negative $\delta^{13}C$ values. Such findings are limited by the small number of samples, but they do raise the possibility that the sheep grazed on slightly different areas of the landscape or were foddered in a different way compared to the cattle during this period, at both sites. Factors which may cause sheep to have more negative $\delta^{13}C$ values than cattle are either the consumption of forage from wetter locations or the consumption of forage from more closed environments (i.e., woodlands). It therefore seems strange that sheep – commonly perceived as grazing in dry and open landscapes – have more negative values. The small difference between the animals' values limits any further speculation as to the significance of this difference in terms of animal management practices; an increased sample size would help us to understand if the pattern is just an artefact of low sample numbers.

The $\delta^{13}C$ values of the pigs are consistently higher than those of the other animals at both Lyminge and Stratton. The isotopic difference between pig and the other ruminants is not gut-related, as the differences in digestive systems should show the *opposite* trend, with the ruminants enriched in $^{13}C$ due to methane production (Hamilton and Thomas, 2012, 251). The difference could be related to the pigs consuming plants from relatively drier locations compared to the wetter locations of the ruminants, or the consumption of fungi by pigs. The consumption of fungi has been shown to have the opposite effect to shade on the $\delta^{13}C$ values of its consumer, and this could explain the enriched $^{13}C$ values of the pigs at Stratton and Lyminge (Hamilton and Thomas, 2012). The pig $\delta^{15}N$ values are also not overly enriched, suggesting that these animals were not consuming a high proportion of $^{15}$N enriched food scraps such as meat. Instead, the similarity of the herbivore and pig $\delta^{15}$N values indicates a similar trophic level: pigs were more herbivorous than omnivorous. It is possible that an omnivorous signal in pigs is being dampened down by the consumption of pulses, but disentangling this possibility is very difficult. Overall, it seems likely that the pigs consumed proportions or types of food different from those consumed by sheep and cattle, and the lack of change over time suggests that this was a long-term practice.

Other isotopic research has found a difference between urban and rural pigs in medieval England, with urban pigs being more omnivorous (Albarella, 2006, 79); this correlates with the isotopic results from Stratton and Lyminge. Historical documents indicate that medieval swine husbandry relied on the exploitation of woodlands: providing areas for the pigs to forage on roots, acorns and beech mast (pannage) (Albarella, 2006, 77). Pannage is thought to have extended as far back as the seventh century (Trow-Smith, 1957, 51). The Domesday Book also provides an indication of the connection between pigs and woodland: woodland was measured in terms of the number of pigs it could support (Albarella, 2006, 77). The results from Stratton and Lyminge may reflect the driving of pigs within woodland for pannage. The more positive $\delta^{13}$C signal may reflect the higher dietary consumption of fungi (compared to the cattle and sheep), while the limited $^{15}$N enrichment indicates a high proportion of plant protein in their diet, potentially from mast and other woodland fruits and nuts. However, fattening of pigs using pannage is traditionally seasonal, occurring in autumn and winter, and therefore the pigs may have had a different diet for the other half of the year (Wiseman, 2000, 33; Albarella, 2006, 77). Other options would include feeding on crops, and possibly pasture or stubble fields, an idea which has been explored above (Kelly, 1997, 83; Arabella, 2006, 77; Trow-Smith, 1957, 53).

## Conclusion

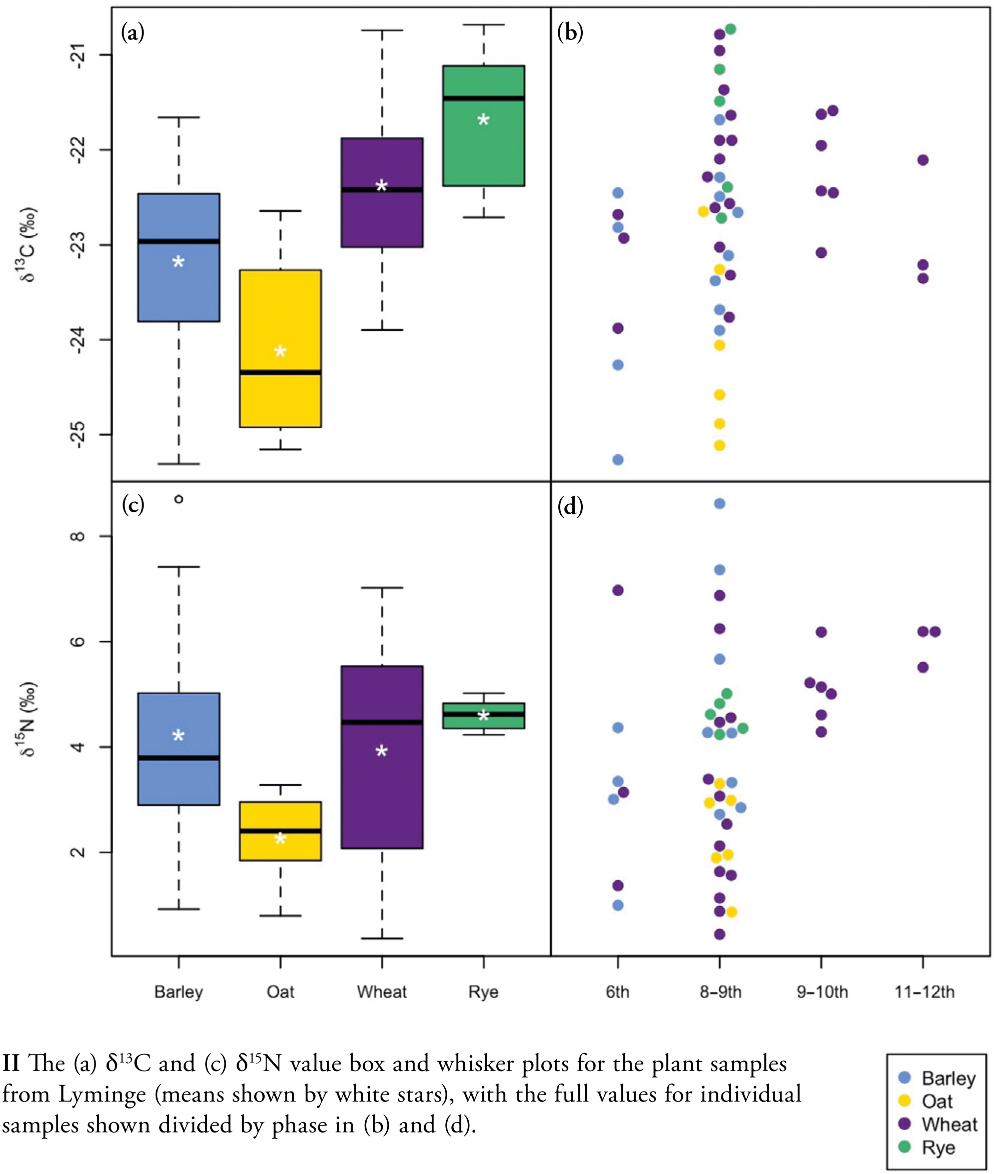
The early medieval sites of Lyminge and Stratton provide the opportunity to investigate changes in crop and animal husbandry over time and between different species. At Lyminge, stable isotope analysis of crop remains indicates that the crops were cultivated in a landscape with variable $^{15}$N enrichments, potentially representing different soil types. Differences between the crop species suggest that systematic crop rotation was not occurring during the periods for which we have isotope data; however, it is possible that rotation was occurring on a non-systematic basis, practised by individual farmers. The collagen results add additional data points to already published isotopic values from Lyminge and, coupled with the cereal grain results, allow for an attempt at animal dietary reconstruction to investigate stubble/fallow field grazing. The results indicate a high likelihood of similar isotopic values between natural vegetation and arable forage (such as fallow fields and stubble), a consequence of limited manuring due to extensification (see Bogaard et al., this volume). Such conditions make it difficult to differentiate between the two dietary sources. Similar findings at Stratton highlight the problem of distinguishing between pasture and arable fodder isotopically. At both Stratton and Lyminge, however, the isotopic results do highlight differences in the animals' grazing/foraging locations within the landscape. Sheep and cattle had similar diets, grazing on the pastures surrounding the sites and potentially on the fallow fields. Pigs consumed forage which may have included fungi, which suggests extensive foraging in woodlands.

This research for the first time brings together stable carbon and nitrogen isotopic results from both plant and animal remains from early medieval England. The results provide additional information regarding crop and animal husbandry during the period, which, when combined with results from zooarchaeology, archaeobotany and palynology, help to provide a much more detailed picture of early medieval agriculture.

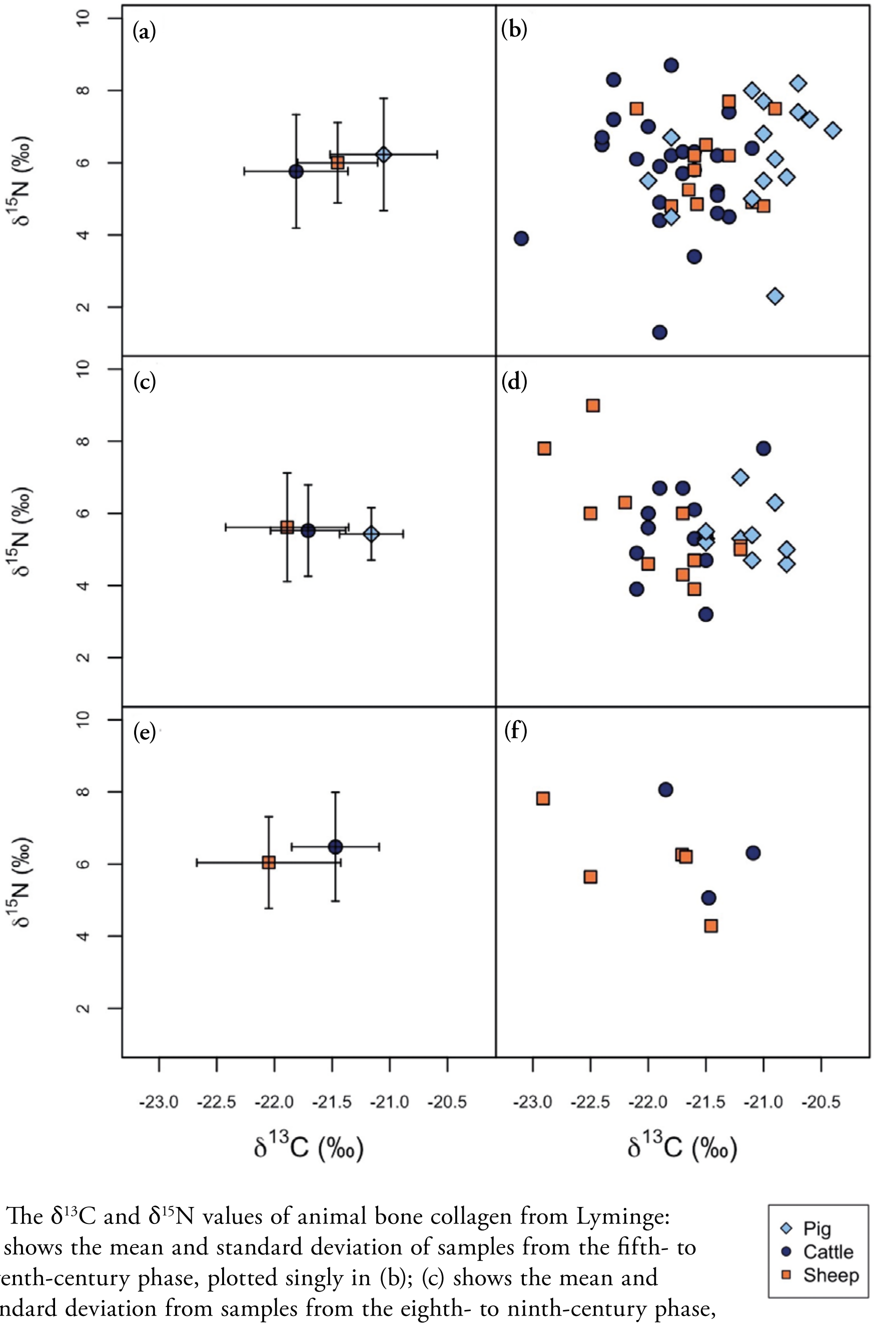
(a)

(b)

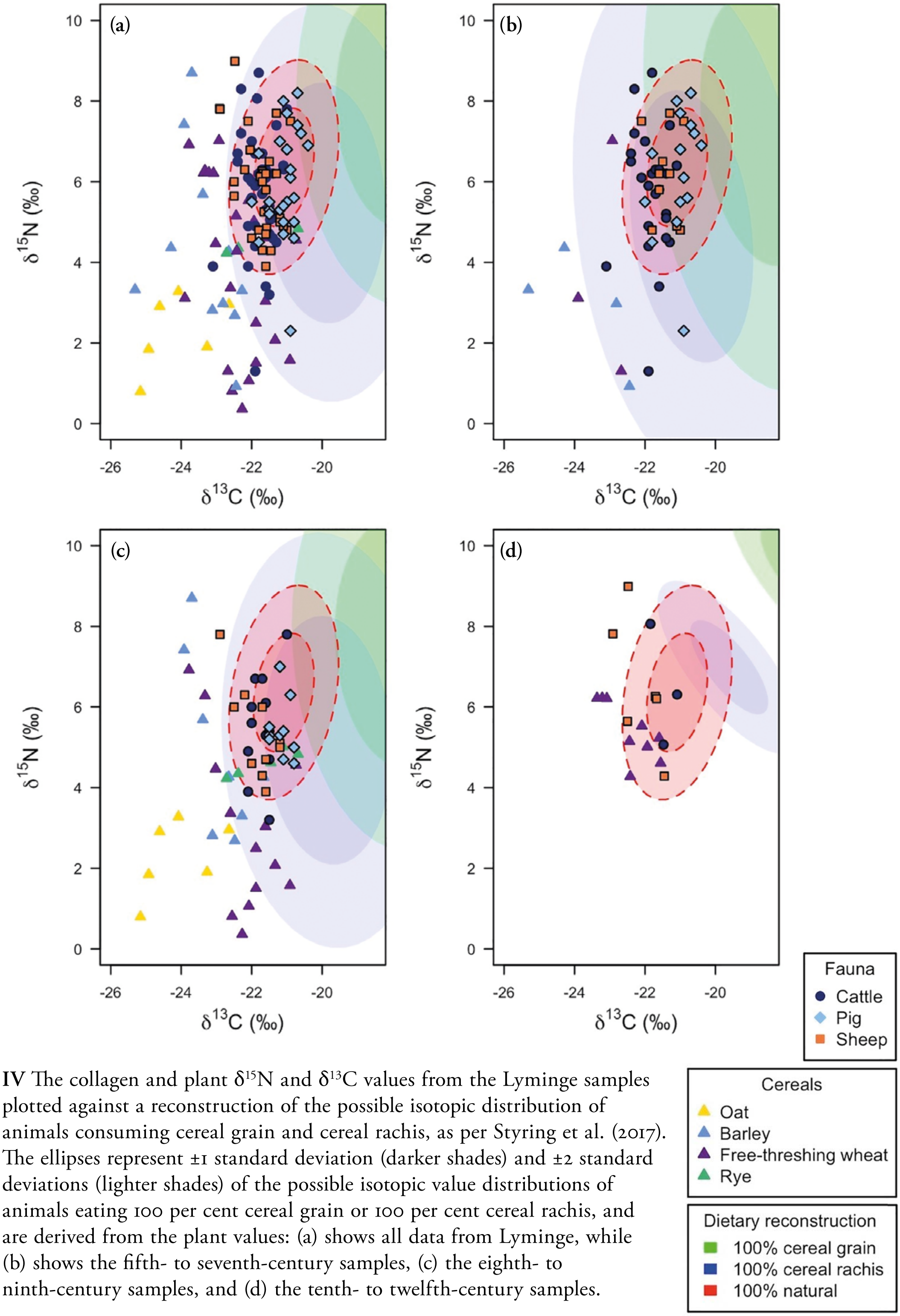
**I** The flora of relevant habitats at Laxton and Highgrove: (a) meadow verge ('syke') near Mill Field at Laxton, Nottinghamshire; (b) organic cereal field at Highgrove's Duchy Home Farm, Gloucestershire.



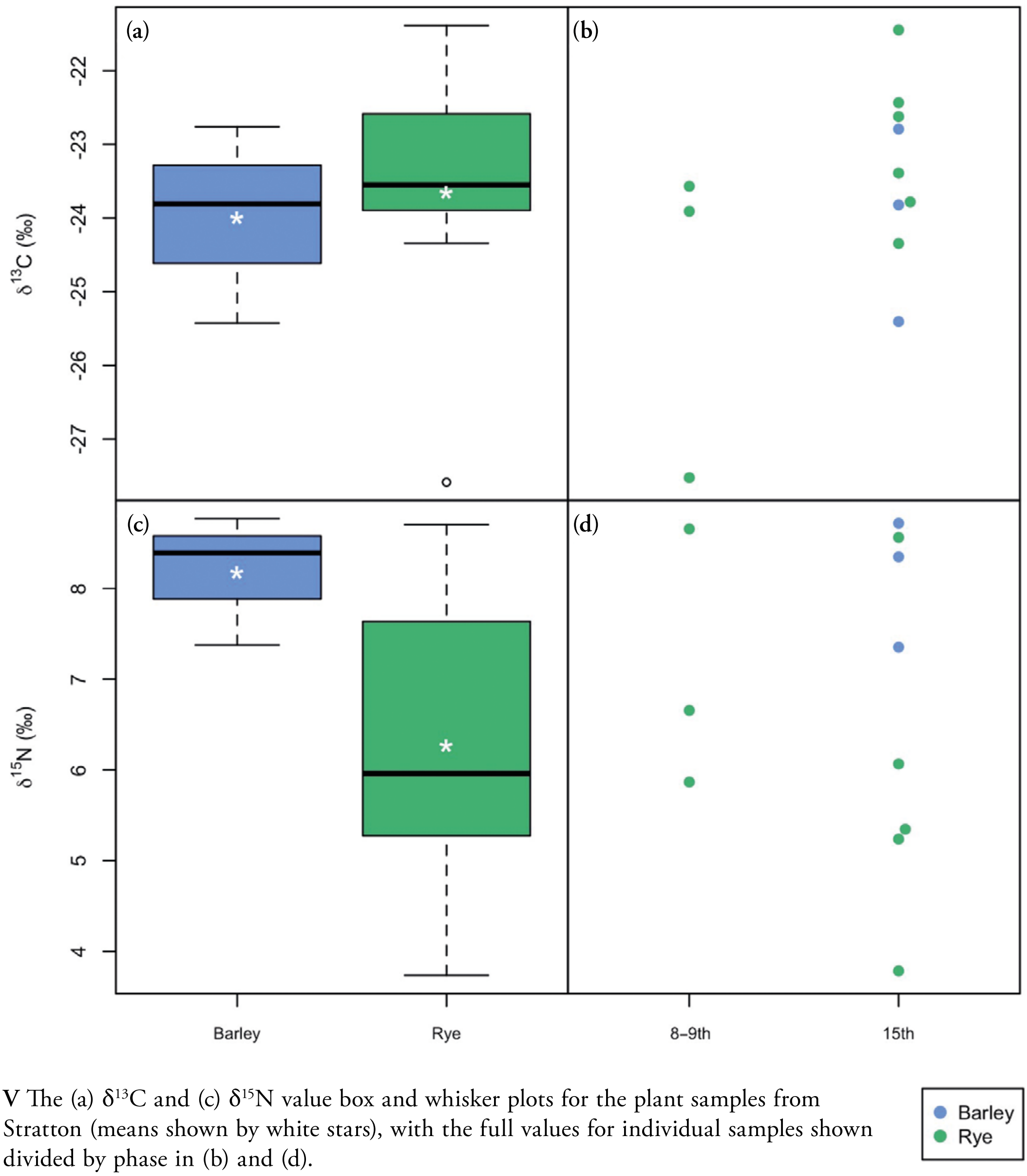

**II** The (a) $\delta^{13}C$ and (c) $\delta^{15}N$ value box and whisker plots for the plant samples from Lyminge (means shown by white stars), with the full values for individual samples shown divided by phase in (b) and (d).



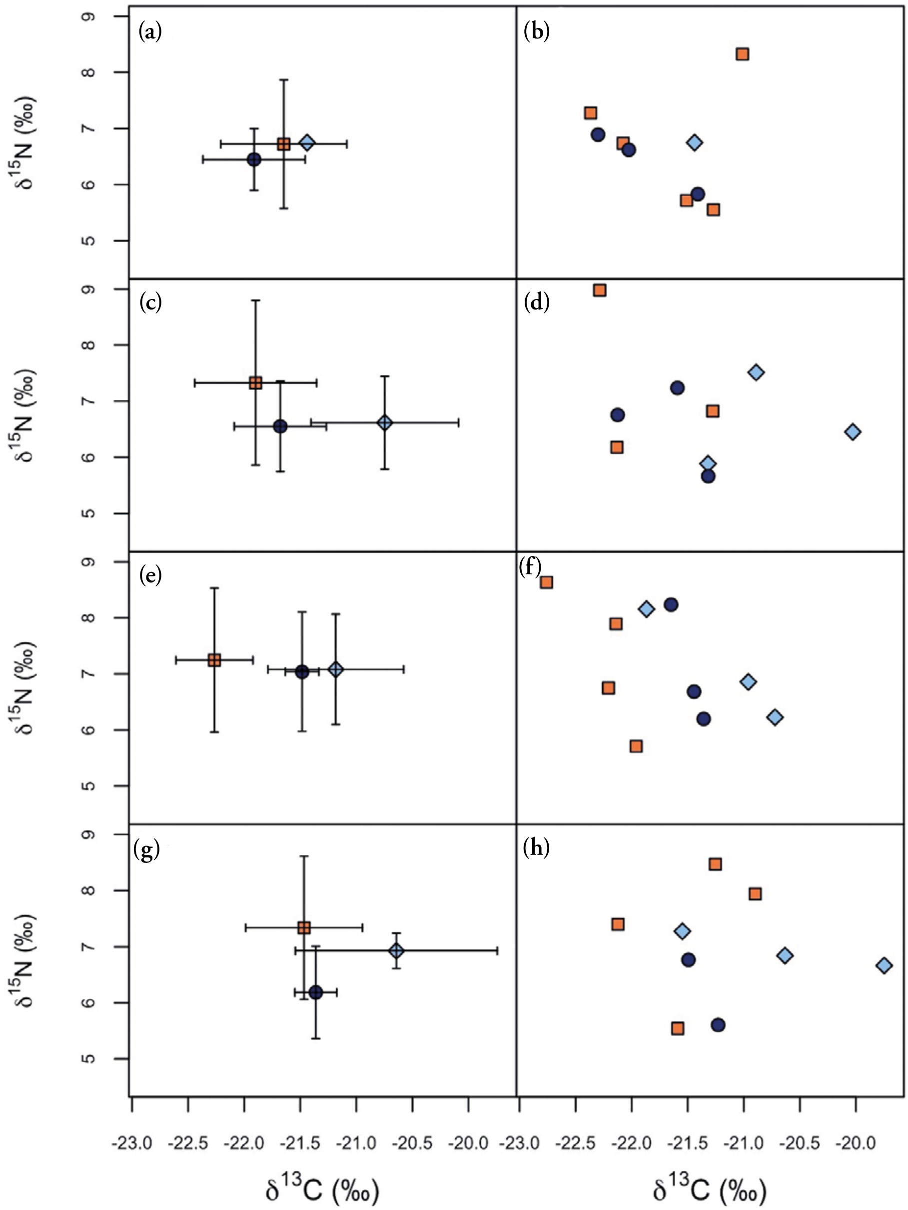

**III** The $\delta^{13}C$ and $\delta^{15}N$ values of animal bone collagen from Lyminge: (a) shows the mean and standard deviation of samples from the fifth- to seventh-century phase, plotted singly in (b); (c) shows the mean and standard deviation from samples from the eighth- to ninth-century phase, plotted singly in (d); and (e) shows the mean and standard deviation of samples from the tenth- to twelfth-century phase, plotted singly in (f).



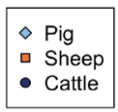

**IV** The collagen and plant $\delta^{15}$N and $\delta^{13}$C values from the Lyminge samples plotted against a reconstruction of the possible isotopic distribution of animals consuming cereal grain and cereal rachis, as per Styring et al. (2017). The ellipses represent ±1 standard deviation (darker shades) and ±2 standard deviations (lighter shades) of the possible isotopic value distributions of animals eating 100 per cent cereal grain or 100 per cent cereal rachis, and are derived from the plant values: (a) shows all data from Lyminge, while (b) shows the fifth- to seventh-century samples, (c) the eighth- to ninth-century samples, and (d) the tenth- to twelfth-century samples.

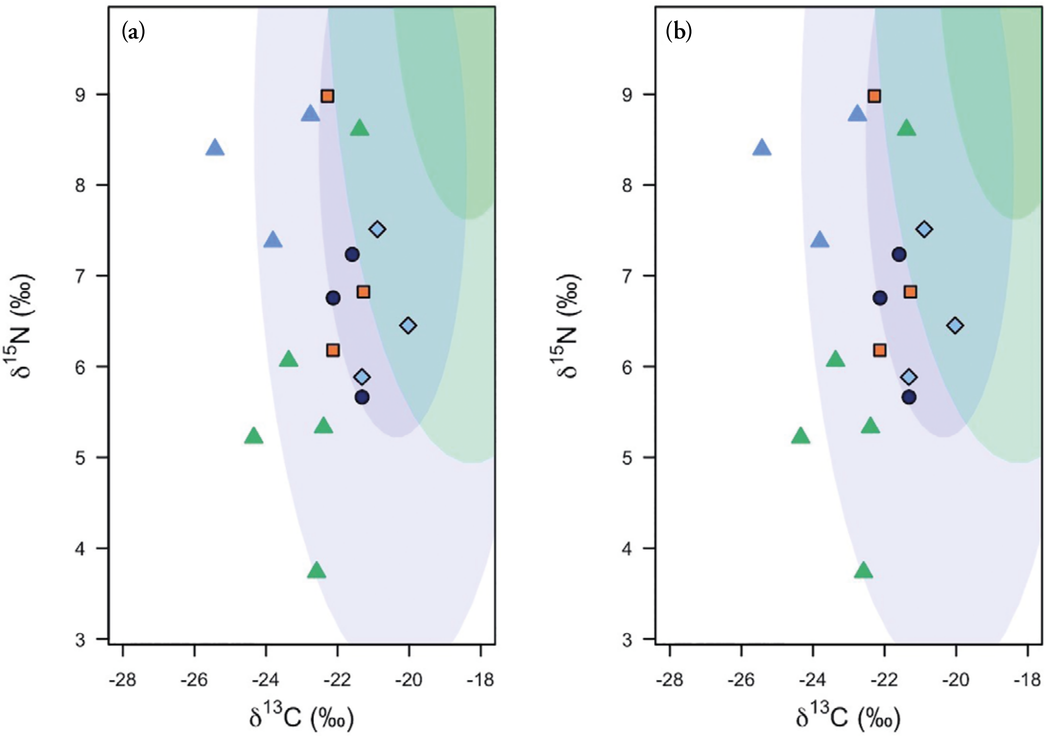



**V** The (a) $\delta^{13}C$ and (c) $\delta^{15}N$ value box and whisker plots for the plant samples from Stratton (means shown by white stars), with the full values for individual samples shown divided by phase in (b) and (d).

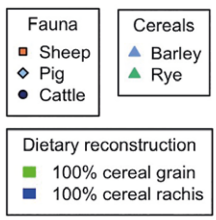


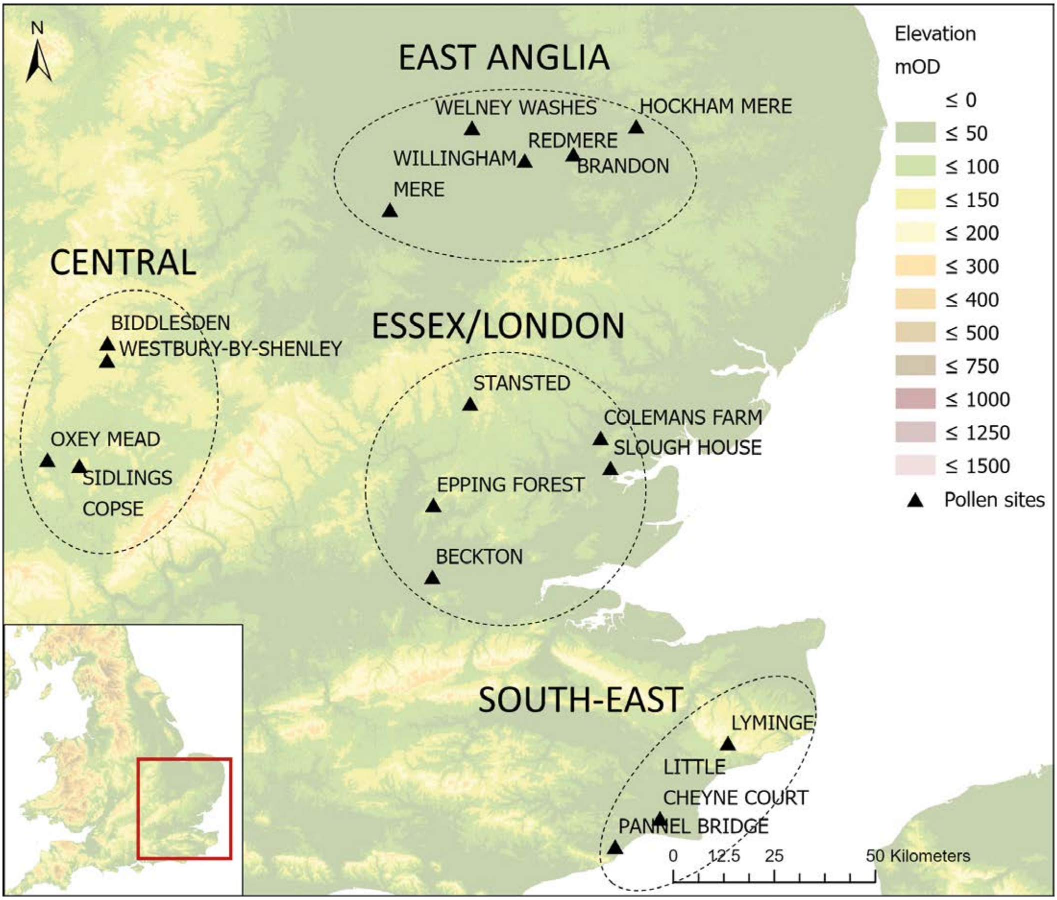

**VI** The $\delta^{13}C$ and $\delta^{15}N$ values of collagen from animals from Stratton: (a) shows the mean and standard deviation of the three species from the fifth to the sixth centuries with the sample values plotted singly in (b); (c) shows the mean and standard deviation of the species from the seventh to the ninth centuries, with the sample values plotted singly in (d); (e) shows the mean and standard deviation of species from the tenth to the twelfth centuries, with the sample values plotted singly in (f); and (g) shows the mean and standard deviation of the species from the thirteenth to the fourteenth centuries, with the sample values plotted singly in (h).



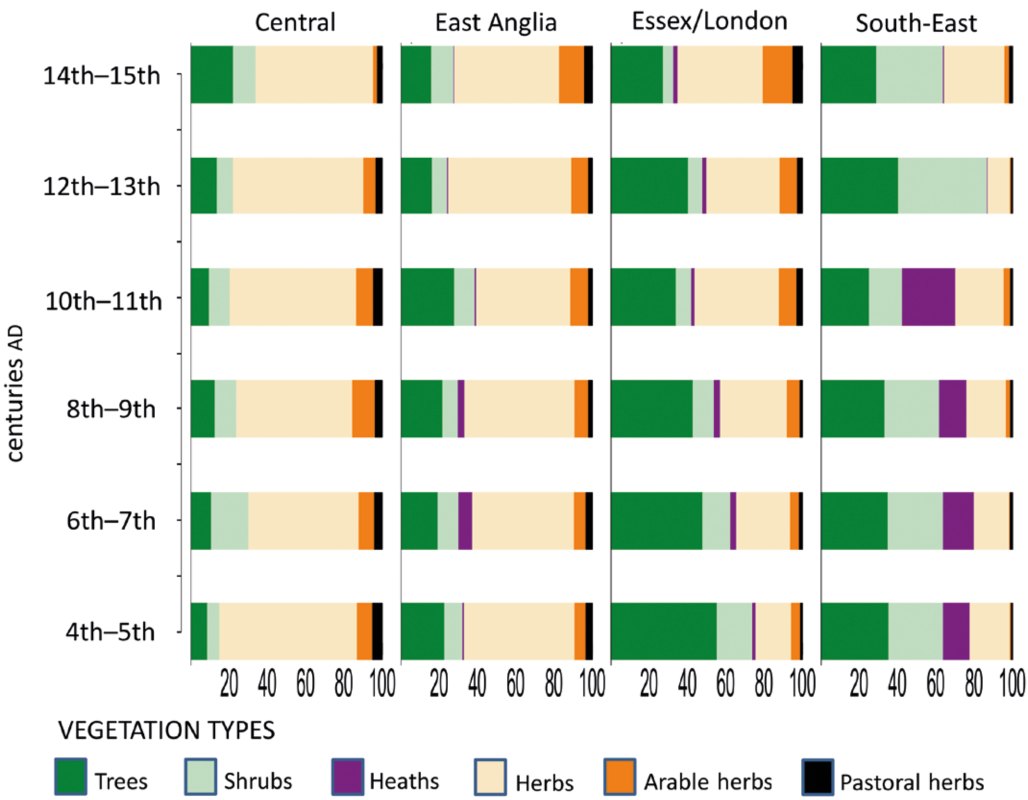



**VII** The Stratton collagen and plant isotopic values for (a) all phases, and (b) the seventh- to ninth-century phase, plotted against a reconstruction of theoretical isotopic distribution of animals consuming cereal grain and cereal rachis, as per Styring et al. (2017). The ellipses represent ±1 standard deviation (darker shades) and ±2 standard deviations (lighter shades) of the possible isotopic value distributions of animals eating 100 per cent cereal grain or 100 per cent cereal rachis, and are based on the plant isotopic values.

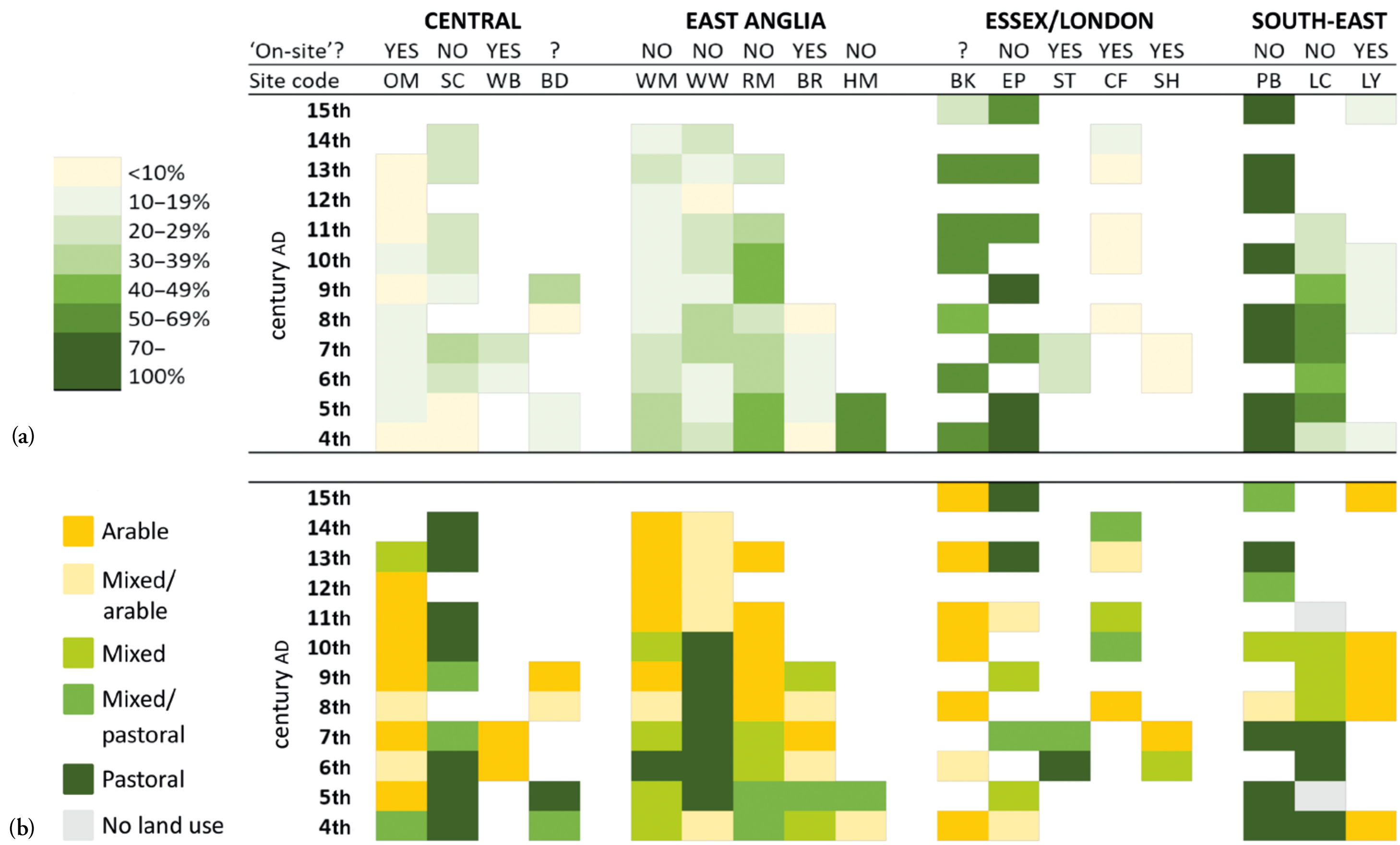




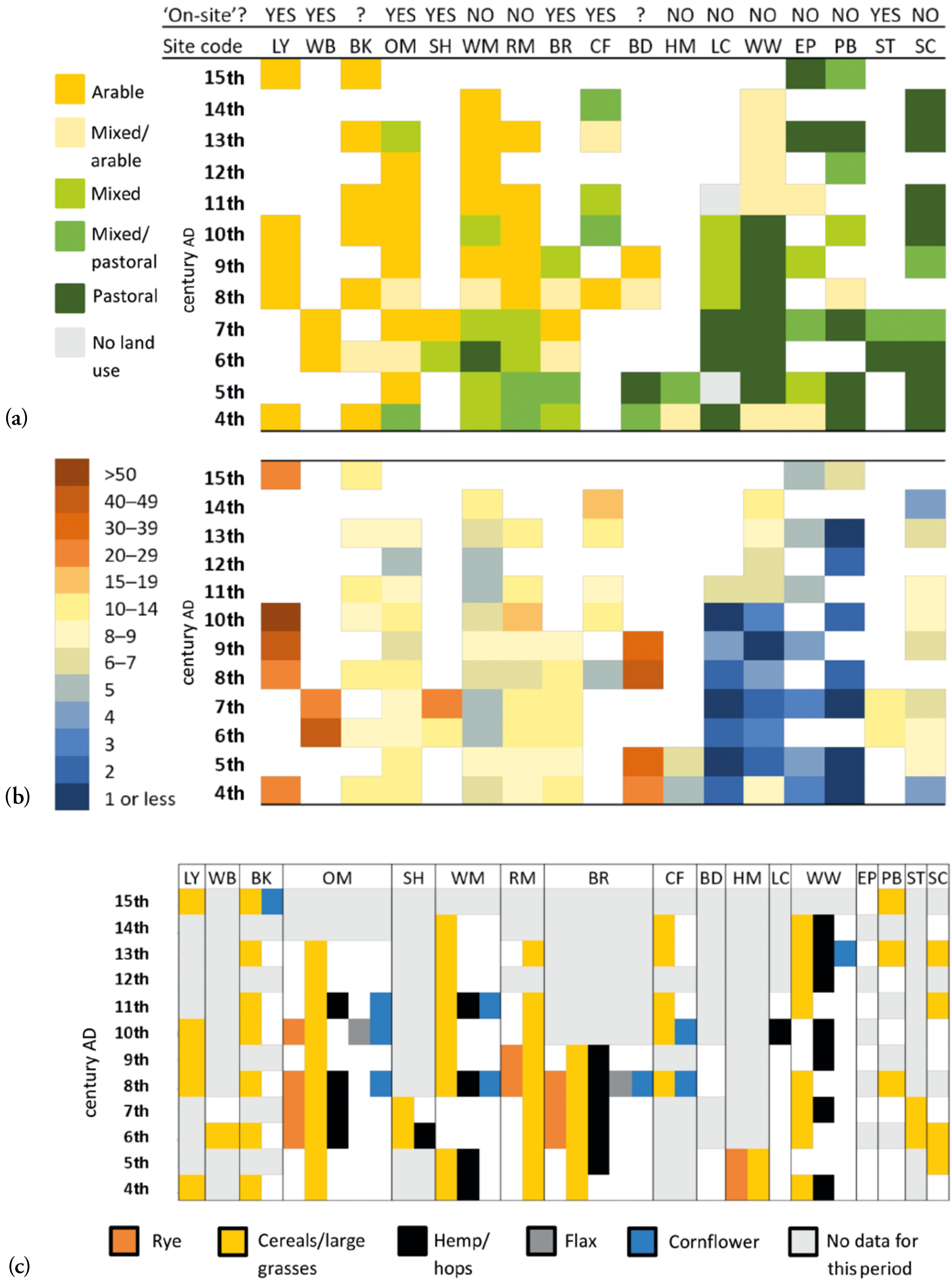

**VIII** Elevation map showing regional clusters of pollen sites discussed in the text.



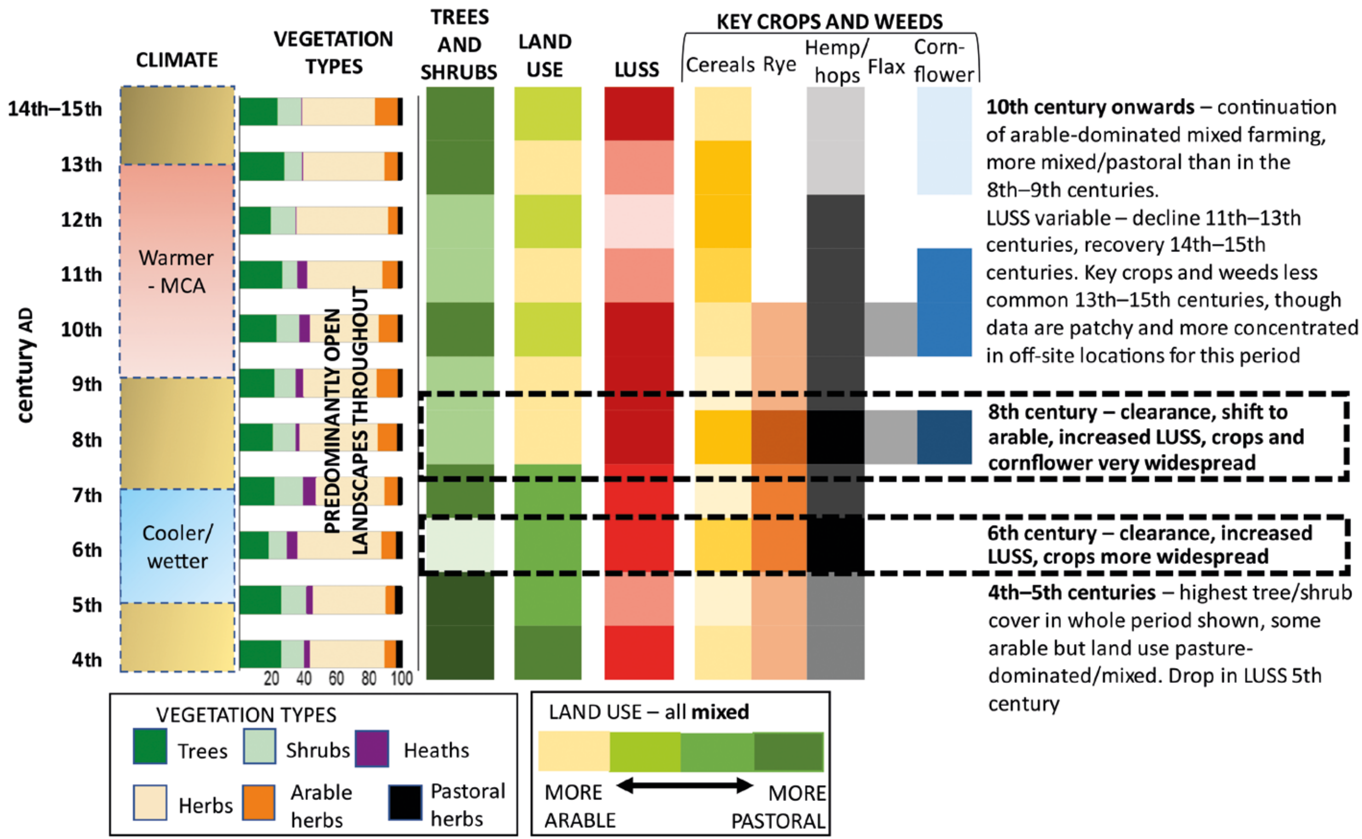

**IX** Vegetation patterns within regional clusters averaged over two centuries. Very small catchment sites and those with records covering fewer than five centuries were excluded.




X (a) Percentage tree/shrub pollen and (b) agricultural land use based on API. Sites are arranged west to east within each cluster (see Table 1 for site codes). Where multiple samples at a site date from a single century, the total percentage of tree/shrub pollen and the API were averaged.




**XI** (a) Agricultural land use based on API, (b) ALUSS (agricultural land use signal strength) – percentage of pollen related to arable/pasture, and (c) presence of key crops and arable weeds. See Table 1 for site codes and names.




**XII** Vegetation and agricultural land use patterns: combined data for all sites. See Plates IX and X for keys to vegetation type, trees/shrubs and agricultural land use type. Sites in the latter two are divided into 'open' (O), 'semi-open' (SO) and 'wooded' (W), and 'arable' (A), 'mixed' (M) and 'pastoral' (P) respectively, depending on the dominant vegetation/land use over time. ALUSS (agricultural land use signal strength): the darker the colour, the higher the signal strength. Key crops and weeds: the darker the colour, the greater the percentage of sites at which each type occurs (based on number of sites with data for the same period). Temperature and precipitation varied throughout the post-Roman to medieval periods and in different areas: only substantial shifts in climate are highlighted here.

# 4 Agricultural Land Use in Central, East and South-East England: Arable or Pasture?

*Emily Forster and Michael Charles*

Pollen data provide the best available large-scale, long-term evidence for vegetation and agricultural land use. In this paper we bring together data from numerous studies covering parts of central, east and south-east England spanning *c.* AD 300–1500, in order to understand how the landscape, and particularly the nature and scale of farming, changed over time.

This period encompasses the late Romano-British to post-Roman transition of the fourth to fifth centuries, a time when population declined and long-distance trade networks collapsed (Esmonde Cleary, 1991). These changes are often assumed to have resulted in the abandonment of farmland, as a significantly smaller population and the end of army provisioning and grain exports would have reduced demand for crops (e.g., see Lodwick, 2017a, and this volume). Arable land might have been left fallow, used for pasture or colonized by woodland/scrub plant communities in this case. Farming is generally thought to have been small-scale and mixed (arable and pasture) in the mid-fifth to early seventh centuries (Banham and Faith, 2014). As Hamerow (this volume) discusses, significant changes occurred in the so-called 'long eighth century' (*c.* AD 680–830), including the appearance of infrastructure for crop processing/storage and livestock management. Population increased considerably between the ninth and thirteenth centuries, and much of the landscape came to be characterized by large-scale, 'extensive' (i.e., low-input) arable production during this period (Bogaard et al., this volume).

We are very grateful to all who made pollen data available either directly or through the EPD, to Petra Dark for valuable email exchanges about Sidlings Copse, and to Michael Grant for searching BPOL for relevant sites.

However, the timing of changes in the nature and scale of farming in Anglo-Saxon and medieval England are much debated (e.g., Hamerow, 2012; Williamson, 2013; Banham and Faith, 2014; Hall, 2014; McKerracher, 2018). In this paper, we use pollen evidence to determine the scale and type of agricultural land use – namely arable, pasture or a combination of the two – and to test assumptions about land use in the post-Roman to medieval period, such as whether arable land was abandoned in the early post-Roman period or expanded at

**Table 1 Pollen sites included in this study**

| Code | Site | County, cluster | Elevation (metres) | Bedrock geology | Local soils |
|---|---|---|---|---|---|
| **OM** | Oxey Mead | Oxfordshire, Central | 60 | mudstone, siltstone and sandstone | seasonally wet deep clay |
| **SC** | Sidlings Copse | Oxfordshire, Central | 100 | limestone, sandstone, siltstone and mudstone | loam |
| **WB** | Westbury-by-Shenley | Buckinghamshire, Central | 100 | sandstone, limestone and argillaceous rocks | shallow loam |
| **BD** | Biddlesden | Northamptonshire, Central | 115 | sandstone, limestone and argillaceous rocks | seasonally wet deep clay |
| **WM** | Willingham Mere | Cambridgeshire, East Anglia | 2 | mudstone, siltstone and sandstone | deep clay |
| **WW** | Welney Washes | Norfolk, East Anglia | 2 | mudstone, siltstone and sandstone | seasonally wet deep silt |
| **RM** | Redmere | Norfolk, East Anglia | 0 | mudstone, sandstone and limestone | peat |
| **BR** | Brandon | Suffolk, East Anglia | 1 | chalk | peat |
| **HM** | Hockham Mere | Norfolk, East Anglia | 33 | chalk | peat |
| **BK** | Beckton | London, Essex/London | 4 | clay, silt, sand and gravel | seasonally wet deep clay |
| **EP** | Epping Forest | Essex, Essex/London | 117 | clay, silt, sand and gravel | seasonally wet deep clay |

the expense of pasture in the ninth to thirteenth centuries. There is considerable overlap between FeedSax and other large-scale landscape studies, including the *Fields of Britannia* project (Rippon et al., 2015), the *English Landscapes and Identities* project (Gosden et al., 2021) and, before that, Petra Dark's seminal book, *The Environment of Britain in the First Millennium* AD (Dark, 2000). Although we draw on datasets utilized in those important works, our approach to identifying agricultural land use is quite different, as detailed below.

| **Site type** | **Relative catchment size** | **Dates used in model** | **Notes on chronology** | **References for data** |
|---|---|---|---|---|
| alluvial/ floodplain | small–medium | 2 | one date rejected – extrapolated (up) at constant rate | Greig, 2004 |
| valley fen (stream-fed) | medium | 4 | one date rejected – extrapolated to surface | Day, 1991; 1993; EPD |
| sump/well within settlement | very small | 2 | dendrochronological dates on context | Hale, 1995 |
| mire | medium | 2 | extrapolated (up) at constant rate for uppermost samples | Branch et al., 2005; Jones and Page, 2006; Jones et al., 2006 |
| former lake | large | 2 | extrapolated to surface – radiocarbon dates all pre-date the FeedSax period | Waller, 1994; EPD |
| fen/washes – organic deposits under this | medium–large | 8 | well dated – extrapolated at constant rate for uppermost samples | Waller, 1994; EPD |
| fen – former lake | large | 4 | extrapolated to surface – radiocarbon dates all pre-date the FeedSax period | Waller, 1994; EPD |
| floodplain peat | small–medium | 1 | upper date is based on associated pottery | Wiltshire, 1990 |
| former lake – large, *c.*1km diameter | large | 6 | well dated | Bennett, 1983; EPD |
| wetland | medium | 6 | one date rejected – extrapolated to surface – radiocarbon dates all pre-date the FeedSax period | Batchelor, 2009; EPD |
| mire/bog, edge of forest | medium | 3 | one date rejected; well dated | Grant and Dark, 2006 |

| Code | Site | County, cluster | Elevation (metres) | Bedrock geology | Local soils |
|---|---|---|---|---|---|
| **ST** | Stansted | Essex, Essex/London | 70 | clay, silt, sand and gravel | seasonally wet deep clay |
| **CF** | Coleman's Farm | Essex, Essex/London | 20 | clay, silt, sand and gravel | deep loam |
| **SH** | Slough House Farm | Essex, Essex/London | 10 | clay, silt, sand and gravel | seasonally wet deep loam |
| **PB** | Pannel Bridge | East Sussex, South-East | 4 | sandstone and siltstone | seasonally wet deep clay |
| **LC** | Little Cheyne Court | Kent, South-East | -1 | sandstone and siltstone | seasonally wet deep clay |
| **LY** | Lyminge | Kent, South-East | 100 | chalk | silty |

*Source*: EPD, Institut Méditerranéen d'Écologie et de la Biodiversité (IMBE). www.europeanpollen database.net (accessed 20/07/21).

### The study regions

Pollen data for England have been collated to create a national database as part of the FeedSax project. This paper focuses on a subset from four clusters of sites, referred to here as 'Central', 'East Anglia', 'Essex/London' and 'South-East' (Plate VIII; Table 1). When considering evidence for agricultural land use, important factors are the type and location of the pollen sites. Differences in geology, soils, altitude and hydrology/rainfall all have an impact on the vegetation types within an area and are likely to have influenced decisions about land use. None of the sites in this region is at very high altitude, but Epping Forest (Essex/Greater London) and Lyminge (Kent) are notably higher than other sites in their regional clusters, while in Oxfordshire, Sidlings Copse is significantly higher than Oxey Mead (Table 1). Many of the sites in East Anglia and the South-East are low-lying, and some are in coastal/fen areas, prone to seawater flooding and brackish conditions. This needs to be taken into consideration, as palynologically, coastal/saltmarsh vegetation is difficult

| Site type | Relative catchment size | Dates used in model | Notes on chronology | References for data |
|---|---|---|---|---|
| floodplain peat | small–medium | 2 | extrapolated to surface for approximate accumulation rate – very short sequence | Murphy, 1988; Wiltshire, 1991 |
| palaeo-channel/ alluvial | small–medium | 3 | possible truncation/break in accumulation between dates is problematic, tentative chronology | Murphy et al., 2002 |
| well within settlement | very small | 1 | dendrochronological date on context | Murphy, 1991; Wiltshire, 1992; Murphy and Wiltshire, 1993 |
| marsh | small–medium | 8 | extrapolated to surface – radiocarbon dates all pre-date the FeedSax period | Waller, 1993 |
| marsh | medium | 4 | well dated – extrapolated at constant rate for uppermost samples | Waller et al., 1999 |
| palaeo-channel/ alluvial | small–medium | 4 | dates are for contexts – pollen sample dates estimated according to context | Maslin, 2017 |

to distinguish from an arable weed assemblage (as discussed further below). Equally, Brandon, the only East Anglian site with substantial evidence for heathland, is on the edge of Breckland, an area of sandy heath.

An important consideration for understanding the strength and type of agricultural land use signals from different pollen sites is the extent of the site catchment or 'relevant source area for pollen' (RSAP), which Sugita (1994) defines as the radius beyond which the correlation between pollen and the surrounding vegetation ceases to improve. More simply, the catchment is the area around a pollen sampling site from which most of the pollen is derived. The proportion of pollen arriving from different distances is affected by numerous factors, including the density and type of local vegetation, the type and size of site sampled (e.g., lake, bog, alluvial sediment, archaeological feature), hydrology and topography (Jacobson and Bradshaw, 1981; Sugita, 1994; Bunting et al., 2004). Broadly speaking, the larger the diameter of a lake, mire or other sampled feature, the larger the pollen catchment area will be. A site surrounded by dense woodland or mountains will have a smaller catchment than one in an open, flat landscape. Inflowing streams also increase catchment size, as pollen is carried in from the wider landscape (Brown et al., 2007). For the pollen records discussed here, the most substantial difference is between very small catchment sites within, or close to, settlement areas, referred to as 'on-site', and larger catchment 'off-site' records, from mires and lakes. The former would be expected to have a much stronger representation of local vegetation, while the latter provides a picture of the wider landscape. In a hypothetical scenario where sites of both types were adjacent to arable fields within a landscape containing pasture and woodland (for example), the small catchment site would usually have a stronger arable farming signal than the large catchment site. Interpretation of pollen records from within or very near settlements may be further complicated by the input of pollen from crop processing or dumping of waste (e.g., Lyminge: Maslin, 2017). Both on-site and off-site records are included here, as they each provide valuable insights relating to arable and pastoral land use, but it is important to bear these differences in mind when interpreting the data.

Palaeoenvironmental records from a variety of sources, including north-west European peat bogs and lakes, indicate cooler/wetter conditions around the fifth to seventh centuries AD (e.g., Blackford and Chambers, 1991; Barber et al., 2003; Charman, 2010), which may have had an impact on both 'natural' vegetation and agriculture. In addition, low-lying coastal regions are likely to have been affected by higher/unstable sea levels in the Romano-British period and from around the tenth century AD (Long and Hughes, 1995; Waller et al., 1999). The potential impact of higher temperatures during the medieval climate anomaly (MCA) in the tenth to thirteenth centuries must also be considered; it is possible that changes in average temperature or rainfall patterns made parts of the landscape more or less hospitable to cultivation – and to specific crops – than in previous centuries.

## Data collation and standardization

Pollen survives best in waterlogged, undisturbed, acidic conditions such as peat bogs and lake sediments. In much of central and south-east England, preservation is poor owing to a combination of long-term agricultural disturbance and good drainage (e.g., chalk and limestone bedrock). However, there are pockets of good preservation in small fens/mires, floodplain sediments, palaeochannels and archaeological features such as pits and wells. Any site with pollen data relating to any part of the period *c.* AD 300–1500, where a minimum of 300 land pollen grains[1] had been counted, and which had some form of radiocarbon, OSL or dendrochronological dating evidence, was included in the analysis. Data were downloaded from the European Pollen Database (EPD)[2] or digitized from published tables and diagrams (see Table 1).

Pollen types were standardized using the nomenclature of Bennett (1994). Wherever possible, radiocarbon dates were recalibrated using the IntCal20 calibration curve (Reimer et al., 2020) in OxCal 4.4 (Bronk Ramsey, 2008; 2009; Bronk Ramsey and Lee, 2013) and new age-depth models were created. An age-depth model establishes an approximate range of dates for each pollen sample (i.e., the age of the pollen at any given depth within the pollen core), based on extrapolation between radiocarbon (or otherwise) dated samples. The quality of site chronologies is highly variable; most records do not have dates covering the entire time period, so some dates are based on extrapolation and are therefore more tentative. Dendrochronological dates are usually precise, while older radiometric dates may have ranges of hundreds of years. The length of time covered by pollen data from different sites varies greatly, with some spanning the whole *c.*1,200-year period and others providing data for just 100–200 years. Some have multiple pollen samples per century, others have significant gaps in the record (see Plates X–XI).

### Assessing agricultural land use

The approach to establishing arable or pastoral land use presented here builds on that used in Hamerow et al. (2020). To gauge the type and scale of land use it is necessary to consider the following factors:

1. the type of **vegetation**;
2. the **dominant** form of **agricultural land use** (i.e., arable, mixed farming, or pasture);
3. the **strength** of the signal for agricultural land use;
4. the **diversity** of key crops and weeds.

1 The TLP (total land pollen sum), which is the number of non-aquatic pollen grains an analyst records to complete a sample, is not always stated, but full analysis for publication usually requires a count of 300–500. Some sites have lower counts for certain periods, usually where preservation was poor. Counts of less than 150 have been excluded entirely.

2 European Pollen Database, Institut Méditerranéen d'Écologie et de la Biodiversité (IMBE). www.europeanpollendatabase.net (accessed 20/07/21).

### *1 Vegetation*

The first of these factors concerns the dominant types of vegetation in an area, and particularly the proportion of tree/shrub cover compared to heath and grassland, which can be used to gauge landscape openness. The total percentages of trees, shrubs, heaths and herbs in each century were determined for each site. Where necessary, the TLP was recalculated to exclude reeds, rushes, sedges and aquatics – this was necessary to standardize data between sites, but also because these types are likely to reflect very local conditions (e.g., surface wetness). Tree and shrub data were combined as 'total arboreal pollen'. The percentage of arboreal pollen is not a direct measure of tree/shrub cover within the landscape (e.g., Huntley and Birks, 1983; Bunting, 2002; Smith et al., 2010), although it is a good indicator of relative tree/shrub cover unless there are substantial differences in the species present. Species composition is important as some trees/shrubs produce much larger quantities of pollen than others owing to differences in dispersal mechanisms (e.g., wind-pollinated species produce more pollen than insect- or self-pollinated trees). As many trees and shrubs are wind-pollinated with widely dispersed pollen, it is also difficult (or impossible) to distinguish a small number of local trees/shrubs from a larger, more distant woodland. It is, however, possible to establish approximate arboreal cover – which may include woodland, scrub, hedges and individual trees – for a region by looking at data from multiple sites. This allows us to gauge how much open ground would have been available.

### *2 Emphasis of agricultural land use*

The dominant type of farming in the pollen catchment was determined using Turner's (1964) arable/pastoral index (API), which is the ratio of cereals and likely arable weeds to plantain (*Plantago*, excluding *P. maritima*), a common pasture weed. The index has been shown to work well as a means of establishing the emphasis of agricultural land use in a region (Pratt, 1996). The API had to be adjusted in two cases where anomalously high percentages of taxa classed as 'arable weeds' were likely to have other origins. As mentioned previously, this is particularly problematic for coastal/saltmarsh areas: Chenopodiaceae/Amaranthaceae (fat hen family) and *Artemisia* type (wormwood/mugwort) pollen includes common arable weeds, but also plants which grow in brackish conditions. This affects sites in the East Anglian wash/fens and the South-East and is taken into account in interpretation of the API. For the eleventh-century assemblage at Little Cheyne Court (Kent), the API was not applied as all the indicators point to brackish/marine conditions (Waller et al., 1999), while pollen records from Wiggenhall St Germans (Norfolk) and Hope Farm (Kent) were excluded from the analysis entirely, as conditions were evidently brackish/marine through the late Roman period onwards (cf. Waller, 1994; Waller et al., 1999).

Sidlings Copse has remarkably high percentages of another 'arable' type, Brassicaceae (mustard family). Many Brassicaceae are 'archaeophytes' – non-native species introduced deliberately or accidentally that became naturalized before *c.* AD 1500 – including arable weeds, vegetable and oil crops. However, there are also wild native Brassicaceae that grow in damp areas, hedgerows and on riverbanks (Stace, 2010, 385–425). Based on the pollen it is not possible to determine which types – or even how many different types – are present, but there are strong indications that most, if not all, of the Brassicaceae pollen at Sidlings Copse originated from local aquatic plants (Day, 1991, 463). Brassicaceae were therefore excluded from the API for this site.

Cereals are also included in the API and are obviously a key component of arable farming, but their pollen is problematic for several reasons. First, most cereals are self-pollinating and produce small amounts of large, heavy pollen that does not travel far from the plant (Edwards et al., 1986; Edwards and McIntosh, 1988), meaning they are often underrepresented in pollen assemblages. Second, threshing and other processing activities release pollen, so high percentages of cereal might reflect proximity to crop processing rather than crop fields (e.g., for on-site records). Third, definitive identification of oat, wheat and barley is impossible by existing methods (Andersen, 1979; Tweddle et al., 2005). Rye (*Secale cereale*) is usually identifiable by eye, but other cereals require measurement to separate them into *Avena-Triticum* type (oat/wheat) and *Hordeum* type, which includes barley and large grasses that grow in arable fields, but also large wild grasses that grow in wetlands and coastal areas. *Avena-Triticum* type is less problematic, though it includes wild oat (Andersen, 1979). Unfortunately, cereals are often recorded as a single group, 'Cereal type' or 'Cerealia', with no criteria for identification stated. Where criteria are given, they do not often match Andersen's criteria closely enough to establish an identification. Measurements, if recorded, are rarely published. It is therefore assumed that the FeedSax 'cereals/ large grasses' category encompasses oat/wheat and/or barley type pollen, including large wild grasses.[3]

3 It is possible that rye is also present in this group where it has not been identified separately, though unlikely as the pollen has a distinctive shape and can usually be recognized, if not by eye then by measurement.

Lyminge has remarkably high percentages of cereal/large grass pollen, resulting in a strongly arable API. However, as Maslin notes (2017, 7), seeds of wild oat (i.e., equivalent to *Avena-Triticum* type in the pollen record) were found at the site, and, as mentioned previously, cereal percentages at on-site sampling locations such as Lyminge are likely to be inflated by nearby crop processing (an early medieval threshing barn was identified at the site, for example: Thomas, 2013, 131) and potentially dumping of crop waste. For Lyminge, which is an extreme case, APIs were calculated with and without cereals/large grasses. This had a limited impact on the API (discussed below), so it is the former (with cereals) that is shown in the figures.

### *3 Agricultural land use signal strength (ALUSS)*

The API is useful as a measure of the relative importance of cultivation and grazing but does not convey any sense of scale or intensity of farming, meaning the amount of land being farmed/grazed, or the number of crop plants growing within a given area. This is because the API is based on a ratio. To give an example, a pollen sample with an abundance of cereal and arable weed pollen and far fewer pasture weeds would register as strongly arable in the index, but so would a sample with just one cereal but no pasture weeds. To counteract this, the percentage of pollen contributing to the API was calculated as a measure of the agricultural land use signal strength (ALUSS). It is important to note that for arable land, ALUSS does not necessarily equate to the amount of land used for farming. For a pollen assemblage from a single site, there is currently no reliable way to distinguish 'extensive' and 'intensive' cultivation (see Bogaard et al., 2016; Bogaard et al., this volume; Hamerow et al., 2020): both processes may result in a higher quantity of cereal plants and potentially crop weeds within the pollen catchment. Weed species associated with intensive and extensive cultivation differ, depending on ploughing methods/frequency and fertility (soils, manuring). These differences can be seen in archaeobotanical assemblages (Bogaard et al., 2016; Bogaard et al., this volume), but since many pollen types cannot be identified to species, or even genus, these subtler changes are often impossible to detect other than in rare cases (e.g., cornflower; see below).

Scale may be determined by comparison of pollen records from different sites in a region: if multiple sites have strong ALUSS values and arable APIs, it is more likely that cultivation was occurring on a large scale. Some regions have much better coverage spatially and chronologically than others, which has an impact on the reliability of interpretations.

***4 Diversity of key crops/weeds***
The final component of the analysis was the presence/absence of key crops and arable weeds, namely cereals/large grasses, rye, hemp/hops (Cannabaceae: *Cannabis sativa* and *Humulus lupulus*), flax (*Linum bienne* type),[4] and cornflower (*Centaurea cyanus*), which is a rare example of a crop weed that can be identified to species by its pollen. The appearance of these taxa suggests changes in agriculture through the introduction of – or a new emphasis on – different crops or farming techniques. In terms of new crops, these changes are likely to result from decisions made by farmers or through changes in land ownership. For example, the arrival of hemp or flax at a site might reflect the beginning of (or an increase in) local cloth/rope production. The cereals grown in an area might change because of changing demand for a certain crop, intended usage (baking, brewing, fodder, etc.) or environmental factors (e.g., rye copes better than other cereals on poorer soils). By contrast, the arrival and spread of cornflower was probably incidental, reflecting a change in the way cereals were cultivated. Interestingly, this plant is typical of low-input cultivation (Amy Bogaard, pers. comm.), so would be favoured by more extensive arable farming.

## Vegetation and agricultural land use in East Anglia, Essex/London, Central and South-East England

Major trends in vegetation and agricultural land use identified in this study are described below and shown in Plates IX–XI. It is important to be aware that, although data have been split into centuries, date ranges for individual pollen samples often extend into the preceding and/or succeeding centuries. Also, chronologies for the later periods tend to be more tentative owing to a lack of radiocarbon dates for the upper parts of pollen cores (see Table 1). It is encouraging to see that, although the pollen data themselves had no influence on the age-depth models, key shifts appear to have happened at similar times at multiple sites.

Plate IX shows the average percentages of broad pollen types in the four regional clusters from the fourth to fifteenth centuries. Data were averaged over 200-year periods because most of the sites had at least one sample every two centuries, reducing the 'noise' created by the intermittent presence of sites with very high or very low tree/shrub pollen. When 100-year blocks were used, this 'noise' created

4 The pollen of *Linum bienne* type includes both *L. usitatissimum* (flax) and *L. bienne* (pale flax) but is generally assumed to represent the former.

a false impression of repeated woodland clearance and regeneration, particularly in Essex/London (e.g., see tree/shrub pollen by site in Plate Xa). Sites with short-lived records were excluded, as were those expected to have very small catchments; almost all of the excluded sites were classed as on-site pollen records, reflecting local rather than wider regional vegetation.

As noted in previous large-scale analyses of pollen data from England, including *The Environment of Britain in the First Millennium AD* and *The Fields of Britannia*, the post-Roman to medieval period saw limited change in overall tree cover (Dark, 2000; Fyfe et al., 2013; Rippon et al., 2015; Rippon and Fyfe, 2019). Large-scale clearances occurred from the Bronze Age onwards, but by the late Romano-British period much of the landscape was already 'open'. The Central and East Anglian regions were largely open throughout the period analysed, showing low tree and shrub cover (Plate IX). Arboreal pollen percentages were higher on average in East Anglia, declining from the twelfth to thirteenth centuries onwards, a time at which there was an increase in trees in the Central region. The data from Essex/London and the South-East suggest noticeably higher tree and shrub cover in those areas, with a gradual decline over time in Essex/London.

In the South-East there was a substantial amount of heathland until the tenth to eleventh centuries, although this was mostly at one site in the Romney and Walland Marshes; the loss of heath after this date coincides with seawater flooding the area, curtailing the pollen record from Little Cheyne Court (Waller et al., 1999). It is possible that heath persisted further inland or on higher ground after this date, but it is not seen in the available pollen data. The only other site with substantial heathland vegetation was Brandon, Suffolk (Wiltshire, 1990) on the edge of Breckland (East Anglia), and then only in the sixth to seventh centuries; as mentioned previously, conditions are thought to have been cooler and wetter at this time (e.g., Blackford and Chambers, 1991), which might explain the localized spread of heathland.

Arable and pastoral types were included in Plate IX to give an impression of overall scale of agricultural land use; this is explored in more detail below in relation to ALUSS at individual sites (Plate XIb). Arable and, to a lesser extent, pastoral indicators are seen to increase over time in East Anglia and Essex/London, peaking in the fourteenth to fifteenth centuries. Both types are most common in the Central region in earlier periods, declining gradually after a peak in the eighth to ninth centuries, although this pattern is strongly influenced by the record from Oxey Mead and may not reflect changes in the wider region. By contrast, evidence for both types of land use is very rare in the records from the South-East, though higher in the tenth to eleventh and fourteenth to fifteenth centuries.

Plate X shows percentages of arboreal pollen at individual sites in 100-year blocks, with sites arranged west to east within each region. There is considerable variability between sites within the regions, and some sites have markedly higher tree/shrub pollen than average (e.g., Beckton (BK), Epping Forest (EP) and Pannel Bridge (PB)), but on the whole arboreal pollen percentages are low enough to suggest open landscapes. It is noticeable that, with few exceptions, more 'wooded' sites remain wooded throughout the period under study, while open sites remain open. The marked decline in tree cover at Little Cheyne Court (LC) in the tenth to eleventh centuries coincides with the aforementioned increase in heath and a shift to saltmarsh conditions, not long before the site was inundated (Waller et al., 1999). The on-site pollen records tend to reflect more open conditions than off-site records (Plate Xa). This indicates a lack of substantial tree cover close to settlements but may also reflect small catchment sizes of some sites, causing under-representation of trees/shrubs in the wider region.

Plate XI shows which types of agricultural land use dominate over time, arranged west to east within regional clusters as in Plate X. There is substantial variability, with no clear association between higher amounts of arable or grazing and different regions. In Plate XIa–c, showing agricultural land use type, ALUSS and presence of key crops and weeds, sites are rearranged according to whether farming appears to have been predominantly arable (left) or pastoral (right). Ordering the sites in this way (rather than by region) makes it easier to see correlations between land use type, ALUSS and crops/weeds, and to see broader trends through time. Key periods of change are discussed below.

### Fourth to fifth centuries: abandonment of farmland?

As mentioned previously tree/shrub cover is already low by the fourth century, with much of the landscape 'open' (as opposed to wooded) (Plates IX and Xa). There is relatively little change in tree cover going into the fifth century (Plate Xa). Minor increases occur at Oxey Mead (OM) in the Central cluster and Brandon (BR) in East Anglia, and there is a more substantial expansion of trees and shrubs at Little Cheyne Court (LC) in the South-East. The latter might represent a period of woodland regeneration, perhaps indicating neglect of former farmland. However, it is also possible that the increase in tree cover at this site reflects local environmental conditions: heaths increase, and the taxa responsible for most of the rise in arboreal pollen are *Alnus glutinosa* (alder) and *Corylus avellana* type. The latter is usually presumed to represent hazel, but could be bog myrtle: alder carr and myrtle may well have grown on expanding heathland/wetland. Another factor to consider is the inundation of nearby coastal areas by seawater at this time (Waller et al., 1999), potentially changing the catchment area of the site or flooding grassland/pasture; the weak fourth century signal for pasture at Little Cheyne Court disappears entirely in the fifth century (Plate XIa). Owing to limited data for this early period in the South-East, it is not possible to say whether these changes coincide with a decrease in agricultural land use in the wider region.

Agricultural land use in the fourth century is predominantly mixed, with some sites more arable and others more pastoral in nature (Plate XIa). Beckton (BK) and Lyminge (LY)[5] are both strongly arable according to their APIs, though removing cereals from the index calculation for Lyminge gives a mixed/arable API: this seems more likely as pasture weeds such as plantain and sorrel/dock (*Plantago* and *Rumex*) are common. The ALUSS in most areas is relatively strong but usually lower at sites where pasture is dominant (Plate XIa–b); this might suggest that grazing occurred on a small scale near those sites (e.g., Little Cheyne Court (LC), Pannel Bridge (PB), Sidlings Copse (SC)), while the overall amount of agricultural land was generally higher around sites with mixed and arable APIs (e.g., Lyminge, Beckton, Brandon). Cereals/large grasses are found in all regions and at the majority of sites, but hemp/hops and rye are only present at some East Anglian sites at this time (Plate XIc). Rye is more common in the Breckland area archaeobotanically (Smith et al., 2016, 400), perhaps owing to the suitability of this crop for sandy and unproductive soils.

In the fifth century there is a noticeable shift towards pasture at five sites, three of which are in East Anglia (Plate XIa), which bears out Murphy's observation about a post-Roman reduction in arable farming in the region (Murphy, 1994). Unfortunately, there are no fifth-century data for the two sites that were strongly arable in the fourth century, although Beckton is more mixed (i.e., more pastoral) by the sixth century. Most other sites see no change in emphasis, but the exception is Oxey Mead, which becomes much more arable. Changes in ALUSS vary, with some sites seeing an increase in activity and others a decline (Plate XIb). There is no clear pattern relating strength to type of agricultural land use for this period. No new

5 The date for Lyminge is tentative, but is Roman to early Saxon (Maslin, 2017).

crops/weeds appear and their overall representation does not change, though there are losses and gains at individual sites (Plate XIc).

To summarize, the overall picture for the fourth century is of a mostly open landscape, with both arable and pastoral land use widespread and a substantial amount of the landscape being cultivated/grazed. There were areas with strongly arable or strongly pastoral land use, but the majority of sites appear to have had forms of mixed farming at this time. This does not quite fit the picture built up for these regions by the *Rural Settlement of Roman Britain* project, which stressed the importance of arable in some areas, citing, amongst other evidence, the large number of corn dryers and the presence of weed seeds consistent with a spread onto poorer soils (e.g., Lodwick, 2017a, 82). By contrast, the method of calculating the extent of pasture and arable in the *Fields of Britannia* project tends to indicate a much larger proportion of the landscape being devoted to grazing than to cultivation (e.g., 6 per cent arable and 45 per cent 'improved pasture' in the South-East region: Rippon et al., 2015, 124–25). Looking at the data as a whole, it seems likely that farming was more mixed, with some areas seeing an expansion of arable, balanced by a spread of pasture in others. Although pollen is more suited than archaeobotany to sensing broad patterns of land use, it is important to note that the areas with the best-preserved archaeobotanical and zooarchaeological evidence are often poor areas for pollen preservation, and vice versa, so it is often impossible to make a direct comparison (see Hamerow, this volume).

Very few sites show an increase in tree cover in the fifth century and there is no indication of widespread regeneration of woodland/scrub in any of the regions, such as might occur if farmland was abandoned entirely. There is, however, an increased emphasis on pasture compared to the fourth century; as suggested by Gerrard (2013) and Rippon et al. (2015), a widespread desertion of agricultural land is unlikely given the lack of evidence for expansion of woodland/scrub, yet conversion of former crop fields to pasture would still prevent woodland regeneration. Two of the three sites with increased tree/shrub cover, and several of those where there is a shift towards pasture, are in East Anglia. Mixed farming continued in this region with cereals/large grasses, rye and hemp/hops present, but there does appear to be a reduction in arable land use, which might indicate a reduced need for crops at this time, as would be expected if grain was no longer being exported (see Lodwick, this volume). Although this pattern is clearest in East Anglia, it is important to note that almost half of the sites with data for both the fourth and fifth centuries are in this region. Similar shifts are seen at some sites in other areas, and it is possible that if more data were available for other regions, East Anglia would no longer stand out.

**Sixth to seventh centuries: small-scale mixed farming?**

In East Anglia, tree/shrub pollen is reduced at Willingham Mere (WM) and Redmere (RM) from the sixth century – this is likely to represent clearance of woodland/scrub in the region (Plate Xa). There are no significant changes in overall arboreal cover elsewhere (Plates IX and Xa). Agricultural land use is variable for this period. Some sites become more arable, some more pastoral, while at others there is continuity, but the overall trend is towards an increase in arable. By the seventh century there is a further shift towards arable at some sites, including previously pastoral sites that become more mixed. Changes in ALUSS are variable but, overall, sites where arable increases also tend to see an increase in ALUSS, while sites that become more pastoral see a decrease (Plate XIa–b), suggesting that arable land use was becoming more important. There are minor changes in the presence of key crops and weeds, with cereals and hemp/hops remaining relatively common and rye appearing at two sites (Plate XIc). Westbury-by-Shenley (WB) and Slough House Farm (SH) have very strong agricultural land use signals, particularly by the seventh century. These are both small-catchment, on-site records and may represent local cultivation, though as Hale (1995) points out for the former, crop processing is also a likely source of crop/weed pollen.

At Willingham Mere (WM) there is a drop in agricultural land use and a shift to pasture in the sixth century, with key crops and weeds disappearing. This coincides with a marked increase in sedges/reeds and meadowsweet (*Filipendula*) and a rare find of burnet (*Sanguisorba*), likely to arise from damp ground or possibly wet meadows close to the mere. This might indicate cooler/wetter conditions owing to the sixth-century climatic shift but could also reflect a drop in the mere's water levels, allowing reeds/sedges to colonize the margins (cf. Waller, 1994). There are no other clear signs of Late Antique Little Ice Age (LALIA – e.g., see Büntgen et al., 2016) changes in vegetation for the regions discussed here, and no obvious impacts on agricultural land use. This agrees with Rippon and Fyfe's suggestion that lowland areas would have been less strongly affected by this change in climate than upland regions (Rippon and Fyfe, 2019, 138). Peat macrofossil and other proxy climate records from Britain and Ireland that show cooler/wetter conditions at this time are predominantly from northern regions, peat bogs and upland areas that might be more sensitive to this type of change[6] than southern lowlands (e.g., Blackford and Chambers, 1991; Barber et al., 2003; Charman, 2010).

In summary, the type of agricultural land use was variable in the sixth to seventh centuries. Some sites became more arable, others more pastoral, although a shift to arable in some areas is combined with an increased ALUSS, which suggests that crop farming became more important overall. The degree of variability fits with the idea of relatively small farms practising mixed farming (cf. Banham and Faith, 2014), with the emphasis on crops or livestock varying from place to place. There are no clear impacts of the LALIA on either tree/shrub cover or agricultural land use in the regions covered by this paper.

**Eighth to ninth centuries**

The eighth century sees the first major change in agricultural land use across all regions. Small decreases in tree cover at multiple sites indicate clearance and there is a marked shift towards arable, with almost all sites having an arable or arable/mixed emphasis at this time (Plates Xa–b and XIa). There is also a widespread increase in ALUSS and higher diversity of key crops and weeds, with the appearance of cornflower at four sites and flax at Brandon (Plate XIb–c). Although cornflower appears earlier in archaeobotanical assemblages (McKerracher et al., in prep.), the eighth century seems to be a key time for its appearance in pollen records. This might reflect the increasing scale of arable land use, making weeds more likely to reach pollen sampling sites, but it is also possible that a change in farming techniques allowed cornflower to flourish. As mentioned previously, the functional ecological traits of cornflower indicate that it would be favoured by low-input cultivation, suggesting a shift to more extensive arable farming at this time (see also Bogaard et al., this volume). There is a further increase in arable at Oxey Mead, Willingham Mere and Brandon in the ninth century, though this is less marked than the eighth-century change and is not universal (Plate XIa). ALUSS increases at some sites and decreases at others, with no clear link between ALUSS and either arable or pastoral land use at this time (Plate XIb). Although there are differences in the data used and the approach to interpretation, the eighth century was also identified as a time of 'greater discontinuity' by Rippon et al. (2015, 335), citing an increase in agricultural land use and nucleation of settlements. To

6 Conversely, southern lowland regions might be more sensitive to increases in temperature and reductions in rainfall, e.g., causing drought.

this we can add an increased emphasis on arable and – as explained above – perhaps a more extensive type of cultivation, with larger areas managed less intensively.

### Tenth to eleventh centuries

The tenth century marks the start of another period of change, although its trajectory is less clear than the eighth-century shift. Most regions see no change in tree/shrub cover, but where they do, with the exception of East Anglia, there is a decline (Plate IX). However, there are notable increases in arboreal pollen at Redmere (RM), Sidlings Copse (SC) and Beckton (BK) (Plate Xa). Day identified oak woodland regeneration at Sidlings Copse, beginning around the tenth century and becoming more marked from the eleventh century (Day, 1991, 467). Although data for different arboreal taxa are not presented here, there are similar increases in oak at Beckton (Batchelor, 2009) and Redmere (Waller, 1994) from the ninth to tenth centuries onwards. In spite of a gradual decline in trees/shrubs at Redmere from the eleventh to thirteenth centuries, percentages of oak remain high, suggesting protection/management. Day suggests (1991, 467) that the increases at Sidlings Copse could have been caused by efforts to encourage this species, as oak was highly valued; it was protected nationally in later medieval and post-medieval periods because of its importance for shipbuilding (e.g., Kipling, 1974). By contrast, from the eleventh century onwards, overall tree cover at Epping Forest (EP) is reduced. This reduction might represent clearance within the catchment, but it is also likely to reflect woodland management, including use of the area as wood-pasture. As a royal forest, Epping was also subject to Forest Law, which may have led to an increase in deer grazing or browsing from the medieval period onwards (Grant and Dark, 2006, 10).

ALUSS increases at most sites in the tenth century, affecting both arable- and pasture-focused sites, which suggests an increase in both types of land use (Plate XIa–b). There is an overall shift towards pasture or mixed farming in comparison with the eighth to ninth centuries, though most of the strongly arable sites remain arable. Crops and weeds remain diverse, with flax appearing at Oxey Mead (OM) in the eleventh century (Plate XIc), though, as Greig notes (2004, 377), macrofossils of flax were found in earlier periods at Yarnton/Oxey Mead, so its arrival in the pollen record does not mark its introduction as a crop. Cereals/large grasses, hemp and cornflower remain widespread, although rye is less common by the tenth century and disappears by the eleventh century (Plate XIc). As mentioned previously, it is possible that rye was present at some of the sites where only 'cereal' is recorded but given its relatively distinctive shape this is assumed not to be the case. Significantly, rye is seen to vanish from sites where it was present in earlier periods (Plate XIc). This loss of rye might reflect a narrowing of the range of cereal crops grown at some sites. This is perhaps reinforced by the fact that rye is wind-pollinated and consequently might be expected to be better represented than oat, wheat or barley in the pollen record; wind-pollinated species tend to produce more pollen than self-pollinating plants and release it more readily.

The overall picture for the tenth to eleventh centuries is of an increase in agricultural land use, with both arable and pasture increasing. A minority of sites became more pastoral at this time, resulting in a slight shift to pasture overall, and rye appears to have become less common. Arboreal pollen declined, suggesting further clearances in some regions, while elsewhere woodland management may have been responsible for localized increases in oak.

### Twelfth to fifteenth centuries

Data are patchy for this period and dates are generally tentative, as there are rarely direct dates for the later medieval/post-medieval sections of pollen cores. There is little or no change in tree/shrub cover at most sites, but a marked twelfth-century decline is apparent at Welney Washes (WW), followed by a gradual recovery (Plate Xa). This coincides with an arable/mixed farming signal and the most diverse phase for crops and weeds at the site, with cereals, hemp/hops and cornflower present (Plate XIa and c), suggesting clearance for cultivation. A substantial decline in arboreal pollen at Beckton (BK), and a slight increase in open ground at Pannel Bridge (PB), also indicate clearances by the fifteenth century. This coincides with a marked increase in ALUSS at both sites and the reappearance of cornflower at Beckton (Plate XIb and c); a rare example of cornflower occurs in the late Iron Age/early Romano-British period at the site, after which it disappears until the fifteenth century.

There is a drop in agricultural land use and arable diversity in the twelfth to thirteenth centuries. The decline is exaggerated by the low number of on-site records covering this period, which has an impact on the measure of arable land use in particular, yet the reduction in diversity is notable. Hemp/hops and cornflower are present at fewer sites and – as in the eleventh century – rye is not recorded in any of the studies (Plate XIa–c). Cereals/large grasses are still common, being present at all sites bar Epping Forest (EP). This might suggest

– albeit tentatively, given the data available – a reduction in arable or a shift from more to less diverse ranges of crops growing in some areas. This trend in the pollen data will be examined in more detail in publications examining the national picture, in comparison with archaeobotanical records which provide more direct evidence of crop types (Hamerow et al., in prep.).

For the pollen sites discussed here, there is no clear signal associated with the Great Famine or the Black Death in the fourteenth century. Expected impacts might be a decline in agricultural land use, particularly arable, as the population fell dramatically, and an increase in tree/shrub cover as abandoned farmland was recolonized. In the early fourteenth century, cattle and sheep were depleted by disease (Thomas et al., 2013), but by the later fourteenth century there was a renewed emphasis on pastoralism owing to livestock management being less labour intensive than crop farming, and as the lower demand for grain freed up arable land for grazing (Hopcraft, 1994; Thomas, 2005). It is important to note that this period is poorly represented by pollen data for the regions discussed here; only four sites have data covering both the thirteenth and fourteenth centuries, and none of those continues into the fifteenth century. Of the four sites with continuous data, two see a slight increase in tree/shrub pollen in the fourteenth century, at one site there is no change, and at the fourth trees/shrubs decrease (Plate Xa). Only one site sees a shift towards mixed, more pastoral farming (Coleman's Farm: CF), and – surprisingly – the ALUSS increases at three out of four sites (Plate XIa–b).

Coombes et al. (2009) also saw little evidence of a fourteenth-century decline in pollen and geochemical data from Hulleter Moss, Cumbria; they suggest that, although populations fell, most communities in the area were not destroyed completely, meaning that some arable farming continued. They also hypothesize that grazing pressure prevented significant woodland regeneration, which is likely given the increase in livestock farming. These factors may apply to some of the pollen sites discussed here, although if arable farming declined on a large scale, we should be able to see this when looking at pollen on a regional level; clearer patterns may emerge in the national dataset, within which there are a larger number of records spanning the thirteenth to fifteenth centuries (Hamerow et al., in prep.).

## Summary

Although data for some regions and periods are limited, it has been possible to build up a picture of vegetation and agricultural land use through time, and to identify key periods of change from AD

300–1500. Plate XII summarizes the data for all sites combined. As seen in Plate XIa–c, there are marked differences between sites that had high and low tree/shrub cover, and between those dominated by arable, mixed and pastoral farming. In order to avoid conflating evidence from very different site types, in Plate XII data are grouped for open, semi-open and wooded sites under tree/shrub cover, and for arable, mixed and pastoral sites under agricultural land use. As discussed previously, the landscape was broadly open by the late Roman period and percentages of arboreal taxa were low at most sites. Agricultural land use was mixed, but varied across the regions, with Central sites more pastoral, and a mixed arable/pasture farming signal in East Anglia. Essex/London and the South-East have limited data for this period, but where evidence for agricultural land use (i.e., ALUSS) is strong, sites were focused on arable or mixed/arable farming. There was a slight increase in trees/shrubs at both open and wooded sites in the fifth century (Plate XII), though, as others have noted (e.g., Rippon et al., 2015), there is no evidence for widespread post-Roman woodland regeneration. Although there is variability, overall land use for farming was reduced in the fifth century and there was an increase in the importance of grazing (Plate XII). Site-level data indicate a shift to grazing in East Anglia in particular, suggesting that some arable land may have been converted to pasture in this area.

Agricultural land use trends during the sixth to seventh centuries were variable. A reduction in tree/shrub cover (Plate XII) was caused mainly by woodland/scrub clearance at two East Anglian sites, though this was not seen elsewhere. At some sites, mainly those classed as ‘arable’, there was a shift from mixed farming towards cultivation at this time, while at other site types there was continuity or a spread of pasture. ALUSS recovered to fourth-century levels following the drop in the fifth century (Plate XII), although again this varied from site to site (Plate XIb). Key crops and weeds became more widespread overall, with rye appearing at Oxey Mead and Brandon, perhaps suggesting an expansion of the types of cereal cultivated (cereal-type pollen was already present at both sites). At other sites, cereals disappeared entirely (Plate XIc). These differences might suggest a landscape divided between small farms doing different things, which is compatible with the view that farming was mixed arable/pastoral and relatively small-scale at this time. There is no clear evidence for a large-scale impact of cooler/wetter LALIA conditions on vegetation or land use in the regions discussed here. It is quite likely that this shift was more pronounced in the north and west of England, where average rainfall is higher and there are large areas of upland; this will be addressed in other FeedSax publications focusing on both those regions and the national picture (Hamerow et al., in prep.).

The eighth century was a period of significant change across all of the sub-regions considered here. Both arable and pastoral land use increased, but with a particular emphasis on cultivation, resulting in sites classed as 'arable' becoming strongly arable and 'mixed' sites becoming mixed/arable (Plate XII). Many sites saw an increase in cultivation and became more diverse, with cornflower appearing in three regions, suggesting more extensive, low-input cultivation, while flax appeared in East Anglia. The scale of agricultural land use also increased (Plate XII). These changes suggest a widespread increase in arable farming and potentially the adoption of new, low-input farming practices, corresponding with the appearance of crop processing and storage infrastructure in the 'long eighth century' (Hamerow, this volume).

Oak woodland began to recover at some sites from the ninth to tenth centuries onwards (Plate XIa), perhaps encouraged by forms of woodland management that favoured oak, and later by Royal Forest designations. At some sites there was a further increase in agricultural land use at this time, but this was countered by a reduction at others; as Plate XII shows, although ALUSS remained high in the tenth century, there was no increase overall, and the eleventh century actually saw a marked decline. At sites where there was an increase, this affected both arable and pasture – although, as Plate XII shows, there was a slight shift towards mixed arable/pastoral farming with an increase in pasture. Key crops and weeds remained widespread, though less so than in the eighth century. In terms of the impact on pollen assemblages, the tenth-century shift was less marked and less focused on arable than the eighth-century expansion. It is possible that the warmer conditions caused by the MCA played a role in this continuing growth of farming, but, as discussed by Hamerow, Holmes and others in this volume, this period also saw wider changes in farming techniques and landholding.

Pollen records for the twelfth to fifteenth centuries are patchy in the regions discussed in this paper, and chronologies are less reliable than for the fourth to eleventh centuries. This is problematic when interpreting data for all sites combined, requiring caution: for example, Plate XII shows a disappearance of heaths from the twelfth century onwards, yet as Plate XIa–c shows, this is caused by the termination of pollen records close to heathland (i.e., Brandon and Little Cheyne Court), rather than a genuine loss of this habitat type. Although the data are limited, it is possible to see further increases in agricultural land use in some areas, including examples of woodland clearance by *c.*1500. Other sites saw a drop in arable and a loss of crop/weed diversity in the pollen record, although the low number of on-site records for this period is an important factor here. The data available reveal no clear impacts associated with the fourteenth-century Great Famine or the Black Death, such as widespread woodland regeneration or a reduction in arable land, but this may be due to a lack of data rather than a lack of impact.

It is perhaps surprising that few clear regional differences have emerged. The timing of key shifts is furthermore similar in most places. Looking at the late Roman to medieval period as a whole, there was a general shift from more pastoral and mixed farming to more arable farming over time. Trends varied between sites and did not always continue in the same direction, but the sites with strongly arable pollen records in the earliest periods usually remained arable or mixed/arable throughout. Similarly, sites with more pastoral land use in the earliest phases tended to remain broadly pastoral. Overall agricultural land use also increased, although not in a continuous expansion; the spread was more noticeable in the off-site records than those from on-site locations, as the latter were predominantly arable, small-catchment sites with high levels of agricultural land use from the earliest periods onwards. Although off-site records usually come from wetlands/heath that were (presumably) more suited to rough grazing than cultivation, pollen of crop types and weeds from the surrounding landscape is often present. Off-site records may underestimate arable land use, particularly because of the problems of cereal pollen dispersal discussed earlier, but unlike on-site records they are unlikely to be affected by nearby crop processing; both types of pollen site are liable to be biased but considering them together we can build up a more coherent picture of the landscape.

Where arable expanded at the expense of pasture, it seems likely that livestock would have been moved further afield or grazed on land that was deemed unsuitable for cultivation, such as heaths and uplands. As seen in Plate IX, of the four regions covered here, only the South-East has significant heathland according to pollen data alone; Romney and Walland Marshes show little evidence of farming overall and are broadly pastoral, suggesting these areas may have been grazed as they are today. As mentioned previously, most of the pollen sites discussed here are relatively low-lying, and the regions they represent do not include significant uplands; most land within the study area is below 150 metres OD (Plate VIII). However, two of the higher-altitude sites, Sidlings Copse and Epping Forest, were markedly more pastoral than lower-lying sites nearby. This might indicate that higher ground was more commonly used for grazing in these regions. Hay meadows may also have been a source of grazing or fodder, although distinguishing these habitats from the natural vegetation in an alluvial area or wetland through pollen data is problematic.

**Conclusions**

For the sites and regions discussed in this paper, much of the late Romano-British landscape appears to have been open, with a mixture of arable and pastoral farming under way and a relatively strong land use signal. The early post-Roman period shows limited evidence for woodland/scrub regeneration, and – in agreement with previous studies (e.g., Rippon et al., 2015) – farmland does not appear to have been abandoned on a large scale. There are, however, signs of a reduction in overall agricultural land use and a shift towards pasture in some areas, suggesting that former arable land was grazed.

There is variability in the scale and type of agricultural land use across the regions discussed here through the post-Roman to medieval periods, yet there are clear shifts towards an increase in arable, and in the extent of agricultural land use as a whole, around the sixth century and – more noticeably – the eighth century. Although forms of mixed and pastoral farming continued, there was an increased emphasis on arable at this time; as the overall signal for agricultural land use also increased, it is difficult to gauge how much former pasture was cultivated, but it is likely some arable was converted to pasture. Beyond the eighth century the picture is less clear, but there was a further increase in agricultural land use – this time in both arable and pasture – around the tenth century, with a high diversity of crops/weeds continuing. The eleventh to thirteenth centuries saw an overall drop in agricultural land use and a reduction in the diversity of arable pollen types present. This pattern is partly influenced by the lack of data from on-site records; but even accounting for this factor, there is a decline, and the drop in diversity of crops/weeds appears to hold. Although limited and patchy, the data available for the fourteenth and fifteenth centuries suggest a resurgence of both types of agriculture, with sites more likely to be weighted towards arable or pasture than mixed farming in comparison with earlier periods.

This analysis has shown the value of bringing together pollen records from a wide variety of sites in order to gauge changes in agricultural land use. Within individual pollen records there is often considerable variability but looking at data from multiple sites and using the methods employed here, we have been able to highlight key changes across central, eastern and south-east England. On-site records played an important role in building up the overall picture of vegetation and land use for farming, particularly in those areas where preservation is poor and off-site records are lacking. However, they also provide a valuable insight in areas with better pollen coverage, where they provide a snapshot of activity closer to settlements. Well-dated, high-resolution pollen sequences are crucial for understanding past vegetation and land use, helping us to contextualize archaeobotanical data within the wider landscape, but also to test assumptions based on archaeological and textual evidence.

# 5 Innovation, Technology and Social Change: The Adoption of the Mouldboard Plough and Its Impact on Human–Animal Relationships

*Matilda Holmes*

## Introduction

One of the primary aims of the zooarchaeological analysis undertaken by the FeedSax project was the identification of changes in cattle husbandry that may indicate increased draught use. This was characterized in two major ways: the first using evidence for an increase in older, male cattle, and the second recording bone deformations in cattle feet.

Male cattle have limited intrinsic value beyond providing meat, while females are also useful for milking and breeding. Females can also be used for draught purposes, and on smaller farms where there are only enough resources or space for one working animal, this may have been a shrewd choice (Johannsen, 2011, 15). Nonetheless, numerous medieval texts refer to plough animals as oxen (castrated males), and the greater size attained through the delayed long bone maturation caused by castration would have produced larger, stronger animals capable of generating more power than cows, while being easier to handle than bulls. The disarticulated animal remains

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commonly recovered on archaeological sites do not often allow for identification of complete individual animals, so analysis has focused on demographic profiles at the site/phase level. The presence of older, male cattle provides a good indicator of the use of draught oxen. Work undertaken as part of the FeedSax project has established a steady increase in older cattle from the seventh century, which plateaus in the eighth century, coinciding with an increase in males (although females remain dominant). The age of cattle peaks in the tenth century, further indicating that these may have been periods of agricultural change related to an increased emphasis on secondary products, including traction (Holmes et al., forthcoming).

The second area of investigation concerns the observation of pathological and sub-pathological changes to cattle feet associated with the use of animals for traction (Bartosiewicz et al., 1997; Thomas et al., 2021). Results suggest that there was an increase in changes associated with traction use from the mid-ninth century, which is probably linked to increasing draught use, but this became more pronounced from the mid-eleventh century (Hamerow et al., in prep.).

So far, zooarchaeological analysis has provided the FeedSax project with evidence for a gradual increase in production from the seventh century, and specifically the use of draught cattle from the mid-ninth century. To date, little consideration has been given to the nature of draught cattle use and how it was applied throughout the country. This chapter provides an opportunity to look in more detail at these areas, and in particular to consider:

1. What form did draught cattle use take in medieval England? What were they used for? What characterized a draught animal? How long did they work for?
2. Was the use of draught cattle influenced by external factors? Did differences in geology or topography affect their use? Were there regional differences?
3. How did these factors affect the social structure and place of cattle in medieval agriculture?

**The dataset**

The FeedSax project has produced a considerable quantity of zooarchaeological data from a reanalysis of assemblages from 19 'targeted' sites (Figure 17; Table 2). Sites were included that generated large assemblages of animal bone, reliably dated between AD 400 and 1400. Some sites had two or more assemblages, one for each phase of occupation (Table 2). Reanalysis included the detailed recording of the following zooarchaeological attributes:

1. Pathological and sub-pathological changes to cattle feet (metapodials and phalanges) based on an existing system used to identify draught cattle (Bartosiewicz et al., 1997), modified to remove age-related data (Thomas et al., 2021) and to allow the use of fragmentary metapodials (Carlson Dietmeier, 2018). Analysis produced a modified pathological index (mPI) for each anatomical element, which is a score of deformation ranging from 0, meaning no change, to 1, denoting the most severe possible change (Holmes et al., 2021c). Only assemblages with at least five elements were included.
2. Wear stages of cattle mandibles (Jones and Sadler, 2012a; 2012b). These provide mortality data allowing a comparison of the age profiles of cattle populations at each site. Wear stages range from A (perinatal) to K (elderly).
3. Measurements of metapodials. These were used to identify the presence of male and female animals (Davis et al., 2012).

**'Draught cattle' signature**

Three potential indicators for draught cattle at each targeted site were identified from the analysis of foot bones, the presence of at least two of which was considered to constitute a 'draught cattle' signature (Figure 18; Holmes in Hamerow et al., in prep.). Cattle naturally carry most of their weight over the forelegs, so anatomical elements from this part of the carcass will usually have higher mPI scores than those from the hindlegs; the latter therefore have greater potential for reflecting activity-related changes (Bartosiewicz et al., 1997, 61). High mPI scores from hind limb elements are likely to represent draught animals and this is the first indicator used to identify individual draught cattle (Figure 19). The second indicator comes from the presence of high mean posterior scores from all elements in an assemblage, which indicates that either several animals within a population were worked hard, or many animals were used for lighter traction duties. The third indicator derives from a comparison of the mean values for all hind and fore limb elements from a site, to provide a marker of the relative load on the hind limbs within a population (as in Figure 2). The term 'draught cattle' signature is used throughout this chapter between single quotation marks to emphasize that it denotes only the *potential* for draught cattle to be present, rather than offering a definitive interpretation.

**Table 2 Summary data for the targeted sites subjected to reanalysis**

| N | Site | Phase | Mid-point | Site type | 'Draught cattle' signature | Geology | Height | Region |
|---|---|---|---|---|---|---|---|---|
| 1 | Barking Abbey, Essex | 1066–1200 | 1133 | ecclesiastical | Y | valley terrace | < 10m | South-East |
| 2 | Bow Street, London | 600–750 | 675 | urban | | valley terrace | 10–50m | South-East |
| 3 | Collingbourne, Wiltshire | 700–900 | 800 | rural | | chalk | > 100m | South-East |
| 4 | Cook Street, Southampton | 650–875 | 763 | urban | Y | valley terrace | < 10m | South-East |
| 5 | Eynsham, Oxfordshire | 500–650 | 575 | rural | | clay | 50–100m | Central Zone |
| | | 650–850 | 750 | ecclesiastical | | | | |
| | | 1066–1300 | 1183 | ecclesiastical | | | | |
| | | 1200–1330 | 1265 | ecclesiastical | | | | |
| 6 | Flaxengate, Lincoln | 870–1090 | 980 | urban | Y | clay | 50–100m | Central Zone |
| | | 1060–1200 | 1130 | urban | Y | | | |
| | | 1200–1400 | 1300 | urban | Y | | | |
| 7 | French Quarter, Southampton | 900–1066 | 983 | urban | | valley terrace | < 10m | South-East |
| | | 1066–1250 | 1158 | urban | | | | |
| | | 1250–1350 | 1300 | urban | Y | | | |
| 8 | Lyminge, Kent | 400–700 | 550 | rural | | chalk | > 100m | South-East |
| | | 600–850 | 725 | ecclesiastical | | | | |
| | | 1100–1300 | 1200 | high-status | | | | |
| 9 | Market Lavington, Wiltshire | 400–700 | 550 | rural | Y | clay | 50–100m | Central Zone |
| | | 1100–1300 | 1200 | rural | | | | |
| 10 | Quarrington, Lincolnshire | 450–650 | 550 | rural | Y | clay | 10–50m | Central Zone |
| | | 650–900 | 775 | rural | Y | | | |
| 11 | Ramsbury, Wiltshire | 750–850 | 800 | high-status | | chalk | > 100m | South-East |

| N | Site | Phase | Mid-point | Site type | 'Draught cattle' signature | Geology | Height | Region |
|---|---|---|---|---|---|---|---|---|
| 12 | Sedgeford, Norfolk | 650–875 | 763 | rural | Y | chalk | 10–50m | East Anglia |
| | | 800–1025 | 913 | high-status | | | | |
| 13 | Stafford | 1100–1300 | 1200 | urban | | valley terrace | 50–100m | Western Lowlands |
| 14 | Stoke Quay, Ipswich | 700–875 | 788 | urban | | valley terrace | 10–50m | East Anglia |
| | | 825–1100 | 963 | urban | | | | |
| | | 1050–1200 | 1125 | urban | Y | | | |
| | | 1150–1500 | 1325 | urban | | | | |
| 15 | Stratton, Bedfordshire | 400–600 | 500 | rural | | valley terrace | 10–50m | Central Zone |
| | | 600–850 | 725 | rural | | | | |
| | | 850–1150 | 1000 | rural | | | | |
| | | 1150–1350 | 1250 | rural | Y | | | |
| 16 | Trumpington, Cambridgeshire | 700–850 | 775 | rural | | clay | 10–50m | South-East |
| | | 850–1066 | 958 | rural | Y | | | |
| 17 | Wallingford, Oxfordshire | 900–1075 | 988 | urban | Y | valley terrace | 50–100m | Central Zone |
| | | 1025–1175 | 1100 | urban | Y | | | |
| 18 | West Fen Rd, Ely | 825–1150 | 988 | rural | Y | clay | 10–50m | East Anglia |
| | | 1100–1200 | 1150 | rural | Y | | | |
| 19 | West Parade, Lincoln | 1050–1300 | 1175 | urban | Y | clay | 10–50m | Central Zone |
| | | 1275–1375 | 1325 | urban | Y | | | |

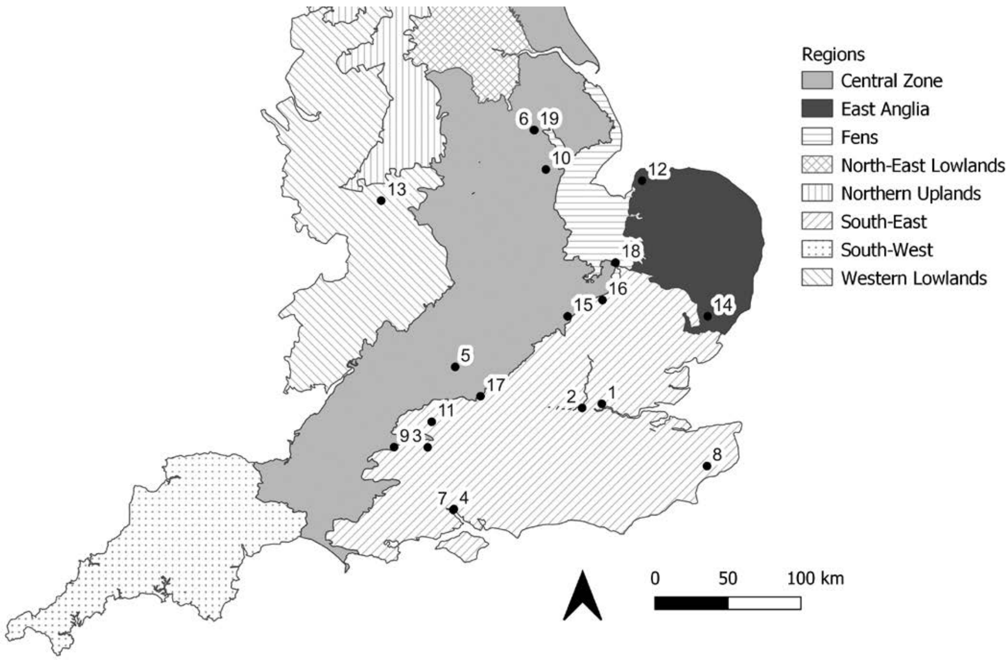
N = location number on Figure 17
Y = present
Proto-urban *wic* sites, active in the seventh to ninth centuries, are here classed as 'urban' for ease of comparison and to distinguish them from contemporary rural and high-status sites (cf. Naylor, 2016).

### Data analysis

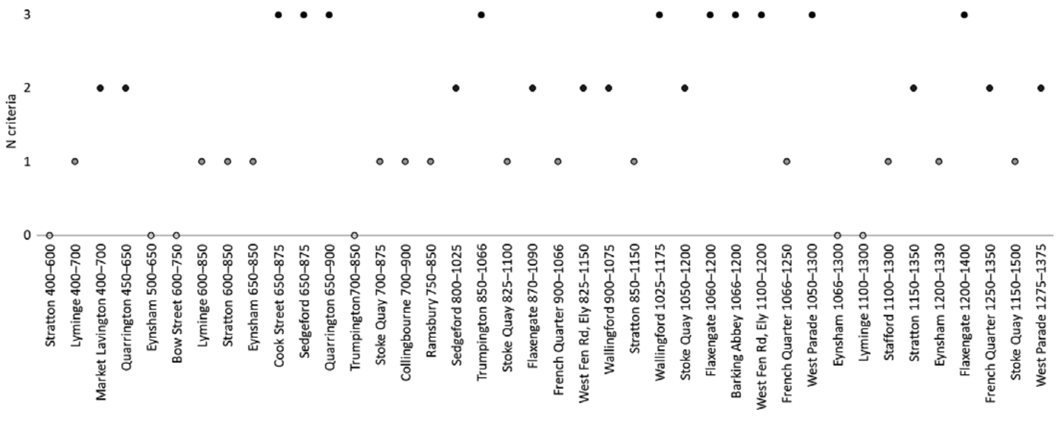
The zooarchaeological data were compared to several site-specific variables that may be expected to affect the level of draught cattle use, all of which are detailed in Table 2.

- Height of the site above ordnance datum (OD).
- Underlying geology, classified as clay (including any mixture of chalk, sand or gravel with clay), chalk and valley terrace (sand, gravel and/or alluvium), based on Rippon et al. (2014).
- Regions were defined by Rippon et al. (2014; 2015).
- Site type: urban (including *wics*), rural and ecclesiastical or secular elite (high-status), as described in respective site reports.

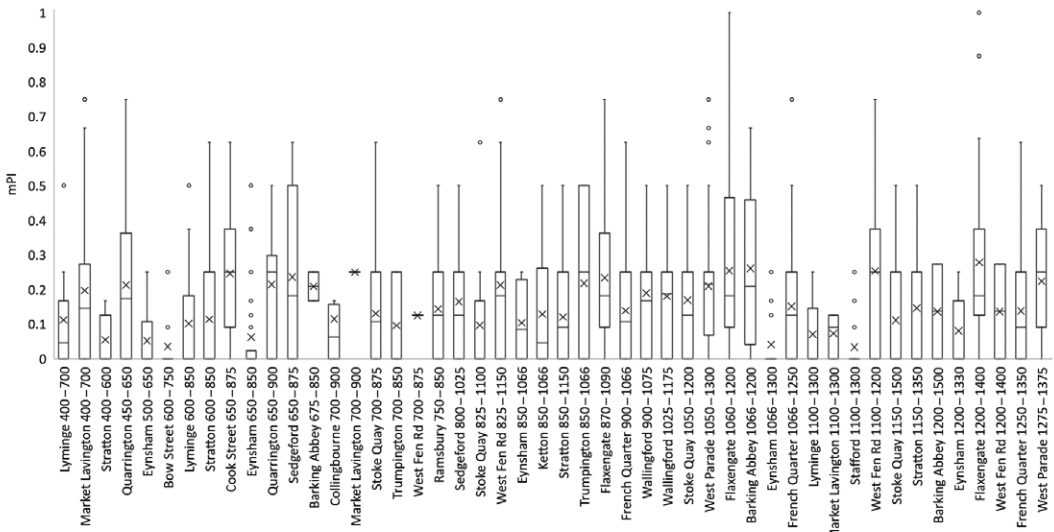
Statistical analysis was performed using PAleontological STatistics (PAST) (Hammer et al., 2001).




17 Location of all targeted sites (numbers correspond to sites described in Table 2). Regional divisions by Rippon et al. (2015). Map created with QGIS (http://www.qgis.org; accessed 08/03/2022).




**18** Zooarchaeological assemblages reanalysed for the FeedSax project in order of the phase mid-point, showing the number of draught cattle criteria they met. The identification of a 'draught cattle' signature is based on the site meeting two or three of the criteria (high mean posterior pathological index; similar mean anterior and posterior scores; and/or individual cattle with high scores for posterior pathological index).




**19** Box and whisker plot representing individual modified pathological index (mPI) scores for posterior elements at each site. × = mean value; ◦ = outlying values; 1 is the maximum mPI score and denotes the greatest level of pathological or sub-pathological change. Elements with values greater than the overall mean (represented by the line) are considered to be from animals likely to have been subjected to intensive or sustained loading as in draught work.

### Use of draught cattle in medieval England

Although the FeedSax project is explicitly interested in evidence for the use of the mouldboard plough, in reality it is impossible to identify the specific use of this implement from a 'draught cattle' signature. Nonetheless, the presence of this signature demonstrates the use of cattle for draught work in general. Documentary evidence for the uses of cattle during the period produces an impressive list of jobs. They were involved in preparing the ground for planting, pulling ploughs, ards and harrows, as well as moving produce in carts and for logging.

The *Anglo-Saxon Chronicle* mentions the use of the plough in AD 877, in relation to the land given to the Viking army in Northumbria (Whitelock, 1996, document 1, 1). Plough teams of eight oxen are a common basis of measurement in the Domesday Book (Fussell, 1966, 181), and one of the earliest explicit mentions of cattle pulling a plough comes from Aelfric's Colloquy written in the late tenth century, where the ploughman describes yoking the oxen to the plough (Swanton, 1975, 108). Yet the types of implement being pulled remain obscure, as these accounts may be referring to an ard or a mouldboard plough. The earliest written mention of a mouldboard comes from Riddle 21 in the Exeter Book, probably dating from the later tenth century. Archaeological evidence for the ard has been recovered from Neolithic Europe and this technology would have been widespread in medieval England (Rowley-Conwy, 1987). Ards cut the earth and break up clods, but the ability to turn the soil to form ridges and furrows only came with the addition of a mouldboard, and this is what defines a plough (Fussell, 1966). Archaeological finds of ploughs themselves are ambiguous, as coulters and shares (used to cut the earth) can potentially be used on ards and mouldboard ploughs alike; good descriptions of the problems involved in their identification, and arguments for their dates of use in Britain, are available elsewhere (e.g., Banham and Faith, 2014; Fowler, 2002). Artistic depictions of ards are common in medieval documents, but heavy ploughs are not represented until the tenth or eleventh centuries; it is believed that they were common throughout England by the eleventh century (Banham and Faith, 2014, 49). No unambiguous physical evidence for medieval mouldboard ploughs has been found to date, potentially because mouldboards would not survive well, and those made of metal would most likely have been recycled once damaged. Some large metal coulters have been recorded throughout the period, which compare favourably with those likely to be found on a heavy plough (Thomas et al., 2016), but it is also possible that they came from a large ard. Similar problems in identifying ards and heavy ploughs from coulters have been described for Roman finds (Brindle, 2017, 42; Lodwick, this volume). Nonetheless, finds of medieval coulters likely to come from mouldboard ploughs have been found in England. The earliest is a seventh-century find from Lyminge, Kent, but others come from Buckden, Cambridgeshire (eighth- to ninth-century), Scraptoft, Leicestershire (tenth-century) and Alnhamsheles, Northumberland (fifteenth-century) (Connor and Billington, 2021; Leahy, 2013; Standley, 2020; Thomas et al., 2016).

Documentary evidence from the Domesday Book and into the twelfth century implies the use of a standard team of eight oxen to a plough on estate land, although peasant farmers were recorded with fewer (Trow-Smith, 1957, 68–70, 90). Cattle were not just used for ploughing but would also have been required to pull harrows and carts. Reference is made in the early twelfth-century *Survey of Manors of the Abbey of Peterborough* to the requirement of sokemen to harrow in spring, winter and autumn (Douglas and Greenaway, 1996, document 177, 4, 1). Documentary evidence for cattle pulling carts comes from Domesday descriptions of tolls payable on salt, where the size of the cart was linked to the number of oxen pulling it (Douglas and Greenaway, 1996, document 210, 4, 2). By the thirteenth century, Walter of Henley describes the waggoner as being in charge of horses, not cattle, which suggests that by this point cattle were less often used for carting, as horses gradually became more common within agriculture (Cunningham and Lamond, 1890, 111; Langdon, 1986).

Cattle were raised for other purposes too; males that were not used for traction would be kept purely for beef as 'grazing' or 'stalled bullocks', while cows were important for breeding and/or milk production (Trow-Smith, 1957, 58). Cows were probably milked at a household level, with milk being available on a seasonal basis, and it is widely considered that sheep would have provided the bulk of the milk required for much of the period (Campbell, 2000, 154; Grant, 1988, 155; Ryder, 1983, 455; Trow-Smith, 1957, 58). Historians have calculated that, at the time of the Domesday survey in 1086, the number of cows recorded was insufficient to indicate that dairy production was carried out on a large scale, with the exception of a few farms in the southwest and at isolated locations elsewhere in England (Trow-Smith, 1957, 73). The zooarchaeological data suggest a far higher proportion of cows: almost 80 per cent of metacarpals from the Domesday period have been identified as female (Holmes et al., forthcoming). The importance of dairy cattle increased from the twelfth century, but the documentary evidence suggests that cattle remained of prime importance for draught and breeding, and sheep remained the milk animal of choice into the fourteenth century (Trow-Smith, 1957, 125). Neither beef cattle nor dairy/breeding cows would be expected to display deformations of foot bones similar to those observed on draught cattle, as pathological and sub-pathological changes to non-draught cows and beef cattle foot bones were significantly lower than those observed on draught cattle in a study undertaken by Bartosiewicz et al. (1997).

**Table 3 Proportion of targeted sites with 'draught cattle' signatures by external variables**

| Phase | Draught cattle | Non-draught cattle | Total | Sites with a 'draught cattle' signature (%) |
|---|---|---|---|---|
| 450–650 | 2 | 3 | 5 | 40 |
| 650–850 | 3 | 8 | 11 | 27 |
| 850–1066 | 4 | 4 | 8 | 50 |
| 1066–1250 | 7 | 5 | 12 | 58 |
| 1250–1400 | 3 | 2 | 5 | 60 |
| **Height above OD*** | **Draught cattle** | **Non-draught cattle** | **Total** | **% draught cattle** |
| < 10m | 1 | 0 | 1 | 100 |
| 10–50m | 7 | 5 | 12 | 58 |
| 50–100m | 1 | 5 | 6 | 17 |
| > 100m | 0 | 5 | 5 | 0 |
| **Geology*** | **Draught cattle** | **Non-draught cattle** | **Total** | **% draught cattle** |
| Clay | 6 | 6 | 12 | 50 |
| Valley Terrace | 2 | 3 | 5 | 40 |
| Chalk | 1 | 6 | 7 | 14 |
| **Region** | **Draught cattle** | **Non-draught cattle** | **Total** | **% draught cattle** |
| Central Zone | 11 | 8 | 19 | 58 |
| East Anglia | 4 | 4 | 8 | 50 |
| South-East | 4 | 9 | 13 | 31 |
| Western Lowlands | 0 | 1 | 1 | 0 |
| **Site Type** | **Draught cattle** | **Non-draught cattle** | **Total** | **% draught cattle** |
| Urban | 10 | 7 | 17 | 59 |
| Rural | 8 | 9 | 17 | 47 |
| Ecclesiastical | 1 | 4 | 5 | 20 |
| High-status | 0 | 2 | 2 | 0 |

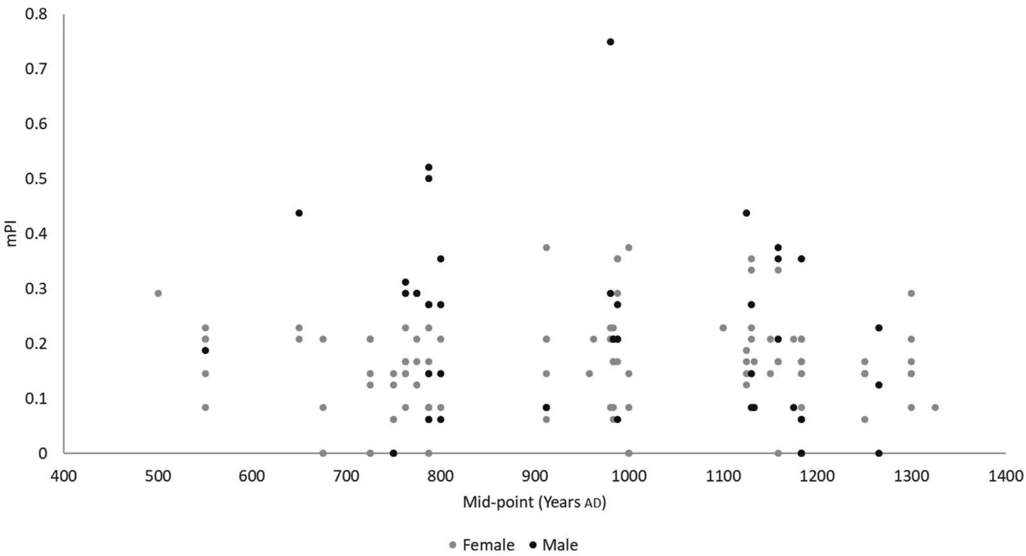
* not including urban sites

Even though it is not possible to tell what specific jobs draught cattle undertook, settlements with a 'draught cattle' signature can be observed throughout the period (Figure 18; Table 2). There was an increase in the number of sites with 'draught cattle' signatures from the mid-ninth century, and such sites are in the majority from the mid-eleventh century (Table 3). When the individual pathological index scores are plotted, it is notable that most sites included cattle that produced low scores well below the mean for the site (Figure 19). These animals would have been subject to loading to a lesser degree, whether because they were used for only a short period, sporadically, pulled lighter loads, or worked as part of a larger team. They may, for example, represent cattle used for harrowing, carting, or with ards on light soil, rather than a heavy plough with a coulter and mouldboard (see also Kropp, this volume).

## Characterizing draught cattle

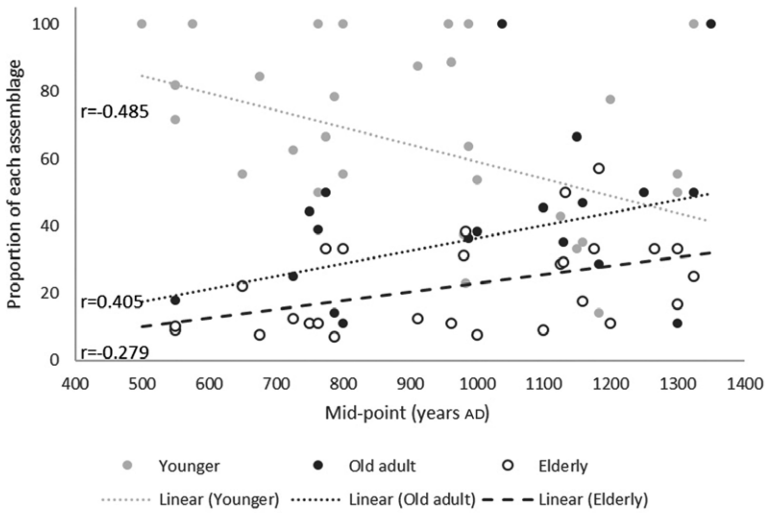
Historically, draught cattle are assumed to have been castrated males (oxen), subject to several years training and worked until old (Campbell, 2000, 120–21; Fowler, 2002, 222). However, there is little explicit historical evidence to support this, and when ethnographic evidence is considered, there is good reason to be more circumspect. In a comprehensive ethnographic study, Johannsen (2011) describes some of the common working practices of modern draught cattle. He notes that, despite modern farmers preferring to use oxen, cows are also utilized in many parts of the world, particularly on small farms that have to balance the need for milk and breeding stock with their draught requirements (Johannsen, 2011, 15). Although medieval plough animals are always referred to as oxen, some historians have suggested that it is likely that cows would also have been harnessed (Moore, 1961, 91; Trow-Smith, 1957, 70). This is an area where the zooarchaeological data can improve understanding, as it is possible to identify an individual metacarpal to sex and calculate its pathological index score (Figure 20). Assemblages dated to the seventh and ninth centuries produced male cattle with the highest scores, which suggests that males were indeed selected for heavier draught work. Yet from the tenth century there is evidence that females were also used for draught purposes. The reasons for this remain ambiguous. It may be that they reflect economic situations that would not stretch to keeping dedicated plough oxen but required the use of cows as multi-purpose animals.

The age that animals are broken to harness also varies considerably, depending on necessity and the type of cattle. Ethnographic




20 Plot of likely female and male cattle metacarpals against their modified pathological index (mPI) scores over time, in order of the phase midpoint. 1 is the maximum mPI score and denotes the greatest level of pathological or sub-pathological change.

research has found that starting animals aged between two and three is most common, although some animals are recorded as being utilized from as young as one, and others as old as five (Johannsen, 2011, 16). The process of training cattle to harness is similar cross-culturally. If experienced animals are available, young cattle can be tied next to the older animal, in which case training takes a few days and they will learn quickly. In cases where experienced cattle are not available, training takes longer, perhaps two to four weeks as the harness, commands and load are slowly introduced (Johannsen, 2011, 16). The length of time cattle may be expected to work ranges from just one season to old age, depending on the ability of the animal to work, the wealth of the farmer, requirement for meat, and the price that could be realized from a sale (Johannsen, 2011, 17). Some clues as to the investment in training cattle for ploughing come from Walter of Henley, who writes extensively on estate management in his thirteenth-century text, *Le dite de hosebondrie* (Cunningham and Lamond, 1890). He writes as a manorial estate manager, so his views most likely represent optimal working practices rather than those of the peasant farmer. He notes that draught animals should be well cared for, 'for you shall be put to too great an expense to replace them; besides, your tillage shall be behindhand' (Cunningham and Lamond, 1890, 23). This suggests that these are not young cattle trained up and used for a single season, but experienced animals that are valued for their ability to work. Yet there is a turnover of draught animals, and it is recommended that in June, 'after St John's Day, to cause all the old




**21** Relative proportions of young cattle (wear stages A–F), old adult cattle (wear stages G and H) and elderly cattle (wear stages J and K) in each assemblage over time, in order of the phase mid-point. Linear trend lines and strength of correlation are plotted (Pearson's r). Younger and old adult animals show a strong correlation with time ($p < 0.01$), but elderly cattle a weak correlation ($p = 0.08$).

and feeble oxen with bad teeth … put them in good pasture to fatten, so the worst shall then be worth the better', and again at Lammas (August) and Martinmas (November) (Cunningham and Lamond, 1890, 97). The link between the ability of cattle to be useful and their dental health is perhaps unsurprising since animals will quickly lose condition if they cannot eat. While this passage may refer to animals with periodontal disease, it is more likely that it indicates old animals (Holmes et al., 2021b). In their study of the tooth wear of cattle of known age, Jones and Sadler (2012b) note that cattle would rarely be expected to live longer than 20 years.

Zooarchaeological data can be used to test the assumption that plough oxen were valued as an investment, and unlikely to be culled at young ages. Unfortunately, it is not possible to attribute age directly to cattle with high mPI values, so mortality data within the same site/phase sample must be utilized. Few elderly cattle were recorded from the targeted sites; only seven were at the oldest wear stage (K – whose molars were worn almost to the roots), indicating animals over 14 years of age (four from Eynsham, one from Flaxengate and two from the French Quarter). Rather more cattle were at wear stage J, between 8 and 16 years (Jones and Sadler, 2012b, fig. 15). Not all of these older cattle will have been draught animals. Walter of Henley notes the presence of old cows (Cunningham and Lamond, 1890, 97), which would have been important for milk and breeding, but given the value attributed to trained draught animals, it is likely that these older animals include draught cattle. The proportion of these elderly cattle observed in assemblages shows a weak positive correlation over time (Figure 21), peaking at sites centred around the mid-eighth to ninth centuries, the late tenth century and the twelfth century, the latter two peaks corresponding to periods when the 'draught cattle' signature is most common (Figure 18).

The proportion of old adult cattle at wear stages G and H, representing animals between four and ten years of age (Jones and Sadler, 2012b, Figure 15), has a stronger positive correlation over time (Figure 21). These would also have been older than prime meat age, indicative of their exploitation for secondary products. Relative proportions of these old adult cattle peak during the same phases (the mid-eighth to ninth centuries, the late tenth century and the twelfth century) observed in the elderly population. Even if it is accepted that some are dairy and breeding cows, the trend implies that a greater proportion of draught cattle were culled after only a few years of use, before reaching their second decade.

### Summary

The significance of the occasional presence of 'draught cattle' signatures from the fifth century should not be underestimated, as it implies heavy workloads for some cattle. Observations of a 'draught cattle' signature at some sites continue into the seventh century and, combined with the discovery of the earliest coulter in England in a seventh-century deposit at Lyminge, further suggest that heavy ploughs were in use on isolated sites in this period. However, a more demanding use of cattle for traction can be observed in the 'draught cattle' signatures from the mid-ninth century, although not at all sites. It is likely, in light of the documentary evidence, that the heavy plough was widespread in England by the eleventh century, and certainly the 'draught cattle' signature is common in assemblages from this period.

An increase in old adult and elderly cattle also occurs throughout the period. The specific exploitation strategies represented by these older animals remain ambiguous, but if dairy produce was largely provided by sheep until the twelfth century, then these older animals most likely reflect increases in draught cattle and breeding cows to replace them. While it is likely that draught cattle were used for many years, and the time spent training them made them valued assets, the high proportion of cattle that died between four and ten years of age, combined with data from draught cattle of known age, makes it likely that some draught animals had a fairly short life, being culled after only a few years of work. The use of more explicit data relating sex to the deformation of cattle feet indicates that draught cattle from assemblages dated between the seventh and ninth centuries were male, although later draught 'oxen' often included cows as well.

## External factors

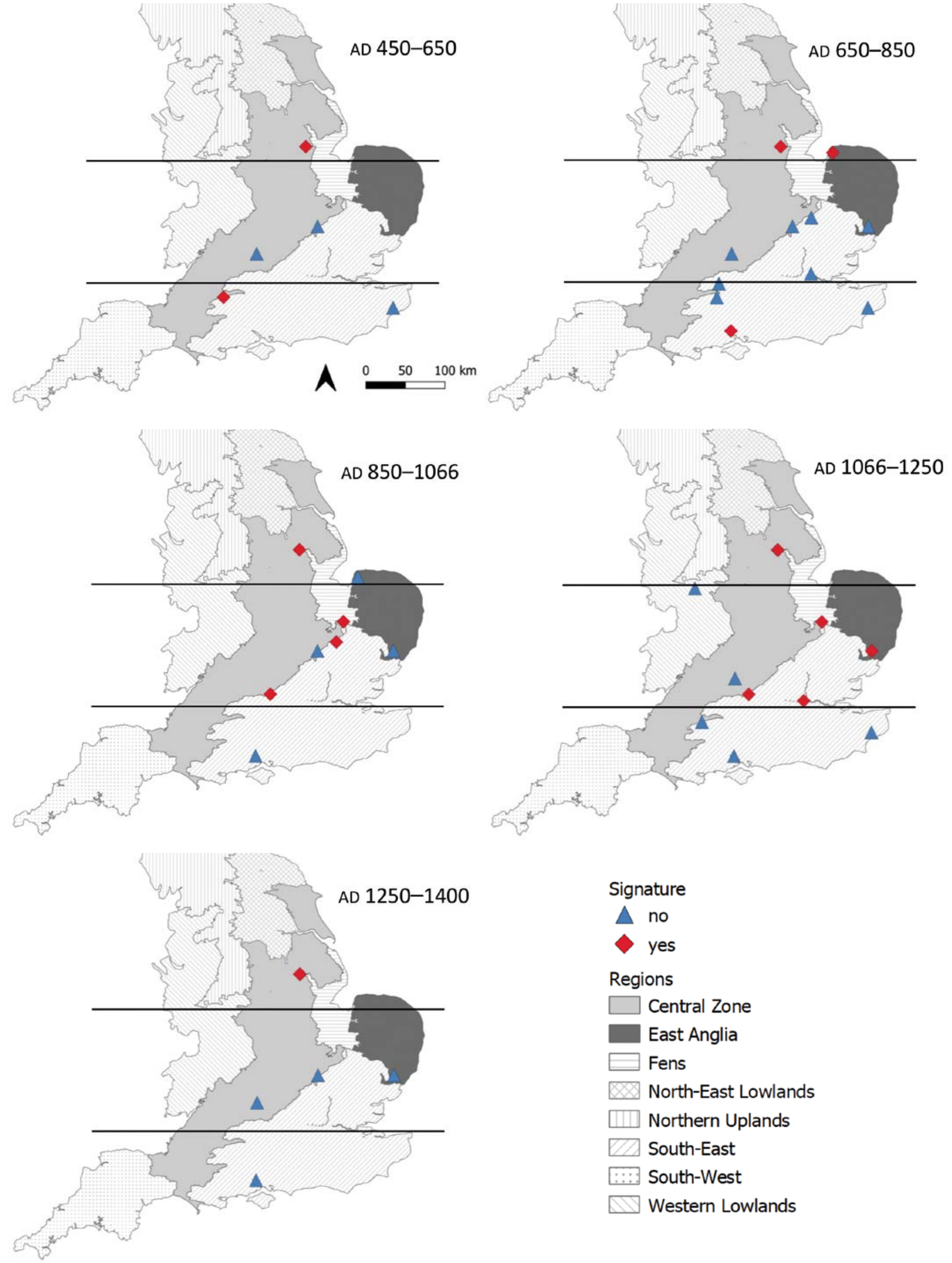
The locations of the targeted sites have allowed the effects of several external variables to be evaluated. This is a complex undertaking as factors such as settlement height, geology and region are inextricably linked to the landscape. For example, all targeted sites situated above 100 metres OD are located on chalk downlands, while the valley terrace sites tend to be below 50 metres; chalk sites are in the east of the country, while the clays are in the midlands (Table 2). Yet, by considering the findings in context, it is possible to identify associations between zooarchaeological variables and environmental factors. Although temporal analysis will be applied, it should be noted that sample sizes become very small when broken down by phase and the patterns generated may be unreliable and warrant further testing. Because of the potential for urban sites to draw on animals from the wider hinterland, these settlements were excluded from analysis of site-specific variables such as topography and geology.

## Topography and geology

Market Lavington (Wiltshire) was the only site situated above 50 metres that produced a 'draught cattle' signature (Table 3). This pattern may be related to the availability of water in lower areas and the higher fertility of soils on the lower valley terraces and clay vales compared to the higher chalk downlands. This theory was borne out when the role of geology was investigated, as draught cattle were more likely to be recorded on heavy clay and valley terrace soils than on chalk geology.

## Region

All sites were considered in terms of their location within the regions defined by Rippon et al. (2015). Overall trends suggest that assemblages with 'draught cattle' signatures were more likely to be recorded in the Central Zone and East Anglia (Table 3), although almost a third of South-Eastern assemblages also exhibited this trait. Sites were mapped onto the regions, so that trends in the location of those with 'draught cattle' signatures over time could be identified (Figure 22). However, no trends could be identified which followed the regional divisions defined by Rippon and colleagues, suggesting that the use of dedicated draught cattle was not restricted to a particular region, but rather that they were widely utilized piecemeal through much of the country. Patterns did emerge when the data




**22** Maps to show the location of sites with a 'draught cattle' signature (◆) and those without (▲), using regional divisions from Rippon et al. (2015); additional lines demarcate northern, central and southern areas referred to in the text. Map created with QGIS (http://www.qgis.org; accessed 08/03/2022).

were considered latitudinally by dividing England into a 'northern' area (from the Wash northwards), a central area and a southern area (south of the Thames; see Figure 22). Between AD 450 and 850, draught cattle were more common in the northern and southern areas, and it is notable that the early coulter from Lyminge (Kent) lies within the southern area. From AD 850 until 1250, 'draught cattle' signatures were more often located in the central area, coinciding with the coulters recovered from Buckden (Cambridgeshire) and Scraptoft (Leicestershire). Sites with a 'draught cattle' signature are less common from the mid-thirteenth century, and only observed in the northern area. It remains to be explored whether this geographical pattern is mirrored by the other national datasets compiled by FeedSax.

### Site type

There was also considerable variability in the proportions of 'draught cattle' signatures among the different site types (Table 3). Elite sites were far less likely to produce 'draught cattle' signatures than other sites, the only example being Barking Abbey (Essex). There does not appear to be any temporal aspect to this observation. Hence, if the data represent innovation driven by an elite, they must also represent the redistribution of old working cattle away from estate centres to rural or urban markets. It remains equally likely that the pattern represents a rural population capable of making their own technological changes in response to a need to increase production (see also Williamson, this volume).

### Summary

The increase in the proportion of targeted sites with a 'draught cattle' signature over time has been complemented by the analysis of external factors. Some of these are likely to relate directly to the agricultural landscape, such as the link with heavier soils on lower settlements, while others probably invite a more economic explanation, such as the marketing of old draught cattle to towns from elite sites. The interconnection of these variables reflects some of the choices that had to be made as production increased, such as the need to utilize heavier, more fertile clay soils, and to have a water source close to the fields. The 'draught cattle' signature is observed in all regions for which data exist but is more common from the mid-ninth century in the central area, again associated with heavy geology, potentially reflecting a shift in arable towards heavier, more productive soils.

## Social implications

### *Production*

There is nothing in the data to suggest a widespread, wholesale move to the intensive use of draught cattle in medieval England. Low-level pathological and sub-pathological changes are recorded throughout the period (Figures 19 and 20), and probably represent the use of cattle for pulling ards and carts. The presence of 'draught cattle' signatures from fifth- and sixth-century assemblages (Figure 18) implies that the intensive use of some animals was in place even from the earliest phase, potentially as a continuation of late Roman practices. An increase in the proportion of assemblages exhibiting such a signature is apparent from the mid-ninth century, and again in the mid-eleventh and thirteenth centuries. This further suggests that there was no single point in time when the intensive use of draught cattle was introduced; rather, it was an ongoing take-up, gathering momentum as grain production escalated. Similarly, there was no clear regional signal for the 'draught cattle' signature within the regions defined by Rippon et al. (2015), implying that it existed in a broader central area including parts of the Central Zone, East Anglia and the South-East. This pattern is consistent with the observation made by Williamson (this volume) that arable farming using mouldboard ploughs, fallow fields and movement of livestock was well established by the time of the Domesday survey in areas outside the 'champion' region.

A strong relationship can be observed between draught cattle use and heavy soils (clays or valley terrace) associated with low-lying settlements. This provides the best evidence for the use of the heavy plough, as such landscapes may have been too difficult to exploit effectively with an ard. The use of a mouldboard plough would have released the potential arable capacity of new areas, creating changes to the working relationship between people and their animals (Holmes et al., 2021a), and between whole communities in some areas (Dyer, 1994, 408; Hamerow and Williamson, this volume).

New roles were also introduced. Rather than one or two household cattle pulling an ard, the new regime required a team of oxen that would be worked by at least two attendants, the senior ploughman walking behind with the plough, and the ox-goad who would walk alongside to keep them in line (see this volume's cover photograph). Individual villagers would be unlikely to own enough draught cattle to pull the heavy plough to work their own holdings, so they had to share or hire animals. The earliest mention of sharing plough cattle is in the late seventh-century laws of Ine of Wessex, in which a standardized payment for the hire of plough oxen is described

(Whitelock, 1996, document 32, 2, 2). Historical and ethnographic data suggest that possessing cattle that were trained at the plough would have elevated a person's status (Holmes et al., 2021a, 10), presenting further opportunities for a more complex social hierarchy to evolve. The seventh-century inhumation cemetery at Sutton Hoo also included a burial tableau interpreted as a ploughman at work, complete with a basic and broken ard (Carver, 1986, 146), placing the role of ploughman as one of importance even after death.

A final insight into the status of plough cattle is provided by the presence of male animals with high mPI scores in assemblages dated to before the tenth century (Figure 20). The apparent requirement to use exclusively male animals for heavy draught work at this time, when cattle were an important form of portable wealth (Holmes et al., 2021a, 9), was likely to have emphasized the status of these animals and, by implication, their owners.

***Symbolic value***

The ability to plough was vital to the economy and to personal fortune in the Middle Ages. This is summarized in the *Dialogue of the Exchequer* written in 1177–79, when, in describing the goods that could be taken from a debtor by the Crown, it is noted that 'First, the debtor's movables are sold; but let them spare, as much as possible, the plough oxen by means of which agriculture is practised, lest, being deprived of them, the debtor be reduced to penury in the future' (Douglas and Greenaway, 1996, document 70, 2, 5). Perhaps because the ability to cultivate land was fundamental to medieval life, cattle and the ploughs they pulled had a value that went beyond the purely economic, and symbolic deposits related to this technology can be observed in the archaeological record.

Direct evidence for plough parts is rare, as wood does not often survive, and iron, when broken, would presumably have been recycled. Therefore, when plough-irons (shares and coulters) are recovered on archaeological sites, their survival suggests that they had assumed a symbolic value beyond the price of base metal. Some are associated with the abandonment of a building, as at Lyminge (Thomas et al., 2016) and Buckden (Connor and Billington, 2021), while others are associated with the foundation of new buildings, as at Alnhamsheles (Standley, 2020). Some plough-irons have been recovered alongside other metal objects in hoards, symbolic deposits related to the abandonment of structures or to sacred places (Leahy, 2013, 754; Thomas et al., 2016). In a review of the symbolic deposits of plough furniture throughout medieval northern Europe, Thomas et al. (2016) provide further evidence for the deposition of plough-irons associated with chapels, suggesting events such as the 'ritual tillage' of consecrated ground. The plough was also associated with the Christian festival of 'plough Monday' that took place in January to mark the start of the ploughing season (Gilchrist, 2012, 106). This celebration may have had a Saxon precursor in a fertility charm that blessed the 'sod and the plough, praying … for fertility of the soil, plowing the first furrow, and laying in it a sacrificial cake' (Baskervill, 1920, 37).

The meaning behind the deposition of plough-irons is indeterminable, though it most likely relates to a deeply ingrained understanding of the essential nature of the plough to unleash the fertility of the land and its essential role in food production. At Buckden, the coulter was surrounded by grain-rich fills (charred rye, barley and wheat), which further emphasizes the relationship between plough and life. At Alnhamsheles, although later than much of the evidence discussed here, the deposition of a coulter beneath a building in the fifteenth century coincided with a period of poor harvests, and it is suggested that it was offered in response to events that would have devastated a community (Standley, 2020). Further evidence of the importance of the plough within a community comes from the use of plough-irons in trials, where they were used as a tool to provide fair justice (Standley, 2020, 753; Thomas et al., 2016, 754).

**Summary**

Social change was interwoven with increased production. In some areas, the need to cultivate more fertile clay soils demanded more work from draught cattle, which led to new social roles for ploughmen and the chance for increased status and wealth for those who owned draught cattle. The fundamental requirement for food, and a need to recognize the roles of fertility within the agricultural economy and community in the lives of those working the land, may have been acknowledged by festivals and the symbolic deposition of valuable iron coulters and shares as foundation or abandonment deposits and hoards.

**Conclusion**

Between the fifth and fourteenth centuries, there was a cohort of cattle used for small-scale, light draught duties such as pulling an ard, harrowing or carting. Other cattle were used for harder work that would have included the pulling of the mouldboard plough, and their presence was most often recorded on heavy soils. Sites with strong 'draught cattle' signatures and finds of coulters from the seventh century suggest that draught cattle and heavy ploughs were in use at an early date in isolated cases, but it was not until the mid-eleventh century that draught cattle became commonplace. The nature of their work varied from settlement to settlement, but from the mid-ninth century settlements with 'draught cattle' signatures were largely centred on the clay lands and valley terraces of the central area of England, potentially as agriculture moved onto the more fertile, but harder to work, heavy soils to maximize cereal production.

The time invested in the training of draught animals meant that some were used for many years. Despite references to oxen as the preferred draught animal, cows were also used, particularly from the tenth century. A fundamental change to social structure occurred in some areas, as production centred upon arable farming and the need to share plough animals meant that people were required to live and work in larger groups, while the uneven distribution of assets increased social inequality. The symbolic value of the plough as the provider of grain, vital to life and the embodiment of fertility, is represented by deliberately deposited plough-irons.

# II Revolutions Revisited: New Perspectives on Agricultural Development

# 6 Cattle and Tillage in Early Medieval Europe: First Results from the Lauresham Laboratory for Experimental Archaeology, Germany

*Claus Kropp*

### Scratching the surface: the source material

Traditional historical approaches to the study of early medieval agriculture are usually based on manorial sources (Kropp and Meier, 2010). These lists and accounts offer us insights into the overall organization of the manorial estates of monasteries, kings and other members of the free upper class (*nobilitas*). They help us to understand how the holdings were structured, what duties and other services the servants had to fulfil on the fields, and what yields had to be delivered (Kropp and Meier, 2010, 98). Research on these sources has demonstrated the major role of cattle for traction and transportation in this period, as well as the appearance and regional use of early forms of three-field crop rotation. What cannot be deduced from these sources, however, is the micro-level detail of agricultural practices: how much draught force was needed to pull a particular type of plough, or to use it in a specific soil type? How did these agricultural implements actually function and what were the individual advantages and disadvantages of each system? What did the actual cultivation processes of different field types look like?

Answers to these questions cannot be found in the documentary record, even if we take other contemporary sources like *leges*, capitularies and chronicles into account. This changes when we turn our attention to the archaeological source material, as these finds and features (e.g., plough marks or historical field horizons, i.e., a layer representing the last state of a field before it was abandoned), artefacts (e.g., plough shares, coulters or wooden fragments of ploughs, harrows and wagons) and other remains (whether faunal or botanical) provide direct evidence of the implements, field systems, crops and livestock involved in the agricultural process. It is therefore unsurprising that, in recent decades, a rising number of interdisciplinary research projects (e.g., Benecke et al., 2003) have assigned a far more vital role to archaeological evidence in seeking a deeper understanding of medieval agriculture. The FeedSax project itself, as well as the other papers in this volume, offer very good examples of this approach. The value of experimental archaeology nevertheless remains underestimated.

Although pioneering studies on ploughing implements (such as Lerche, 1993) have clearly shown the great potential of experimental archaeological research, many possibilities for further experimental research have not been pursued because of a lack of funding, practical skills (e.g., in using draught animals) or opportunities for long-term monitoring. Archaeological open-air museums can play a pivotal role in that respect. This paper is therefore dedicated to presenting the research carried out at the Lauresham Open-Air Laboratory for Experimental Archaeology in Southern Germany.

## The Lauresham Laboratory for Experimental Archaeology

The Lauresham Laboratory for Experimental Archaeology is a 1:1 scale model of an early medieval manor, including houses, meadows, fields

**23** The manorial site at the Lauresham Open-Air Laboratory (picture by M. Thumm).

**24** Ploughing experiment using a professional draught scale in 2018 (picture by Staatliche Schlösser und Gärten Hessen).

and gardens as well as livestock and plants (Figure 23). It is situated next to the UNESCO World Heritage Site of Lorsch Abbey, formerly one of the most powerful Benedictine abbeys in the Frankish Empire and today managed jointly with the Open-Air Laboratory as part of the State Palaces and Gardens of Hesse. On the one hand, Lauresham is following a didactic approach to explaining manorialism, everyday culture and the crafts of the Carolingian era. On the other, it is a research facility dedicated to experimental archaeology, especially relating to settlement archaeology, atmospheric conditions inside houses, and agriculture (Kropp, 2017a; 2017b; 2019; 2020; Schabacker, 2019; Kropp et al., 2017).

The site is 4.1 hectares in size and can be roughly divided into the following three areas: (a) the manorial site itself with houses, barns and a small chapel; (b) a craft quarter of *Grubenhäuser* (sunken-featured buildings) including a smithy, wood- and bone-working workshops and storehouses; and (c) a set of different meadows, gardens, pastures and agricultural fields. The agricultural project with its experimental fields is dedicated to practising a three-field crop rotation system using reconstructed early medieval tillage implements, old crop varieties and draught cattle (Figure 24).

## Early medieval agricultural experiments: research design and parameters

Before embarking upon a detailed discussion of specific research questions being addressed at the Open-Air Laboratory, it is necessary


**25** Overview of the agricultural fields on-site with marked transects for botanical surveys (picture by M. Sonnberger; Copyright OpenStreetMap: © OpenStreetMap-Mitwirkende, www.openstreetmap.org/copyright; accessed 23/07/21; Copyright Google Satellite: © 2021 Google & 2021 GeoBasis-DE/BKG).

to describe the exact set-up of the agricultural fields on site. In general terms, two different field systems are represented: a ridge-and-furrow field cultivated using a mouldboard plough, and a square plot cultivated with ards. The ridge-and-furrow field is itself divided into six strips, each almost 100 metres long and six metres wide (Figure 25).

**26** Experimental ridge-and-furrow field at the Open-Air Laboratory, showing the state of the cultivation cycle in spring 2021: winter crops on the left (rye), fallow in the middle and summer crops on the right (spelt and oats) (picture by Staatliche Schlösser und Gärten Hessen).

The strips are cut in two using a narrow pathway in order to allow comparative studies on the effect of manuring while using the same crops.[1] Five strips were modelled as ridge-and-furrow at the outset, with the highest point of the ridges at 60 centimetres. The one remaining strip was left unformed in order to study the formation process of this specific field type, while the five pre-modelled strips afford the opportunity to research the effects and function of ridge-and-furrow. The square plot measures roughly 45 by 45 metres and is usually cross-ploughed with ards.

Both field systems are included in an overall three-field crop rotation system of winter crops, summer crops and a fallow year (Figure 26).[2] For each field strip and each crop, a diary is used to document all tillage operations (type of plough/ard used, furrow depth and width, weeding, draught requirements) as well as to interrelate them with other factors including rainfall, air temperature, and the humidity and temperature of the soil.[3] A crop diary also includes

1 The subdivision is as follows: a smaller section 30 metres in length, and a longer section 69 metres in length.
2 Although weather extremes and pests have sometimes made it necessary to deviate from that principle.
3 The soil sensors are used on both ridges and furrows and cover a range of 0–90 centimetres in the ground.

regular documentation of BBCH-scale phenological development,[4] stem-length, yield and thousand-seed weight (TSW).

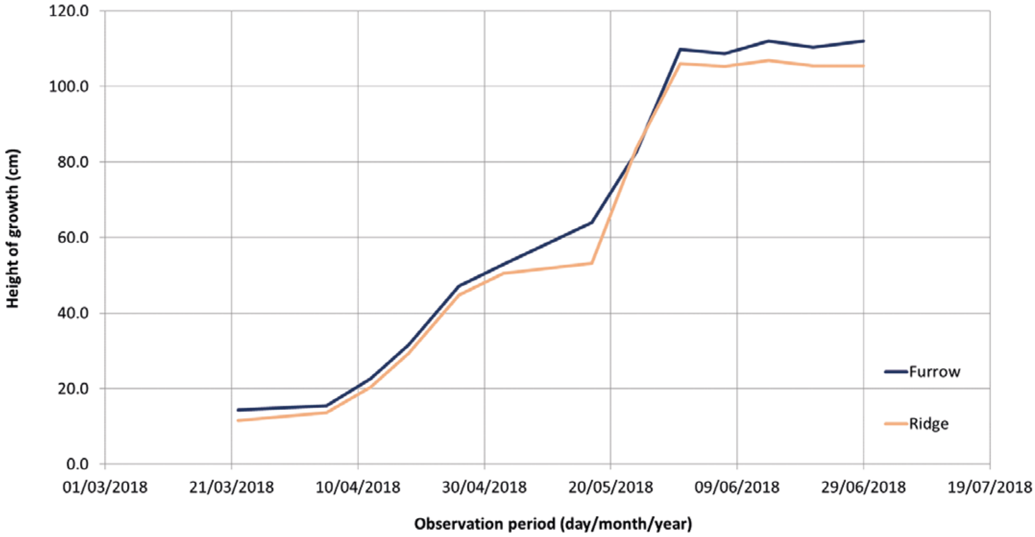
This long-term monitoring furthermore includes the study of changes in weed ecology on the experimental fields. Twice a year, a botanist documents the on-site flora (including invasive species), and the first results from these surveys already indicate a clear difference between the monitored experimental fields and conventional farmland (Sonnberger, 2020). Blueweed (*Echium vulgare*), for example, is still present on the fields in the Open-Air Laboratory, whereas it usually disappears from conventionally farmed agricultural lands. It will, of course, take more years of monitoring before real insights into the changing weed ecology at the site can be expected, but recent results have already supported a functional ecological study of the impact of mouldboard ploughing on arable weed floras (Bogaard et al., this volume).

In April 2021, another monitoring aspect was included: ground beetles. It is to be explored whether the three-field crop rotation system and the ridges and furrows with their microclimatic differences are causing different specialized ground beetle populations to develop in the fields. In the future, the small rodent populations in the fields will also be monitored in order to find out how they influence the harvest as well as how they are affected by specific forms of cultivation.

Yearly soil analysis series are of particular importance for the research projects at the site, not only because soil composition has a major influence on potential draught requirements for tillage implements, but also because a monitoring of the soil allows us to investigate the effects of manuring or changes in nitrogen levels on different crops. A collaboration with the HLNUG (Hessisches Landesamt für Natuschutz, Umwelt und Geologie) in 2019 additionally allowed the creation of a soil profile from the top level of the soil to a depth of up to two metres.

The detailed research parameters at the Open-Air Laboratory have already shown their full potential in previous years. For example, it was possible to provide scientific proof that in the case of the ridge-and-furrow fields cultivated during a dry year, the furrows produce not only taller stems (Figure 27) but also up to double the yield in comparison with the ridges. This has to be seen as a valuable risk minimization strategy of medieval farmers, and as part of an even broader system of subsistence strategies (Kropp, 2019, 14).

4 The BBCH (Biologische Bundesanstalt, Bundessortenamt und Chemische Industrie) scale in modern agriculture is used for the identification of the phenological stages of different field crops in order to determine the right point in time for specific plant treatments as well as the harvest.

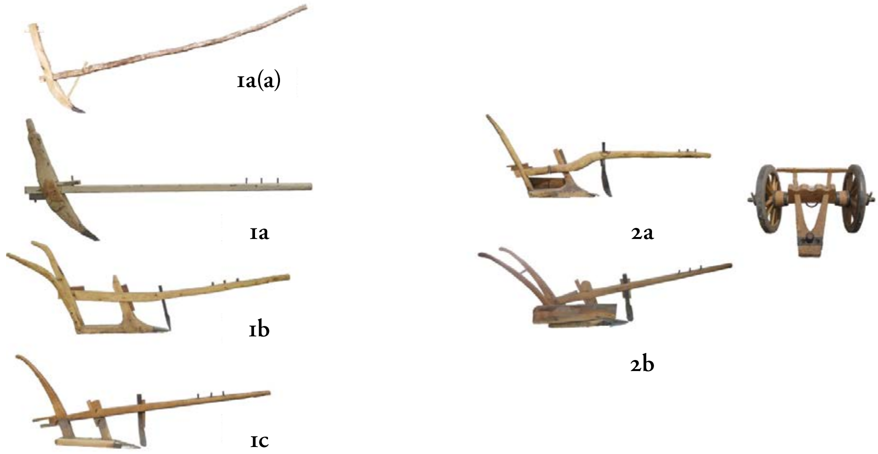



27 Height comparison of spelt (*Triticum spelta*) in the ridges and furrows between March and June 2018 (graph by C. Kropp; Staatliche Schlösser und Gärten Hessen).

### Ploughs and ards: (re)construction and challenges

The agricultural experiments at the site are carried out with a set of four ards and two mouldboard ploughs reconstructed between 2014 and 2020. Lauresham's approach to selection and reconstruction aims to model the entire spectrum from very light, sole-less ards up to heavy mouldboard ploughs equipped with share and coulter (Figure 28). It must be stated that these represent idealized constructions based upon all available data for the early medieval period, rather than specific single-find replicas. This is because the reconstruction of the complete plough-body usually has to be based solely upon the surviving ploughshares. Of course, as many studies have shown (Fries, 1995; Coles, 1973; Bentzien, 1990), different plough types can be derived from the shape, wear and size of the shares, and there remains room for interpretation when it comes to the exact appearance of the corresponding beam and other parts of the plough. All tillage implements (including harrows) at the Open-Air Laboratory therefore serve the purpose of exploring basic functional aspects as well as providing data on draught requirements.

For a better understanding of the underlying scientific process, the construction of the ard model of Osterburken (Figure 28, type 1b) now needs to be explained in greater detail. The hoard from Osterburken (*c.* AD 400) served as orientation for the construction of this ard model, which was built at the Open-Air Laboratory in 2017/18 (Henning, 1985, 574). The symmetrical ploughshare (17.9 by 12.0 centimetres) belonging to this ensemble represents a spout-shaped type




**28** Overview of the ard/plough models in use at the Open-Air Laboratory (picture by Staatliche Schlösser und Gärten Hessen).

that already existed in the Roman Empire and was still widespread in the early Middle Ages; it belongs to a medium heavy ard variant (Henning, 1985, 584; Fries, 1995, 55, share type 6). The original find has spout-shaped, curved shaft flaps. The former width of the share can only be estimated as it is reduced by wear on all sides; the underside of the working part is completely flat, the upper side slightly arched with a light central ridge. The replica of the share was then forged with tool-steel which was 25 millimetres thick and 100 by 100 millimetres across. The manufactured result was largely true to the original with finished dimensions of 19 by 12 centimetres (Figure 29b). The forging process was carried out by the company Trommer Archäotechnik.


**29a–b** Replicas of the Osterburken ard share and coulter (picture by Staatliche Schlösser und Gärten Hessen).

Associated with the ard share within the Osterburken hoard was an iron coulter (Henning, 1985, 576). This association led to the assumption that these two finds might have been part of one ard, and it was therefore decided to reconstruct this element as well, following the same principles as for the share. The final replica has a total length of 48 centimetres with a shaft-profile of 2.5 by 2.0 centimetres (Figure 29a).

Considering the shape of the share together with the coulter, these elements most likely belonged to a sole plough. A matching plough body (plough handle, beam) was then manufactured using ash timber in March 2018. Fine adjustments to manipulate the plough-angle were made possible by three wooden pegs with corresponding wedges. The functionality of the entire ensemble was tested in March 2018 as part of an intensive on-site field test. As of May 2018, the ard was finally ready for use and available for further analysis.

## Cattle traction: (re)constructing draught requirements for tillage implements

For a clear understanding of the agricultural process, and ploughing in particular, it is essential to research the draught requirements of the cattle being used. Only then is it possible fully to assess the advantages and disadvantages of different plough and ard types, and to understand potential cooperative arrangements necessary within a settlement or manor. An integral part of the research efforts at the Open-Air Laboratory is therefore the analysis of the necessary maximum and average draught power involved in the ploughing process. These measurements were carried out using a digital draught scale (ZW 1.0; HKM Messtechnik) which was interconnected between the plough/ard and the cattle.[5] Although the draught itself might not be entirely as steady as if a tractor or traction engine were used, it was nevertheless essential for the wider agricultural research efforts to use draught animals. Problems like high soil compression would have otherwise compromised the results. Furthermore, field systems like the reconstructed ridge-and-furrow can only be farmed efficiently using animal traction because of the slopes involved and the tillage implements themselves.

5 In 2021, a total of eight draught cattle – six oxen and two cows (one of which is a ‘freemartin’, a hermaphrodite) – were used for all the traction on the arable land. The animals are Rhaetian grey cattle, a small high-mountain breed from Switzerland, which, because of its size, compares quite well in appearance with medieval cattle.

The traction experiments at the Open-Air Laboratory are part of a wider study on this subject (Kropp, in prep.). As shown by Minhorst (2015, 154), the traction of cattle depends on their weight, body structure, muscle strength, age, diet, the quality and type of harness, the soil, the weather and the treatment by their handler(s). In order to determine the average draught power, it is therefore necessary to take into account as many research parameters as possible (see also Herold, 2016).

Before the actual traction measurements were taken, the respective test fields were precisely defined and measured using a tape measure. These test fields were established both inside and outside of the Open-Air Laboratory. This was necessary in order to collect data from a wide range of different soil types. The dimensions of the test areas were determined in such a way that, as a rule, three successive furrows per plough model were undertaken. The aim was to increase the statistical significance of the individual series of measurements. The ploughing was only carried out in one direction, so that an empty run was necessary after each furrow.

A simple height profile was created using a levelling instrument from the company Nedo (X 24) in order to determine the relative gradient of the area. The measurement matrix was set with one levelling point per five metres of the test fields.

The weather data were determined on the respective test days directly on the surface using a mobile thermohydrograph (TS34C) from TFA Dostmann. Both humidity and air temperature were recorded. Depending on the duration of the test series, another measurement was carried out if necessary after a time window of three hours. The weather was recorded by means of subjective observation according to the following gradations: sunny, cloudy, overcast and rainy.

To determine the soil composition, a mixed sample was taken before the start of each of the respective test series. Soil material was removed with a gimlet from layers 0–10 centimetres and 10–20 centimetres deep at three points, mixed and then sent to the Landesbetrieb Landwirtschaft Hessisches Landeslabor in Kassel for analysis. In addition, an on-site soil determination with damp sediment was carried out by means of a finger test according to Kinne (2009). To determine the soil moisture during the experiments, a separate mixed sample was weighed using a calibrated precision scale from KERN (EMB 100-3), then dried over a period of two months and finally weighed again.

The test areas were categorized using different parameters. Categorization level 1 initially determined the basic classification of the area according to the type of previous use. A distinction was made between permanent grassland (A) and arable land (B). Categorization level 2 (Table 4) enabled a more precise assignment of the status of each of the areas involved. The relative degree of coverage of the vegetation (categorization level 3) was recorded using a corresponding percentage (0%–25%, 25%–50%, 50%–75%, 75%–100%). As far as possible, the integration into the respective crop rotation system was also determined and documented.

**Table 4 Categorization of the coverage ratio on the experimental fields**

| | | | |
|---|---|---|---|
| 1 | Fallow | a | one year |
| | | b | multi-year |
| 2 | Stubble | a | autumn-furrow |
| | | b | spring-furrow |
| 3 | Prepared | | |

Before each of the test series, the body weight and withers height of each individual draught animal were calculated. The weight estimate was determined according to a principle of combining body length and chest circumference. During the test series, in order to stimulate consistent conditions, the same people took on each of the tasks whenever possible.

Because not all of the field experiments within and outside of the Lauresham Open-Air Laboratory have been concluded, the result of one particular case study must serve as a paradigm to demonstrate the high research potential of this approach (Tables 5–6; Figure 30).

The data reveal that draught requirements vary enormously, depending on the complexity of the tillage implement (from 66.6 kilograms for a light, sole-less ard, to 132.3 kilograms for a heavy mouldboard plough with coulter). These datasets can only be representative of the exact conditions recorded in this case study. Nonetheless, they allow for some initial interpretations concerning the ratio of implement to draught animal, and hence some conclusions may be drawn. For example, we may ask what these numbers mean when it comes to the possible draught performance of an early medieval cow, taking one of the draught cows from the Lauresham Open-Air Laboratory as a case study.[6] The cow currently weighs 400

6 For the avoidance of doubt: 'cow' here refers to a female. Both cows and oxen are used for draught purposes at Lauresham.

**Table 5 Experimental series metadata for case study at Soultzeren, France**

| **General data** | |
|---|---|
| Date of experimental series | 11 October 2019 |
| Location | Soultzeren, France<br>Arable land, 2a, 0%–25% coverage |
| Weather | Sunny<br>10:40 a.m.: 15.4°C ,74% humidity<br>01:57 p.m.: 25.4°C, 44% humidity |
| Gradient of the field | + 8.2% |
| Soil moisture | 19.31% |
| Soil type | silty sand (14.2% clay, 23.1% silt, 62.7% sand) |
| Animals and harnessing system | Vosges cattle; castrated male, well trained<br>Head yoke<br>Led by Philippe Kuhlmann; behind the plough Sebastian Diehl<br>**Ox 1 (Milou)**<br>withers height: 139 cm<br>chest measurement: 207 cm<br>calculated weight: 667 kg<br>body length: 168 cm<br>**Ox 2 (Mani)**<br>withers height: 145 cm<br>chest measurement: 220 cm<br>calculated weight: 780 kg<br>body length: 174 cm |

**Table 6 Traction results (based on three consecutive furrows) from case study experiment at Soultzeren, France**

| **Plough/ ard type** | **Average draught power (kg)** | **Maximum draught power (kg)** | **Average furrow depth (cm)** | **Average furrow width (cm)** |
|---|---|---|---|---|
| 1a | 66.60 | 133.20 | 9.80 | 22.00 |
| 1b | 112.80 | 185.00 | 17.33 | 29.00 |
| 1c | 87.15 | 190.90 | 16.50 | 19.00 |
| 2a | 116.30 | 203.70 | 16.00 | 34.30 |
| 2b | 132.30 | 210.10 | 21.00 | 34.60 |

kilograms. Several studies (Masson, 2015; Harrigan et al., 2015) have shown that draught animals can easily pull up to 10 per cent to 15 per cent of their body weight for a long period. Knowing that ploughing is a task which requires continuous traction, we can state that, on the one hand, the light ard fits quite well within the performance

30 Traction experiments at the Kuhlmann Farmstead in Soultzeren, France (picture by Staatliche Schlösser und Gärten Hessen).

spectrum of that cow, meaning that she would be able to pull it alone. The heavy mouldboard plough, on the other hand, would need up to four animals in order not to overload the individual cow. It is also interesting to observe that the Osterburken model (Figure 28:1b), although an ard, scores almost as highly as the lighter of the two mouldboard ploughs (Figure 28:2a).

These results overall shed an interesting light on how we can calculate the workforce involved when it comes to tillage in the early Middle Ages. They can also contribute to the ongoing discussion about when, how and if the mouldboard plough replaced the ard on a larger scale during the Middle Ages. It has become very clear that, while turning the soil more efficiently (especially on heavier soils), the mouldboard plough with an asymmetrical plough share in general also required much higher traction. This raises the question of whether its use was at first primarily restricted to larger manorial contexts, or if this might even imply a higher-than-expected cooperative effort among early medieval peasants – it may be that both scenarios occurred. A simple black-and-white scheme of agricultural innovation from ard to plough over the course of the Middle Ages cannot therefore be postulated. The experimental studies at the Open-Air Laboratory have shown that the ard might have remained the tillage implement of choice throughout the Middle Ages, if the soil allowed and if the available draught force was insufficient for anything else (see also Schreg, 2006, 335).

### Reality check: experimental data and its applicability to the source material

The potential of the experimental archaeological approach hinges on the question of its applicability and dependence on the source material itself. First – and this is something which needs to be researched for every individual region – in order to apply these datasets to archaeological sites or contexts, it is necessary at the outset to evaluate the appearance of the cattle represented there, including possible body weight reconstructions. A regional study, in this case concerning the Upper Rhine Valley, is currently being undertaken by the author. An assemblage of more than 100 complete metapodials (both metacarpi and metatarsi) has been zooarchaeologically analysed so far in order to get a better sense of the regional varieties of cattle between AD 500 and 1050. A better understanding of the potential draught force of the cattle prevalent there might also help us to better interpret possible finds of tillage implements or plough marks of the periods in question. Second, as agricultural field studies always include certain irregularities throughout the agricultural cycle, only long-term monitoring will help to compensate for these. It is the great advantage of the Lauresham Open-Air Laboratory that the organization and governmental funding of the site allow exactly this pivotal long-term perspective.

# 7 Prospect and Protect: Syntironomy and Cereals in Early Medieval England

*Mark McKerracher*

## Introduction

Teleology, derived from the Greek τέλος (end), is defined as 'the interpretation of phenomena in terms of their purpose rather than possible causes' (*Chambers Dictionary*, 2003). In history and archaeology, therefore, a teleological approach is one which interprets the 'earlier' through the lens of the 'later'. The study of medieval English farming between the seventh and thirteenth centuries naturally invites a teleological approach because many of the relevant sources are relatively late. Documentary evidence for agricultural practice is extremely scarce prior to the thirteenth century, and cartographic evidence largely dates from the early modern period. Extant features in the modern landscape and nineteenth-century Ordnance Survey maps offer invaluable palimpsests from which long histories of agriculture and rural settlement may be teased out (Roberts and Wrathmell, 2000; Hall, 2014). The scant – primarily archaeological – evidence for the seventh to twelfth centuries is therefore most readily interpreted with reference to those richer later records: inviting us to explore the 'origins' of open fields, nucleated villages, and other phenomena which later became so prominent in the landscape (Rippon, 2008, 1–26).

This kind of teleological perspective is problematic, not least because of its arbitrary and question-begging assumption that later medieval and early modern landscapes represent the (perhaps inevitable) culmination of earlier medieval endeavours. It might be called a retrospective approach: taking a perceived 'culmination' and looking backwards in time to find the developments from which it emerged. Such a retrospective approach to history encourages us to fixate on emergent moments or accomplishments, and trajectories of progress or failure. It does not encourage us to look at developments on their own terms; but how could we achieve that when the terms available to us date largely from later periods?

## Escaping the white bear

A related issue has been explored in a study by the English Landscapes and Identities project (EngLaId), concerning England in the period *c.*1500 BC to AD 1086 (Ten Harkel et al., 2017). This paper challenges the common view of pre-modern agriculture as a 'socio-economic' activity, arguing instead that it was inseparable from ritual or religion. The authors contend that 'agricultural intensification is often regarded as being predominantly about creating surplus … In contrast, the EngLaId project starts from the assumption that in looking at periods before the invention of modern rationalism during the seventeenth century such distinction between pragmatism and ritual is unhelpful' (Ten Harkel et al., 2017, 414). The paper makes a strong, evidence-based case for the inextricability of agriculture and ritual between the Bronze Age and the medieval period, and – in an implicit critique of teleology – argues more generally that the concepts and terminology that pervade much archaeological literature impose a misleadingly modern perspective on the past:

> people probably had no separate categories of agriculture, craft production, trade, religion and so on. These would have been intermingled and mixed in ways we find confounding … For people of the medieval period and earlier, ploughing and prayer were both equally necessary to ensure a good harvest. (Ten Harkel et al., 2017, 416)

Having made this point, however, the authors do not make clear what alternative terms or concepts should be preferred. On the contrary, the concluding discussion refers to 'full-blown agriculture' in the Iron Age, and an 'increasingly complex economic system and a complex mixture of ritual traditions' in the Roman period (Ten Harkel et al., 2017, 432–33). What do these phrases mean if we are not allowed to name 'agricultural', 'ritual' and 'economic' as separate kinds of activity? It seems that, while the authors argue against the distinction between the agricultural and the ritual, they cannot entirely escape it themselves. In order to argue for the complete entwining of the agricultural and the ritual, one must refer at the outset to ritual and agriculture, otherwise the argument could not be expressed or understood by a modern 'rational' scholar.

This paradox could be seen as an instance of ironic process theory, which holds that 'processes that undermine the intentional control of mental states are inherent in the very exercise of such control' (Wegner, 1994, 34). The 'white bear' experiment provides a vivid illustration of the theory: subjects who were asked not to think about a white bear found themselves unable to suppress the thought of a white bear (Wegner et al., 1987). By the same token, the mind would struggle to maintain a complete entanglement of ritual and agriculture without also naming (and thus perceiving) them as two different concepts. Similarly, it could prove near-impossible deliberately to avoid a teleological perspective on early medieval agriculture without, in the process, keeping later phenomena (such as open-field systems) in mind.

How can we escape our teleological bears? It would surely be simpler never to have thought of a bear in the first place, rather than having consciously to discard the thought. What if we could examine the historical and archaeological evidence for plants, animals, buildings and fields without initial reference to modern ideas of agriculture, trade, craft, religion or culture? While such concepts are evidently useful to historians and archaeologists and need not be abandoned altogether, could we nonetheless *start* from a different theoretical perspective: one which is less dependent upon modern categories and which makes minimal assumptions at the outset?

## Introducing syntironomy

As an alternative to the white bears of teleology, this paper introduces a novel theoretical perspective: syntironomy. Syntironomy rests upon the minimal assumption that time is linear and therefore, in order for things to exist, they must persist over time. The nature of existence is persistence: existent phenomena, both abstract and concrete, must tend towards persistence even if they eventually cease to exist. This is the syntironomic principle, and it can be stated succinctly as 'nature abhors an ending'.

Derived from the Greek συντηρώ (to sustain or conserve), syntironomy is concerned with interpreting how phenomena are sustained or conserved over time: how their persistence is maintained. It proposes that there are four basic methods by which persistence may be achieved: 'Provision', 'Protection', 'Propagation' and 'Prospection'. These four syntironomic methods are defined below. In these definitions, a 'resource' can mean something material such as food, fuel or clothing, but it can also denote a process, custom, or idea.

'Provision' means persistence through the exploitation of resources which are already available. For example, human respiration depends upon the Provision of oxygen. Foraging activities depend upon the Provision of edible wild plants and fungi. Replicating a style of garment relies upon the Provision of a pattern. Newborn babies are almost exclusively dependent upon Provision.

'Protection' means persistence through the retention of those resources which are already available. Protection can take obviously physical forms, such as the tough hide of a rhinoceros or the impregnable walls of a castle. Other manifestations include the freezing or desiccation of foodstuffs to prevent decay; insurance policies; legal contracts; weaponry; digital backups; and immune systems.

'Propagation' means persistence through the increase of available resources. Human reproduction is an obvious form of Propagation, serving to maintain (among other things) a family and a species. Propagation methods also include the sowing of seed corn to extend the Provision of a crop beyond a single year's harvest, and the breeding of livestock to maintain or increase a herd. The accrual of interest on a monetary deposit can also be seen as a form of Propagation. More abstractly, the printing of books Propagates ideas and knowledge.

Finally, 'Prospection' means persistence through the exploration and acquisition of new resources. This could include the exploration of new hunting grounds, or experimentation with new crop species. Prospection is inherent in the idea of 'divergent thinking' – the simultaneous exploration of multiple solutions – as a key cognitive factor in problem-solving (Runco and Acar, 2012). At an unconscious level, genetic mutation is a form of Prospection, as it creates opportunities for new and potentially advantageous characteristics to emerge within a species, thus increasing the chances of its survival.

At least one of these four syntironomic methods must be at work for any given abstract or concrete phenomenon to exist, but they may occur in any combination or number. Often, there will be more than one application of a method – for instance, a piece of cheese wrapped in aluminium foil and placed in a refrigerator is subject to (at least) two forms of Protection. Cheesemaking itself is a form of Protection because it preserves milk from spoiling. Eventually, however, even cheese will be consumed: by fungi, if not by a human. This example illustrates syntironomic failure, when a phenomenon or entity (the piece of cheese) ceases to exist because it has been *superseded* by another entity's syntironomic methods (an organism obtaining nutrients, i.e., Provision). Such supersession is another key principle of syntironomy: all things tend towards persistence until their syntironomic methods are superseded by those of another phenomenon or entity.

Syntironomic methods are not necessarily consciously exercised, since they apply to sentient and non-sentient, living and non-living things alike. Cell biology offers a good illustration of unconscious syntironomy. Animal cells persist fundamentally through respiration, which rests upon the Provision of oxygen and glucose. The cells also benefit from Protection, offered not only by their own outer membranes but also, ideally, by the immune system of the parent organism. Collectively, cells also persist by Propagating themselves through cell division, and particularly through the replication of their DNA. It is at this level that the cells engage in Prospection, since genetic mutation during replication can be seen as a form of cellular innovation, or exploration, which can contribute to the collective syntironomic success of the cells (as well as the parent organism and, ultimately, the species). Supersession of cells can take many forms – for instance, the Prospection of viruses seeking to Propagate themselves by hijacking the cells' own syntironomic methods.

**Syntironomy and human survival**

The conscious syntironomy of humans is more complex. The nexus of syntironomic methods employed by a human (or group of humans) is limited only by their ingenuity and environmental constraints. It is not possible, therefore, for this paper to characterize a complete syntironomy of human life. Rather, by way of example, it focuses upon the acquisition of plant foods – above all, cereals – the consumption of which supports the persistence of the body. Local availability of sufficient and accessible wild foods could allow humans to depend strongly upon Provision for their food security, whether attained via fishing, hunting or gathering. The traditional subsistence strategies of the Ju'/Hoansi Bushmen of the Kalahari offer a modern, though diminishing, example of such complete reliance upon the Provision of wild food sources (Suzman, 2017). Where wild resources are less reliable or environments more hostile, other methods may be employed. Alternative terrains can be Prospected for new resources, while abandoned terrains are thus Protected in order for them to recover from potential depletion, perhaps within a seasonal migration cycle such as that practised by the Saami of northern Finland until the nineteenth century: 'the whole way of life aimed at preserving the natural resources' (Hicks, 1993, 138).

Such nomadic or semi-nomadic lifeways might be glossed collectively as 'hunter-gatherer mobility' (Kelly, 1983); but from a syntironomic perspective, a particular *sedentary* practice can be interpreted in a comparable way. The Early Neolithic 'pre-agricultural plant management' of wild perennial grasses, identified at Sheikh-e Abad in modern Iran, is said to have entailed 'weeding, watering, protection *etc*.' without creating 'the selection pressures necessary for domestication' (Whitlam et al., 2018, 828). Domestication is here taken to mean the genetic separation of varieties of plant or animal which thrive in an anthropogenic environment, and which in turn benefit humans: effectively, the evolution of a symbiotic relationship with *Homo sapiens* (Zohary et al., 2012, 20–22).

The common syntironomic characteristic of hunter-gatherer mobility on the one hand, and sedentary non-agricultural plant management on the other, is this: passive human interaction with natural syntironomy. In these models, the syntironomic methods of wild food plants or quarry animals are not harnessed, altered or superseded, but rather (ideally) allowed to continue indefinitely in their own way. Alternatively, humans can interact more actively with the syntironomic methods of wild plants and animals, harnessing and altering those methods to improve Provision for human needs. Domestication, as defined above, offers a prime example. Whereas wild cereals rely upon the shattering of their ears for seed dispersal and thus Propagation, domesticated cereals under cultivation are subject to the opposite selection pressure: non-shattering ears are preferentially harvested and therefore resown as seed corn. The Propagation strategies of humans thus create a new ecological niche, and the genetic Prospection of the cereal plants allows them to adapt to that niche, to the mutual benefit of both the plants and the people.

## Syntironomy and cereals

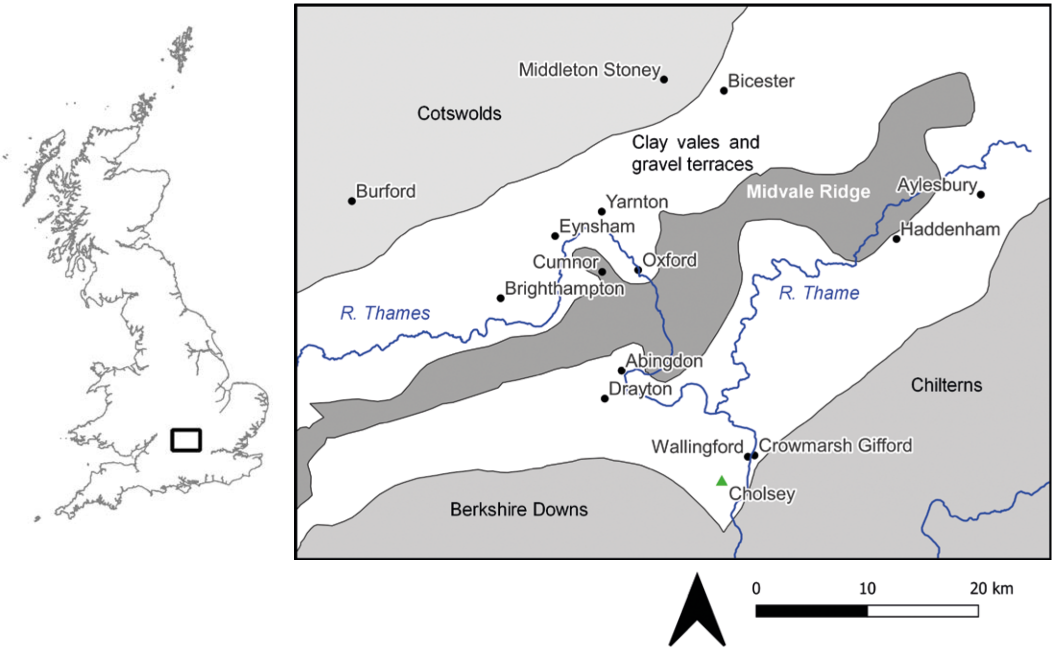
More than 9,000 years after their original domestication in the Middle East, wheat (especially free-threshing bread wheat: *Triticum aestivum* L.) and barley (especially hulled barley: *Hordeum vulgare* L.) were well-established in early medieval England (Moffett, 2006). The genetic Prospection methods of these cereals had allowed them gradually to adapt to environments very different from those of the 'Fertile Crescent' over the intervening millennia. England's early medieval crop spectrum also included oats (*Avena* L.) and rye (*Secale cereale* L.), which had originally been tolerated as weeds of wheat and barley in the Middle East, but came to be domesticated and cultivated in their own right as they were carried into central and northern Europe: an especially successful instance of 'crop mimicry' as a means of Propagation (Behre, 1992; Zohary et al., 2012).

All of the foregoing discussion might seem to be a laborious and tortuous way of describing the origins of agriculture, its spread to the British Isles, and its continued evolution through to the early medieval period and beyond. However, reversion to that paradigm falls foul of the EngLaId critique: that branding certain activities as 'agricultural' blinds us to the nuances of pre-modern times. Instead, the perspective taken above has followed the syntironomic success of cereals as much as the survival of their human cultivators.

The persistence of these cereals in England from the early medieval period onwards goes beyond their continued cultivation through the fifth to thirteenth centuries. The fact that archaeological research projects such as FeedSax can study large datasets of preserved cereals and associated arable weeds (e.g., Bogaard et al., this volume) is testament to the durability of certain plant parts in the archaeological record. The incomplete combustion of grains, seeds and other elements reduces them to carbon, producing the charred plant remains which are the mainstay of archaeobotany (Charles et al., 2015). They are resistant to microbial decay, and often physically robust enough to endure for millennia in the soil. Cereals are particularly apt to be preserved by charring: they are processed in ways that bring them into close contact with fire (e.g., drying or malting), and their suitability for long-term storage and processing in bulk renders them vulnerable to the accidental conflagration of barns, granaries and mills (van der Veen, 2007). The physical persistence of some cereal plants over centuries and millennia has thus benefited indirectly from the Protection methods of humans, seeking and sometimes failing to keep their staple foods safe by drying and storing them in bulk.

Nonetheless, it must be remembered that the seventh to thirteenth centuries in England witnessed some 700 harvests at thousands of settlements, producing countless billions of cereal grains of which only a tiny fraction survives in the archaeobotanical record; the vast majority were consumed at the time by humans, livestock, wild animals, insects, fungi, bacteria or fire. Of the tiny surviving fraction, it is likely that only a small (though increasing) proportion has been retrieved and analysed by archaeobotanists, who must make a working assumption that they have a reasonably representative sample from which to draw conclusions about past environments and practices.

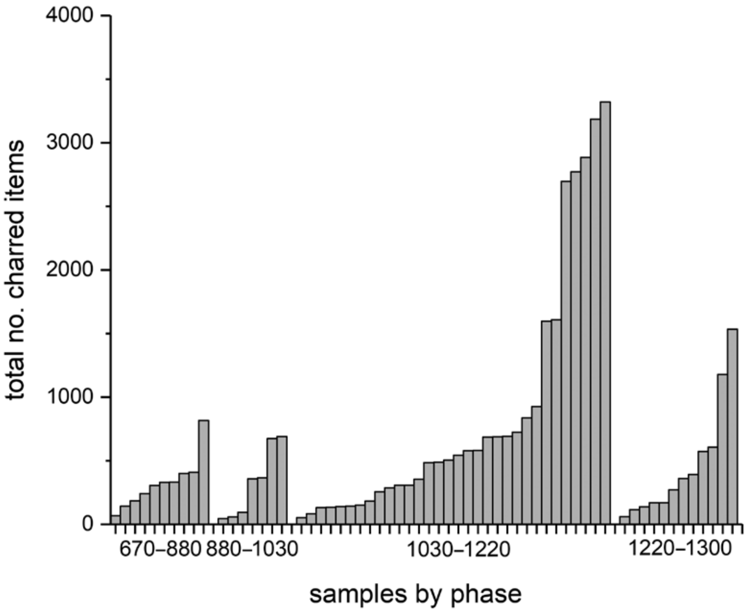
In short, the archaeobotanical remains of early medieval crops and weeds represent the proverbial tip of an iceberg. What does it mean, then, if that tip appears to grow over time: if the archaeobotanical record for a region becomes richer, more abundant? This appears to be the case in the Upper Thames valley, a region in England's 'Central Zone' characterized by heavy clay vales, lighter gravel terraces and alluvial clays on the floodplains (Booth et al., 2007). The wider region




**31** The Upper Thames valley case study area. Black dots indicate sites which have produced archaeobotanical data analysed in this paper; the triangle marks Cholsey, the site of a large medieval tithe barn discussed in the text. Contains Ordnance Survey Open Data © Crown copyright and database right 2017, under the Open Government licence. Terrain boundaries after Natural England's National Character Areas (https://www.gov.uk/government/publications/national-character-area-profiles-data-for-local-decision-making; accessed 23/07/21). Map created with QGIS (http://www.qgis.org; accessed 08/03/2022).

as defined in this paper (Figure 31) also includes the valley of the Thame, a tributary which flows south-westwards into the Thames; the limestone dip slope of the Cotswolds to the north-west, which rolls gently south-eastwards into the Thames valley; the Midvale Ridge of low limestone hills, which bears dry, sandy, acid soils; and to the south, the chalk hills of the Berkshire Downs and Chilterns.

The FeedSax project collected archaeobotanical data pertaining to 84 samples from 26 excavated sites in this region, each sample containing charred grains and other plant remains of seventh- to thirteenth-century date (Figure 31; Tables 7 and 8). Each of these samples has a crop component dominated by the four free-threshing cereals which characterize early medieval English farming: free-threshing wheat, hulled barley, oats and rye (cf. McKerracher, 2019). Among these 84 samples are 65 which are datable to one of four phases: *c.* AD 670–880, 880–1030, 1030–1220 and 1220–1300. These 'best fit' phases have been devised by the FeedSax project to



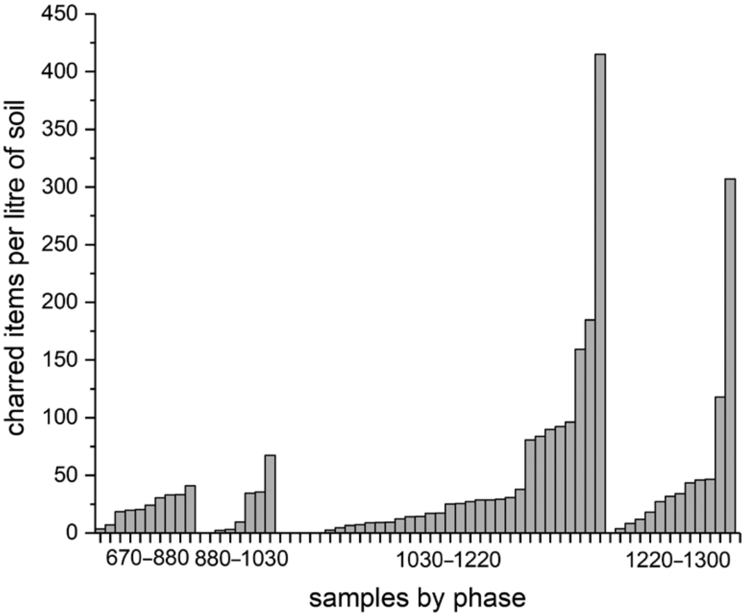

**32** Abundance of charred plant remains per sample, grouped by phase. Excludes four anomalously rich samples whose inclusion would obscure overall patterns (see main text).

accommodate both commonly used ceramic phases and radiocarbon date ranges obtained from the IntCal20 calibration curve (Hamerow et al., in prep.; Reimer et al., 2020). The remaining 19 samples cannot be specifically assigned to any one of these phases, but they nonetheless date from sometime between the seventh and thirteenth centuries.

Figure 32 charts the overall abundance of charred plant remains (including cereal grains, chaff items and arable weed seeds) in each of the 65 phased samples, grouped chronologically, excluding four anomalously rich outliers (with more than 4,000 items each) whose inclusion would have obscured patterns among the other samples.[1] This graph shows that, in simple numerical terms, the period 1030–1220 produced significantly more charred plant remains than the other periods: more items in more samples at more sites. Put another way, the cereals of this period have enjoyed greater syntironomic success through to the present day.

Why might this be? Could these results be artificial, an artefact of recovery due to the sampling of larger soil volumes from sites

1 These four samples derive from contexts 3693 at Yarnton (20,157 items; phased 670–880); 113/9 at All Saints Church, Oxford (4,643 items; phased 880–1030); 1590 at Merton College, Oxford (8,680 items; phased 1030–1220); and the ‘medieval grain spread’ at the Prebendal, Aylesbury (130,921 items; phased 1030–1220).




**33** Average density of charred plant remains per litre of soil, per sample, grouped by phase. Excludes four anomalously rich samples whose inclusion would obscure other patterns (see main text).

of this period? We can check this by calibrating the results by soil volume, i.e., by calculating the average density of items per litre of soil. This can be achieved for 56 samples, having excluded those four anomalously rich outliers mentioned above (whose inclusion would again obscure patterns among the other samples) and a further five for which no soil volume data were available. The resulting density data are displayed in Figure 33 and clearly echo the pattern seen in Figure 32, thus demonstrating that the trend is not due to differences in samples' soil volumes.

How should we interpret these results? There are several aspects to disentangle here. First, there is a significantly greater number of sites – and samples – represented for the period 1030–1220 than for the earlier and later periods (Table 8). The greater number of samples in the period 1030–1220 is largely a function of the greater number of sites: no single site contributes an absolute majority to the total number of samples in this period, so the overall trend is not being distorted by one unusually fruitful excavation. In fact, such a bias only occurs for the period 670–880, for which a single well-sampled site (Yarnton) contributes all 11 of the samples, including one of the four anomalously abundant/dense samples which were excluded as outliers from Figures 32 and 33. Yarnton is, in a sense, the exception that proves the rule, demonstrating that sites of that period *can* add rich charred crop assemblages to the archaeological record, but in practice seldom do.

**Table 7 Upper Thames valley sites included in the dataset used in this study**

| Site | Samples | References for data |
|---|---|---|
| Abingdon: 75 Ock Street | 2 | Hull, 2006 |
| Abingdon: Morlands Brewery | 3 | Pine and Taylor, 2006 |
| Abingdon: West Central Development | 4 | Brady et al., 2008 |
| Aylesbury: The Prebendal | 1 | Moffett, 1989 |
| Bicester: Chapel Street | 1 | Harding and Andrews, 2003 |
| Bicester: Langford Park Farm | 1 | Pine and Mundin, 2018 |
| Brighthampton: The Orchard | 1 | Ford and Preston, 2003 |
| Burford: 47–53 High Street | 7 | Coles et al., 2008 |
| Burford: Priory | 1 | Thompson, 2010 |
| Crowmarsh Gifford: Lister Wilder Site | 2 | Laban, 2013 |
| Cumnor: Dean Court Farm | 6 | Moffett, 1994 |
| Drayton: 54–80 Abingdon Road | 1 | Anthony and Taylor, 2006 |
| Eynsham: Abbey | 2 | Hardy et al., 2003 |
| Haddenham: Fort End | 2 | Bray and Weale, 2014 |
| Haddenham: Townsend | 1 | Bray and Weale, 2014 |
| Middleton Stoney | 1 | Rahtz and Rowley, 1984 |
| Oxford: 113–119 High Street | 1 | Walker and King, 2000 |
| Oxford: All Saints' Church | 2 | Dodd, 2003 |
| Oxford: Jesus College and Market Street | 3 | Bashford and Ford, 2014 |
| Oxford: Lincoln College | 12 | Kamash et al., 2003 |
| Oxford: Merton College | 5 | Poore et al., 2007 |
| Oxford: Nun's Garden | 1 | Teague et al., 2015 |
| Oxford: Sackler Library | 2 | Poore and Wilkinson, 2001 |
| Oxford: St John's College | 2 | Wallis, 2014 |
| Wallingford: 51–53 St Mary's Street | 1 | Preston, 2012 |
| Yarnton | 19 | Hey, 2004 |

**Table 8 Distribution of sites and samples, by period**

| Period (years AD) | Excavated sites | Samples |
|---|---|---|
| 670–880 | 1 | 11 |
| 880–1030 | 3 | 8 |
| 1030–1220 | 10 | 34 |
| 1220–1300 | 5 | 12 |
| No single period | 13 | 19 |
| **Totals** | **26** | **84** |

Nonetheless, there is an artificial modern bias contributing to the predominance of evidence from the period 1030–1220: three of the ten sites represent excavations within Oxford. The city of Oxford is systematically over-represented in the early medieval archaeological record for this region, first because of the high frequency of excavations consequent on urban development there, and second because of Oxford's central roles through the tenth to thirteenth centuries, from a Late Saxon *burh* to a revived post-Conquest town (Dodd, 2003, 19–63). By contrast, urban settlements elsewhere in the Upper Thames valley were much less developed in the period 880–1030, and non-existent in the period 670–880. Hence, a comparison between the evidence for 670–1030 and that for 1030–1300 is, to a large extent, a comparison between rural and urban, with the latter usually yielding richer, denser charred crop deposits.

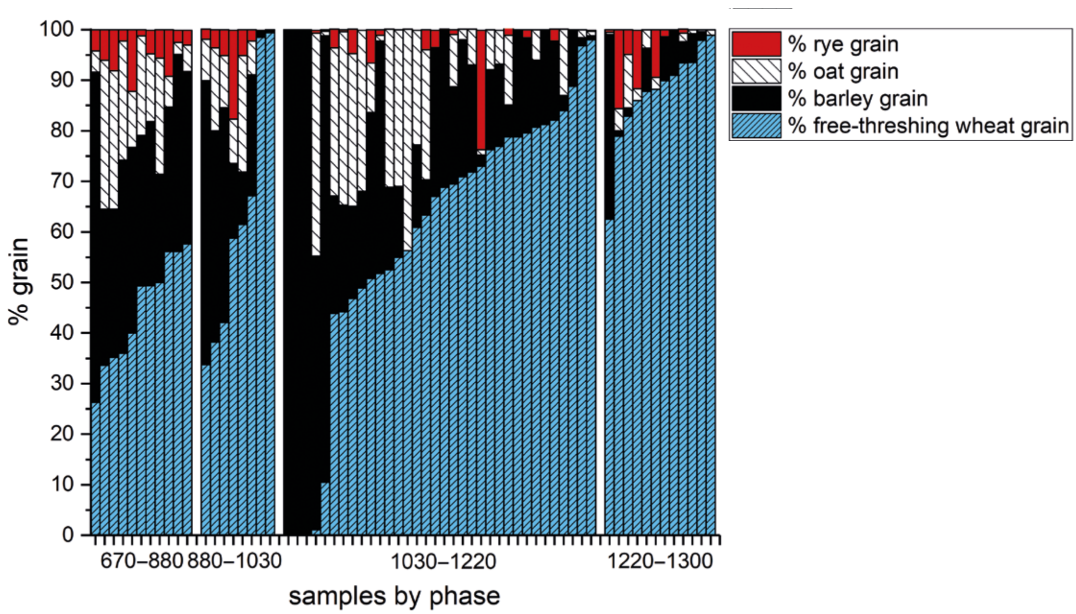
What may explain the greater syntironomic success enjoyed by the cereals that were imported into towns? The high concentration of modern excavations in urban centres helps to explain the greater overall *number* of samples retrieved, but not necessarily the *density* of charred plant remains within those samples. It is not necessarily the case that, as more and more samples are retrieved, the chances of discovering very dense deposits must increase; that is only true as long as there are dense deposits still awaiting discovery. There is, however, some correlation between density and settlement type. It is significant to note that among the denser samples from *c.*1220–1300 are not only samples from Oxford but also some from Abingdon – home to a wealthy medieval abbey – and its grange at Dean Court Farm, Cumnor. These assemblages share a common historical context: the supply of surplus crops to 'consumer' (i.e., non-harvesting) monastic and urban populations, which were generally much larger by the thirteenth century than they had been in the seventh century. Relatively dense concentrations of consumers (as in towns and monasteries) create relatively dense concentrations of food (as also in related production and storage contexts, such as monastic granges and tithe barns), and thus create dense archaeological concentrations of food remains.

Witness, too, the development of crop storage facilities and mills across England over this same period. No specialist storage structures appear to have been built between the fifth and mid-seventh centuries, a dearth which suggests that harvests typically did not exceed what could be stored within households (Hamerow, 2012, 51–52; McKerracher, 2018, 70–76). But then, somewhere between the later seventh and late ninth centuries, granaries were constructed at Yarnton covering an area of some 125 square metres (Hey, 2004, 124–27). Some five centuries later, probably around the turn of the fourteenth century, a huge tithe barn covering some 1,500 square metres was constructed for Reading Abbey at Cholsey in Oxfordshire (Figure 31; Horn, 1963). The construction of mills, which indicate a scale of crop processing well above that of individual farms, followed a similar trajectory. They are absent in the archaeological record of the fifth to mid-seventh centuries; around 60 watermills are known from archaeological and documentary sources for the late seventh to tenth centuries; more than 5,000 watermills are recorded in the Domesday Book of 1086; and perhaps 10,000 or more mills (including windmills) were in use by 1300 (Historic England, 2018).

Taken together, all of this archaeobotanical, archaeological and documentary evidence indicates a continued escalation of surplus storage, processing and consumption between the late seventh and late thirteenth centuries. In syntironomic terms, we could see all of these trends as avenues of Prospection and Protection for the security of those producing the crops. Prospection entailed the exploration of new storage and processing technologies. Protection entailed the use of such facilities to protect harvests from the depredations of rodents, insects and damp; but Protective methods also encompassed the sale of corn to urban consumers which allowed the conversion of perishable harvests into less perishable possessions and wealth. In addition, by the twelfth century, Provision of labour and surpluses to landlords Protected tenants from dispossession (Dyer, 2003, 107).

### The persistence of wheat

Returning now to the archaeobotanical evidence from the Upper Thames valley and its wider environs: what of the cereal crops themselves? Which species contributed to these growing surpluses? We can address this question by taking the 65 phased samples (Table 8) and calculating for each one the relative proportions of wheat, barley, oat and rye grains, as a proxy for the relative proportions of crops harvested and/or stored in each period and locality (Figure 34). More specifically, a working assumption is made that the cereals in these samples represent crops intended for human consumption, rather than animal fodder, thatching, bedding or other uses. This assumption is made on the basis that cereals intended for human consumption are inherently more likely to be preserved by charring – in malting kilns, for instance, or whilst being dried prior to milling – than are fodder or thatching crops. In addition, the great majority of these samples can be classed as grain-rich 'product' samples (cf. McKerracher, 2019, 37–48), representing harvests which had already




**34** Percentages of free-threshing wheat, barley, oat and rye grains in samples, grouped by phase.

been threshed, winnowed and therefore probably earmarked for human consumption.

In the periods 670–880 and 880–1030, the percentages are very variable, with wheat and barley – and occasionally oat – constituting relatively high proportions of the total grain counts. The main exceptions to this variability are two wheat-dominated samples, dated *c*.880–1030, from the excavations at All Saints' Church in Oxford.

To some extent, this variability continues among the 1030–1220 samples, with three samples (from Oxford) containing 100 per cent barley, and others containing significant proportions of wheat, barley and oat grains (in comparison, rye generally registers only a negligible presence in this period). However, what is most striking about the data for 1030–1220, and for the following period (1220–1300), is the large number of samples clearly dominated by wheat grains. Of the 46 samples collectively spanning 1030–1300, wheat grains constitute more than 60 per cent of the total grain count in 32 of them. Excavations in Oxford, Abingdon and Cumnor (specifically the monastic grange at Dean Court Farm) are well represented among these 32 samples, but other sites such as Burford – a town with an ecclesiastical hospital, at the edge of the Cotswolds – are represented too. It is difficult to escape the conclusion that, of all four cereals in cultivation, wheat contributed most of all to the growing surpluses produced and consumed from *c*.1030 onwards. This chimes well with the documentary evidence for the central importance of wheat. The

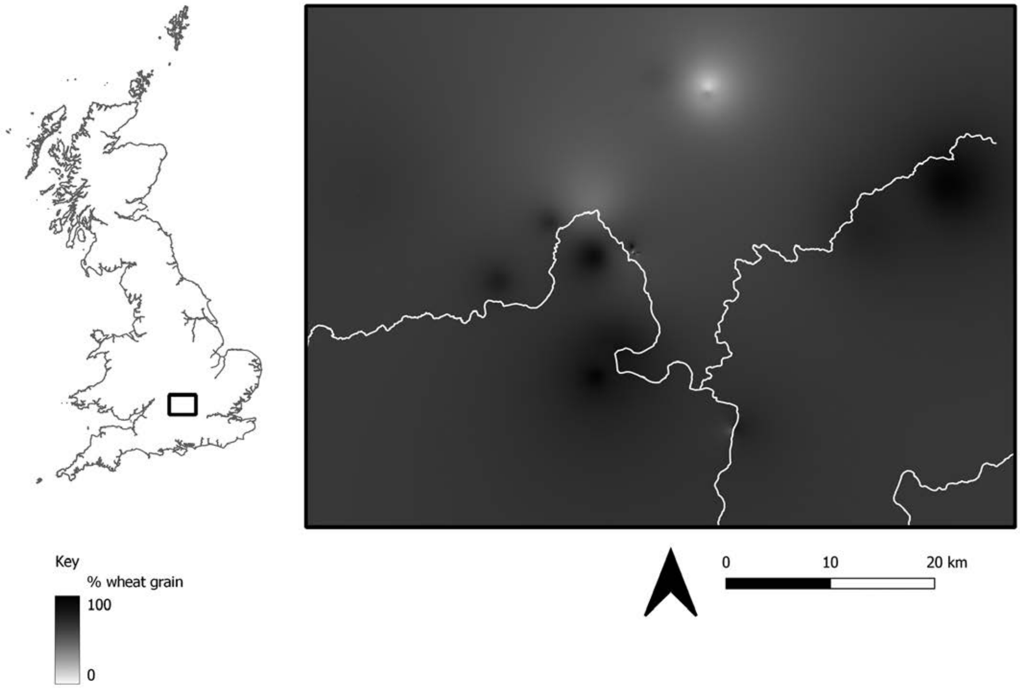
*Anglo-Saxon Chronicle*, for instance, illustrates the severity of the 1044 famine with reference to the inflating price of wheat, implying that the latter was a common index of food security and exchange – and therefore that wheat was the key staple and/or highest value cereal food of the time, at least in the eyes of those responsible for writing such documents (Banham, 2010, 181; Banham and Faith, 2014, 24–25).

Hence, the syntironomic success of wheat – culminating in its strong archaeobotanical representation in urban excavations – is attributable to its being an important and particularly desirable staple of human diet, especially from the eleventh century onwards. An exhaustive discussion of why wheat should have achieved this central status is beyond the scope of this paper; the reasons are likely to be varied and complex, including such factors as its flavour and baking qualities (Banham, 2010). But an environmental factor also deserves consideration. The percentages of wheat grains per sample, as graphed above in Figure 34 but now also including the 19 samples which cannot be assigned to any single phase, can be mapped using a technique called Inverse Distance Weighting (Chapman, 2006; McKerracher, 2019, 82). This approach interpolates geographical trends from the sample-by-sample data, taking account of geographical distances between the parent sites, and produces a shaded matrix in which the darker shades indicate higher percentages of wheat grain per sample: black corresponding to 100 per cent wheat, white corresponding to 0 per cent (Figure 35).

The resulting map clearly illustrates that the greatest concentrations of wheat-rich samples are among the sites nearest to the rivers Thames and Thame: that is, well within the clay vales rather than on the limestone dip slope to the north, where barley and oat are more prominent. There may be an ecological reason for this pattern: barley, oat and rye are more tolerant of poorer and drier conditions, whereas wheat thrives on richer, heavier soils such as clayey loams, as long as they are sufficiently well-drained (Moffett, 2006, 48; Banham, 2010, 182–83). For towns such as Oxford and Abingdon, then, situated advantageously on the water source and transport route of the Upper Thames, wheat may well have been the most abundant local crop – the crop of greatest Provision – as well as a desirable, tradeable good for a riverine market town.

## Expansion and disturbance

If wheat was preferentially imported by urban populations, and urban populations were growing, then it stands to reason that



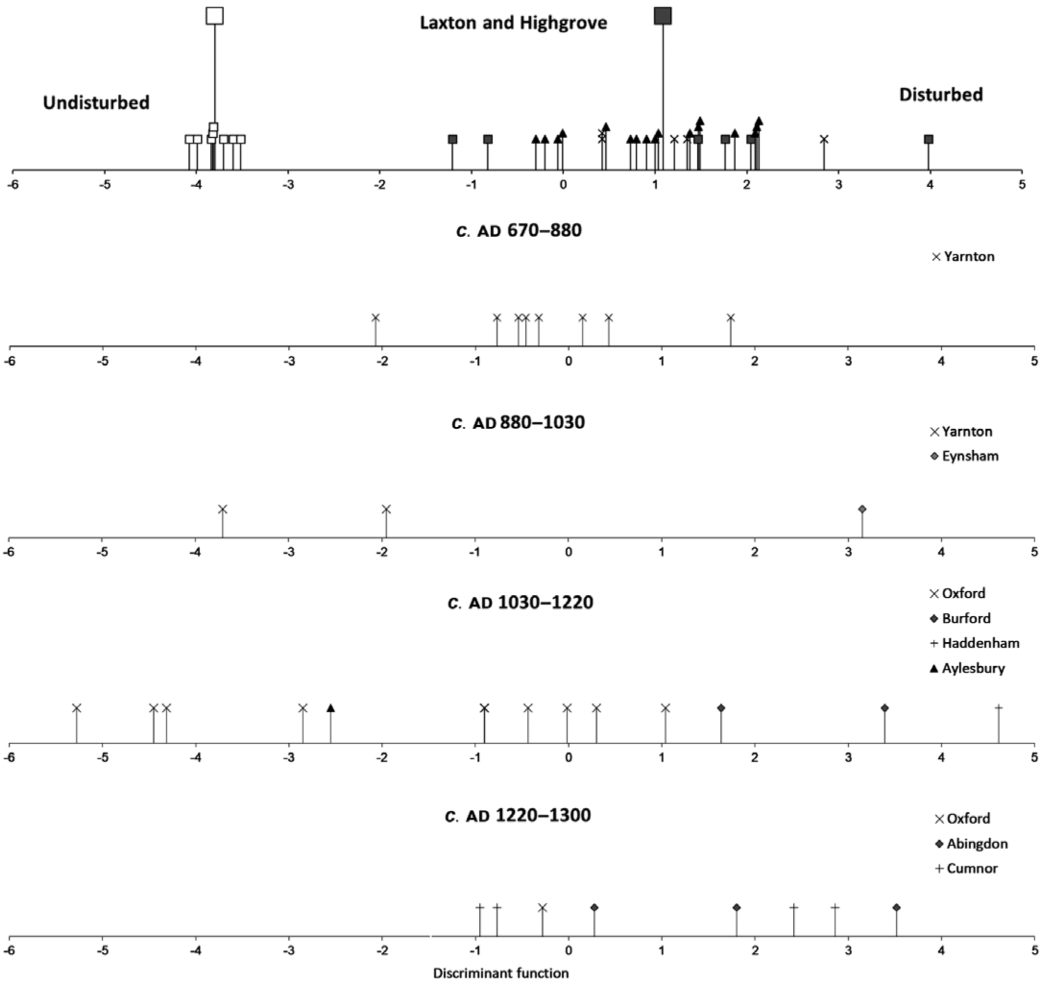

**35** Interpolated map of percentages of free-threshing wheat grains in samples from all phases. Map created with QGIS (http://www.qgis.org; accessed 08/03/2022).

the cultivation of wheat – and perhaps other crops too – must have expanded over this period. The Provision, Protection and Prospection methods discussed so far cannot alone explain the twinned syntironomic successes of cereals and humans between the seventh and thirteenth centuries. Surely there must also have been a Propagation method which worked to increase the available surpluses both for consumption and for seed corn? The most obvious manifestation of Propagation in this context would be the physical expansion of arable land, a process which can leave traces in the pollen record. The broad palynological picture from sub-regions in central, east and south-east England, as investigated by Forster and Charles (this volume), highlights a significant increase in arable land use in the eighth century, a slight increase in arable and pasture but with more of an emphasis on pasture at some sites in the tenth century, and a decline in land use around the eleventh century. In other words, despite archaeological and archaeobotanical evidence for a continuing growth in crop surpluses from the seventh century onwards, there is no definitive palynological evidence for a steady expansion of arable land unfolding *continuously* through this whole period. On the contrary, it is likely that much of the arable land in use in the thirteenth century had already been cultivated since at least the eighth century. Therefore, the persistent growth of crop surpluses between the seventh and thirteenth centuries cannot be explained in terms of a continuous, general expansion of arable land through this period.

If there was not a continuous, general expansion of arable land between the seventh and thirteenth centuries, could changes in crop husbandry strategies help to explain the overall persistence – and particularly the Propagation – of surplus crop production through this period? The functional weed ecology method developed by Bogaard et al. (this volume) allows us to shed some light on this issue. Bogaard's method for gauging soil disturbance from archaeobotanically preserved weed flora can be applied to the data from the Upper Thames valley, with a significantly wide range of results (Figure 36).

As with previously studied data from Stafford (Hamerow et al., 2020, 598, fig. 8) the samples from the Upper Thames valley return a wide range of discriminant scores. Those for the period 670–880, all from Yarnton, reflect a moderate level of disturbance. For the subsequent period, 880–1030, there is a polarization between Yarnton's two samples with low disturbance and Eynsham Abbey's one with high disturbance. The samples from 1030–1220 show the greatest variability of all, registering low, moderate and high disturbance with no clear correlations between disturbance levels and settlement status. Indeed, a very wide range of low and moderate disturbance signatures is represented by the samples from Oxford, perhaps unsurprisingly for an urban centre drawing in corn from various sources. Higher disturbance is registered by two samples from Burford – the town with an ecclesiastical hospital – but the highest of all is represented by a sample from a supposed croft (i.e., a cultivated plot attached to a house) excavated at Haddenham. Finally, although none of the samples from 1220–1300 registers low disturbance, they nonetheless cover a range from moderate to high disturbance, with the two principal sites – Abingdon, and Abingdon Abbey's grange at Cumnor – represented at both ends of this spectrum.

It thus appears that in the period of greatest apparent growth in cereal surpluses (*c.*1030–1220), a potentially very wide range of husbandry practices contributed to the syntironomic success of cereals and their cultivators: practices which may have spanned heavy and light ploughing, two- and three-course crop rotations, different degrees of fallow ploughing, and a variety of terrains – different combinations of these factors resulting in a wide range of disturbance signatures. This variety is exactly consonant with a syntironomic model, in which Prospection seeks out and fills available 'niches' in both human and natural ecosystems and continues to do so as opportunities and restrictions change over time: like water percolating




**36** Weed ecological discriminant analysis of soil disturbance (analysis by Amy Bogaard, following method of Bogaard et al., this volume). Topmost plot shows the relationship of Laxton sykes (low disturbance) versus Laxton and Highgrove arable fields (high disturbance) to the discriminant function; lower plots show the relationship of archaeobotanical samples from the Upper Thames valley, phase by phase, to the discriminant function (larger symbols indicate centroids for the modern groups).

down through a soil matrix, branching and changing course in response to obstacles, apertures and textures. The sparse but polarized data for 880–1030 could indicate that the main spreading, ranging or percolation of crop husbandry practices had occurred (or at least begun) by the late ninth century. The result, taken collectively, resembles a form of overall, long-term Protection: the greater the range of strategies employed across the landscape, the less likely it is that all will fail in a given year. Such large-scale Propagation methods as may have been employed by cultivators are likely to have occurred in discrete, episodic events, such as the claiming of new arable lands by assarting (Dyer, 2003, 161), rather than in a general, continuous, year-on-year investment of intense labour.

## A syntironomic perspective on the medieval 'agricultural revolution'

Syntironomy thus offers an alternative perspective on the paradox discussed by Bogaard et al. (this volume), whereby medieval farming combined aspects of both low-input and high-input cultivation strategies (essentially, low fertility and high disturbance), such that a strict distinction between 'extensification' and 'intensification' begins to break down. In syntironomic terms, the evidence presented here indicates an active pursuit of Protection strategies and a much smaller emphasis on Propagation methods throughout most of the period under investigation. The most conspicuous general expansion of arable land use – that is, the most energetic phase of both Prospection and Propagation – appears to have happened comparatively early in the period, around the eighth century (Forster and Charles, this volume). This broadly coincides with the diversification of crops and renewed construction of mills, granaries and grain ovens which can be identified in the archaeological record for much of England between the late seventh and late ninth centuries (Hamerow, this volume; McKerracher, 2018).

Expansion, diversification, renewal: in syntironomic terms, these are the hallmarks of Prospection, which explores, experiments and invents in order to bolster Provision (by finding new productive terrains), Protection (by devising new granaries, for example) and Propagation (by expanding areas of cultivation). In this way, we can see the period *c.*670–880 as a time of great and wide-ranging Prospection in terms of cereal production. But around the end of the ninth century, in areas of central and southern England such as the Upper Thames valley, the trajectory of Prospection changed. Prospective strategies for Propagation and Provision began to peter out as land shortages loomed, and the ingenuity of both producers and consumers alike was turning instead to Protection: overturning weeds, improving drainage, building bigger barns, focusing on local marketable staples, exchanging perishable produce for less perishable wealth, or imposing obligations upon tenants to preserve lordly might – this latter strategy bolstered in particular by a shortage of land in the thirteenth century (Dyer, 2003, 141). In short, more energies went into 'keeping' than into 'creating'; both of these can be means of increasing surpluses. Despite the general success of this approach, however, none of these Protective methods could be entirely secure against crises such as war, famine, disease or flood. And, ultimately, tragically, the grand syntironomic sweep of medieval 'cerealization' was widely superseded in the fourteenth century by the Propagation and Prospection of *Yersinia pestis*: the Black Death.

It might be that a wider syntironomic study of medieval England, reaching beyond the relationship between humans and cereals, could find parallel trends of Prospection and Protection. For instance, it could be argued that, after the creative Prospection that led to the emergence of England's first illuminated manuscripts in the seventh to eighth centuries, the persistence of hand-copied books as rare, expensive and often devotional possessions served to Protect rather than Propagate literacy and knowledge – until Caxton's introduction of the press to England in the fifteenth century triggered the mass Propagation of the printed word.

Further exploration of such ideas lies beyond the scope of this paper. However, by recasting early medieval agriculture in the independent framework of syntironomy, this study has presented a new model for integrating biological, technological, economic, taphonomic and any number of other considerations in future archaeological studies, thus escaping the white bears of teleology.

# 8 The Precursor to the Revolution? Current Understandings of the Agrarian Economy of Roman Britain

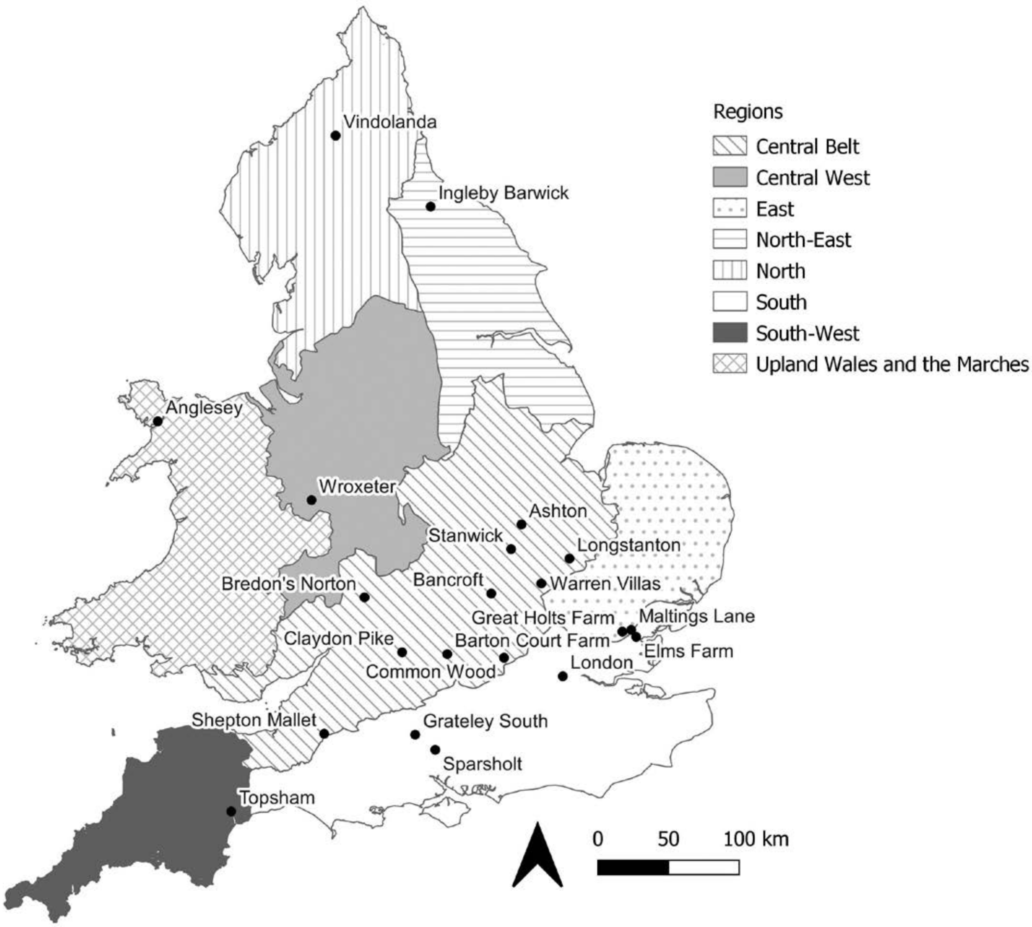
*Lisa Lodwick*

## Introduction

The early medieval agricultural boom has been the subject of a prolonged and detailed debate, as seen in this volume. However, critical discussion on the agrarian economy of Roman Britain has somewhat lagged behind. Both eras have in common an agrarian economy based upon the large-scale surplus production of cereals, and now a large quantity of available archaeological data with which to investigate this. The Roman period is often used as a touchstone to which early medieval rural settlement returns, and ultimately surpasses, for both its demographic peak and its archaeological evidence for agricultural infrastructure: namely, hay meadows, extensive networks of trackways and paddocks, and cereal processing installations (Gardiner, 2013; Hamerow, 2012, 147, 151). Many of the same processes – extensification, surplus production, capital investment in cereal processing infrastructure – have all been variously identified in both the Roman and the early medieval periods (Hamerow, 2012; van der Veen, 2016; Allen et al., 2017; McKerracher, 2018). Yet, unlike the early medieval period, where agrarian systems have been placed at the heart of a model of socio-economic change through the rise of lordship, villages and the rebirth of towns, Roman rural agrarian communities are generally attributed little agency in debates on the character of, and changes in, Roman society in Britain (Gerrard, 2013, 96; Taylor, 2013). Agricultural practices are rather seen as a reaction to the new markets created by the needs of the occupying forces (Campbell, 2016; van der Veen, 2016). Furthermore, the details of these two agrarian systems tend to be discussed separately, leaving little understanding of the long-term significance of the agricultural system underpinning Roman Britain.

By placing the early medieval agricultural revolution in the *longue durée* context of the first millennium AD, this contribution will consider the similarities and differences between these two agricultural systems: in terms of the concepts applied to investigate them, the crops cultivated and the key crop husbandry aspects of the so-called medieval 'agricultural revolution'. Doubtless, the end of Roman power in the west, and the fragmentation of rural farming systems, mean arguments for importance through the legacy in today's settlement patterns do not directly apply. However, there are clear continuities in aspects of the agrarian system between the Roman and early medieval periods: the strong similarities of grain-drying ovens (McKerracher, 2014), the continuity of some of the crop repertoire (McKerracher, 2018) and evidence for continuity of field systems (Rippon et al., 2015). Furthermore, due to the research undertaken through various 'Big Data' projects in the 2010s, capitalizing on the post-PPG16 (1990) upsurge in developer-funded excavation, the two periods can be considered together. The Leverhulme Trust-funded *Rural Settlement of Roman Britain* (RSRB; Smith et al., 2016) and *Fields of Britannia* projects (Rippon et al., 2015), and in north-eastern Gaul the RurLand project (Reddé, 2018), have provided data-rich overviews which enable a cross-period comparison. Whilst these projects were a priori focused on rural settlement, agriculture did feature strongly in the datasets collated; nevertheless, there were no central question-driven hypotheses concerning crop husbandry practices. Whilst the conclusion of the RSRB project highlighted the sheer complexity of rural settlement, and presented compelling evidence for shifts in agricultural practices, reasons for change or continuity in agriculture were not explored at length (Fulford, 2017).

Elsewhere, previous region-specific studies, namely the *Thames Through Time* series, have enabled a long-term view of the first-millennium farming system to be taken in the Upper Thames valley (Booth et al., 2007), albeit based on qualitative reviews of the datasets. Similarly, in Fowler's *Farming in the First Millennium AD*, the underlying data are largely individual site-based environmental archaeological case studies (Fowler, 2002). By contrast, agriculture has received a great deal of attention in Mediterranean research – with special focus on villa-based oleiculture and viticulture. Overall, emphasis has been placed on the scale of processing and trade connectivity (Bowman and Wilson, 2013; Horden and Purcell, 2000; Erdkamp, 2005), rather than cereal husbandry practices, which sit at the root of the FeedSax debate.




37 Map of key sites mentioned in the text, plotted against regional divisions employed by the *Rural Settlement of Roman Britain* project (Smith et al., 2016). Map created with QGIS (http://www.qgis.org; accessed 08/03/2022).

Prior to such a comparison between Roman and early medieval farming systems, it is necessary to align the terminologies used. This chapter will first compare the concepts of agricultural practice through which the Roman agrarian economies have been studied and the perceived impacts of agrarian change. A brief summary will describe the major contributions to agrarian studies over the last century and the datasets available for analysis. Second, the crop repertoire of Roman Britain will be considered from the perspective of the archaeobotanical evidence, before the three main aspects of FeedSax's 'mouldboard plough package' (see Hamerow, this volume) are considered on the basis of evidence from Roman Britain and nearby regions. Once the concepts and categories of information have been aligned, a cross-period comparison of the timing, character and impact of key agrarian changes will be made. This comparative analysis will show that whilst many of the pieces of the medieval 'agricultural revolution' were in place in the Roman period, they did not coalesce in the same way. The absence of social cohesion through open-field cultivation and the sharing of mouldboard ploughing, or the unsustainability of a limited crop repertoire, will also be considered. Sites mentioned in this chapter are mapped in Figure 37.

## Cerealization: concepts

In the mid-twentieth century, at a conference taking place in Oxford on the subject of rural Roman settlement in Britain, C.E. Stevens resurrected an idea from the early twentieth-century study of Welsh law tracts, of a landscape of Roman Britain dotted with common fields, strip fields, and overall infield-outfield systems featuring manuring and rotation (Stevens, 1966). Stevens was essentially working with the evidence of a handful of settlement plans, and his arguments did not gain traction. Just under a decade later, Applebaum suggested that a three-course rotation of winter spelt (*Triticum spelta* L.) and rye (*Secale cereale* L.) and summer club wheat (*Triticum compactum* L.) and emmer (*Triticum dicoccum* Schübl.) was practised, based on the evidence of a handful of antiquarian grain finds (Applebaum, 1972, 113). However, the predominant narrative of rural Roman Britain continued to be focused on villa economies, and principally informed by agronomic texts (Branigan, 1989).

Following the introduction of systematic environmental archaeology techniques, the terms of debate changed. In the 1980s, Martin Jones was able to set out a model of late Iron Age agricultural innovation, early Roman expansion, and late Roman innovation (Jones, 1981; 1982). This model was based on a handful of archaeobotanical assemblages from the Thames valley and Hampshire Downs, and a compilation of various reports of impressions and small collections of charred cereals. Jones's model was adopted by the highly influential synthesis of Millett (1990, 201), which largely holds up today (Lodwick, 2017a). In the late 1990s, van der Veen and O'Connor advanced the discussion by conceptualizing the husbandry practices of the Roman agrarian expansion in the 'intensive/extensive' terminology promulgated by the Sheffield palaeoecology school, on the basis of now growing evidence for the shift to an agricultural system focused on cattle and spelt wheat. The evidence base for this argument was provided by archaeobotanical work undertaken in the 1980s by Jones and Robinson in the Upper Thames valley, Murphy in East Anglia and van der Veen in the north-east, as well as King's compilation of faunal data (van der Veen and O'Connor, 1998).

Whilst the introduction of environmental archaeology techniques was able to shape the form of debate early on, detailed interrogation of this model has been slow to take place. The detailed study of Iron Age to Roman agricultural change in the Danebury Environs project did offer support for seeing the late Iron Age and then the mid- to late Roman periods as key periods of change (Campbell, 2008a; 2008b). Assessment of agricultural practices at the Late Iron Age *oppidum* at Silchester showed continuity in arable practices, but change in the areas of foddering and crop provision (Lodwick, 2017b). A major synthesis by Parks provided detailed data from the east of England to underpin the argument for mid-Roman expansion, extensification and an increase in scale in arable farming, evidenced particularly by an increase in the density of crop-processing material (Parks, 2012; van der Veen, 2016). The late Roman innovations proposed by Jones (1981; 1982) have, however, largely fallen by the wayside. More generally, agricultural intensification continues to be identified in broader studies of the period, but with an intended meaning of higher overall production rather than shifts in crop husbandry practices per se (Lodwick et al., 2021).

Despite the growth in data and detailed studies, the character of crop husbandry practices has not become an area of wider discussion, especially where the pervading research themes in Roman Britain have been ones of identity. The social significance of animal husbandry practices has been highlighted by Chadwick (2016) and more recently there have been calls for addressing rural society in its own terms. Analysis has so far been focused on the use of space within aisled barns, the temporality of exchange practices, and the use of material culture by rural societies (Gardner, 2012; Taylor, 2013) – but, as of yet, not crop husbandry practices themselves. The range of hypotheses presented by the work of Stevens, Applebaum and others in the 1960s–80s were not incorporated into models of how Roman Britain worked, and most of the theoretical and methodological innovation in recent decades has been focused on cultural aspects of consumption, dress and literacy rather than social aspects of agrarian life.

A major reason for this is that the perceived outcomes of the early medieval 'agricultural revolution' – wealth inequality, urbanization, and the emergence of villages – are still felt today and are unequivocally important for understanding historical process. These arguments and debates have been well rehearsed and will not be repeated here (see Hamerow, this volume). Agriculture in Roman Britain has not been argued to have changed anything. Late Iron Age proto-towns or *oppida* are not linked to any shifts in arable practices (Lodwick, 2017b); Roman towns were founded before the mid-Roman agrarian boom, partly on the basis of imported staple foods. The wealth displayed in rural villas through architecture such as bath houses, wall paintings and mosaics is often considered to have been sourced from agriculture surplus (e.g., Cunliffe, 2008, 48). However, it has also been argued that this wealth cannot be linked to the agricultural activities practised at individual sites (Millett, 2007, 152; Taylor, 2011). More widely, villas are still perceived as being reliant on surplus extraction from surrounding farms (Halsall, 2007, 357–58). The only impact of Roman cereal production on the settlement hierarchy is seen through the development of defended small towns – but this is a consequence of the flow of cereals through these settlements, rather than husbandry practices (Smith and Fulford, 2019).

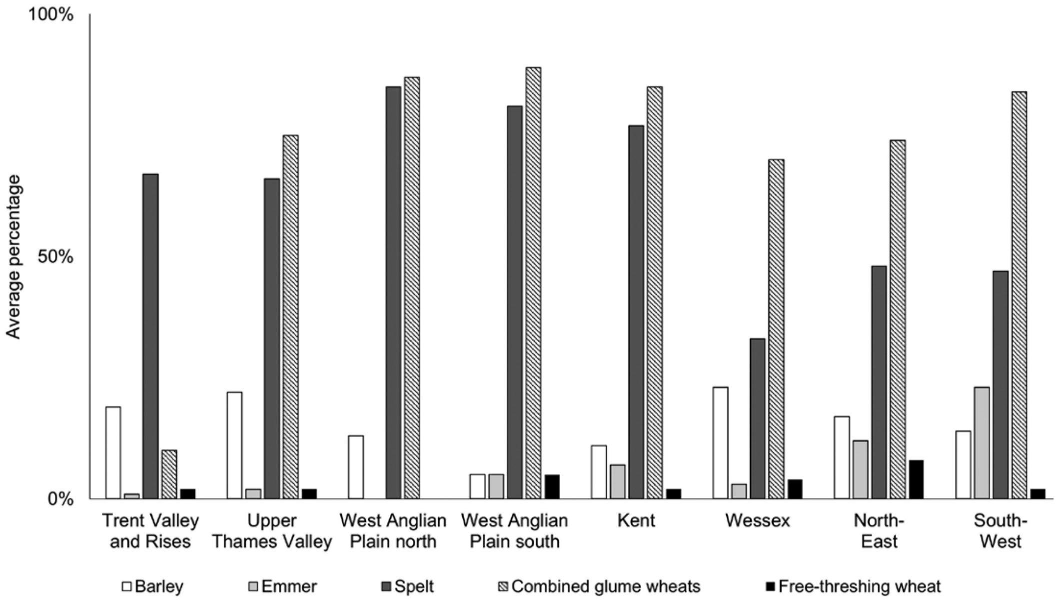
Looking beyond Britain, Roman archaeology continues to focus on change emanating out from Italy, where discussions of agriculture are dominated by historical sources, villas and survey archaeology (Witcher, 2016). The methods of environmental archaeology have been much more slowly adopted. Arguably, the hypothesis which has gained the most traction over the last decade is Kron's argument for ley farming, which is essentially a long rotation with sown fodder crops. Alongside the literary evidence, he presented this argument on the basis of a charred *in situ* deposit of hay from Opplontis, and the presence of taxa which could be used as fodder crops at a range of sites (Kron, 2004). The increasingly widespread identification of rotation and integrated farming is being seen as an important advance in the imperial period (Marzano, 2020, 437), without enough consideration of pre-Roman husbandry practices or sufficient archaeobotanical evidence. In summary, key aspects of the early medieval 'agricultural revolution' – rotation, and integration with animal husbandry – are now being identified in regions with limited environmental archaeology, but these aspects have simply not been areas of sustained debate in the data-rich regions of the north-west provinces.

## Cerealization: counts

Whilst concepts of investigation are similar in terms but not in application in the Roman period, datasets are larger in scale, if not greater in quality. Whilst core foci of early medieval rural settlement have been identified in regions such as the East Midlands and the Upper Thames valley (Hamerow, 2012, 2), the distribution of farming settlements within the Roman province is wider, with villa structures now recorded as far north as Ingleby Barwick (North Yorkshire), and T-shaped grain-drying ovens recorded as far west as Anglesey (NW Wales) and Topsham (Devon) (Lodwick, 2017a). However, the impact of post-PPG16 developer-funded excavations, and rescue excavations in the 1980s where environmental recovery was incorporated, should be comparable across periods.

In terms of the hard data with which to work, for the Roman period the *Rural Settlement of Roman Britain* project collated settlement evidence, coins, small finds, faunal NISP count and ageing data, presence/absence plant data, and burial data, resulting in evidence from *c.*2,500 rural settlements, with data entry completed in 2015 (Allen et al., 2018). This evidence can be used to identify the broad extent, and processing and storage aspects, of agrarian practices, but not the details of husbandry. A wealth of archaeobotanical data is in existence – initial analysis of 2,022 samples from 216 sites from eight case study regions highlighted patterns in crop choice, and identified crop husbandry practices based on coarse autecological analysis (Lodwick, 2017a). Historical sources only inform about the supply of cereals rather than their cultivation; the Bloomberg (London) and Vindolanda Tablets indicate supply relationships and sometimes intermediary storage locations of crop consignments, but say nothing of rural production (Bowman, 2003, 38; Tomlin, 2016). Later, the writings of Zosimus and Ammianus discuss the supply of grain from Britain to the Rhine frontier (Ireland, 2008, 144).

Settlement evidence from the early medieval period has been previously compiled – resulting in 84 settlements from the fifth to eleventh centuries (Hamerow, 2012; cf. Blair, 2018) – but no single database is available. Whilst there is not scope for detailed analysis here, it could be observed that the material culture record of most rural Roman settlements is more substantial than that of early medieval rural settlements, which have been described as 'disappointingly "clean" in archaeological terms, yielding few finds other than pottery and bone' (Hamerow, 2012, 2). Detailed archaeobotanical data have, however, been brought to bear by McKerracher (2019), and other more broad-scale studies have utilized crop data (Rippon et al., 2013). However, with the FeedSax project, the combination of isotopic, faunal, palynological and archaeobotanical analyses – and, crucially, the integration of these – is a major step forward (Hamerow et al., 2020). In summary, rural Roman Britain has the brute force of quantity of material, but not yet the precise analyses which would reveal detailed agrarian practice – such as zooarchaeological pathologies, functional weed ecology or fine-grained meta-analysis of crops.




**38** Average percentages of crops per site, based on Lodwick, 2017a, table 2.6.

## Crop choice

Crops form the foundation of an agricultural system, and as data have amassed for the Roman period, evidence for sudden changes in crop systems has dwindled. Earlier work on the Roman period in Britain suggested a rise in bread wheat at some sites, and rye and oats at other sites, and linked these divergent strategies to inequality (Jones, 1989, 133). Whilst the early medieval bread wheat hypothesis has been so clearly set out and then unpackaged (McKerracher, 2016b), arguments continue for the rise of free-threshing wheat in the Roman period in the Mediterranean provinces (Heinrich, 2017). Archaeobotanical meta-analysis in Britain has not found any strong evidence for this (Lodwick, 2017a), albeit the difficulties of separating free-threshing from spelt wheat remain (Campbell, 2016, 201) and further analysis is required.

Presence data per site-phase show a dominance of spelt wheat and barley in all periods, and fluctuations in the minor crops: rye, oats and free-threshing wheat (Lodwick, 2017a, 17). But this pattern is based on all sites in the RSRB database, lacking rigorous archaeobotanical quality checks. Considering fully quantified data from regional case studies, the dominance of spelt wheat is particularly strong in regions including the Nene and Ouse Valley (West Anglian Plain north and south) (Figure 38 and Lodwick, 2017a, figs 2.15, 2.16). A dominance of spelt wheat is seen at many sites, including villas, farmsteads and roadside settlements. This is contra to earlier narratives, based on much smaller numbers of reports, which saw a more diverse crop repertoire, and movements towards free-threshing wheat focused production in the fourth century AD (Fowler, 2002, 213).

Rather than status, or economic choice, geography appears as the main factor contributing to crop variation. The geological regions proposed by Rippon et al. (2015, 81) show associations between soil types and crops, such as more oat in the south-west and more wheat on clay lands. The coarse-level analysis of the RSRB reflected these associations, with a higher frequency of barley in the Hampshire Downs (Lodwick, 2017a). Such differences are echoed in the analysis of Zech-Matterne in northern Gaul, showing more free-threshing wheat on the deep soils of the Paris Basin and more barley on the varied soils to the east (Lepetz and Zech-Matterne, 2018; cf. Schroeder, this volume). Despite regional fluctuations, Roman agriculture appears to be a largely risky agricultural strategy with low crop diversity within regions.

### Aspects of the agricultural revolution 1: tillage

This chapter now turns from the crops themselves, to how they were cultivated, first through preparation of the soil for crop sowing. Tillage in the Roman period is still thought to have been undertaken with ards (Lodwick, 2017a, 41–44), with continued archaeological finds of iron shares, iron share tips and wooden ards (Brindle, 2017). No detailed assessment of tillage artefacts from Britain has been undertaken for several decades (Rees, 1979; Manning, 1985, 44). More iron fore shares and coulters are considered to be in use in the late Roman period (Rees, 2011, 93), but numerous examples come from late fourth-century hoards, hindering interpretations of their wider use. The most recent summary considers the presence of a more sophisticated and heavy type of plough as likely, with share and coulter passing through the beam, and perhaps a mouldboard, given the presence of asymmetric shares (Rees, 2011, 94).

There have been few additions to the list of coulters since Rees's assessment (1979, 59–61). Some new finds are incorporated within the ten coulters recorded in the RSRB database (Allen et al., 2018). A large-socketed blade with a rivet was recovered from a room within Sparsholt Roman villa, without specific dating (Stoodley, 2014), and possible identifications of iron coulters have been made from Common Wood, Penn, dated to AD 75–225 (Edwards, 2008), and Maltings Lane, Witham (Davies and Robertson, 2004), none of which have been studied in detail. A further coulter, from the Walbrook Valley in London, has been studied in detail by Humphreys (2018, 87). Asymmetry observed on the coulter blade here, as well as in examples at Silchester, whilst possibly stemming from use with a mouldboard, are considered more likely to be an artefact of the manufacturing process (Humphreys, 2018, 540).

Of the ard mark evidence, the only indication of asymmetrical plough marks is at Warren Villas, Bedfordshire (Lodwick, 2017a, 43). Broad analysis of weed flora has indicated no decrease in the presence of perennial weed taxa which could indicate a move towards ploughing (Lodwick, 2017a, 44), although application of the functional ecology model developed in the FeedSax project (Bogaard et al., this volume) would be needed to shed further light on this subject.

In summary, no definitive evidence is available for a Roman mouldboard plough in Britain, and more widely this innovation is seen as occurring beyond the borders of the Roman empire (Henning, 2016, 29). However, heavy clay soils were being cultivated in the Roman period, in the Nene Valley and elsewhere in the Central Belt (Smith, 2016; Lodwick et al., 2021), whilst stinking chamomile (*Anthemis cotula* L.), an indicator of clay soil cultivation, is widespread in archaeobotanical assemblages across different regions (Lodwick, 2017a, table 2.17). The question remains of how extensively one can cultivate with an ard.

In Roman Britain, cattle are increasingly well evidenced in faunal assemblages through time; older cattle in particular are better represented through time in the south and east. Cattle also get larger over time. For instance, the cattle at Bancroft in the Late Roman period were 20–30 centimetres taller than in the Iron Age (Allen, 2017, 112–13, figs 3.22, 3.23, 3.34). This increase in cattle occurrence, age and size is frequently linked with increased needs for traction for tillage, especially in the south-east (Allen, 2017, 112–13).

A detailed study of traction pathologies has yet to be undertaken for the Roman period. Traction pathologies are, however, widely observed at sites such as Wroxeter, Longstanton and Elms Farm, but the lack of consistent recording criteria has thus far inhibited a synthetic analysis (Allen, 2017, 113). Several studies have calculated pathological indices for cattle bones (cf. Holmes, this volume). A recent study at the small town of Ashton, Northamptonshire, found cattle foot bones to have an average pathological index that increases in the first century and then again in the early to late third century (Mahoney, 2016, 92, fig. 4.21). Beyond Britain, the use of large cattle for traction in the early Roman period was indicated in the *Civitas Tungrorum*, Belgium, with pathological index values of 54 to 66

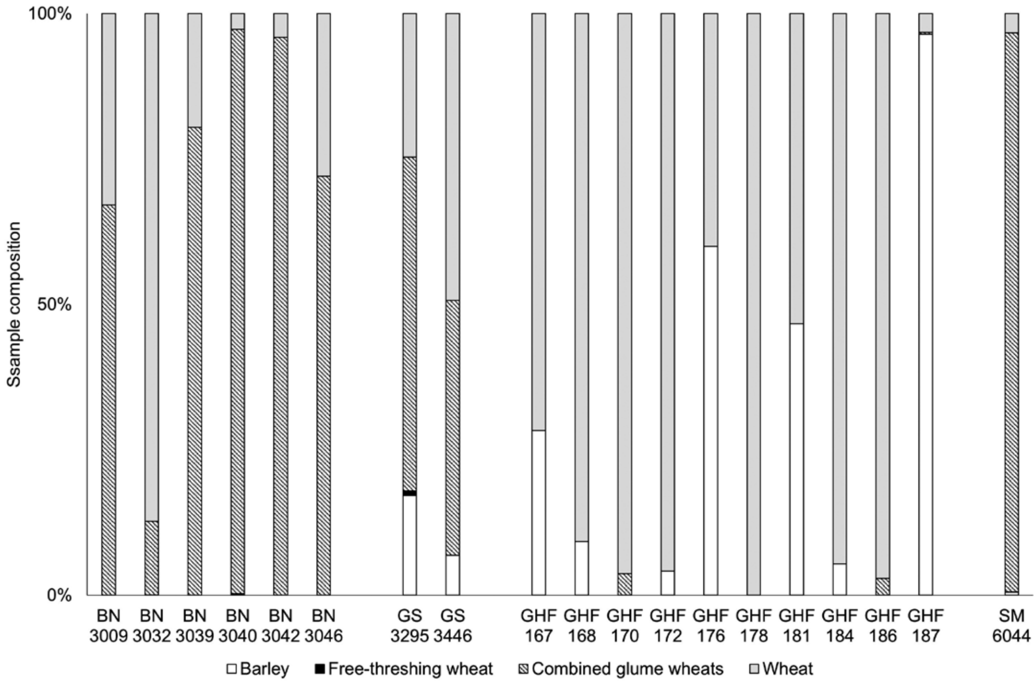
(Pigière, 2017). All indications show the increased importance of cattle for tillage, from the beginning of the Roman period.

### Aspects of the agricultural revolution 2: rotation

As with tillage, crop rotation is yet to receive sustained and analytical discussion for the Roman period. Given Roman Britain's reliance on just two main cereal crops – spelt wheat (*Triticum spelta* L.) and hulled barley (*Hordeum vulgare* L.) – the subject has not garnered much attention in recent syntheses (Parks, 2012; Campbell, 2016; van der Veen, 2016; Lodwick, 2017a). The presence of scatters of flax seeds (*Linum usitatissimum* L.) and Celtic bean (*Vicia faba* L.) in charred assemblages – for instance, at Barton Court Farm, had been adduced as evidence for rotation in early studies (Jones, 1981, 113), and more broadly the presence of Celtic bean and pea (*Pisum sativum* L.) have also been used as the basis for suggestions of crop rotation from the Late Bronze Age onwards (Treasure and Church, 2016, 120–21). In the Danebury Environs study, Campbell argues that spelt wheat and barley were cultivated separately over much of the Roman period (Campbell, 2008b, 68), contra to the preceding Iron Age, but does not go as far as saying that they were grown in rotation.

Unfortunately, storage deposits from rural settlements are scarce. There exists a handful of rural sites with grain storage deposits preserved *in situ*: Grateley Building 4 in Hampshire (Campbell, 2008a), Great Holts Farm in Essex (Murphy, 2003), Bredon's Norton in Worcestershire (Hunter, 2016) and Shepton Mallet in Dorset (Straker, 2001). These deposits show a dominance of glume wheat (mainly spelt) at Bredon's Norton, Grateley South and Shepton Mallet, and some barley-rich samples from Great Holts Farm, which may indicate the mixing of separate stores during conflagration (Figure 39). Based on this evidence alone, it cannot be concluded whether monocropping was the norm, and whether this was practised in rotation.

In contrast to the lack of discussion over rotation in Roman Britain, it has been argued that rotation was practised in north-east Gaul, on the basis of pure storage finds of cereal grains showing that maslins (mixed crops) were no longer cultivated. For example, the Paris Basin has evidence for free-threshing wheat, lentils (*Lens culinaris* Medik.), bitter vetch (*Vicia ervilia* (L.) Willd.) and barley cultivation. In particular, sites with a high abundance of free-threshing wheat also have high abundances of pulses, leading to conclusions of a pulse–wheat rotation (Lepetz and Zech-Matterne, 2018, 353–55).




**39** Composition of rural storage samples based on grain counts. Sites as follows: BN: Bredon's Norton (late fourth/ early fifth century AD), GHF: Great Holts Farm (late third/fourth century AD), GS: Grateley South (fourth century AD), SM: Shepton Mallet (late second to third century AD).

Direct evidence for crop rotation is currently limited. Isotopic analysis of emmer, spelt and barley remains from Iron Age and Roman Stanwick, Northamptonshire, showed no statistical difference in the $\delta^{15}N$ or $\delta^{13}C$ (beyond the barley–wheat offset) values for the Iron Age or Roman period (Lodwick et al., 2021). Either they were grown in rotation from the Iron Age, or no move towards rotation of these crops in different fields took place. While there is, as of yet, no positive evidence for crop rotation, it continues to be deemed an entirely likely practice in the Roman period (Fowler, 2002, 209; Booth et al., 2007, 299).

## Aspects of the agricultural revolution 3: extensification

The final aspect of the FeedSax 'mouldboard plough package' is extensification – a now well-characterized process of decreasing inputs of labour and manure per unit area (Hamerow and Bogaard et al., this volume). The Stanwick stable isotope study does show a statistically significant decline in $\delta^{15}N$ values from the Iron Age to the Roman period. With no environmental reasons for this decline, a decrease in the quantity of manure applied and hence extensification appears the most likely explanation (Lodwick et al., 2021). More broadly, autecological analysis of weed seeds suggests an increase in the frequency of low soil fertility indicators in the early Roman period, before a slight decrease in later samples (Lodwick, 2017a, fig. 2.28). Taking the well-rehearsed caveats of autecological analysis into account, more conclusive assessment of extensification requires functional weed ecology (e.g., Bogaard et al., this volume). Weed species indicative of the cultivation of wet soils – common spike-rush (*Eleocharis palustris* (L.) Roem. & Schult.) and blinks (*Montia fontana* L.) – show pronounced early and mid Roman peaks respectively (Lodwick, 2017a, fig. 2.24). However, this could of course indicate expansion in the areas cultivated, rather than extensification per se (van der Veen and O'Connor, 1998).

Based on a comparison between faunal and archaeobotanical evidence, extensive farming practices are considered the most likely agricultural strategies in Roman Britain (Allen and Lodwick, 2017), but mapping the rate of change across rural communities, and through the period, requires more fine-grained analysis.

## Scale and connectivity, rather than husbandry practice

On the basis of the evidence currently available, there is no convincing evidence for a sudden change or revolution in husbandry practices during the Roman period in Britain, although further detailed analysis is required. North-east Gaul may provide more convincing evidence, and this is where agricultural innovations are attested, namely the reaping machine known as the *gallic vallus* (Shaw, 2015, 101–20).

Targeted analysis on the level of the FeedSax project will be required in the future. What is unequivocally attested in the archaeological record is a step-change in the scale of cereal processing from the preceding Iron Age, in the form of grain-drying ovens, mills and bread ovens. Recent work on mills has indicated a landscape of powered mills across central southern Britain, occurring at a range of settlement types and regularly spaced across the landscape (Shaffrey, 2015). A substantial body of evidence is emerging for grain-drying ovens or corn-dryers, below ground flues linking a fireplace to an elevated drying floor. On the basis of abundant charred germinated cereal grains, some of these structures can be positively associated with malt production, for ale (Lodwick, 2017a). Written documents have shown the demands for ale in London in the later first century AD (Tomlin, 2016), and on Hadrian's Wall at Vindolanda (Bowman, 2003), but malting complexes have thus far only been found at rural settlements.

Many of the malting complexes identified in the first and second centuries AD are associated with roadside settlements and farmsteads close to the road network (Lodwick, 2017a, 63–66). The scale of these structures varies, but the majority feature one or two pairs of drying ovens and cisterns, seemingly at a smaller scale than the recent discoveries at Sedgeford (see Faulkner and Caroe, this volume). A key contrast is apparent here whereby in the Roman period, malting emerges as a relatively dispersed activity linked to roadside traffic; whilst in the early medieval period, it is seen in centralized, capital intensive projects.

More widely, whilst substantial variation in settlement form can be recognized, variation in agricultural strategies is relatively limited. Certainly, investments in viticulture and horticulture are evidenced, especially in the eastern area of the Central Belt, but these are relatively small in scale, and localized. Overall, a picture of homogeneity emerges. The early medieval model places emphasis on crop husbandry practices, as the provision of cereals enabled the growth of local power. By contrast, much cereal processing in Roman Britain can be linked with long-distance mobilization of cereals.

Storage structures are notably rare in the countryside of Roman Britain, with the majority of farmsteads not having any granaries. Aisled barns are certainly considered to have stored some material, and the *in situ* grain stores discussed above show the use of other buildings: attics in disused bath houses, previous mosaic rooms, etc. By contrast, grain-drying structures are widespread, indicating the extraction of grain on regular occasions (Lodwick, 2020). Long-distance mobilization of cereals is evidenced by the distribution of black-burnished ceramics up the east coast (Bidwell, 2017).

The widespread presence of hay meadows can also be linked with connectivity. Hay has been recorded at 40 rural sites in the RSRB database (Lodwick, 2017a, 80–81). The presence of hay at a rural site could be an indication of the intensive production of fodder to support animals at that farmstead. At rural excavations which have benefited from high-quality analysis of waterlogged plant remains, evidence for hay production has been identified, as at Claydon Pike (Robinson, 2007), for export to Cirencester (Booth et al., 2007, 48). Indeed, finds of stable flooring deposits, representing the disposal of stable litter containing hay, are predominantly limited to urban and military sites, such as Ribchester, Lancaster, London and York (Kenward and Hall, 2012). In summary, it could be argued that this further agricultural shift is associated with connectivity and military extraction, rather than capital investment at a settlement level.

To return to the questions underpinning the FeedSax project, agricultural practices in Roman Britain did shift: the crop repertoire narrowed, and extensification appears to have been a continuous process, although no clear change can be seen yet in rotation or tillage. Agricultural changes were landscape-wide, and not based on individual settlement types or communities. The connectivity of settlements, with the road system and military and urban consumers, is considered here as a key driver for the changes that are witnessed in cereal processing. But ultimately the crop spectrum and husbandry practices had their roots in the Iron Age, and it is in this period, with the increased availability of iron for tools and community nucleation, that the origins of this process of extensification need to be examined.

It is impossible to disentangle the decline of the Roman agricultural system from the fragmentation of Roman society in Britain. Lack of longevity in farming practices is perhaps due to reliance on external demands. To follow Gerrard's arguments, once the demands of the Roman state for tax and the extraction of rent disappeared at the beginning of the fifth century, the need for the production of agricultural surplus decreased markedly (Gerrard, 2013, 96–103). The construction of drying ovens within villa buildings can be seen as part of this fragmentation of power, with local elites now providing beer for clients and tenants (Gerrard, 2013, 256–59). Ultimately, in a fragmented society without a point of surplus extraction, the pursuit of extensive, low-diversity cropping strategies lacks agroecological sense.

## Conclusion

This comparative analysis has shown that whilst many of the pieces of the medieval 'agricultural revolution' were in place in the Roman period, they did not coalesce in the same enduring way. Indications of improvements in tillage practices, extensification and rotation occur throughout the Roman period, but as crop husbandry is not at the root of broader models of social change, detailed data collection and analysis have not been undertaken.

It is considered here that the difference between extractive extensification from the second century AD onwards, and opportunity-driven extensification from the eighth century AD, meant that shifts towards a limited crop repertoire, extensive cultivation and centralized processing lost their relevance following the cessation of tax and rent extraction at the beginning of the fifth century.

# 9 An Agro-Social Revolution in a Mid Saxon Village: Making Sense of the Sedgeford Excavations

*Neil Faulkner*[†]

## Introduction

The term 'revolution' is overworked. Any concept is liable to break down, to become epistemologically useless, if deployed without due regard for scientific precision. And unlike the 'natural' sciences, where scientific precision is de rigueur, the 'social' sciences are plagued by a cavalier attitude to terminology and definition. So I am obliged to substantiate my use of the term 'agro-social revolution' in relation to developments in Sedgeford during the Mid Saxon period or 'long eighth century' (*c.* AD 680–830; see Hamerow, this volume), as revealed during our 25 years of excavation on a summer research and training project.

An agricultural revolution is necessarily a social revolution, since it involves the reconfiguring of the labour process, and therefore the reorganization of the labour force, in line with new technologies and practices in the working of the land. I am using the term 'revolution' to reference the combined 'agro-social' transformation which I believe to be implicit in the archaeological evidence we have uncovered. I am hypothesizing that the lives of the people of Sedgeford in AD 850 were radically different from those of their forebears in AD 650. Broadly, I imagine a shift from scattered small communities of more-or-less independent subsistence farmers to a centralized village community

Every SHARP volunteer past and present has contributed directly or indirectly to this paper, but particular thanks are due to colleagues with whom I have worked closely on the excavation of the Mid Saxon malting complex in Trench 23 and on the exploration and interpretation of the wider contemporary landscape. These include Eleanor Blakelock, Hannah Caroe, Ian Drummond, Brian Fraser, John Jolleys, Gary Rossin and David Wood.

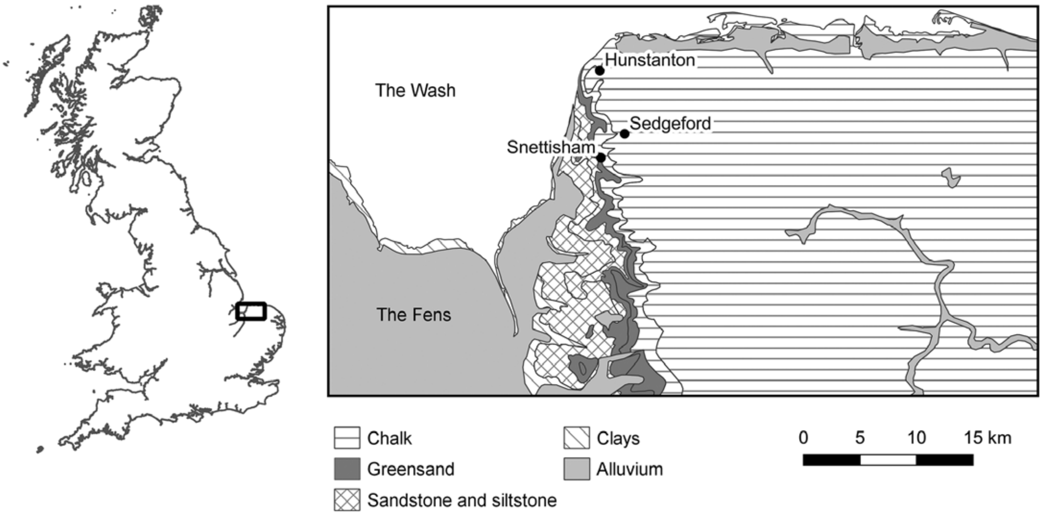
of dependent peasants whose lives were shaped by lordship, labour service and food render. Moreover, I see the main events of the transformation concentrated in a relatively short period, perhaps *c.* AD 725/750–800/825 – that is, playing out over perhaps three generations, and there seems to be nothing as radically transformative as this in Sedgeford again until the eighteenth century. We perhaps bear witness, during the 'long eighth century', to the creation of a class of agrarian producers subject to the authority of a class of landowners; in other words, the class structure of the medieval/feudal countryside appears to have been forged in the Mid Saxon period. That, surely, was a revolutionary transformation.

I present the evidence in the form of a summary list of observations and speculations arising from 25 years of fieldwork. Full publication of much of this is to be found elsewhere or is still in process (e.g., Faulkner and Blakelock, 2020; Caroe, this volume). This chapter, on the other hand, is a synthetic overview that brings together a diverse range of evidence to substantiate our core working hypothesis: that Sedgeford experienced an agro-social revolution during the 'long eighth century'.

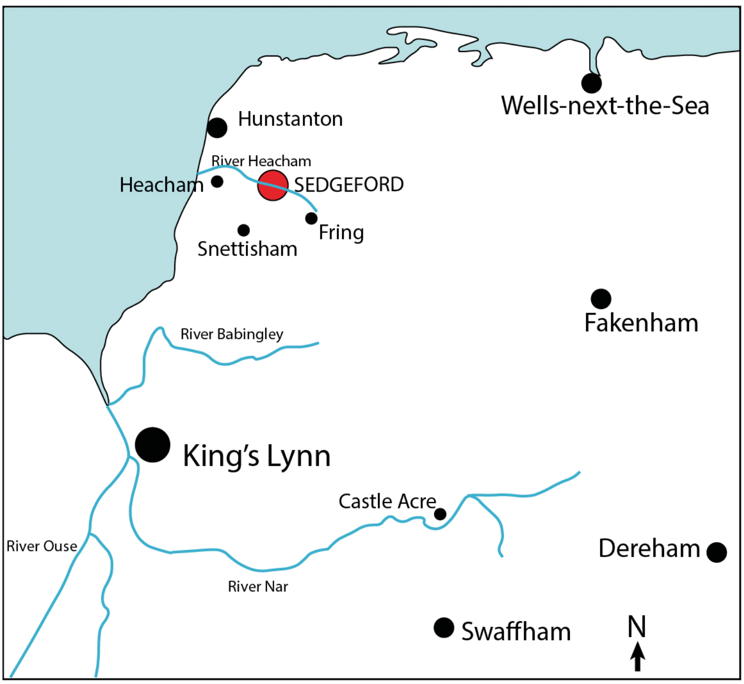
## The geography and chronology of the project

Sedgeford is located on the low Western Escarpment that runs north–south along the western edge of Norfolk (Figures 40 and 41). This rolling landscape is a complex of chalk bedrock, carstone outcrops (a locally important sandstone) and overlays of fluvio-glacially deposited sands, gravels, loams and boulder clays. This geology is dissected by a series of small westward-flowing rivers that have cut the region into a succession of little valleys. The usual pattern today is for each valley to constitute a parish and to have its own village. Sedgeford, in the valley of the river Heacham, is typical in this respect.

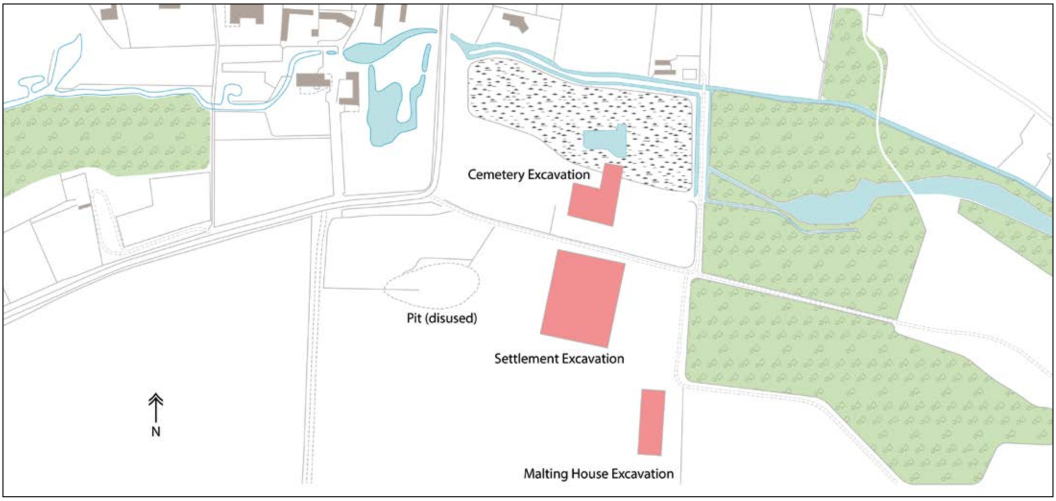
Building on a handful of antiquarian records, significant but unpublished research excavations in 1957, 1958 and 1960, and a small commercial investigation during pipe-laying in 1993, the Sedgeford Historical and Archaeological Research Project (SHARP) was set up in 1996 as a long-term, self-funded, volunteer-based research and training excavation. Since then, each year, the project has usually involved a six-week summer season (with up to 75 people on site each day), a short Easter season for fieldwalking, metal-detecting, geophysical survey, etc. (involving a dozen or so people) and an ongoing programme of archive research, post-excavation analysis and publication.




40 Geography matters. Sedgeford lies between Snettisham and Hunstanton on the Western Escarpment of north-west Norfolk. The Fens to the west were a major barrier to movement, whereas Sedgeford's small river (the Heacham) connected it via the Wash and the North Sea to Ipswich and other coastal, estuarine and river sites in the Kingdom of East Anglia and perhaps to a wider North Sea zone. Contains BGS Geology 625K Data © UKRI 2021, sourced via BGS Digital Data under the Edina Licence; and Ordnance Survey Open Data © Crown copyright and database right 2017, under the Open Government licence. Map created with QGIS (http://www.qgis.org; accessed 08/03/2022).




41 Sedgeford's location in north-west Norfolk. Plan: Gary Rossin/ SHARP.




**42** The three main excavation areas on the Mid Saxon site at Sedgeford: Cemetery (Phase 1, Boneyard-Reeddam, 1996–2007), Settlement (Phase 2, Lower Chalkpit, 2007–16), and Malting Complex (Phase 3, Trench 23, 2014 and continuing). Plan: Gary Rossin/SHARP.

Our study area is the present-day parish of Sedgeford (and the term 'parish' is used below even in relation to the Mid Saxon period as a convenient geographical shorthand). Our investigations have been thoroughly multi-disciplinary, involving, in addition to the main Mid Saxon excavations, archive research, landscape exploration, geophysical survey, standing-building recording, garden test-pits, small evaluations and medium-size open-area excavations; investigations that have yielded evidence in particular for the Late Iron Age, Roman and later medieval archaeology of the parish. But throughout, a large Mid Saxon site in the centre of the parish, on the southern side of the Heacham valley, immediately opposite the modern village of Sedgeford, has been the primary focus. Work here has fallen into three distinct phases (Figure 42).

Between 1996 and 2007, we explored a Mid Saxon cemetery on the Boneyard-Reeddam site, taking a sample of 291 inhumations, in the course of which we also observed several phases of boundary ditches and various structures. Between 2007 and 2016, our attention shifted a short distance to the south – higher up the southern slope of the valley of the river Heacham – where geophysical survey had revealed evidence for a settlement, confirmed by fieldwalking finds to be Mid to Late Saxon in date, in the neighbouring Chalkpit Field (these first two phases of work are summarized in our synthetic monograph: Faulkner et al., 2014). And since 2014 – and still continuing – we have been exploring a third zone, a cereal-processing plant located a short distance south-east of the settlement in a shallow gully towards the eastern side of Chalkpit Field (Trench 23). This third phase of excavation has been supplemented by historical and landscape work, including archive research, geophysical survey, auger survey and trial trenching, designed to contextualize the exceptional discovery of a Mid Saxon industrial complex comprising at least three and possibly more individual malthouses.[1]

### A Mid Saxon 'shuffle'

The notion of a Mid Saxon 'shuffle' – a localized shift from many, small, dispersed settlements to single consolidated villages in new, typically valley-floor locations – has long been part of the conceptual architecture of Anglo-Saxon settlement studies (e.g., Williamson, 1993, 89–91). This was confirmed to be the case at Sedgeford early in the SHARP excavations. Though no Early Saxon (mid-fifth- to mid-seventh-century) site has been properly excavated in the parish, we have recent metal-detector evidence for one substantial cemetery of late fifth- to early seventh-century date (with both cremations and inhumations, and some richly furnished graves) and antiquarian evidence for at least one and possibly two or three other cemetery sites (represented by accidental discoveries of funerary urns during the nineteenth and early twentieth centuries).

On the other hand, no evidence of any kind for Early Saxon activity has been recovered during our three open-area research excavations on the Mid Saxon site in the middle of the parish. Despite encountering a Late Neolithic/Early Bronze Age crouched burial, a Middle Iron Age crouched burial, a Late Iron Age water's-edge ritual site notable for the discovery of the Sedgeford Hoard (39 gold staters, 20 of them still inside their cow-bone container), the evidence in this area for activity between the first and seventh centuries AD has been virtually zero, except for a 'background noise' of occasional degraded Roman pottery, presumably representing midden spreads and subsequent hillwash (Faulkner et al., 2014).

Our current working assumptions are that: (a) Early Saxon settlements existed in the parish (on the basis of the cemetery evidence); (b) no such settlement was located beneath the Mid Saxon one; (c) the Mid Saxon settlement therefore appeared *de novo*, probably at some point in the second half of the seventh century AD; (d) this settlement was essentially a village of farmers but probably also some sort of estate centre; (e) no other Mid Saxon settlements

1 A full description of Malthouse 1 can be found in Faulkner and Blakelock, 2020. A summary description of our current knowledge of the wider malting complex can be found in Blakelock and Caroe, forthcoming; see also Caroe, this volume'.

were present in the parish (this mainly deduced on the basis of extensive fieldwalking); and (f) that the cemetery served mainly or wholly the settlement rather than a wider area beyond the parish.

### A Mid Saxon village and cemetery

Little is known about the new village in its earliest form (Phase 3; Plate XIIIa).[2] We know of a ditched trackway/droveway running south-east to north-west on the Lower Chalkpit settlement site, the ditches re-cut at least three times, the features dated by local, handmade, grass-tempered pottery, which presumably pushes the date earlier than *c.* AD 725, when the first Ipswich Ware is likely to have arrived at Sedgeford. This trackway/droveway was broadly contemporary with two parallel north–south ditches on the Boneyard-Reeddam cemetery site, though we cannot be certain that burials were yet being made.

Matters become a good deal clearer in Phase 4 (*c.* AD 725–?775/825). We now have a substantial curvilinear boundary ditch on the Lower Chalkpit site, at least 100 metres long on the evidence of geophysical survey, with a second ditch, almost as long, aligned south-west to north-east, meeting it at right angles in the vicinity of an apparent entranceway (Plate XIIIa). Just inside the entranceway were found the remains of a structure, formed of 20 postholes representing three sides of a rough rectangle, with a putative fourth side lost to a later ditch. A structured deposit comprising an articulated calf skeleton covered by a layer of unprocessed mussel shells was found at the northern limit of the curvilinear ditch. There seems little doubt that these features are evidence for the first incarnation of the Mid Saxon settlement.

Of greater significance, however, is the associated cemetery on Boneyard-Reeddam (Plate XIIIa). We cannot be certain it was extant as early as Phase 3, but it was certainly in use throughout Phases 4 and 5 (so can be dated *c.* AD 650/725–850/875), a date based on stratigraphic sequence, associated pottery and several radiocarbon determinations. Our excavations (1996–2007) recovered 291 discrete inhumations, we know of a further 126 excavated in 1957, 1958 and 1960, and we have also recovered a large assemblage of disarticulated bone representing burials disturbed by later feature-cutting and modern ploughing on the site. Extrapolating from the density of

2 Phases 1 and 2 on the site are Late Iron Age and Early Roman respectively. There is then a long hiatus, perhaps as long as half a millennium, before Phase 3, dated *c.* AD 650/700–725. The principal Late Iron Age discoveries are reported in Dennis and Faulkner, 2005.

burials in the areas sampled by excavation and what we know about the likely limits of the cemetery, we can estimate a total of between 800 and 1,600 burials in all. The burials were aligned east–west, some bodies in coffins, most in shrouds, and there were no associated grave-goods.[3] The implication, of course, is a cemetery managed by Christian ecclesiastical authority, an impression perhaps confirmed by a small posthole structure respected by the burials and assumed to be some sort of funerary chapel.

What matters for the argument here is that the cemetery implies not only an organizing authority, but also a pooling of labour and therefore of resources. If we make a number of working assumptions – about the size of the cemetery (1,200 burials), its duration of use (175 years) and average life expectancy (45 years) – we arrive at a rough estimate of the living population at the time. Because of the unknowns and uncertainties, the calculation is crude, but it does provide a ballpark figure of around 300. This turns out to correspond closely with the estimated population of Sedgeford in the late eleventh century (based on the Domesday survey of 1086), which is 277–338. We might suggest, therefore, that by the early eighth century AD, a community of about 300 people had been brought together under some sort of centralizing authority.

## A grid-planned landscape

Phase 5 (*c.* AD ?775/825–850/925) saw radical change. The curvilinear boundary around the settlement on Lower Chalkpit was replaced by a new rectangular grid oriented approximately north-south/east-west, with individual plots defined by ditches measuring approximately 30 by 25 metres, and individual buildings, aligned with the boundaries, measuring approximately 10 by 5 metres (Plate XIIIb). The settlement retained this basic form for up to 200 years, throughout Phases 6 (*c.* AD 850/925–?900/950) and 7 (*c.* AD ?900/950–?975/1025), both dated by Thetford Ware. Boundaries were repeatedly re-cut, buildings periodically replaced, and during Phase 7 a large D-shaped enclosure was established on the southern edge of the village, interpreted as a thegnly residence – that of a minor local lord, the Saxon equivalent of a knight or lord of the manor – given the monumental size of the boundary ditch and the substantial interior features seen in excavation (Plate XIIIb–c).

3 There were only two significant anomalies, perhaps suggestive of 'Final Phase' pagan practice, one a horse burial, the other a small pit containing a pot, a couple of knives and some smithing slag. See Faulkner et al., 2014, 92–93.

The new gridded layout, moreover, appears to employ the 'short perch' measure (4.6 metres) identified by Blair et al. (2020) as a standard unit in Mid Saxon planning. SHARP landscape archaeologist David Wood found that a short-perch grid overlain at an angle of 115°T on a composite of Google Earth satellite images, magnetometry survey results, and a plan of excavated features corresponded with the alignments of a medieval trackway still in use and the northern boundary of the D-shaped enclosure, and also with the alignments and measurements of various individual plot boundaries (Plate XIV). Furthermore, the buildings excavated within the plots also displayed regularity: with one notable exception, more substantially built and oriented 115/295°T (a church?), the buildings were oriented 025/205°T and measured approximately one short perch by two short perches.

The grid was then extended to the wider landscape, with a short-perch furlong (184 metres) as the unit of measurement, but retaining the 115°T orientation derived from the settlement evidence (Plate XV). This hypothetical Mid Saxon grid showed remarkable correspondence with existing field boundaries (accounting for nearly 40 per cent of them), and also with lost field boundaries recorded on a 1631 estate map, on a 1797 estate map, on the 1880 first edition OS map and in magnetometry surveys (adding half as many again matching lines). Additional support for the working hypothesis of a planned Mid Saxon estate centred on Sedgeford arises when the view is extended further, to neighbouring parishes, where quite different alignments of field boundaries are apparent.[4]

The implications are numerous. The circumstantial evidence that the Church was the repository and disseminator of essentially Roman techniques of surveying is compelling (Blair et al., 2020, 87–154). The need for some sort of overarching authority, whether secular or ecclesiastical, to organize this level of landscape planning seems obvious. The preoccupation with standard measurements, straight lines, and right angles – that is, with a symmetrical reconfiguring of the landscape – implies a wider concern with order and control. The deliberate demarcation of plot boundaries betokens a community concerned to define individual rights and obligations (a notion explored at length by Reynolds, 2003).

4 Work is still in progress and will in due course be the subject of a separate paper. A notable feature of this work is the use of a 3D digital terrain model, as opposed to reliance on 2D conventional mapping, since Mid Saxon surveyors will have worked 'as the pheasant walks' not 'as the crow flies'.

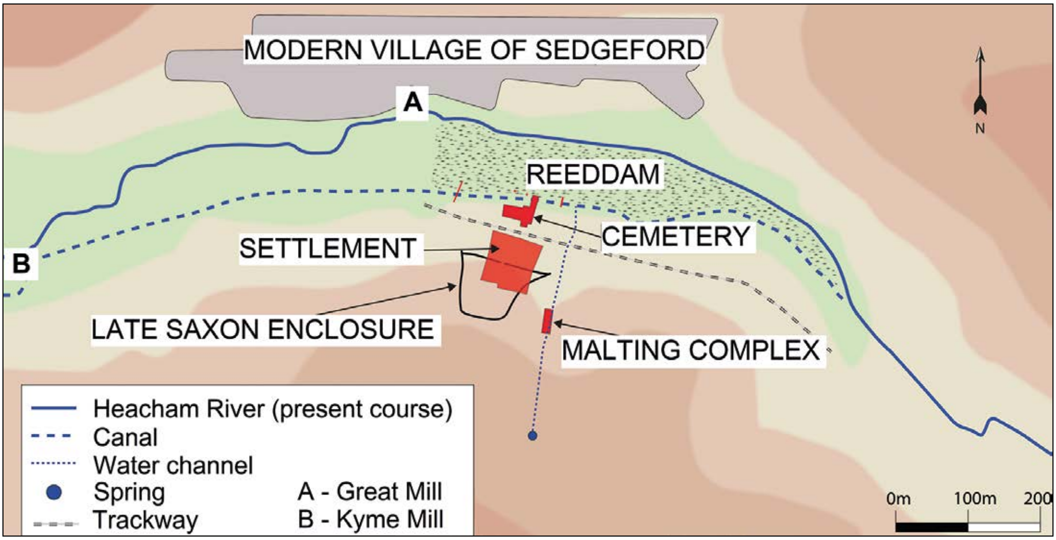

43 Plan showing the line of the River Heacham and the (Roman/Anglo-Saxon) Sedgeford Canal. Plan: Gary Rossin/SHARP.

**Water power and water transport**

Broadly contemporary with the grid-planning of the village and the presumed associated estate landscape was a wholesale remodelling of the water system in the parish. The river Heacham rises at Bircham Newton in the low chalk hills of north-west Norfolk and runs for about ten miles via Fring, Sedgeford, Eaton, and Heacham to the Wash (Figure 43). Fed by numerous springs along its route, the flow was stronger in medieval times, and the river was navigable at least between Fring and the sea.

We know of three major developments in the medieval period in relation to this waterway. First, the river itself was canalized, managed, and maintained so as to power a number of watermills. The Domesday survey recorded a mill at Fring, four at Sedgeford, and three at Heacham. Our investigations, involving both archive research and field reconnaissance along the line of the river, have identified six possible mill sites within the Sedgeford parish boundary. We have also recovered fragments of both basalt lava stone from the Eifel region of north-west Germany and grit stone from the Dark Peak area of north Derbyshire.

Second, a 16-acre wetland immediately south of the current river-line in Sedgeford, known as 'the Reeddam', appears to have a Mid Saxon origin (Figure 44). Though the earliest historical references go back only to the thirteenth century, when the Reeddam was described as a fish-pond and reed-bed, a series of separate archaeological interventions, mainly a mix of augering and trial-trenching carried out by SHARP since 1996, have provided a relatively




44 Plan showing major Mid Saxon hydraulic engineering works in the centre of Sedgeford. Plan: Gary Rossin/ SHARP.

well-dated stratigraphic sequence. Of decisive significance are two layers of homogeneous white/grey chalky clay without inclusions, almost certainly representing deliberate deposition (Plate XVI). The upper layer seals a deposit rich in occupation debris dated by Ipswich Ware; crucially, despite the abundance of Thetford Ware across the settlement and cemetery site immediately to the south, and the relatively large ceramic assemblage recovered from the Reeddam, *no Late Saxon pottery has been found beneath the upper chalky clay*. Some uncertainties remain, but our current working assumption is that this layer represents a deliberate relining of the Reeddam in the Mid Saxon period.

Third, running along the southern edge of the Reeddam, but extending much further to the west – it has been traced for more than five miles – is a U-shaped canal measuring six metres in width and 1.5 metres in depth down to its chalky-clay base (Figure 44). We have not been able to date this feature with confidence. It may be cut into chalk bedrock in places, and it appears to have been repeatedly dredged in the later medieval period, with no fewer than 14 re-cuts observed in one excavated section. Nonetheless, we strongly suspect that the canal was in use in the eighth century AD – part of a wholesale refurbishment of Roman-period features.[5]

The reasoning is as follows. Between the lower and upper chalky-clay layers in Reeddam, we seem to have a mix of Romano-British

5 See Blair, 2007 for evidence for Anglo-Saxon canal-building in general and reuse of Roman facilities in particular.

pottery at the lower level and Ipswich Ware at the upper level, with the strong implication that the lower chalky-clay was a Roman deposit, the upper chalky-clay a Mid Saxon one. We can therefore speculate that the putative Mid Saxon authority responsible for the grid-planned remodelling of village and estate was also responsible for restoring an old water-management system designed for power, transport and wetland resources. The river would have provided power for the watermills. The Reeddam would have functioned as a mill-pond, a reserve power-supply, and a source of fish, fowl and reeds. The canal would have facilitated rapid transhipment of bulk goods in barges, unimpeded by the workings of the watermills on the river. This interpretation must be tested by further investigations, but it provides a strong working hypothesis.

## Monoculture and industrialized food processing

Our assumption of watermills and barge-transports in the eighth century is driven in part by the evidence for specialized production and mass processing of grain represented by our Mid Saxon malting complex. This is discussed in detail in my colleague Hannah Caroe's chapter in this volume, so I offer here only a brief summary and one or two wider interpretative remarks.

The excavation of Trench 23 is ongoing, but much is already clear (Plate XVII). The malting complex is located in a small but steep-sided gully about a minute's walk to the south-east of the Mid Saxon village. The gully, lying towards the base of a long, gentle slope with a loose, sandy topsoil, is subject to rapid infilling. This is responsible for the exceptional preservation of the Mid Saxon levels, which comprise a relict Mid Saxon ploughsoil (see below) overlying and sealing a Mid Saxon malting complex whose remains include floor surfaces, collapsed walls, burnt-clay structures and traces of carbonized wood.

This entire sequence is dated by pottery and radiocarbon determinations. Despite the abundance of (later Anglo-Saxon) Thetford Ware on the nearby settlement site, and the presence of abraded (later medieval) Grimston Ware in the upper ploughsoil on Chalkpit Field, both classes of material are *entirely absent* from the sealed lower ploughsoil in Trench 23, which lies buried under deep accumulations of orange, sandy, relatively sterile colluvium. This lower ploughsoil contains an abundance of midden material – animal bone and oyster shell – and is dated by relatively large quantities of Ipswich Ware, which is the only pottery present except for occasional small abraded sherds of residual Iron Age and Roman wares. The ploughsoil provides a *terminus ante quem* for the underlying malting complex. This malting complex, however, is also dated by small quantities of associated Ipswich Ware and by three radiocarbon determinations derived from charred grain samples. Allowing the Ipswich Ware to provide both a *terminus post quem* of *c.*725 and a *terminus ante quem* of *c.*850, the three calibrated radiocarbon dates can be modelled to give the following approximations, each with 68.3 per cent confidence: cal. AD 748–770 (Kiln 1), 734–775 (Kiln 2) and 772–819 (Kiln 3).[6] Also relevant here is that the radiocarbon dates obtained from the charred grain samples probably relate to terminal fires, that is, to the destruction of the malthouse in question, not its construction. This pushes our hypothetical date for the establishment of the first malthouse on the site even earlier. The evidence therefore implies that the malting complex pre-dated somewhat the grid-planning of the village (dated *c.* AD ?775/825). Nonetheless, it could still be regarded as part of the same associated 'package' of changes – our hypothetical 'big bang' – since we assume these to have rolled out over three generations, from perhaps *c.* AD 725/750 to 800/825.

What the radiocarbon determinations also suggest is that Kilns 1 and 2 may have been broadly contemporary, while Kiln 3 may have been somewhat later; and that the entire malting operation probably did not continue for more than about 85 years altogether (Mark McKerracher, pers. comm.). This brings us to the nature of the complex itself. This comprises at least three, probably four, and perhaps more separate malthouses. The best understood is Malthouse 1, which comprises the three key elements of steeping area/tank, germination floor and drying kiln (Faulkner and Blakelock, 2020). Malthouse 2 lies immediately to the north, but seemingly on an east–west alignment, rather than north–south along the length of the gully like Malthouse 1; in this case, moreover, only the kiln and the germination floor have been identified. Malthouse 3 is similar: it lies immediately north of Malthouse 2, is aligned east–west, and has so far yielded no evidence for a steeping area/tank (this evidence is discussed further by Caroe, this volume). Malthouse 4 – if such it is – lies at the opposite, southern end of Trench 23, and little is yet known of it, for it is still at an early stage of excavation. Since, in places, the remains of the malting complex extend beyond the limits of excavation, it is possible that further malthouses lie hidden.

6 Mark McKerracher, pers. comm.; McKerracher et al., forthcoming. AMS (accelerator mass spectrometry) dates produced by the Oxford Radiocarbon Accelerator Unit (OxA-40485, OxA-40414 and OxA-40415 respectively).

The apparent anomaly of missing steeping areas/tanks may be easily explicable. Malthouse 1's steeping tank was placed in a deep hollow, but this would not have been necessary to its operation. Traditional malthouses place their steeping tanks at ground-level. It is possible that we may yet find ephemeral evidence for this in Trench 23; or it may be that, in these circumstances, no traces of any kind will survive. On the other hand, to further complicate the picture, there is some evidence that Malthouse 4 may in fact include a hollow comparable with that excavated in Malthouse 1: this remains to be determined. Suffice to say, we have absolute confidence that we are observing three and possibly four separate malthouses, all of similar dimensions, placed side by side in the gully. This layout need not, of course, indicate contemporaneous use; it may represent a process of replacement, the new being built while the old was still in operation. At this stage, we do not know.

Also worth mentioning are the spring and stream (visible on geophysical survey plots) which supplied water to the malting facility. The stream was canalized into two channels which ran either side of the malthouses, and, given the box-shaped cross-sections revealed in excavation, we can be pretty certain these were wood-lined. The malting process required large quantities of water for steeping (with regular changes of water recommended), while at the same time the stream flow needed to be diverted around the actual malthouses.

There are two critical points to be made about the malting complex relevant to the theme of this chapter: they concern scale and expertise. Estimates of grain-processing capacity involve a series of assumptions and estimates. But on the basis of what we know about (a) traditional malting practices, (b) the size of our germination floors and (c) medieval crop yields at Sedgeford, we calculate that, if Malthouse 1 had been in operation for a full eight-month malting season (October to May), it could have processed the product of approximately 45 acres. We can further calculate that processing this quantity of grain might have yielded approximately 28 tonnes of malt, representing around 1,500 barrels or 400,000 pints of full-strength ale – or as much as double that quantity if the main brew was a low-alcohol 'small beer'. To give that some context, average per capita beer consumption in Britain today stands at around 150 pints per year.[7] We might suggest, therefore – continuing to round our figures into 'ballpark' estimates – that Malthouse 1 might have been capable of producing sufficient malt to supply a population of between 2,500 and 5,000 people with

7 www.statista.com/statistics/447137/united-kingdom-volume-beer-consumption-per-capita (accessed 01/05/21).

ale.[8] Needless to say, if more than one malthouse was operational at any one time, these estimates would need to be multiplied accordingly.

Then there is a question about the technical expertise embodied in the malthouses. As with other aspects of our big bang – the measured survey grid, the regularities in the dimensions of buildings, the probable creation of the millpond, the refurbishment of the canal, the probable construction of watermills – a skilled organizing authority seems implicit. The malthouses, like everything else associated with the Mid Saxon settlement at Sedgeford, appeared *de novo* in the landscape. Indeed, when we look further afield, to the Anglo-Saxon evidence as a whole, among 25 separate grain-dryers known at nine different sites, not a single one seems to date earlier than the late seventh century AD (Faulkner and Blakelock, 2020, 88–89, table 1). We have, therefore, a hiatus of about 250 years between the latest Romano-British grain-dryers and the earliest Anglo-Saxon ones. I have not had time to research the European evidence. I do not know whether we have dated examples of grain-dryers for this period in the European archaeological corpus. Nonetheless, a reasonable working hypothesis must be that the technologies of mass processing of foodstuffs – in contrast to the relatively low-tech methods of Early Saxon subsistence farmers – are likely to have been transmitted from the Roman period to the Carolingian/Mid Saxon period by the Christian Church. Regardless of whether the organizing authority for Sedgeford's transformation was secular or ecclesiastical, it seems highly likely that the expertise of internationally networked clerics was called upon (cf. Blair et al., 2020).

### Heavy ploughs and open fields

Nucleated villages facilitate pooling of labour and resources. Most important, perhaps, was the pooling necessary to provide and operate heavy ploughs (cf. Williamson, this volume). By 'heavy plough' I mean a more substantially constructed plough designed to hold a coulter (for cutting the sod), a share (for tearing the sod), and a mouldboard (for turning the sod over on itself). Because such a plough was designed to dig deep and throw the sod – as opposed to merely 'scratching' the surface – it required strong animal traction, provided ideally by at least two oxen, but possibly four, six, even eight, depending on the soil (cf. Kropp, this volume). The Domesday survey, which records

8 I am indebted to Jake Lambert of Crisp Malt for relevant figures for traditional malting and to John Jolleys of SHARP for archive evidence of medieval crop yields.

a population of around 300 at Sedgeford, gives five as the number of plough teams. If we assume two oxen per plough, each of these teams might have ploughed an acre or more a day, especially given Sedgeford's relatively light soils, and perhaps between 60 and 120 acres per season (Banham and Faith, 2014, 54). Moreover, for maximum efficacy, heavy ploughs required a throwing down of boundaries and the creation of large open fields, because an ox-drawn plough is slow to turn and involves a wide turning-circle. From these observations we gain a sense of the investment of equipment, animal-power and human labour, and the likely reorganization of field systems, implicit in the kind of agricultural transformation we are envisaging. By contrast, it is difficult to imagine a viable monoculture being based on the scratch ploughs and small fields of subsistence farmers.

Nonetheless, our evidence of the use of heavy ploughs and the creation of open fields is suggestive rather than definitive. It comprises seven distinct observations regarding the Mid Saxon ploughsoil deposit overlying the remains of the malting complex in Trench 23. They are as follows: (1) the presence of numerous north–south plough marks on the underlying malting-complex features, and the complete absence of crosswise east–west marks; (2) the depth of this scoring, sometimes cutting deeply into hard burnt-clay features; (3) the depth of the ploughsoil deposit; (4) the poorly sorted nature of the deposit, with distinct 'clod-like' mottling of lighter brown and darker grey soil; (5) the suggestion in places (no more than that) of diagonal layering of these 'clods', as if thrown by the last ploughing; (6) an abundance of apparently 'ploughed-in' midden material in the matrix, with much bone, shell and pot distributed fairly evenly through the deposit; and (7) the identification of stinking chamomile (*Anthemis cotula* L.) seeds in archaeobotanical samples taken from the ploughsoil, a weed associated with heavy soils and perhaps, therefore, indicative of deep ploughing (Hannah Caroe, pers. comm.).

## Connectivity

Mid Saxon Sedgeford is likely to have been producing far more malt than could have been brewed into ale and consumed in the village; industrial-scale malting implies connection with a wider economic network. The remodelling of the local river system as a transport highway down to the sea is one indication of that connectivity; another is our Ipswich Ware assemblage.

This material is so familiar – so ubiquitous and diagnostic on East Anglian sites – that it is occasionally useful to remind ourselves how remarkable it is. All of it was made in Ipswich, where manufacture was on an industrial scale. In form and fabric it was highly standardized, comprising about 95 per cent jars of various sizes, otherwise mainly pitchers. It was virtually the only pottery used in East Anglia between *c.* AD 725 and 850, and, though some Ipswich Ware pots were transported further afield, its concentrated and more-or-less exclusive distribution within East Anglia can reasonably be taken to define the extent of the eighth-century Anglo-Saxon kingdom (Blinkhorn, 2012). That said, the distribution within East Anglia is highly skewed. Sedgeford has produced one sherd for every 2.2 square metres excavated, for example, whereas North Elmham (also in Norfolk) produced only one sherd per 75 square metres.[9] All this points to a politically controlled distribution mechanism; nothing points to any sort of 'free market' system. Nor, given the unadorned, somewhat lumpy, obviously functional character of the pots, can we assume that they were being moved around for their own sake. They must have been ceramic containers (or *ambers*, to use a contemporary term), used to transport relatively low-bulk, high-value produce such as ale, beeswax, butter, dried fruit, honey, lard, mead, preserved fish, preserved meat, salt, spices, tallow, wine or other commodities. Sometimes they might have been returned as 'empties', sometimes they may have been reused at their destination for the export of other produce; but very often, of course, they were simply recycled as domestic storage vessels and cooking pots (as *crocca*, for example), since this is how the great majority of them seem to have entered the archaeological record.

Sedgeford's Ipswich Ware sherd count, now at around 4,500, is one of the highest known. Though the parish lies on the edge of the former kingdom of East Anglia, and on the opposite side of the territory from Ipswich, it is nonetheless very close to the coast and is served by a navigable river. It seems reasonable to take the abundance of Ipswich Ware in Mid Saxon Sedgeford as evidence for its connectivity within a regional system of politically managed and socially embedded distribution. I shall have a little more to say about this in the conclusion below.

## Labour services

Brian Fraser, SHARP's site manager and a chartered quantity surveyor, was tasked with estimating the investments of labour-power implicit in the many substantial infrastructure projects either evidenced or implied by what we know about Mid Saxon Sedgeford. The results of his work are summarized in Table 9.

9 Estimates based on our own results and Wade-Martins, 1980.

**Table 9 Estimates of person-days required in various construction works undertaken in Mid Saxon Sedgeford**

| **Task** | **Labour (person-days)** |
| --- | --- |
| Quarrying of chalk for lining canal and millpond | 8,308 |
| Transporting chalk from quarry to construction site | 1,859 |
| Recutting and relining 9 km-long canal | 8,915 |
| Cutting and lining 0.75 km of new canal | 1,984 |
| Dredging and relining 16-acre millpond | 5,574 |
| Constructing Tamworth-type watermill | 241 |
| Constructing Sedgeford-type malthouse | 250 |
| **Total** | **27,131** |

Our aim here is to provide ourselves with some rough orders of magnitude in assessing the labour demands placed on the inhabitants of Mid Saxon Sedgeford. To do this, we make three assumptions: (1) that the workforce would have comprised mainly adult, able-bodied men, so perhaps 100 or so, one-third of the estimated population of Sedgeford at the time; (2) that the work was spread across about three generations, so perhaps 75 years in all; and (3) that working days were restricted to 150 days per year, allowing for Sundays, holy days, weddings, funerals, etc., this being a common medieval pattern. This gives us a labour capacity of 7,500 person-years, which translates into 1,125,000 person-days. Even if we assume, as we reasonably might, that some men may not have been subject to labour service – the later Domesday entry for Sedgeford lists 14 freemen – it is immediately apparent that these tasks would not have represented an unsustainable burden, especially given that they would surely have been fitted into slack periods in the agricultural cycle. The critical matter would have been the existence of an organizing authority with effective control over the collective labour of the villagers. The implication, in my view, is the successful establishment of feudal social relations at Sedgeford in the eighth century AD.

## Conclusions

Sedgeford has produced eighth-century evidence for: the creation of a nucleated village; centralized control over labour-power; the use of heavy ploughs in open fields; a new gridded layout of plots and fields; mass production and processing of grain; large-scale hydraulic engineering to power mills and facilitate transport; investment in the high-tech plant of watermills and malthouses; integration into some sort of regional distribution network; and an enclosed thegnly residence.

Evidence of this kind is easily misinterpreted. It is open to two kinds of simplistic assumption in particular: that it presents increased production; and that it betokens the development of markets, trade, and proto-capitalism. Neither assumption is implicit in the evidence.

We have no way of knowing how productive independent subsistence farmers in the Early Saxon period may have been in comparison with peasant villagers like those at Sedgeford in the Mid Saxon period. There is a world of difference between an intensive, mixed, family-based 'garden plot' regime and an extensive, specialized, village-based 'open-field' regime (cf. Hamerow and Bogaard et al., this volume). The former may, in fact, constitute a more efficient use of land because of high labour inputs by self-motivated producers. There are countless examples in the historical record of poor land use in the context of feudal-type social relations characterized by forms of forced labour.

As for market-based exchange – with foodstuffs being produced and traded as commodities – there is no evidence whatsoever for this at Sedgeford in the eighth century. The common assumption in so much of the secondary literature that this is what is represented by agricultural specialization, by coin assemblages, by so-called 'productive sites', and so on, is precisely that, an assumption, and, I would argue, one based on viewing the early medieval world through a modern 'neoliberal' lens and applying wholly inappropriate economic categories to it.

The evidence of Sedgeford's agro-social revolution is best understood as an expression of the rise of lordship, the division of the land into great estates, and the imposition of labour services and food renders on a class of dependent peasant villagers. This, I suggest, gave rise to a tributary economy based on elite control over food surpluses and to an elaborate anthropology centred on food consumption that played out in mead halls, around peasant hearths, and at harvest festivals. The Mid Saxon lord – the putative 'Lord of Sedgeford' – was a food mountain and the source of food flows (upwards, downwards and sideways) that created the complex networks of patronage and dependence which bound the newly emerging medieval society together (Faulkner, forthcoming).


(a)

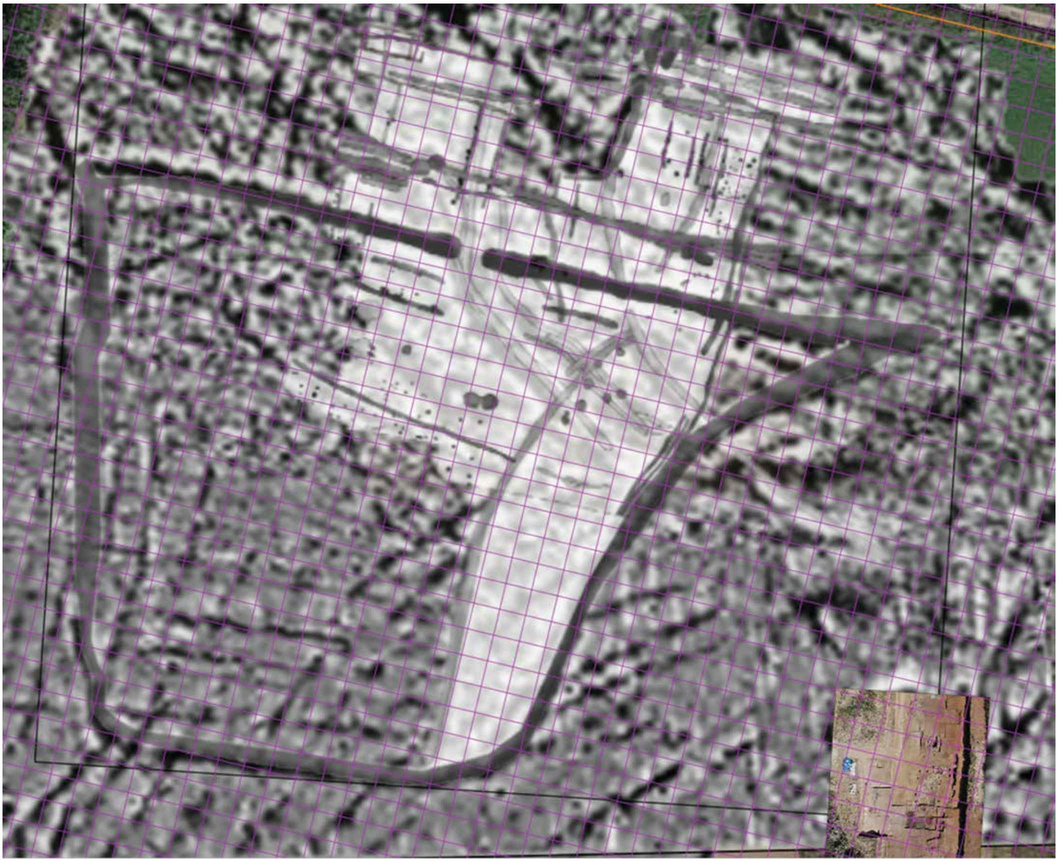
**XIIIa–XIIIc** The Mid Saxon settlement sequence at Sedgeford: (a) Phases 3 and 4 represent the first appearance of the settlement; (b) Phase 5 sees a 'big bang' remodelling of the settlement, broadly contemporary with major infrastructure projects to provide water power, canal transport, and mass grain-processing facilities; (c) Phase 7 sees the appearance of a probable thegnly residence. Plans: Jon Cousins and Gary Rossin/SHARP.

Structure D
Boneyard/Reeddam Cemetery
Structure J
Trackway
Structure I
Structure H
Structure F
Structure G
Structure E
Phase 5a AD 775/825–?900/925
Phase 5b AD 775/825–?900/925
Phase 6 AD 859/925–900/950
0
100m
N
Malthouse 2?
Malthouse 1


(b)

Trackway
Structure K
Phase 7
AD ?900/950–?975/1025
0
100 m
N

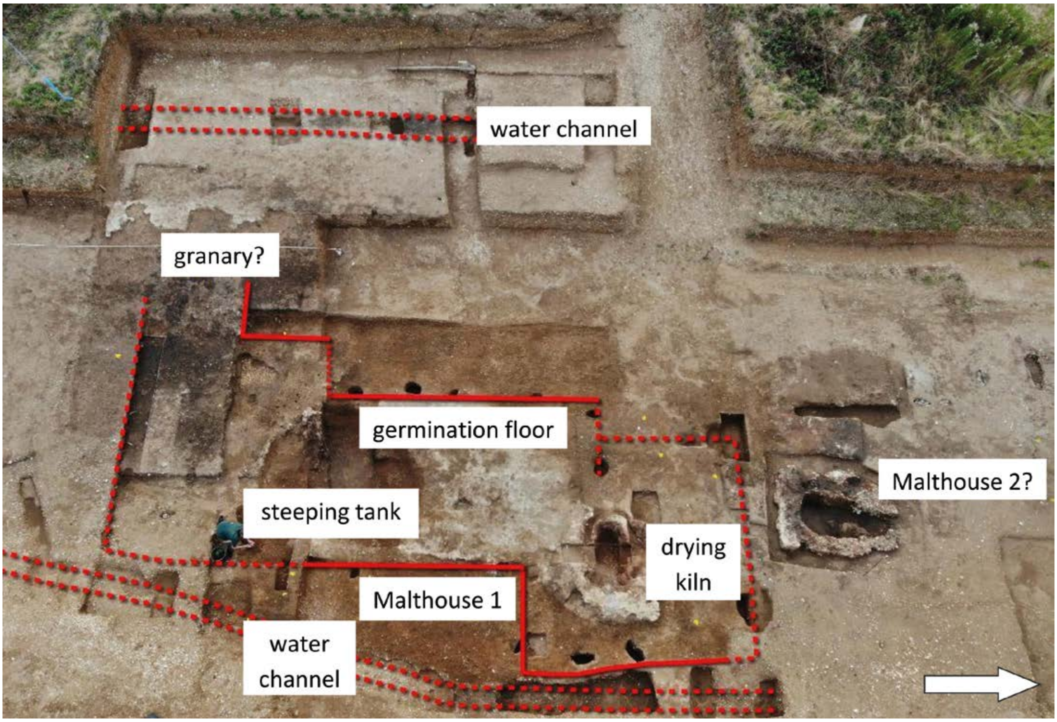

(c)



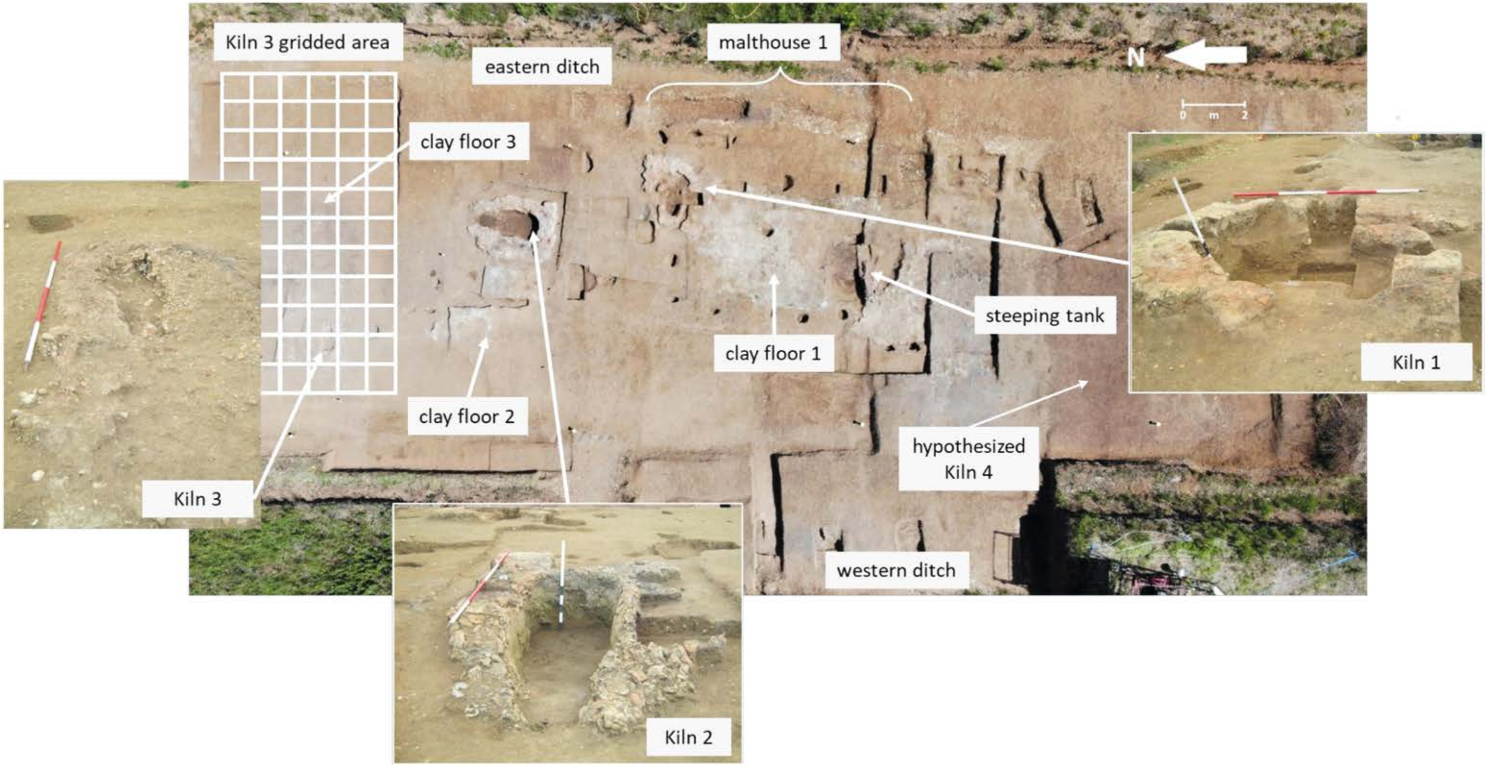
**XIV** Short-perch grid superimposed on a combined plot of geophysical survey results and excavated features overlain on a Google Earth image shows the close correspondence between the short-perch measurement and the boundaries and buildings of the Mid Saxon settlement site on Chalkpit Field. The malting complex in Trench 23 (bottom right) also appears to conform. Image: David Wood/ Google Earth, 2021.

**XV** Short-perch furlong grid aligned with the short-perch grid shown in Plate XIV. This in turn is aligned on two dominant features, the straight line of the 'D' enclosure around the later Anglo-Saxon thegnly residence (towards the top of the superimposed geophysical survey plot), and the parallel line of the extant trackway, also assumed to be Anglo-Saxon in origin. The orange lines represent field boundaries visible in the landscape today, recorded on old maps, or seen on geophysical survey plots. Image: David Wood/Google Earth, 2021.

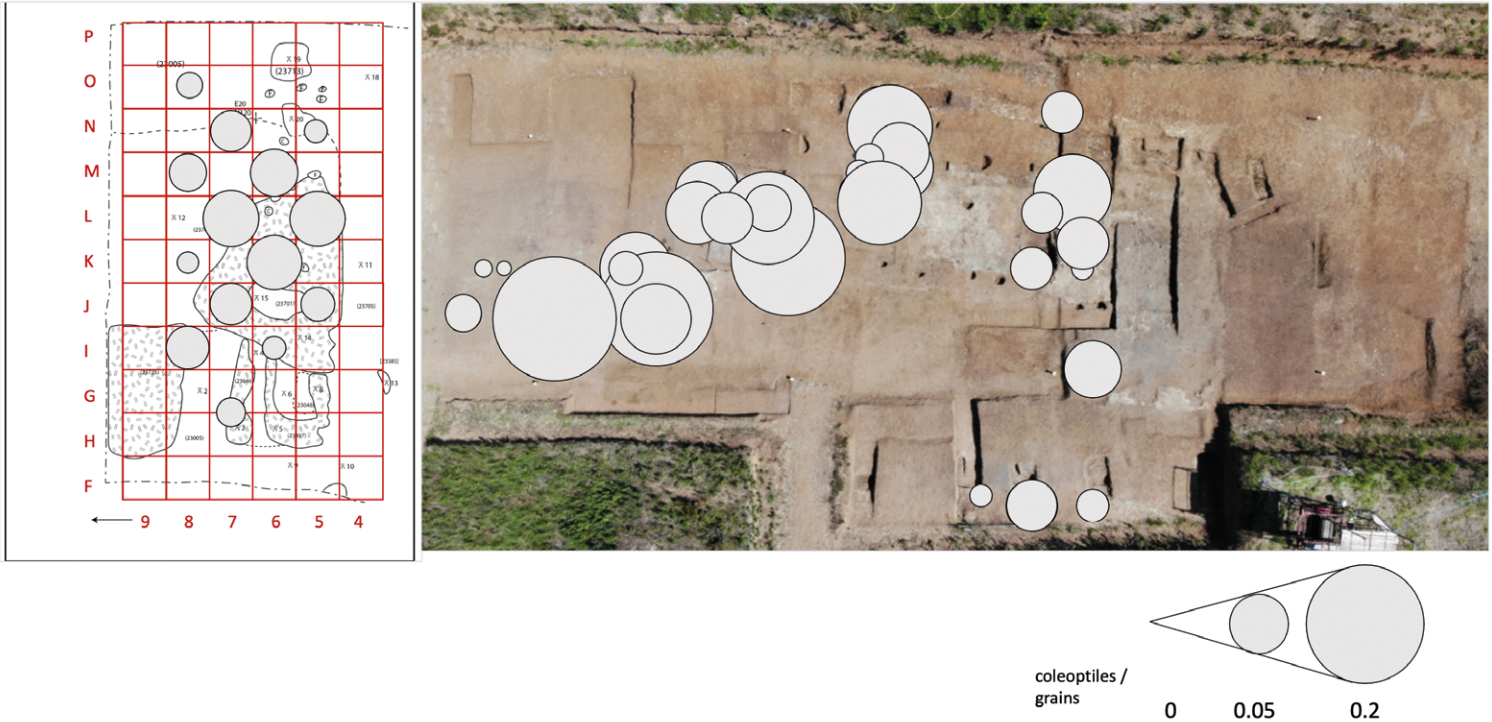
**XVI** Test-pit in Reeddam from 1996 showing clearly the upper chalky-clay deposit which appears to be a Mid Saxon lining. Image: Tim Snelling/SHARP.




**XVII** Drone shot of Malthouse 1 showing hypothetical reconstruction. Image: Ian Drummond/Gary Rossin/SHARP.




**XVIII** Aerial photograph of the malting complex at Sedgeford (taken 4 July 2019), with primary features highlighted, and inset photographs of Kilns 1, 2 and 3 (taken 6 August 2019). Image: Ian Drummond/SHARP 2019.




**XIX** Chart displaying relative density of detached coleoptiles in samples across the malting complex, and in the Kiln 3 gridded area (left) respectively, with bubble size corresponding to coleoptile frequency relative to grain frequency.


**XX** Landscape variations within the 'champion' in the medieval period (after Williamson et al., 2013). Above: eastern Northamptonshire, around the river Nene. A largely arable area, with a near-continuous furlong pattern, interrupted by only a few, narrow ribbons of pasture. Below: western Northamptonshire. Here the arable furlongs are interrupted by numerous areas of unploughed ground.

# 10 Malting, Brewing and Beer in Anglo-Saxon England. Mid Saxon Sedgeford: A Case Study

*Hannah Caroe*

## Introduction

The Anglo-Saxons drank beer on an 'oceanic scale' – or so claimed Finberg in 1972 (Finberg, 1972, 422). Literary sources from the period would seem to confirm this. However, as Carruthers and Hunter-Dowse have recently argued, there is a dearth of archaeobotanical evidence for malting and brewing in the early medieval period to corroborate Finberg's claim (Carruthers and Hunter Dowse, 2019, 107).

This paper focuses on an assemblage of charred plant remains from a hypothesized malting complex at Sedgeford in north-west Norfolk, securely radiocarbon-dated to the Mid Saxon period (conventionally *c.* AD 650–850; see also Faulkner, this volume). It is hoped that the provisional archaeobotanical results presented and discussed here will go some way towards righting the evidential bias against early medieval malting and brewing.

## Beer in Anglo-Saxon England: consumption

Such was the scale of alcohol consumption amongst all sectors of Anglo-Saxon society that Bede felt led, in his eighth-century *Historia Ecclesiastica*, to write disparagingly of 'even our Lord's own flock, and its pastors … giving themselves over to drunkenness … and other such sins' (*Historia Ecclesiastica* I.xiv; Colgrave and Mynors, 1969). It is known that the Church issued numerous edicts to control drunkenness

My warmest thanks to the entire SHARP team (particularly Ellie Blakelock and Tom Cross), to my supervisors Amy Bogaard and Michael Charles and to all the archaeobotanists at the University of Oxford's School of Archaeology. Dedicated with greatest fondness to the memory of Neil Faulkner. *Soli Deo Gloria*.

amongst clergy and religious communities (Hornsey, 2003, 237). For instance, the late eighth-century *Penitence* of Egbert specifies that if a monk or other religious should vomit the Eucharist through drunkenness, he should do 60 days' penance (Wasserschleben, 1851, 527). Most certainly, however, heavy drinking was not limited only to people of the cloth. For instance, Hough identifies four references in the epic poem *Beowulf* to the retainers of Hrothgar and others being 'druncen' (Hough, 2004, 303). Ample supply of drink is known to have been an expected feature of the frequent and symbolically significant feasts laid on by secular elites (see below for discussion of the roles of ecclesiastical and secular elites in Anglo-Saxon society) to win favour from retainers and tenants; according to Hagen, feasting 'always involved the consumption of liquor', whilst 'praiseworthy hospitality involv[ed] the supply of unlimited drink' (Hagen, 2006, 15, 240, 409). Van der Veen, discussing the symbolic value of luxury foods, highlights that in medieval and other (pre-state) societies that were relatively little stratified, 'luxury' consisted in consuming great quantities of common staples such as meat and beer (van der Veen, 2003, 412). In such a context, hospitality featuring luxury (quantities of) food was used to create or strengthen social relationships, and reify political position (van der Veen, 2003, 413).

There are frequent documentary references (often in royal charters) to ale and malt given as gifts, dues, and, above all, commanded as tributes by secular and ecclesiastical authorities (Unger, 2007, 24; Hagen, 2006, 208–9; Hardy et al., 2007, 204). For instance, Ine, a West Saxon king reigning 688–726, issued an early set of laws with a clause specifying that a particular tenant, as rent for ten hides of land, should pay dues, including: '12 *ambers* of Welsh ale, and 30 of clear ale' (Whitelock, 1996, no. 32, passage 70.1). Æthelwyrd, king of East Anglia (d.854), left one day's food rent to the monastic community at Bury St Edmunds every year, including forty *sesters* of ale (Robertson, 1939, 59). Royal food renders at Berkeley, Gloucestershire, in 883 consisted of – amongst other things – *bēor*, *ealu* (ale) and honey (S 218; Finberg, 1972, 49–50).[1] Among many references to rents paid in malt are those in the tenth-century will of Æthelgyfu, abbess of Shaftesbury, who left

1 A word on terminology: the Anglo-Saxon terms *bēor* (beer), and *ealu* (ale) are not interchangeable: *bēor* is believed to denote a strong and sweet liquor often consumed by the elite, which may not even have been cereal-based, while *ealu* refers to a less alcoholic drink widely imbibed by the general population (Fell, 1975; Hornsey, 2003, 251–59; Hough, 2004; Unger, 2007, 22; Hagen, 2006, 200–202; Brettell et al., 2012, 778).

land to Ælfwold on condition that he gives, every Lent, 'six *mittan* of malt'; equally, Leofsige, bishop of Worcester, was required to pay annually either three days' food rent to the abbey at St Alban's, or a set of items including 16 *mittan* of malt (Whitelock, 1968, 8, 10). A will fragment from Bury St Edmunds afforded 'five ores for malt … for the first funeral feast' (Robertson, 1939, 253).

Ale was consumed not only by elites – it was a staple in the diet of the peoples of Anglo-Saxon England: in his tenth-century *Colloquy*, abbot Ælfric asks his charge, Ælfric Bata, what he drinks; the latter responds, 'Ale if I have it, or water if I have no ale' (Garmonsway, 1939, 47). Ale is the most commonly mentioned liquid in Anglo-Saxon *leechdoms* (collections of medical remedies) and, as Kelly notes, was recognized at the time not only for sating thirst and treating maladies, but also as a source of nutrition (Cockayne, 1851, 3.78, 120, 136; Kelly, 1997, 333). Clearly, the importance of beer to the lives of peoples in the Anglo-Saxon period cannot easily be overstated.

## Beer in Anglo-Saxon England: production

In terms of production, beer can be defined as an alcoholic drink produced from a starch source – generally germinated cereal grains – involving enzymatic conversion of starch to fermentable sugars, followed by yeast-based fermentation. Despite a rich array of literary evidence concerning the consumption and exchange of beer in Anglo-Saxon England, little is known about where and how beer was brewed (Unger, 2007, 7). As Wendy Smith writes, 'traditional … methods of brewing and malting are not well documented and even in the historical period individual stages of malting are frequently glossed over' (Smith, 2011, 110). This is certainly the case for Anglo-Saxon England. To glean what we can from the few known written sources, it is helpful first to summarize the stages of brewing as practised today by modern brewers using 'traditional' methods.

Brewing commences with the soaking of cereal grains – today, almost invariably grains of two-row hulled barley (*Hordeum vulgare* subsp. *distichum* L.) – in water: a stage known as *steeping*, which begins the process of germination. Brewers alternate wet and dry 'stands' as grains are placed in, and removed from, the water in the steeping tank, over two to three days. Thereafter, grains are turned or 'couched' onto a floor, where the key processes occur: grain germination, the growth of a sprout (or *coleoptile*), rootlets and – crucial to the brewing process – the release of a set of *diastase* enzymes within the grain body. Modern brewers are careful to maintain constant levels of humidity and temperature at this stage, to ensure even germination; grains on a germination floor require regular turning (e.g., Stika, 2011, 44). After four to six days, the grains are 'kilned', or dried in an oven at a relatively low temperature (about 55°C), sufficient to stop the process of germination without denaturing the diastase enzymes (e.g., Briggs, 1998; Hornsey, 2013). These are the three stages of malting, which concern us most here.

Subsequently the grains are milled and added to warm water during *mashing*, facilitating the enzymatic conversion of starches in the grain bodies to sugars. The liquid mixture (or *wort*) is boiled, during which process a flavouring and preservative, such as hops, are added. Finally, during *fermentation*, yeast is added to the mixture and causes the conversion of sugars to alcohol (Hornsey, 2013).

One rare documentary source describing early medieval malting and brewing methods is the Irish law text *Senchus mór*, which (paraphrased by Joyce, 1903) describes beer-making thus: 'when the ale was to be prepared, the ground malt was made into a mash with water, which was fermented, boiled, strained etc. 'til the process was finished' (Joyce, 1903, 118; Hancock and O'Mahoney, 1869, 241–45). Whilst superficially this description bears resemblance to beer-making today, as just described, key distinctions exist between early medieval and modern brewing.

First, whilst modern brewing relies heavily for its starch source on two-row hulled barley, any cereal can in fact be used to produce malt for brewing, and barley was not widely established as the grain of choice for malting until the sixteenth century (Hillman, 1982, 140; Shellhammer, 2014, 3).[2] Both documentary and archaeobotanical evidence attest that medieval people malted and brewed using a variety of different cereals, including six-row hulled barley (*H. vulgare* subsp. *hexastichum* L.), oat (*Avena sativa* L.) and bread wheat (*Triticum aestivum* L). It was common to malt, and sometimes cultivate as a maslin, several species of cereal together (Tusser, 1812, 46; Campbell, 1994; Moffett, 1991; 1994; Stika, 2011, 41). For instance, the *Domesday of St Paul's* (1222) refers to the canons of St Paul's Cathedral in London brewing 67,814 gallons of ale from 175 quarters of each of wheat and barley, and 708 of oat (Hale, 1858, 160–64). A herbal cited by Corran describes brewers as late as 1588 taking, 'wheat, barley, spelt, rye or oats, either one kind (for good beer can be prepared from all these cereals) or two or three together' (quoted and translated by Corran, 1975, 48–49).

2 'The German Reinheitsgebot, a brewing purity law established in 1516 and still in existence today, decreed that beer could be made only from barley, hops, and water' (Shellhammer, 2014, 3).

Secondly, hops (*Humulus lupulus* L.), so ubiquitous in modern beer-making, are argued to have been first introduced in European beer-making in the ninth century (Behre, 1999, 35; Zeist, 1991, 119).[3] Exactly when hops were first cultivated for brewing in England is a vexed question. Famously, a tenth-century boat excavated at Graveney in Kent was found to contain abundant partial hop inflorescences, inferred to have been a part of the boat's cargo (Wilson, 1975). Significantly, in his comprehensive review of 96 sites with Mid Saxon archaeobotanical remains in the Upper Thames valley and East Anglia, McKerracher found only one occurrence of hops, in eighth- to ninth-century deposits in Ipswich (McKerracher, 2018, 115). Certainly, there is no archaeobotanical evidence for widespread usage of *Humulus lupulus* in Mid Saxon England.

Prior to the widespread use of hops, the most commonly referenced flavouring and preservative agent in Anglo-Saxon literature was *gruit*, whose ingredients are the subject of conjecture, but which most likely comprised a mixture of herbs, most prominently sweet gale (*Myrica gale* L.) (Unger, 2007, 31). Otherwise known as bog myrtle, this plant has a natural range encompassing the whole of the British Isles and is evidenced at a number of Iron Age and medieval sites across Europe where brewing is believed to have taken place (Behre, 1999, 42; Zeist, 1991, 119; Viklund, 2011). Other flavourings used by early medieval brewers probably regularly included fruits or honey; more obscure substances reportedly utilized include alder tree bark, cinnamon and even fresh egg (Stika, 2011, 41; Hagen, 2006, 212; Unger, 2007; Wilson, 1991, 373).

Finally, the crucial role of yeast in brewing was not understood until the nineteenth century (Shellhammer, 2014, 3). However, Anglo-Saxon brewers would probably have understood the need to skim foam (containing yeast) from the top of the fermentation vessel for reuse in the following fermentation (Shellhammer, 2014, 42). According to Kölling-Paternoga (Hans-Peter Stika, pers. comm.), yeast 'pitching' (addition to the fermentation tank) in 'traditional' brewing may have been aided by insect vectors such as *Drosophila melanogaster* (fruit-flies).

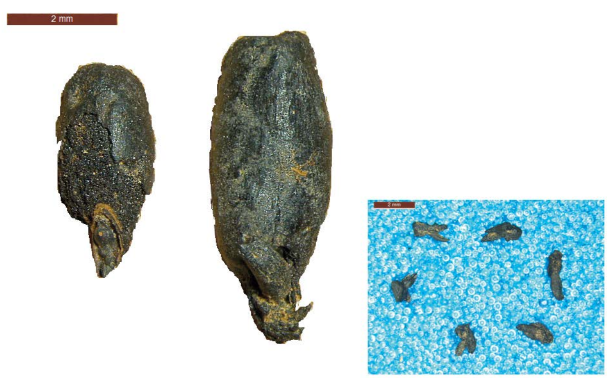
Considering where beer was brewed: in the Mid Saxon period, which saw the emergence and establishment of both secular and ecclesiastical elites, there is persuasive evidence that large-scale beer-making was taking place at monasteries. In Carolingian Europe,

3 However, archaeobotanical evidence, with 175 specimens recovered at Develier in Switzerland dated to the sixth to eighth centuries, suggests hops were earlier implicated in brewing (Brombacher et al., 1997).

the Swiss St Gall plan for an idealized monastery, dated to AD 820, incorporates a malthouse, kiln, mill-room, three breweries and storage cellars (Horn and Born, 1979, 2.261). Indeed, Horn and Born posit that, 'Before the twelfth and thirteenth centuries … the monastery was probably the only institution where beer was manufactured on anything like a commercial scale' (Horn and Born, 1979, 2.261). However, contrary to this, there is evidence from Higham Ferrers in Northamptonshire for 'industrial-scale' brewing in the Mid Saxon period, at a likely royal tribute collection site (Hardy et al., 2007, 204). Finally, widespread domestic beer-making certainly persisted, with ethnographic analogies indicating that domestic brewing commonly uses between 15 per cent to 30 per cent of household grain supply (Unger, 2007, 34; Dietler, 2006, 238).

### Identifying malting and brewing in the archaeological record

The most often referenced archaeobotanical evidence for beer-making is the indication in preserved grains of the growth of a coleoptile (sprout) – interpretable as a sign of germination and therefore, arguably, of malting (Helm and Carruthers, 2011, 363; Larsson et al., 2018, 5; Moffett, 1997, 79; Stika, 1996, 83). The coleoptile may itself be preserved, either attached to or detached from the grain (Figure 45); however, attached coleoptiles are rare (especially where there is no intact 'husk') since these readily detach with even gentle mechanical disturbance (Stika, 2011, 45). In 'hulled' grains, such as hulled barley and oat, the coleoptile grows within the glumes (husk) along the dorsal side of the grain, often leaving a diagnostic channel or 'dorsal furrow', visible under light microscopy. In 'naked' cereals including free-threshing wheat (*Triticum* L. free-threshing type) and rye (*Secale cereale* L.), the coleoptile generally grows away from the




**45** Free-threshing wheat (left) and rye (right) grains from Sedgeford, each showing a coleoptile growing away from the embryo end of the grain. Inset: a collection of detached coleoptiles from the Sedgeford assemblage.

grain endosperm, hence no such dorsal furrow is formed, and the coleoptile is more readily detached since it is not protected by a husk (see Figure 45) (Cordes et al., 2021, 2).

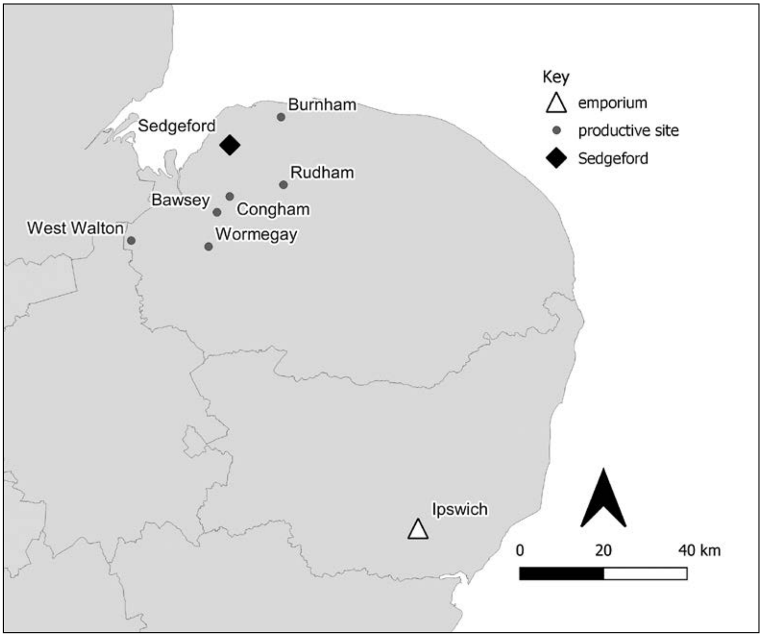
Considering that grains can germinate because they are accidentally wetted, it may be argued that a significant proportion of grains in a sample – van der Veen specifies more than 75 per cent – should show signs of germination before malting can be hypothesized (Stika, 1996, 86; van der Veen, 1989, 305). However, at fifth- to seventh-century Uppåkra, Larsson's identification of malting is based on up to only 29 per cent of grains showing germination; it is suggested that where grains are subject to occasional accidental charring rather than a single conflagration, less evidence of germination is to be expected (Larsson et al., 2018, 7–8).

Further archaeobotanical evidence for brewing may include the remains of plants known to have been used as beer flavouring. For example, sweet gale (*Myrica gale* L.) has been found – and interpreted as additional, confirmatory, evidence for beer-making – at late medieval Bryggen, Bergen in Norway, and at tenth- to eleventh-century Vinberg in Sweden (Krzywinski et al., 1983, 153; Viklund, 2011, 236).

As noted by Cool (writing of beer-making in Roman Britain), brewing generally leaves few characteristic architectural remains (Cool, 2006, 142–43).[4] Wooden vessels are generally not preserved except at waterlogged sites.[5] Further, structures such as ovens and tanks may represent malting kilns and steeping cisterns but can often be otherwise interpreted. Lodwick observes that tanks at an archaeological site may indicate a range of industries, 'from salt-making, to dyeing' (Lodwick, 2017a, 62) whilst malting kilns may be very difficult to distinguish from drying ovens; indeed, ovens were most likely often multi-purpose (cf. Rickett, 2021). These considerations highlight the vital role for archaeobotanical analysis in identifying malting and brewing.

4 Due care must of course be taken when applying references to malting/brewing methods in earlier or later centuries to the early medieval period. The author judges this is admissible in the cases used in this paper since, as Dineley argues, although the ingredients of malting and brewing may have altered somewhat over time, 'floor malting traditions and techniques seem to have remained unchanged across the millennia' (Dineley, 2015, 65).

5 'Beautifully preserved' (Meriel McClatchie, pers. comm.) wooden vessels, hypothesized to have been used for brewing, have been found at the early medieval Drumclay crannog in Ireland (Bermingham et al., 2013).




**46** Map of East Anglia locating Sedgeford, the *emporium* at Ipswich, and 'productive sites' in north-west Norfolk (as identified by Rogerson, 2003). Contains Ordnance Survey Open Data © Crown copyright and database right 2017, under the Open Government licence. Map created with QGIS (http://www.qgis.org; accessed 08/03/2022).

## Introducing Mid Saxon Sedgeford, Norfolk

The archaeological site featured in this paper lies in the southern part of the parish of Sedgeford, six kilometres inland from the coast of north-west Norfolk (Figure 46). The description of the Sedgeford excavations in this section complements the more extensive account by Faulkner in the preceding chapter.

## Mid Saxon East Anglia

Carver has argued that, in the fifth century, East Anglia was the first area of Britain to be settled by Anglo-Saxon immigrants (Carver, 1989, 147–48). Indeed, the princely ship burial at Sutton Hoo in Suffolk, dated to the early seventh century, suggests ongoing connection between East Anglia and Scandinavia, these being the only areas in Europe where boat burials occur in the period; this connection is also seen in the stylistic parallels between grave goods buried at Sutton Hoo and in Vendel-period Scandinavia (Yorke, 2002, 61; Hines, 1984, 286–88).

By comparison with other Anglo-Saxon kingdoms, few written records survive from East Anglia, probably because of the destruction of documents during the ninth-century Viking raids; this scarcity limits present knowledge of the kingdom's history (Yorke, 2002, 58). However, it is widely believed that the kingdom was firmly established by *c.*600 (Yorke, 2002, 61). The *emporium* at Ipswich (located in Figure 46), a significant international trading and craft centre (and the source of Ipswich Ware pottery, a form of ceramic almost ubiquitous at Mid Saxon sites in East Anglia), was established by the seventh century (Blinkhorn, 2012; Hodges, 1982, 70–73). A number of inland market sites established by the late seventh century, represented by the so-called 'productive sites' located by metal-detectorists, have been identified in East Anglia, with six recognized in north-west Norfolk (Davies, 2010a; Rogerson, 2003) (Figure 46). Recognizable by their abundant coin finds, these were probably implicated in trading relationships with both the rural hinterland and Ipswich's *emporium* (Crabtree, 2014, 107; Hamerow, 2007, 228).

According to Wareham, East Anglia was the wealthiest and second most populous area of England – after London – in the medieval period (Wareham, 2005, 115). However, despite having a high population density, west Norfolk remained un-urbanized until the twelfth century (Davies, 2010a, 95, 118). Arguably, Norfolk as a whole was a later addition to the earlier East Anglian kingdom, which centred on the Suffolk coast (Yorke, 2002).

## The Mid Saxon cereal processing complex at Sedgeford

The long-running excavations of a Mid Saxon settlement and cemetery by the Sedgeford Historical and Archaeological Research Project (SHARP) have been discussed in the preceding chapter (Faulkner, this volume). In 2013, the SHARP team began to excavate an area south-east of the settlement site, investigating anomalies apparent in magnetometry surveys (Jolleys et al., 2019, 73). Early evaluation here revealed rich deposits of charred grains, accompanied by kilns and associated structures, implying a cereal-processing complex (Faulkner and Blakelock, 2020). Ongoing excavation at the complex has uncovered at least three kiln structures, with tentative evidence for further kilns. Early archaeobotanical analysis of charred plant material found that a high percentage of grains here show signs of germination: an indication of malting, as discussed above (Wolff, 2017). This led to the kilns being reinterpreted as malting ovens, with associated features now understood to represent one or more steeping tanks/cisterns and several germination floors (Faulkner and Blakelock, 2020). Kilns 1, 2 and 3, with associated features, are marked in the aerial photograph (Plate XVIII).

Kiln 1, together with a hypothesized steeping tank/cistern, clay-lined germination floor and associated post-holes, comprise 'malthouse one', as shown in Plate XVIII. Kiln 1 is oriented east–west, and (like all of the kilns) constructed from clay wattle and daub. Its outer dimensions are 3.0 by 2.1 metres, with the internal drying chamber oval in shape and measuring 2.1 by 1.9 metres, with a depth of at least 0.46 metres.[6] The kiln is argued to have been 'worked' (supplied with fuel and cleared of ash) from a one-metre opening on the western side. The hypothesized Kiln 1 germination floor (Plate XVIII) comprises puddled grey clay up to 0.1 metre thick, and measures approximately 4.5 metres north–south and up to 3.5 metres east–west (Faulkner and Blakelock, 2020, 81).[7]

The supposed steeping tank feature to the south of the clay floor comprises a semi-circular depression, a rectangular structure in the depression – characterized by burnt daub and carbonized timbers – and a further clay floor (possibly a working surface) to the south (Faulkner and Blakelock, 2020, 77). The discovery of two large iron hooks in this area supports a hypothesis that sacks of grain were suspended for steeping in the water-filled cistern (Jolleys et al., 2019, 73; Blakelock and Caroe, forthcoming). The remaining kilns and associated features are described in detail elsewhere (Blakelock and Caroe, forthcoming).

## Dating the malting complex

Initially dated by the abundant Ipswich Ware in the trench, subsequent radiocarbon dating of a sample from each of the three excavated kilns confirms that they were most likely in use between the early eighth and early ninth centuries (see Faulkner, this volume). A review of 27 sites dated to the early and later medieval periods in the UK at which evidence for malting and/or brewing has been claimed, suggests that Sedgeford's malting complex is the earliest yet discovered archaeological feature of its type: the single (though 'monumental') malting kiln at Higham Ferrers in Northamptonshire, also radiocarbon-dated to the Mid Saxon period, contrasts with the *series* of kilns at Sedgeford; apparent Mid Saxon deposits of barley and oat malt in a storage context at Ipswich's Buttermarket are not known to be accompanied by archaeological features associated with malting (a nearby kiln having been identified as a pottery kiln); and no claim has been made that the set of four pits, radiocarbon-dated to the seventh to ninth centuries, hypothesized to be drying kilns and

6 The fill of the drying chamber might not (as yet) have been fully excavated.

7 The entire extent of the germination floor may not yet have been excavated (Faulkner and Blakelock, 2020, 81).

found to contain germinated barley at South Hook, Pembrokeshire (Wales), are accompanied by either a steeping tank or germination floors (Hardy et al., 2007, 163; McKerracher, 2014; Murphy, 1991, 7, 9–11; Carruthers in Crane and Murphy, 2019, 174–75).

## Methodology

Samples of archaeobotanical material were retrieved from the malting complex in excavation seasons from 2013 to 2019. All samples were processed using manual flotation on site. Flots were collected in a sieve with 300-micron mesh and, once dried, scanned using a stereoscopic light microscope. All plant material in the flots was charred. The non-floating residue was collected in a sieve with 500-micron mesh. Of this, 100 per cent was sorted, and charred plant macrofossils identified in the residue were amalgamated with the flot for subsequent scanning and analysis. The charred plant macrofossils have been analysed by the author, with nomenclature following Stace (2010).

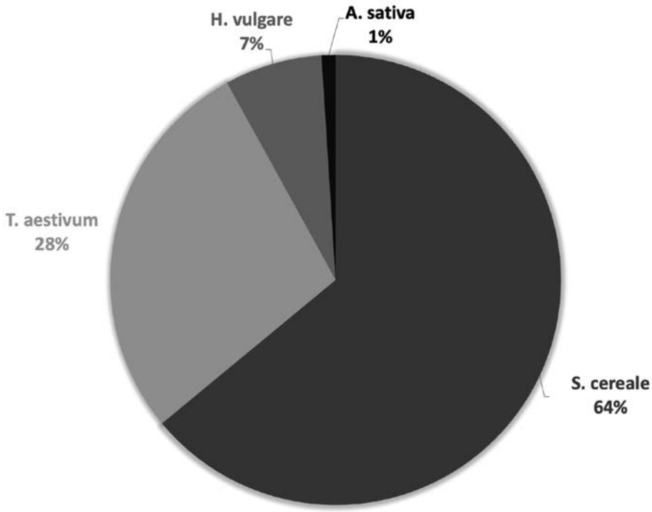
Of those samples extracted from the malting complex, a total of 55 have been analysed, including 15 from a gridded area around Kiln 3 measuring 11 by 6 metres. In addition, five samples from the 'settlement' part of the site were analysed, for comparative purposes. A minimum number of individuals (MNI) approach, as espoused by Glynis Jones, was used for quantifying grains, wild/weed seeds, and also detached coleoptiles, with items counted only where specific 'diagnostic zones' were present (Jones, 1991, 65–66). For instance, detached coleoptiles were recorded only where these included the coleoptile 'base'.

In addition to estimating germination levels in cereal grains from the site by recording the frequency of detached coleoptiles, the author quantified the abundance of germinated grains in the Sedgeford assemblage directly. This necessitated developing and applying novel methods for assessing levels of germination in 'naked' grains based on gross morphology – a problem described above (see Caroe, forthcoming, for a full account of these methods).

## Summarized results of archaeobotanical analysis

The results from preliminary analysis of the archaeobotanical assemblage from Sedgeford's malting complex are briefly summarized here.

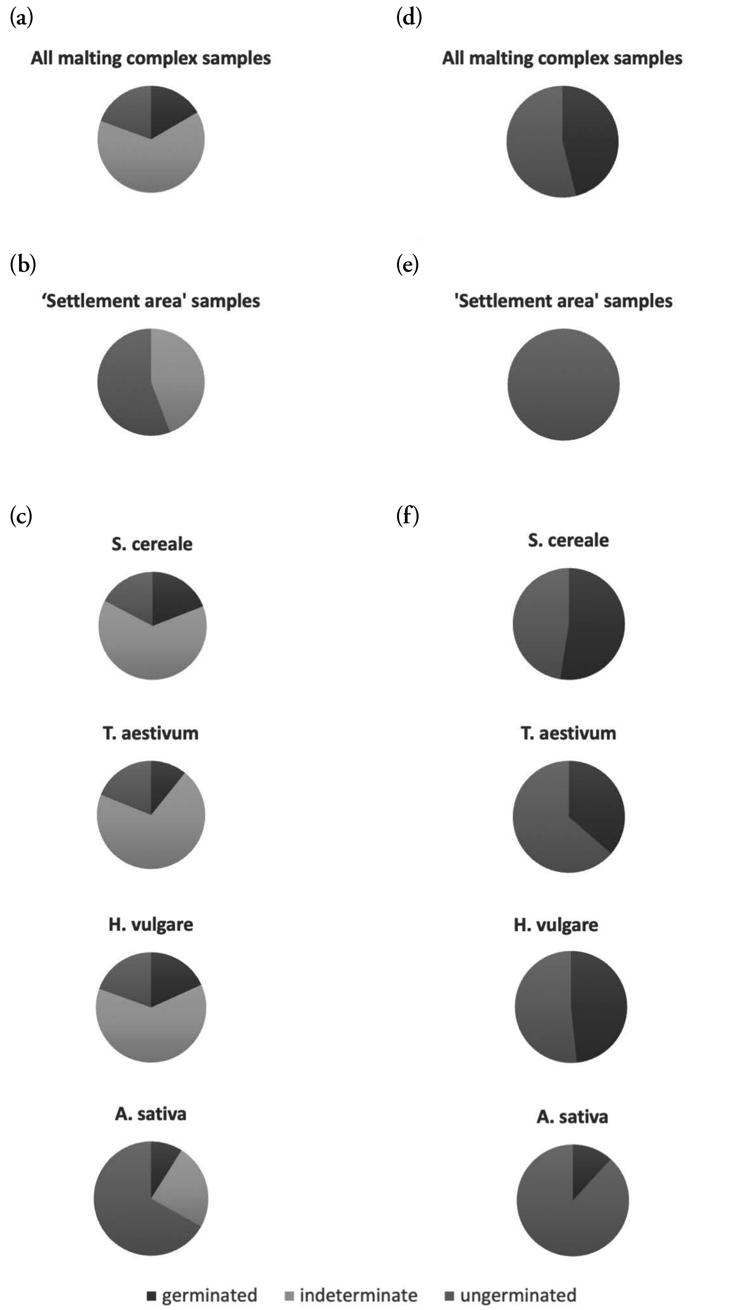
The samples are grain-rich, comprising on average 78 per cent grains. The mean proportion of wild/weed seeds is 16 per cent, whilst 20 of the 55 samples are entirely without chaff. Notably, on average,




47 Pie chart showing proportions of each cereal taxon among all sampled charred grains from across the malting complex and in the Kiln 3 gridded area (combined).

samples contain 3 per cent detached coleoptiles, and these occur across the trench, in 45 of 55 samples (see Plate XIX). Both rye (*Secale cereale* L.) and free-threshing wheat (*Triticum* sp.; co-occurring chaff indicates that this includes bread wheat, *Triticum aestivum* L.) are present in 100 per cent of samples (Table 10). Some 64 per cent of all grains in the assemblage are of rye, with 28 per cent free-threshing wheat (Figure 47). Both *S. cereale* and *T. aestivum* are 'naked' cereals (see above): hence, 92 per cent of all sampled charred grains in the malting complex assemblage are without a hull – with, as discussed above, implications for discerning evidence for germination. Barley grains are present in 96.4 per cent of samples and constitute 7 per cent of the total grain count, while oats (*Avena* L.) are present in 49.1 per cent of samples and constitute only *c.*1 per cent of the total grain count (Table 10; Figure 47). Co-occurring chaff implies that the barley is a six-row hulled variety (*H. vulgare* subsp. *hexastichum* L.) and that some of the oat grains may likely represent a weedy contaminant form rather than cultivated oats (*Avena sativa* L.).

Figure 48 has been created utilizing the novel methods for discerning germination in naked grains (here, rye and bread wheat) mentioned above, and summarizes the total proportion of germinated grains (of all four taxon types) in samples across the malting complex (three samples were excluded from this analysis, as poor preservation in these precluded assessment of germination). Overall, the total proportion of clearly germinated grains is 17 per cent (this increases to 46 per cent when grains of indeterminate germination status are proportionately reassigned). In total, 98 per cent (51/52) of samples




48 Pie charts showing total proportions of germinated, ungerminated and indeterminate cereal grains for (a) samples from the malting complex, including the Kiln 3 gridded area (52 samples in total), (b) samples from the 'settlement' area of the site at Sedgeford (four samples in total) and (c) each of the four cereal taxa, for samples from the malting complex. Charts (d) (e) and (f) represent the same samples respectively, but here 'indeterminate' grains have been proportionately reassigned between 'germinated' and 'ungerminated'.

from the malting complex include germinated grains. Five samples from the 'settlement' part of the site (where malting is not believed to have taken place) were similarly assessed for comparative purposes.

One was excluded due to poor preservation. Among the remaining four samples, no grains showed evidence for germination, 44 per cent were indeterminate and 56 per cent ungerminated.

Figure 48 also shows, for samples from the malting complex, the overall proportions of germinated grains among each of the cereal taxa. Although there is some variation in germination levels between the taxa, it is notable that over 11 per cent of rye, wheat and barley grains are germinated (increasing to over 36 per cent of grains when those that are indeterminate are proportionately reassigned).

The most ubiquitous weed seeds co-occurring with grains in the archaeobotanical assemblage are those of bromes (the *Bromus* sub-family of grasses), corncockle (*Agrostemma githago* L.) and black bindweed (*Fallopia convolvulus* (L.) Á. Löve) – which occur in 98 per cent, 76 per cent and 65 per cent of samples respectively (Table 10). All are common arable weeds whose seeds 'mimic' cereal grains in size – using the terminology of Glynis Jones, they are 'big, free, heavy' – and can be removed from a collection of harvested plant material only by hand-sorting (Jones, 1984, 55).

**Table 10 Summary of ubiquity and abundance of crop and weed remains in all 55 samples from the malting complex**

| Plant item | Samples where present | | Maximum items per sample | Sum of items |
|---|---|---|---|---|
| | no. | % | | |
| **Cereal grains** | | | | |
| Rye | 55 | 100.0 | 1,391 | 21,814 |
| Free-threshing wheat | 55 | 100.0 | 997 | 9,518 |
| Hulled barley | 53 | 96.4 | 267 | 2,363 |
| Oat | 25 | 45.5 | 40 | 321 |
| **Chaff** | | | | |
| Rye rachis | 22 | 40.0 | 125 | 699 |
| Bread wheat rachis | 12 | 21.8 | 32 | 124 |
| Hulled barley rachis | 15 | 27.3 | 48 | 204 |
| Wild oat floret base | 2 | 3.6 | 8 | 12 |
| **Weedy/wild seeds** | | | | |
| Weedy/wild taxa total | 55 | 100.0 | 544 | 9,446 |
| Brome grass | 54 | 98.2 | 236.9 | 2,765.5 |
| Corncockle | 42 | 76.4 | 120 | 1,183 |
| Black bindweed | 36 | 65.5 | 480 | 1,791 |

## Discussion

To summarize the results presented above: the archaeobotanical assemblage from Sedgeford is grain-rich, or 'clean', with conspicuously little chaff and relatively few weed seeds. Significantly, there is strong evidence to support the hypothesis that Sedgeford's cereal processing complex is in fact, more specifically, a malting complex. A high percentage of grains from this part of the site are germinated (and direct evidence for germination is corroborated by the high frequency of detached coleoptiles), and the area has a set of structural features which could potentially have been associated with malting (see above).

As at Roman Northfleet, so widespread is evidence for germination (including detached coleoptiles) across the trench that this is difficult to account for in terms of natural and accidental 'wetting' of grains, which we would expect of specific concentrations of germinated grains in certain locations (Smith, 2011, 109). According to Lodwick, a broad distribution of evidence for malting in several samples across a site is suggestive of large-scale malting (Lodwick, 2017a, 63). Although deliberate germination cannot be proven, we can say of Sedgeford, as Smith writes of Northfleet, that 'cereal storage/processing … must have been an activity extraordinarily prone to accidents if they were not malting' (Smith, 2011, 110).

Further, the broad distribution of evidence for germination across the trench implies that each of the three main kilns was, at least some of the time, utilized for malting. However, the possibility that the kilns were also at times being used to parch grain to facilitate milling cannot be excluded, particularly as, when combined together, 19 per cent of grains from the malting complex display no evidence for germination.

Assuming, as seems reasonable, that the charred cereal remains at Sedgeford's malting complex represent material utilized for malting, it is clear that several cereal taxa were being exploited. Rye, bread wheat and six-row hulled barley grains all show a high rate of germination (Figure 48); their co-occurrence in most samples may indicate mixed-crop brewing, but rye was clearly the most prevalent crop. The dominance of rye in the malting complex is unusual and noteworthy: rye was almost absent from Roman Britain, and (although more common) remained a minor crop in Anglo-Saxon England, though seemingly more often cultivated in East Anglia (Lodwick, 2017a, 20; Banham, 1990, 34; McKerracher, 2018, 97, 111, fig. 79). Arguably, the abundance of rye may represent an adaptation of farmers to the local sandy soils, since the crop's extensive root system renders it more drought-resistant than other cereals (Moffett, 2006, 48).[8] Significantly, rye was the most frequently cultivated cereal crop in north-west Europe throughout this period (e.g., Behre, 1992); this point is discussed further below.

Regarding the weedy/wild taxa which occur alongside the grains, it may be argued that corncockle (*A. githago*) and black bindweed (*F. convolvulus*) could each have been deliberately added to the crops – or, more likely, their presence tolerated – by Sedgeford's maltsters, as these species had known desirable properties as beer flavourings (see Caroe, forthcoming).

**Sedgeford's malting complex in context**

The Mid Saxon period, or 'long eighth century', is widely recognized as having been an era of significant transformation in the lives of the peoples of early medieval England, with the establishment of kingdoms, emergence of elites (both secular and ecclesiastical), transitions in settlement hierarchy and structure, and significant shifts in agricultural practice (e.g., Hamerow, this volume; Hansen and Wickham, 2000; Loveluck and Tys, 2006; Ulmschneider, 2000). Mid Saxon Sedgeford has been claimed to 'typify' some of these transitions, for example in the apparent re-organization of the settlement in this period (Faulkner, this volume). However, the most notable feature at the site, evidencing a significant transition in the organization of local society, is unquestionably the malting complex itself. With at least three malting kilns and up to six germination floors, this complex is – surely even more so than the single Mid Saxon malting kiln at Higham Ferrers (Northamptonshire) – much 'too elaborate and substantial a structure to have been part of someone's domestic brewing operation' (Hardy et al., 2007, 204).

Sedgeford's malting complex is seemingly incontrovertible evidence for a transition from autarkic farming methods typical of the fifth and sixth centuries AD to specialized farming and cereal processing techniques. According to the distinctions established by van der Veen, Sedgeford could be classed as a 'producer' site, capable of producing a surplus, probably of malt (van der Veen, 1992, 99).[9]

8 Eighteenth-century Parliamentary Enclosure Acts record the soil at Sedgeford as poor, probably because of its high sand content (as noted in the 1795/97 Parliamentary Enclosure Committee report, sourced from Norfolk County Records Office).

9 No evidence for later stages of brewing has yet been recovered at Sedgeford, although this may occur in as-yet unexcavated areas.

The high grain content (or 'cleanness') of samples from the malting complex, with conspicuously little chaff and relatively few weed seeds, supports the suggestion that – as theorized for Higham Ferrers – Sedgeford was a 'collection centre' for crops harvested and cleaned (i.e., threshed, winnowed and sieved) by local farmers in the surrounding area, then brought to Sedgeford and processed into malt at the malting complex (Hardy et al., 2007, 203).

Such action would have required a new level of organization in society, and the novel oversight of a local elite, whether secular or ecclesiastical, seems indubitable; as McKerracher writes, 'many of the … innovations in seventh- to ninth-century agriculture required a scale of investment (in both labour and raw materials) and a degree of planning which might have proved impossible without strong and stable lordship' (McKerracher, 2018, 124; see Faulkner, this volume, for further discussion). Whilst Sedgeford is not classed as a coin- or metal-rich 'productive site', the discovery of a writing stylus and vessel glass may indicate 'the supervising presence of an outside authority' (Davies, 2010a, 114; Jolleys et al., 2019, 76). Indeed, Davies infers, from a review of zooarchaeological material from the site, a shift from Mid Saxon ecclesiastical to Late Saxon secular oversight at Sedgeford – though distinguishing between ecclesiastical and secular governance in the Mid Saxon period is not a simple matter, as Davies himself concedes (Davies, 2010b, 268, 328–29).

With a clear capacity for surplus production and proximity to transport routes, we can reasonably claim – as, for example, does Hamerow for the early medieval rural centre at Dalem in Lower Saxony – that Sedgeford was probably engaged in export and trade (in malt) with emerging 'consumer sites', both within and perhaps beyond the East Anglian kingdom (Hamerow, 2002, 137). Unger records the very great comparative cost of transporting beer, malt and other goods overland as opposed to by water in the medieval era (Unger, 2007, 59). Further, the superabundance of oyster shells recovered at Sedgeford suggests regular contact with the coast (Davies, 2010a, 114).[10] We can imagine malt being transported to the coast along the part-canalized river Heacham, perhaps to one or more of the inland 'productive sites' (see Figure 46), and even by sea to the *emporium* at Ipswich.

Ipswich was at this time actively engaged in international trade (e.g., Wade, 1988, 96; Scull, 2011). Arthur and Sindbaeck argue that evidence for long-distance exchange – from Ipswich or elsewhere in early medieval Europe – in bulk cargo such as grain (and,

10 The discovery of what has been identified as a whale bone at Sedgeford would seem to corroborate this (Wolff, 2017, 23).

we can surmise, malt) is 'inconclusive' before the tenth century (Arthur and Sindbaeck, 2007, 312). However, intriguingly, Doherty reports an excerpt from Jonas of Bobbio's seventh-century *Life of Abbot Columbanus*, which mentions a shipment of 'one hundred measures of wine, two hundred of (wheat) grain, and one hundred of beer' between north-west France and Ireland; Doherty takes this to suggest regular sea-transport of beer and grain in the seventh century (O'Hara and Wood, 2017, 149; Doherty, 1980, 77). Moreover, discoveries at Sedgeford of both a Frankish coin and basaltic millstone probably fashioned on the continent are suggestive of international connections here in Mid Saxon times (John Jolleys, pers. comm.). It seems that claims for international trade in Sedgeford's malt are, if perhaps somewhat far-fetched, at least worthy of further investigation.

A final consideration: cultural connections between East Anglia and north-west Europe in the Mid Saxon period have been highlighted above. Hines notes, for example, the abundance of objects from early medieval Scandinavia (including brooches, bracteates and pendants) found across the East Anglian kingdom (Hines, 1984, 376, Map 6.1). Such connections are an active area of research for archaeologists and historians of eastern England. It has even been suggested that the eastern seaboard of early medieval England may have been culturally closer to littoral Scandinavia than to its own rural 'hinterland' in central and western parts of England (Blair, 2018, 44). Is it thus conceivable that the abundance of rye at Sedgeford (Table 10) represents more than expedient adaptation by the area's farmers to local environmental conditions, and might in fact be an artefact of economic and cultural continuity with the North Sea-facing continental zone, where rye was the predominant cereal crop (a suggestion also made by Wolff, 2017, 10)?

## Conclusion

It is to be hoped that discoveries at Sedgeford, including the abundance of malted rye and the potential use of particular 'weed' seeds as flavourings, as well as tentative (though not unsupported) hypotheses concerning the malting complex's place in local, regional and even international cultural and socio-economic contexts, sketch a useful and multidimensional picture of the earliest known such site in early medieval England.

Further revelation and 'texture' should be added to this picture of Mid Saxon Sedgeford through planned functional weed ecology and carbon and nitrogen stable isotope analyses of samples from the malting complex – analyses which will add particularly to our understanding of the local agricultural regimes (cf. Bogaard et al. and Stroud, this volume).

Additional helpful investigations beyond the range of the current project might include analysis of plant impressions in daub remains from the collapsed walls of one or more of the malting kilns; testing of residues lining some of the abundant Ipswich Ware ceramic sherds found in the malting complex (as a means of revealing use patterns); and stable isotope analyses of collagen from skeletal remains recovered from the site's Mid Saxon cemetery – which might, inter alia, shed light on the origins of some of Sedgeford's Mid Saxon population. Already a site rich with discoveries, it seems that Mid Saxon Sedgeford and its malting complex have a great deal more to gift us.

# 11 The 'Cerealization' of Continental North-West Europe, *c.*800–1200

*Nicolas Schroeder*

Around 1120, a monk from the abbey of Marchiennes, in modern northern France (Figure 49), produced a description of his monastery's estates and their history (Delmaire, 1985). His writing was part of a broader attempt by the abbot Amandus to reorganize and defend the monastic properties against the encroachments of lay lords. In one chapter, the author describes an estate named Bouvignies:

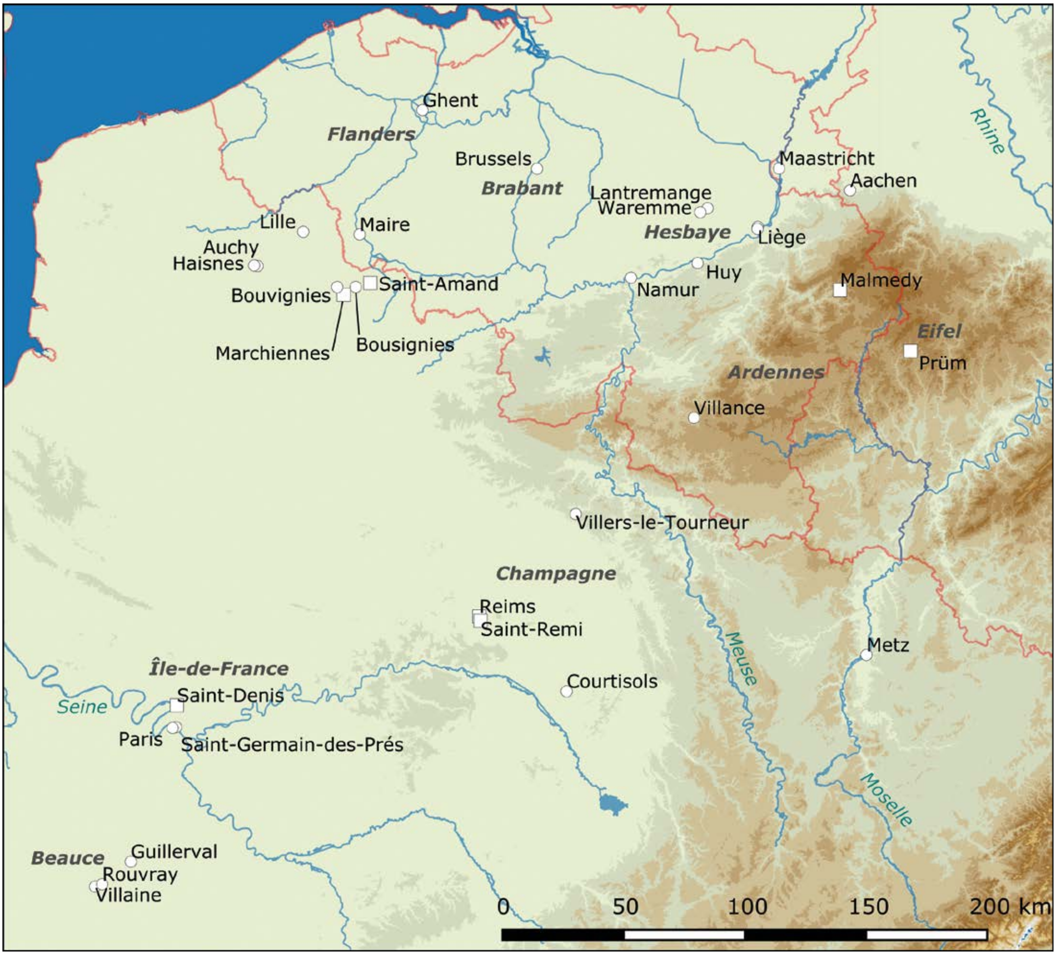
> In a place where the surrounding waters retreated, there is a cleared field, with fertile soil, that was recently reclaimed, as well as the farmsteads of two inhabitants who hold them for a rent of one shilling. (Delmaire, 1985, 82)[1]

In another passage, he describes the services that are owed by tenants on two estates:

> And concerning the fallow, if they own horses or oxen, the tenants from Haisnes and Auchy have to perform this service when they are asked to, and if they have no [horses nor oxen], each of them pays a penny, and they do the same to cover the seeds as well as in March for the oats. (Delmaire, 1985, 94)

These two quotations evoke some of the major elements that historians and archaeologists have come to see as characteristic of the high medieval agrarian history of continental north-west Europe: the expansion of permanent arable land, the diffusion of the heavy mouldboard plough pulled by horses rather than oxen and three-year crop rotations. They are often presented as achievements

1 Unless stated otherwise, translations from Latin are mine.




**49** Map of sites mentioned in the text.

and innovations of medieval societies, which contributed to the so-called 'cerealization' of north-west Europe in the early and high Middle Ages (Duby, 1962, 1.145–75; White, 1962, 39–78; Mitterauer, 2010, 5–12; Hoffmann, 2014, 114–33). This dynamic, which comprised the conversion of woodland, wasteland, pastures or wetlands into arable, and a general increase in grain production, went hand in hand with a larger process of demographic, commercial and urban expansion.

In the last three decades, historians, archaeologists and palaeoenvironmentalists have shed new light on these dynamics. For a long time, written evidence was the main source of information about 'cerealization'. Now, material evidence provides us with new knowledge about this process and some of its dimensions that were largely undocumented in the past. Besides the obviously crucial contributions of archaeobotanical and palynological studies, various disciplines inform our understanding of 'cerealization'. Remarkable advances in settlement archaeology provide new insights into grain storage structures in northern France; a survey published by Édith Peytremann (2013), for example, confirms that the overall production of grain increased between the eighth and twelfth centuries, but also draws attention to the cultural significance of grain storage, beyond socio-economic criteria. Zooarchaeological analyses indicate that cattle and horses became more and more important in the Carolingian period in several regions of northern France, a change which was, in all likelihood, related to increased grain production (Clavel and Yvinec, 2010, 76–77). A study of animal remains from a castle in the Ardennes indicates that the proportion of cattle to pig bones increased in the second half of the eleventh century, probably as a consequence of land clearance and the growth of arable cultivation (Ervynck and Woollett, 2006). Another study indicates that in the coastal areas of Flanders, sheep were predominant in the early Middle Ages, but that they were superseded by cattle in the twelfth to thirteenth centuries (Clavel and Frère, 2007). This shift might have been caused by the gradual transformation of salt marshes into arable land (in general, see Tys, 2013).

These are just a few examples of the new perspectives on medieval 'cerealization' in continental north-west Europe. Much work has been done that provides new insights into this process, highlights its regional diversity and, sometimes, also challenges older ideas. This paper synthesizes some of these contributions and ideas about the expansion of cereal farming in the early and high Middle Ages. It focuses on modern northern France and Belgium (Figure 49). Three main themes are discussed in turn: crops, rotations and field systems.

## Crops

Post-Roman and early medieval agricultural regimes were marked by significant changes in the type of crops that were grown by farmers. In continental north-west Europe, the cultivation of cereals such as hulled barley (*Hordeum vulgare* L.) and spelt (*Triticum spelta* L.) was progressively reduced, while bread wheat (*Triticum aestivum* L.), oats (*Avena* L.) and rye (*Secale cereale* L.) were increasingly adopted in post-Roman times (Devroey, 1989, 89; 1990, 239–40; Devroey and van Mol, 1989, 1; Devroey et al., 1995, 6–7; Mitterauer, 2010, 3–5; Bonnaire and Wiethold, 2010, 172). These dynamics have sometimes been presented as a major precondition of medieval economic growth. The adoption of rye and oats in particular is seen as a sort of 'bio-innovation' that made it possible to cultivate successfully in new ecological niches (Mitterauer, 2010, 1–27). Palynological evidence does indeed suggest that, from the fifth to sixth centuries onwards, rye was, for example, cultivated continuously in upland regions such as the Eifel (Litt et al., 2009, 686). The adoption of this crop, which is the most productive of cereals under conditions of low temperatures and fertility, certainly contributed to reducing the vulnerability of agriculture in demanding upland ecosystems, forming a precondition for medieval 'cerealization'. It is, however, important not to reduce the success of rye or oats to these functional aspects. Recent research emphasizes that the adoption of new crops in post-Roman times was, in fact, influenced by the complex interweaving of economic, social, cultural and environmental factors (Squatriti, 2019; Banham, 2010). As discussed more fully in the third section of this paper, it is equally important to resist a triumphant narrative of the diffusion of a Carolingian 'innovation package' that neatly combined new crops, the three-field system and the bipartite manor (see, for example, Mitterauer, 2010, 28–41). In fact, the diffusion of new crops was a *longue durée* process that unfolded with high levels of regional and chronological variation, even within the heartland of the Frankish empire.

Archaeobotanical analyses by Emmanuelle Bonnaire and Julian Wiethold indicate, for example, that in the fertile Île-de-France, the cultivation of barley was already limited in the Iron Age, following the broader adoption of bread wheat. In the Champagne region, however, where chalky soils are predominant, barley remained an important crop throughout the Roman and post-Roman periods: the transition towards bread wheat, rye and oats set in later, in the eighth century, and was only completed in the eleventh (Bonnaire and Wiethold, 2010, 171–72; cf. Lodwick, this volume). Written evidence provides further information about these patterns and dynamics. The *Polyptych of Saint-Germain-des-Prés*, which was produced in the 820s and describes several estates located in the Île-de-France, confirms that bread wheat was a central cereal on the demesne land of the monastery, with spelt and rye being mentioned in a few estates only (Elmshäuser and Hedwig, 1993, 343–44). Conversely, in the middle of the ninth century, spelt was preferentially cultivated on the extensive tracts of demesne land that belonged to Saint-Remi of Reims's estates on the poorer chalky soils of the Champagne region, between the rivers Aisne and Vesle (Devroey, 1989, 93–95; Bakels, 2009, 212–14). The monastery's estates to the south of the river Vesle, where soils are more diverse and tend to be richer, produced bread wheat, rye, spelt and barley. Oats were only cultivated in an estate named Villers-le-Tourneur, which was situated in a wooded area.

It is clear that these regional and local differences largely reflect environmental conditions (here, soil types). However, social factors, such as the specific needs of Carolingian monasteries, should not be underestimated. Analysing Carolingian royal and monastic estate records, Jean-Pierre Devroey (1990, 240) has demonstrated that in the ninth century, spelt was an important crop on the demesne land of several royal and monastic estates in the region between Lille and Aachen. It is likely that spelt was privileged on the large fields of the demesne of these estates because this hulled wheat (or 'glume wheat') can be stored for long periods of time and is therefore particularly well suited to the military and political objectives of the Carolingian aristocracy. Moreover, as we will see later, it was also well suited to the type of agrarian 'extensification' that these elites could achieve by requiring corvée labour from the peasantry. With the collapse of Carolingian power in the late ninth and early tenth centuries, these particular incentives to produce spelt disappeared, accelerating the adoption of rye and bread wheat (Devroey, 1990, 241). Indeed, eleventh-century records from estates of Saint-Remi show that, by then, spelt (and barley) were not cultivated any more on their demesne. They were replaced by rye or bread wheat, on more fertile soils, and oats (Devroey, 1989, 96).

This process did not, however, signify the end of large-scale spelt cultivation in all regions. Spelt was still cultivated in some parts of modern French-speaking Belgium in the high Middle Ages and later (Billen, 1990). Alexis Wilkin (2008, 539–45) has shown that in the late thirteenth century the canons of Saint-Lambert in Liège cultivated spelt in monoculture on the demesne land of their estates located in the Hesbaye region: an area with profound and fertile loess cover which has been an open-field landscape at least since modern times. Spelt was favoured by canons for their own consumption and on the local markets where they were selling surplus. This point is important, since rye and oats have sometimes been characterized as 'the main crops responsible for the "cerealization" of Europe' as their diffusion was associated with the 'general acceptance' of the three-field rotation system (Sonnlechner, 2004, 46). In the light of recent palaeobotanical and historical analyses, this generalization seems excessive. Even on the rich loessic soils of the Carolingian heartlands between the rivers Seine and Rhine, 'cerealization' was a complex and diverse process. It involved the cultivation of various cereals and a wide range of crop rotations.

## Crop rotations

Much scholarly attention has been devoted to the origins of the three-year crop rotation, which is sometimes presented as 'the predominant system in the Carolingian empire north of the river Loire, at least from the eighth century onwards' (Bakels, 2009, 210), and a crucial element of medieval 'cerealization'. In fact, recent research tends to relativize these ideas and to highlight the diversity of early and high medieval agrarian practices in continental north-west Europe. As pointed out by Marie-Pierre Ruas (2010, 62), archaeobotanical analyses attest three-course rotations of winter-sown bread wheat or rye and spring-sown peas or vetches in the Île-de-France as early as in the seventh century. Carolingian estate records also show the application of three-year rotations: in some polyptychs, we find mentions of three ploughings a year as corvée labour on the same parcel of the demesne (a first ploughing in June to turn the stubble into fallow; a second ploughing in October for the winter sowing; and a single ploughing in the spring for the spring-sown grain). A famous example of demesne land organized as a three-field system is provided by the *Polyptych of Saint-Amand*, which records that in the monastery's estate in Maire 'ten *bunuaria* [around two and a half acres] are sown for winter grain with 40 measures [of grain], and ten *bunuaria* for spring grain with 60 measures, and ten *bunuaria* are between [two cultivation successions]' (Hägermann and Hedwig, 1990, 104). However, such a neat repetition cannot be found on all of Saint-Amand's estates: in Bousignies, five out of the eleven *bunuaria* of arable land had to be sown with a winter crop and six with a spring crop (Hägermann and Hedwig, 1990, 103). We cannot be sure of the crop succession in this case, but it certainly was not a regular three-course rotation. Other ninth-century estate records confirm that alternative rotations could be organized on the demesne of monasteries. In the middle of the century, in Saint-Remi of Reims's estate of Courtisols, rye and spelt were cultivated in monoculture in two-year rotations, respectively on small enclosed fields (*avergariae*) and extensive fields of the demesne (*culturae*) (Devroey, 2014, 47). Oats were grown in monoculture on the demesne of Saint-Remi's estate in Villers-le-Tourneur in the middle of the ninth century and on the demesne land (*culturae*) of Prüm's estates of Villance in the Ardennes at the end of the same century (Devroey, 1989, 95 and Schwab, 1983, 201). Archaeobotanical evidence confirms the diversity of early medieval rotations in continental north-west Europe. Marie-Pierre Ruas and Véronique Zech-Matterne have observed, for example, that in the early Middle Ages, in what is now northern France, oats could be cultivated in two-year rotations associated with a winter grain, in three-year rotations as a spring grain and/or as a winter grain, and finally by alternating arable and pasture (ley farming) (Ruas and Zech-Matterne, 2012, 306).

Some of these practices are also attested in later times, for example in central Flanders (south of Ghent), where Erik Thoen (1994a, 136–42; 1994b, 176; 1997, 72–73; 2018, 168) has observed that, in the twelfth and thirteenth centuries, oats destined to produce ale were cultivated using ley farming. Spelt or oats monoculture, respectively in Hesbaye and Flanders, challenge the idea that three-year crop rotations became almost hegemonic in continental north-west Europe as a result of Carolingian and high medieval 'cerealization'. The point of these observations is not to deny that three-course rotation was a component of this process. Rather, it now seems clear that its importance has been exaggerated on occasion. In this context, François Sigaut (1976, 635–37) has questioned the notion that three-year rotations are inherently more productive than two-year rotations. On the same terrain and with the same amount of manuring, a two-year rotation of a winter-sown corn such as bread wheat will produce more of this grain every year than a three-year rotation. Of course, there is no spring-sown harvest, but from a commercial perspective, selling a certain amount of bread wheat – a grain with very high commercial value – rather than a slightly larger amount of oats – a grain with low commercial value – might actually be more lucrative. In fact, the adoption of three-year crop rotations mainly increases productivity as part of 'extensification', that is to say, by taking more land under the plough. The fact that the ploughing for spring crops takes place in the late winter/early spring, at a moment of the year when there is not much other work to do on the farm, probably explains the success of this rotation in the early and high Middle Ages. However, it seems unlikely that three-year crop rotations were as hegemonic in Carolingian and post-Carolingian continental north-west Europe as they have sometimes been described. The growing of spelt in monoculture in the Hesbaye region is a good example to support Mathieu Arnoux's claim that, for high medieval landowners and farmers, three-year crop rotations were nothing more than 'one option among others' (Arnoux, 1997, 135). Regional and local environmental conditions did, of course, influence the selection of crops and rotations. In the case of central Flanders, introduced above, oats were cultivated on poor and light sandy soils (Thoen, 1997, 72). However, farmers and landowners could also opt for two-year rotations, three-year rotations or different alternations between pasture and arable if one of these practices was more adapted to their socio-economic context. This observation has important consequences for our understanding of field systems, agrarian landscapes and their dynamics.

### Field systems, landscapes and their dynamics

Thorough research carried out in recent decades by Samuel Leturcq and other scholars has led to an important conclusion: there is no conclusive evidence that rigid open-field systems with compulsory crop rotation existed in continental north-west Europe in the early and high Middle Ages (Derville, 1988; Arnoux, 1997, 138–40; Leturcq, 2015; 2018). Open fields (that is, fields with intermingled strips and collective management) are certainly documented in many regions (Leturcq, 2007; Thoen, 2018; Schroeder, 2018). They could be extensive (occupying the entire arable land of a settlement), form patchworks (being composed of different fields spread over a settlement's arable land) or formed of a single 'infield' surrounded by other fields, pasture, wasteland or woodland (see the detailed typology established for Flanders by Thoen, 2018, 165–79). It could be beneficial, in all these cases, to follow the same rotation on all strips and to create the conditions for collective grazing. There is evidence that groups of farmers did just that. These practices required collective management. However, it is now increasingly accepted that legally, except for land that was rented and therefore subject to the will of a landowner, farmers always had the right to pull out of collective arrangements and to follow the rotation of their choice (Arnoux, 1997, 138–40; Leturcq, 2015; 2018; for Flanders, Thoen, 1997, 74–77 accepts the existence of Flurzwang – i.e., compulsory rotation – but also emphasizes that 'crop rotations were extremely flexible'; also see Thoen, 2018). This observation is crucial to discussions concerning the dynamics of field systems throughout the process of medieval 'cerealization'.

The available evidence for the Carolingian period suggests that the agrarian landscapes of north-west Europe were quite diverse in this time. Adriaan Verhulst's discussion of this remains a solid starting point: 'field complexes – either demesne lands known as culturae or plots of individual farmers […] did not yet form continuous open areas and were still separated by woods, heath, or uncultivated plots and possibly even enclosed by hedgerows or trees' (Verhulst, 2002, 63–64). There is no convincing evidence that extensive open fields with compulsory rotations existed at the time (to my mind, Joachim Henning's (2014) argument for the existence of three-field systems in the eighth century is not convincing in the light of the basic, but necessary, source criticism formulated by Hildebrandt, 1980, 197–235).

In such landscapes, different areas could be submitted to different agrarian practices, and Jean-Pierre Devroey (1984, 33 and 65; 1990, 246; 2019, 443–48) has observed that the demesne land of the estates of Saint-Remi of Reims in the Champagne region comprised smaller enclosed fields that were cultivated intensively (manured) to produce bread wheat, rye or barley, and large unenclosed fields that were cultivated extensively to produce spelt. We should add to this that the fields of peasants – be they tenants or owner-cultivators – are not documented and that they might have been home to yet other agrarian practices. Indeed, important discrepancies emerge from the comparison of archaeobotanical evidence found in excavations and the written record (Bakels, 2009, 212–13; Preiss et al., 2016, 177). Although it is not the only one, a robust explanation of this fact is that the cereals produced for lords – which are mirrored in the written evidence – and those produced by peasants for their own subsistence or commercialization are not necessarily the same.

Put together, these observations about social and physical aspects of Carolingian field systems define a dynamic framework for our understanding of medieval 'cerealization' from *c.*800 to 1200. The relatively complex agro-ecosystems of the Carolingian period were composed of several 'sectors' in which agrarian practices could be taken in different directions by different actors in order to increase, decrease, diversify or specialize production. Following remarks formulated recently by Roland Viader (2017), in this context, particular attention should be given to the remarkable potential of temporary cultivation. Building on François Sigaut's (2004, 13–14) argument that one of the main technical functions of the heavy plough is to cut through grass roots and bury weeds, Viader has suggested that the association of the heavy plough with the three-field system might have obscured its importance for other practices, such as ley farming. One of Viader's most powerful suggestions is that the extension of arable farming in the early and high Middle Ages might have been achieved largely by transformations in the temporal and spatial succession of practices that alternate between arable and grassland.

This idea accords with Adriaan Verhulst's (1966) and Jean-Pierre Devroey's (2006, 547–51) observations that the development of monastic and royal estates in Carolingian times was, to a large extent, based on command of corvée labour – that is, ploughing services – with the objective of clearing more arable land, be it permanently or temporarily. Viader's approach also fits well with Samuel Leturcq's (1999) observations about Saint-Denis's estates in the Beauce region in the early twelfth century: in *De administratione*, abbot Suger describes how several estates were 'disorganized', meaning some of the land was not cultivated, covered in grass or heath (Suger, 1996, 75–91). As we just saw, this does not, in fact, signify that they were not put under the plough occasionally in a system of ley farming. Be that as it may, Suger then required more rent from the monastery's tenants and thereby increased the revenues from these estates. It is likely that in these places, Suger's intervention was a crucial step in the emergence of the open-field landscape that characterizes the Beauce region to this day (Leturcq, 1999). These examples show that seigneurial demand was an important driver of 'cerealization' and that it could lead to the 'standardization' of agrarian practices. But this was not always the case, as a final example indicates.

Two documents from the late eleventh to early twelfth centuries provide interesting information about agrarian practices in two neighbouring estates located in the Hesbaye region (see Figure 49). One of these estates is situated in a place named Waremme and belonged to a countess named Ermengarde (Kupper, 2013). The second one is located in Lantremange, which is less than three kilometres away from Waremme and belonged to the monastery of Malmedy (Schroeder and Wilkin, 2014, 42–43). Tenants in these two estates were not facing similar demand from their lords. Some of them only had to pay cash, which means that they had to produce surplus that could be commercialized (perhaps at the market in Waremme). These tenants had a strong incentive to direct some of their farm's production according to market demand. Other tenants had to deliver rent in kind (oats, peas, lambs or pigs), which means that they had to adjust the production of their farms in order to meet seigneurial demand. Malmedy, a monastery situated in the Ardennes – 60 kilometres away, as the crow flies – required peas and oats. The advocate, mayor and cellarer managing the monastic estate were paid with peas and oats, but also bread wheat and rye, suggesting that these crops were also cultivated locally. The rent for Ermengarde, a countess with substantial property in the region, was paid in animals and malt (made from barley, oats or spelt). Besides rent from tenancies, she also received rent from the 11 mills and five breweries located in the estate. A significant part of these revenues consisted of bread wheat.

These observations are not sufficient to get a clear sense of how production was organized in these settlements. However, they suggest that in the relatively small area under investigation, different farmers had to cultivate different crops in order to feed their families, meet the specific demands of their lord, and sell surplus produce. The deep loessic soils around Waremme are quite fertile and in the late eleventh to early twelfth centuries, the towns of the river Meuse (e.g., Namur, Huy, Liège, Maastricht) and the religious houses of the region were booming (Joris, 1993a; Verhulst, 1999, 70–75, 119–48; Wilkin, 2008, 494–99, 557–62; Suttor, 2013). From this perspective, the social and economic context of Waremme and Lantremange in the late eleventh century is typical of the process of high medieval 'cerealization' associated with the development of aristocratic power, urbanization and commercialization. Yet the evidence analysed does not suggest that these estates were organized according to the ideal type of the manor with its three-field system that constrained farmers to adopt a relatively limited and standardized set of crops, rotations and agrarian practices. In fact, the evidence presented here points rather towards a relatively complex agrarian system that could, at the level of these two settlements, be described as polycultural. Indeed, to make sense of the evidence presented here, we have to imagine – just as in Saint-Remi's estates in ninth-century Champagne – that at the level of these two settlements, different 'sectors' of agrarian production coexisted. The practices of different tenants – and perhaps owner-cultivators – in their gardens and fields and what happened on demesne land were not necessarily aligned. In the different 'sectors' of a settlement's agrarian landscape, practices could be more or less intensive and more or less specialized.

These observations also provide a good understanding of what happened at the end of the period under investigation in the most urbanized and 'productive' regions of north-west Europe, starting with Flanders. The relative flexibility of field systems – beyond arrangements assuring collective grazing – was instrumental in further developments in the thirteenth century. Not only did it afford the possibility for individual farmers to grow cash crops such as woad, madder or weld on some of their parcels (Joris, 1993b; Thoen, 1997, 79–80); it was also a crucial structural condition of intensification. Research that investigates the relationship between urbanization and agrarian practices in Flanders, northern France or Brabant indicates that high-input practices, that had hitherto been characteristic of infield and garden cultivation (manual spreading of manure, flexible rotations, careful weeding, emphasis on leguminous and spring-sown crops, etc.), were increasingly applied to fields and the growing of cereals from the thirteenth century (Verhulst, 1985; Derville, 1995, 66). Paolo Charruadas (2007) has, for example, drawn attention to a charter from 1258 that reports difficulties in the collection of tithes in the countryside around Brussels because farmers were growing vegetables on fields as if they were gardens, and grain in gardens as if they were fields. Strong collective regulations and compulsory rotations have often been seen as obstacles to the initiative of individual farmers and the application of high-input practices on their land (Verhulst, 1990, 68–70). If, however, farmers were (as recent historical research suggests) legally authorized to pull out of collective practices, the path towards these innovations must have been much more straightforward than previously assumed. From this perspective, the flexibility of crop rotations was a key element in the development of more productive agricultural systems in some regions during the transition period to the later Middle Ages.

## Conclusion

Fascination with particular models of agrarian history such as the three-field system, and the teleology of medieval demographic and economic growth, have sometimes created an image of 'cerealization' as a linear process that unfolded irresistibly after being set in motion by a few factors, finally leading to the formation of relatively standardized agrarian systems and practices. Recent work by archaeologists, historians and palaeoenvironmentalists suggests rather that the 'cerealization' of continental north-west Europe between 800 and 1200 was a gradual process, which was very diverse in its causes, forms and outcomes. Cereals such as hulled barley and spelt, forms of temporary cultivation that alternate between pasture and arable, two-course rotations, and flexible and complex field systems that integrate ley farming, all deserve as much attention in our narratives and models of 'cerealization' in continental north-west Europe as the spread of bread wheat or three-field systems.

# 12 Agriculture, Lords and Landscape in Medieval England

*Tom Williamson*

## Introduction

The proposed 'revolution' in agriculture which forms the subject of this volume, and which occurred across much of Europe between the eighth and the late twelfth centuries, comprised two key elements. The first was the use of a mouldboard plough, which allowed ground to be cultivated more rapidly and effectively, and heavier soils to be brought into cultivation (cf. Holmes and Kropp, this volume). The second was the adoption of regular forms of crop rotation, involving a year-long fallow every second or third year, which ensured that fertility could be maintained through direct manuring by livestock, rather than by the spreading of manure by hand (cf. Bogaard et al. and Stroud, this volume). These developments may have produced lower yields than the 'intensive' methods they supposedly replaced, but they permitted much more land to be cultivated because they required lower inputs of labour per unit area (Hamerow et al., 2020, 585–86; Hamerow, this volume). The 'revolution' helped a lordly elite to 'amass wealth by greatly expanding the amounts of land under cultivation and exploiting the labour of others' and was thus, by implication, initiated or at least led by them (Hamerow et al., 2020, 585). And the new, 'extensive' modes of agriculture may, it has been suggested, have been associated with another 'revolution' much discussed by archaeologists and historians over many decades: the emergence of nucleated villages and the extensive, highly communal open-field systems with which they were intimately associated (Hamerow et al., 2020, 586). The aim of this chapter is primarily to explore the character of the connections between these two suggested 'revolutions' – in settlement and field systems on the one hand, and in agricultural practices on the other.

But it will also critique some aspects of the proposed 'agricultural revolution' itself, and some of the assumptions inherent in top-down models of agrarian change.

## Revolutions in agriculture

The concept of an early medieval 'revolution' is borrowed from the long-established idea of the agricultural 'revolution' of the late eighteenth and nineteenth centuries, itself modelled by its earliest proponents – most notably Lord Ernle – on the industrial revolution with which this was broadly contemporary and closely connected (Ernle, 1912). Industrialization depended on a significant increase in food production. Not only was it associated with unprecedented rates of population increase: following a phase, lasting nearly a century, of low or negative growth, the population of England and Wales rose from around six million in 1750 to nine million by 1800, reaching nearly 18 million by 1851 (Wrigley and Schofield, 1989, 160–62). Industrialization also, by definition, required the maintenance of a large, agriculturally unproductive workforce. In 1760, the output of each agricultural worker could feed around one other person: by 1841, it could feed another 2.7 (Overton, 1996, 121–28). The increasing demand for grain was met with only limited imports, which were restricted for much of this period by the Corn Laws. Had large-scale imports been necessary, capital would have leached from the country, choking off the investment required for industrial growth (Clark, 1988). This modern 'revolution', as formulated by Ernle and elaborated by scholars like John Chambers, Gordon Mingay, John Beckett and Mark Overton, combined elements of both extensification and intensification (Chambers and Mingay, 1966; Beckett, 1990; Overton, 1996). The large-scale enclosure of common land allowed for a significant increase in the area of arable, especially in southern and eastern England, and in the extent of improved pasture. But much of the land reclaimed was of poor quality, and remained so in relative terms, and increases in production also came through raising yields per unit area by employing a range of techniques.

Of particular importance was a development which, in part, overturned one of the key innovations of the suggested medieval 'revolution'. The widespread cultivation of fodder crops allowed, in many although not all areas, the eradication of regular fallow years. The integration, in their place, of turnips and clover in arable rotations permitted larger numbers of livestock to be kept, thus enhancing manure supplies and increasing yields per acre (Chorley, 1981). Sheep and cattle might be grazed directly on clover or other 'artificial grasses' and to an extent on turnips, but the latter – in another partial reversion to early practice – were more usually lifted, fed to cattle over-wintered in yards on straw, and the resultant manure taken to the fields by cart and spread by hand. In addition to improving crop yields, the new practices ensured that livestock were better fed and could enjoy a more sedentary life, which did not involve searching across the fields for the meagre pickings of the arable weeds or, in the case of sheep in areas of light soils, a daily trek from grazing grounds to fallow fold. Indeed, proponents of the conventional agricultural revolution have always emphasized improvements in the livestock sector. Across the period 1700–1850, annual meat production in England may have increased by 150 per cent and dairy production by 220 per cent (Overton, 1996, 75).

The conventional agricultural revolution included other elements. The contribution of new forms of machinery, highlighted by Ernle, has largely been discounted by more recent scholars, but enclosure of open fields is still seen as important by most, and several other developments have been highlighted: changes in the geographical distribution of production encouraged by regional deindustrialization and improvements in transportation systems; a reduction in the size and length of hedgerows in old-enclosed districts, and in the numbers of hedgerow trees, as coal displaced wood as the main domestic fuel in rural areas; and improved methods of land drainage, and of dealing with soil acidity through marling and liming (Warde and Williamson, 2014, 78–82; Williamson, 2002, 67–70, 85–97, 159–63).

The concept of a revolution in farming in the late eighteenth and nineteenth centuries continues to find much support from historians. The fact that a population, growing at an unprecedented rate, was fed without large-scale imports is a powerful argument in its own right. But in the 1960s and 70s an alternative 'agricultural revolution' was proposed by Eric Kerridge (1967; 1969; 1973). This, he argued, had occurred during the previous period of demographic growth in England, during the sixteenth and earlier seventeenth centuries. In part, this 'early modern' revolution involved the same techniques as that of the eighteenth century, but now given an earlier chronology, Kerridge arguing in particular that the use of turnips and clover was widespread in the seventeenth century. But it also comprised a range of other innovations, including the drainage of wetlands, the adoption of 'up-and-down' or convertible husbandry, and – crucially – the artificial irrigation or 'floating' of water meadows, a technique designed both to enhance the supply of fodder (through increasing the hay crop) and to reduce the need for it (by encouraging an early growth of grass). This, like the adoption of turnips and clover, served to raise stocking densities and thus increase manure supplies. Other innovations have been added by Kerridge's relatively few followers, most notably Robert Allen, who suggested that yields per acre were raised during the early modern period by the careful selection of cereal seed (Allen, 1991; 1992).

This is not the place to discuss the relative importance of these rival 'revolutions'. My aim is instead to see what light they might shed on the suggested agricultural innovations of the early medieval period. We might begin with the obvious yet important observation that both post-medieval 'revolutions' coincided with periods of rising population and were separated by a phase – spanning the late seventeenth and early eighteenth centuries – of stagnant or negative growth. This suggests, unsurprisingly, that as population rises agricultural producers are more prepared to innovate – or, perhaps more accurately, to invest in and implement existing innovations – than they are at times when the market, especially for cereals, is stagnant. This impression is strengthened when we note that the 'medieval' revolution discussed in this volume similarly coincided with the previous period of demographic expansion and ended shortly before the population began its post-1300 decline. All this perhaps supports the suggestion made by Joan Thirsk more than three decades ago, discussing the current debates about the timing of an 'agricultural revolution', that English agricultural history is best understood as a 'continuum, to be divided between periods of more or less rapid change' (Thirsk, 1987, 57–58).

Second, it is striking that many if not most of the new techniques which constituted these proposed post-medieval 'revolutions' were labour-intensive in character. In particular, turnips only succeed on a well-worked seed bed, and if assiduously weeded and hoed; manure from yards needs to be carted and spread (Hanley, 1949, 1.139). Even those improvements which might be considered 'extensive', such as the enclosure and reclamation of marginal land, required large amounts of labour. Rising population (associated in the case of the 'traditional' revolution with regional de-industrialization) lowered labour costs significantly, allowing innovations to be implemented. It can indeed be argued, in the case of the eighteenth-century revolution especially, that the more intensive cultivation – weeding and the like, which lower wage costs permitted – may in itself have served to increase cereal yields, irrespective of the adoption of new practices (Wade Martins and Williamson, 1997; Williamson, 2002, 168–70). In a similar way, Bruce Campbell has argued persuasively that rapid demographic expansion during the eleventh, twelfth and thirteenth centuries did not necessarily lead, in the kind of Malthusian–Ricardian manner envisaged by Postan, to a crisis of over-worked land and declining yields, but instead to an increase in agricultural production through greater inputs of labour, in some circumstances leading, in the manner predicted by Boserup, to the development of new agricultural practices (Postan, 1973; Campbell, 1983). Such arguments raise interesting questions about the model of medieval 'extensification' elaborated by other contributors to this volume. As a general approach, it seems oddly suited to a situation of increasing labour abundance, and growing pressure on land.

Third, although Kerridge's ideas are currently unfashionable, there is good evidence that the key innovations he discusses were important in regional terms, and that the different post-medieval 'revolutions' affected different areas of the country to differing extents, partly for social but mainly for environmental reasons. The irrigation of meadows probably *was* a major factor in increasing grain production in the seventeenth century on the chalk downlands of southern England, where the environmental conditions for the adoption of this technique were ideal (Bettey, 1999; Cook, 2007). But it made almost no impact in the key grain-growing districts of eastern England, which, a century or so later, were to be lead adopters of turnip-based rotations (Wade Martins and Williamson, 1994). We should not, in other words, expect to find all innovations in agriculture to be adopted to the same extent in all regions; the stimulus to increase production presented by expanding markets might lead to different developments, or different emphases, in different areas. Farming is not a 'one size fits all' business. Indeed, this is perhaps especially true of the key innovation of the classic eighteenth-century revolution, the new rotations, for these were principally adopted in areas of light, freely draining land, where turnips could thrive and manure supplies were of crucial importance, because of the rapid leaching of nutrients. They made less sense on the kinds of heavy, fertile claylands where, today, most of England's wheat is grown. Here, other new techniques, such as systematic under-drainage, were unquestionably more important in raising yields (Williamson, 2002, 85–97).

Historians, and even some archaeologists, can be suspicious about the kinds of comparisons, crossing several centuries, which I have made in the foregoing pages. But examining the contexts and determinants of the better-documented 'revolutions' of the post-medieval period does serve to highlight some issues about the suggested agrarian changes of the Middle Ages. In particular, it raises the question of why, at a time of rising population and decreasing availability of good-quality arable land, the chosen and universal response of cultivators was to adopt methods which reduced labour inputs and decreased yields per unit area. It also suggests that we should not, perhaps, expect any form of uniform 'revolution' in production in the circumstance of expanding markets, but rather the adoption of different emphases or approaches in different social, environmental or landscape contexts.

## Regions and the 'revolution'

England, even if we restrict our attention to lowland areas, displayed by the twelfth century a diverse range of landscapes. 'Champion' countryside, to adopt a useful shorthand based on early modern topographic usage, was found in a broad band running from Yorkshire and Durham, through the Midland counties, to the south coast, and with an outlying extension along the South Downs (Figure 50; Rackham, 1986, 1–5; Roberts and Wrathmell, 2000; 2002). Throughout this extensive region, farms were usually clustered together in villages, albeit ones displaying much variation in terms of their compactness, size and morphology. The arable land of the farms lay intermingled, as numerous unhedged strips or 'lands', which were scattered with varying degrees of regularity through the territory of the township. The strips were grouped into blocks called furlongs, usually the basic unit of cropping, which were in turn aggregated into larger units called 'fields'. There were usually two or three of these in each township, one of which lay fallow or uncultivated each year and was grazed in common by the livestock of the community (Hall, 1982; 1995). This ensured that the land was adequately dunged, thus restoring the nitrogen and other nutrients which were constantly depleted by cropping. The complex routines of such a system – decisions about when to plough, sow and harvest, the courses of cropping to be followed within each furlong – were decided by village meetings and usually enforced by the manorial court (Dyer, 2018). Manorial demesnes sometimes took the form of dispersed strips but they could also comprise compact blocks near to manor houses.

There were a number of variations on this broad theme, related in part to environmental conditions. On the heavy clay soils of the Midlands, individual strips were usually ploughed in ridges, a practice principally intended to improve drainage, and the holdings or 'yardlands' in a township (each owing the same rent and other obligations) were often laid out within the fields in a highly structured fashion, according to a fixed and regular sequence. On lighter land, holdings were often less regularly scattered, individual lands were seldom ploughed in ridges, and extensive tracts of unploughed ground often survived beyond the arable – chalk downs and heaths – on which large sheep flocks were grazed by day, to be close-folded on the


50 The distribution of 'champion' landscapes in England, as suggested by different authorities: (a) the boundaries of Howard Gray's (1915) 'Midland System'; (b) the 'Central Province', as defined by Roberts and Wrathmell (2000); (c) Oliver Rackham's (1986) distinction between the 'planned' and the 'ancient' countryside, equivalent to 'champion' and non-champion areas.

fallows by night, a practice which was well established by the eleventh century (Belcher, 2020, 74, 85). Nutrients were rapidly leached from light soils and successful cultivation was only possible with substantial and regular applications of dung (Kerridge, 1992). Close-folding was less common on heavier ground, where leaching was less rapid and closely packed livestock tended to compact the soils (Kerridge, 1992, 77–79; Fox, 1984, 130–33).

To the south and east of this 'champion' belt, and to the west, very different arrangements could be found. In some areas open fields accounted for most of the arable land, but holdings, rather than being widely scattered and intermixed across the arable of a township, were instead clustered in restricted areas, close to the farmstead; each farmer thus had comparatively few neighbours, and the annual fallow was usually fragmented, rather than forming a single continuous block. Elsewhere, open fields of this 'irregular' type formed part of 'patchwork' landscapes, which included areas of enclosed fields. Such landscapes merged imperceptibly into true 'bocage' or 'woodland' countrysides, in which all the arable land lay in parcels surrounded by walls or hedges, and was individually cultivated (Postgate, 1973; Roberts, 1973; Hunter, 2003; Roden, 1973; Martin and Satchell, 2008, 147–73). All these alternatives to 'champion' arrangements were associated with more dispersed patterns of settlement. Villages could be found in many areas – often associated with the largest areas of open field – but there were also outlying hamlets and/or scattered farms.

It is important to emphasize that the boundaries of the central 'champion' belt have been mapped in slightly different ways by different researchers, uncertain in particular how to treat areas which displayed mixed or intermediate characteristics (see Figure 50). Moreover, these broad regions were not uniform in character. Some areas of dispersed settlement and complex, multiple field systems could be found deep within the 'champion', while nucleated villages with extensive and regular open fields could occasionally be found well outside it (Brown and Taylor, 1989). Indeed, the differences between these two broad landscape types should not be exaggerated. Many areas of dispersed settlement, as already noted, also featured some larger nucleations; while some 'champion' villages were only loosely nucleated, comprising a number of semi-detached and individually named 'ends'. Similar plan elements could be found in all types of settlement pattern. For example, some 'champion' villages were clustered around a central common – a 'village green' – and many more featured a number of small greens. One common form of dispersed settlement was the hamlet closely clustered around the small green; another was a scattering of farms around the margins of a more extensive area of common land (Rowe and Williamson, 2013, 71–78; Warner, 1987). Medieval landscapes were more like variations on a number of shared themes than a series of unitary, hermetically sealed entities, with radically different determinants.

The diversity of medieval landscapes raises obvious questions about any necessary connection between the agricultural innovations of the eight to twelfth centuries and nucleated villages farming extensive areas of open-field arable. For the regions lying outside the champion belt do not simply represent sparsely settled zones of woodland and pasture whose inhabitants were principally involved in livestock farming. They, too, were mainly mixed farming systems with an emphasis on grain production. Domesday is a problematic source but it suggests little if any correlation between the two broad landscape types on the one hand and the density of either population or plough-teams on the other. Indeed, many of the most densely settled districts lay outside the champion: in Norfolk, for example. By the end of the twelfth century, the great city of London was surrounded by landscapes of dispersed settlement, enclosures and irregular open fields, yet it was here that much of the grain it consumed was grown. 'The pre-eminence of enclosed land did not mean that the economy was based primarily on pastoral or woodland activities', for most was, by the time records become abundant in the thirteenth century, in tillage (Roden, 1973, 341). Twelfth- and thirteenth-century Suffolk was densely settled, with most of the land in cultivation, but its settlement pattern was dispersed and its fields either 'irregular' open fields or enclosures (Bailey, 2007). Conversely, we should not consider champion landscapes as necessarily displaying a clear and overriding bias towards cereal production. In areas of light land, the sheep flocks might be vast and the pastures extensive. But even in a county like Northamptonshire, characterized by heavier soils, quite large areas of unploughed ground sometimes existed. Although in many townships arable occupied, by the thirteenth century, much of the land surface, some on heavier soils contained extensive blocks and ribbons of pasture, so that less than 60 per cent of their land was in tilth, only half of which was actually sown at any one time, the other half providing, in the form of fallows, further reserves of grazing land (Plate XX; Williamson et al., 2013, 110–12). But above all we should note that, in almost all regions, arable farming by the time of Domesday involved the use of a heavy mouldboard plough, regular fallows, and direct manuring of fields by livestock. These were not practices uniquely associated with 'champion' countryside.

## Open fields, efficiency and extensification

Superficially, champion landscapes, with their rigid fallowing arrangements and their ploughlands extending for a considerable distance from the clustered farmsteads, seem to epitomize an 'extensive' approach to agricultural production. It might be argued that the alternative forms of field and settlement simply represent partial and less successful adoptions of the 'revolution', where full implementation was perhaps held back by social or environmental factors. But the suggestion that farming in extensive, 'regular' open fields was a way of reducing labour inputs per unit area would certainly have surprised eighteenth-century improvers, who repeatedly emphasized the inherent inefficiencies of such arrangements. Indeed, the fact that farming widely scattered strips actually involved *greater* inputs of labour is arguably one of the main reasons why rents for open-field land were, by the eighteenth century, around half those commanded by enclosed fields (Chambers and Mingay, 1966, 85). Admittedly, new techniques in agriculture had by this stage increased the relative disadvantages of the former, but it is clear that some inefficiencies were built into the system and operated in all circumstances.

Karakacili, studying open-field villages in Cambridgeshire and Bedfordshire, calculated that by the early fourteenth century between 7.9 and 13.4 days of labour were expended on each arable acre, although these figures relate to demesne land, rather than peasant holdings, where inputs may have been higher (Karakacili, 2004, 34). In the Norfolk parish of Martham, where field systems were highly irregular and holdings clustered, Campbell suggested a figure of ten days, while Fox's study of two Devon manors – again, lying well outside the Midland belt – produced figures of 13.4 and 13.7 days per acre (Campbell, 1983, 38–39; Fox, 1996, 544–45). For a variety of reasons, these three sets of figures are not strictly comparable but they do not suggest any very clear superiority of 'champion' systems, in terms of labour efficiency, and this is unsurprising. Extensive open fields might look efficient if we focus exclusively on manuring, but this was only one of a great many agricultural tasks, which, in addition to ploughing, would have included harrowing, sowing, weeding, reaping, gathering and binding, and carting the harvested crops back to the farmstead. All required more man-hours in a landscape of nucleated settlement and extensive open fields than in the alternative systems. This was not only because holdings lay in widely scattered strips, involving much movement between them. Indeed, given that strips commonly covered between a half and one acre, some of these tasks would take a working day to accomplish on each. It was also because much time and energy were expended reaching those parts of the holding that lay towards the periphery of the township, commonly three or more kilometres away.

Even considered solely in terms of manuring, champion landscapes were not entirely geared towards labour-efficient approaches. Farmers in these areas did not eschew the hand-spreading of manure from farmyards and byres. Manorial court rolls make it clear that in Midland villages, to quote Karakacili, farmers 'were well aware of the potential benefits of applying marl and manure to the soil and went to great lengths to obtain them for their holdings' (Karakacili, 2004, 36). If farmers had no interest in physically moving manure to their scattered strips it is strange that by-laws from Midland villages prohibited such things as the removal of dung from communal meadows (Ault, 1972, 66). Jones has suggested that in the Whittlewood area, on the border between Buckinghamshire and Northamptonshire, the absence of ninth-, tenth- and eleventh-century sherds recovered by fieldwalking from the area of the former open fields indicates a reduction in the movement of dung from farms, associated with the development of open fields and an increasing reliance on direct manuring by livestock (Jones, 2004, 167–68). Relatively little pottery was present on farms before the Conquest, however, and as larger amounts came into use in the twelfth century the ceramic 'signature' of manuring reappears, although only in the furlongs lying close to the villages. Furlongs lying more than 750 metres away contained tiny quantities of sherds; those more than a kilometre distant, none at all (Jones, 2004, 171–72).

In a similar manner, fieldwalking in areas of dispersed settlement, such as Fransham in Norfolk, reveals that 'sherd scatters were thicker in fields, and in those parts of fields, lying close to the numerous settlement sites than they were in more outlying areas' (Rogerson, 1994, 189–90). But because farms were more scattered here, sherds were more evenly distributed across the landscape. It would appear that arable fields in regions lying outside the champion were on the whole more likely to receive manuring material from middens, and thus presumably from byres and yards, than the more peripheral furlongs, at least, of champion townships. Dung carts did not have to make interminable journeys to widely scattered strips, many located at a considerable distance. Land instead lay in convenient proximity to the farmstead.

It is thus far from clear that nucleated villages and extensive open fields represent a less labour-intensive form of farming than the various alternative ways of arranging an agricultural landscape. Even in terms of manuring, the differences were ones of degree, engendered by the spatial relationship between a farm and its land. Moreover, if 'regular' open fields were, indeed, deliberately planned to reduce the amount of time and effort related to the spreading of manure, their designers wilfully ignored the increased inputs of labour which their adoption produced in other aspects of farming. They also ignored the various other negative impacts they would have had on farming communities.

Once again, post-medieval sources are instructive and, while in some ways the problems they describe are specific to the period, others were inherent. In particular, while champion landscapes were not entirely lacking in trees and hedges – the perimeters of the great fields were sometimes hedged, for example – they contained far fewer hedges and hedgerow trees than enclosed landscapes or most 'irregular' field systems. Given the size, shape and number of strips, it was impossible to enclose them with hedges, even if this had been compatible with the free movement of the common herds or flocks. True, this saved much of the labour of hedge maintenance: plashing or laying every decade or so. But it also denied farmers what was elsewhere often their principal source of fuelwood, as countless sixteenth- and seventeenth-century writers observed (Williamson et al., 2017, 65–67).

### The open-field 'revolution'

If champion landscapes were designed as part of an agricultural revolution, with the aim of cultivating more land using less labour, they do not seem to have succeeded very well. But were they really designed at all, at least in their earliest manifestations? Or did they develop over time, path-dependent, their final forms unforeseen? The idea that villages and open fields were a revolutionary development first emerged in the late 1970s and 1980s in studies of the Midland county of Northamptonshire carried out by Glenn Foard and David Hall (Foard, 1978; Hall, 1982). They suggested, on the basis of extensive and meticulous field surveys, that villages had developed sometime between the seventh and ninth centuries through the abandonment of a more dispersed settlement pattern of scattered farms, apparently revealed by fieldwalking. This nucleation 'event' was accompanied by a more general replanning of the landscape, involving the laying out of open fields. Evidence that these changes were sudden and planned, rather than gradual and organic, was provided by the regular layout of many Northamptonshire villages, with neat arrangements of parallel tofts; and by the highly regular arrangements of virgate holdings already noted, featuring repetitive sequences running through the entire area of a township's fields (Hall, 1995, 82–86). The notion that such large-scale reorganization must have been directed by local lords, and was a manifestation of the emergence of local lordship, soon became firmly entrenched (Saunders, 1990).

The concept, and the chronology, of a 'great replanning' of the landscape in the period between the eighth and tenth centuries fit in well with the proposed 'agricultural revolution'. But, as I have argued elsewhere, the familiar 'Northamptonshire model' has a number of problems (Williamson, 2003; Williamson et al., 2013). Amongst them we might note that villages as we see them today, or as they existed by the twelfth century, are simply too large to have been created by the 'nucleation' of the scattered farms which existed in the eighth century. In spite of the intensity of fieldwork in the county, over half the townships have so far produced no evidence for these abandoned outlying sites. Where they have been found, moreover, they are usually present in only small numbers, usually between one and three; and where excavation has taken place, it does not suggest that all were occupied contemporaneously, on the eve of the nucleation 'event' (Shaw, 1994). The evidence might better be interpreted in terms of the stabilization of a mobile pattern of settlement, with at most the clustering in reasonable, but not very close, proximity of two or perhaps three farming establishments, a development which we might plausibly associate with the need to share ploughs, and to pool plough oxen, as this part of the 'revolution' gathered pace. But true villages only developed gradually, as population increased in the period between the eighth and twelfth centuries. In some cases, two or three of these initial foci, lying a few hundred metres apart, expanded and fused to form a 'polyfocal' village (*sensu* Taylor, 1977); but sometimes, growth from a single nucleus is indicated. Stages in the slow development of villages are often preserved in their plans. Some appear to have first expanded around the margins of an area of common pasture, followed by a phase of building on the pasture itself, creating rather irregular clusters of tofts and crofts around a network of winding streets linking diminutive greens, the remaining fragments of a once more extensive area of open ground. But in some cases expansion occurred, largely or entirely, across land that had already been ploughed and divided into strips, thus creating the pattern of neat, parallel tofts interpreted in the model as a sure sign of 'planning' (Figure 51; Williamson et al., 2013, 84–87).

The field systems associated with these villages must also have developed over time, through gradual expansion; a succession of historians, over many decades, have proposed models of how this might have happened. Where farms were being divided, or land allocated in the form of service-tenancies, in an equitable manner, the various portions could not easily take the form of single contiguous blocks. Those portions lying further from the settlement might embrace land of poorer quality (not least because land nearest the farms would have received larger amounts of manure over the preceding years); they would certainly take longer to reach, a critical issue at harvest or, in particular, during winter ploughing, when on heavy soils the amount of time the land was suitable for cultivation might be very limited. To


**51** Contrasting plans of 'champion' villages. Left: Grafton Underwood, Northamptonshire. Villages made up largely or entirely of parallel, 'strippy' tofts are usually considered to have been laid out in accordance with some predetermined plan. In reality, most appear to derive their distinctive form from the fact that they have expanded over arable land, already divided into plough strips. Right: Yardley Hastings, Northamptonshire. Typical irregular plan, featuring a number of small greens, evidently formed by the progressive infilling of a large central area of common land.

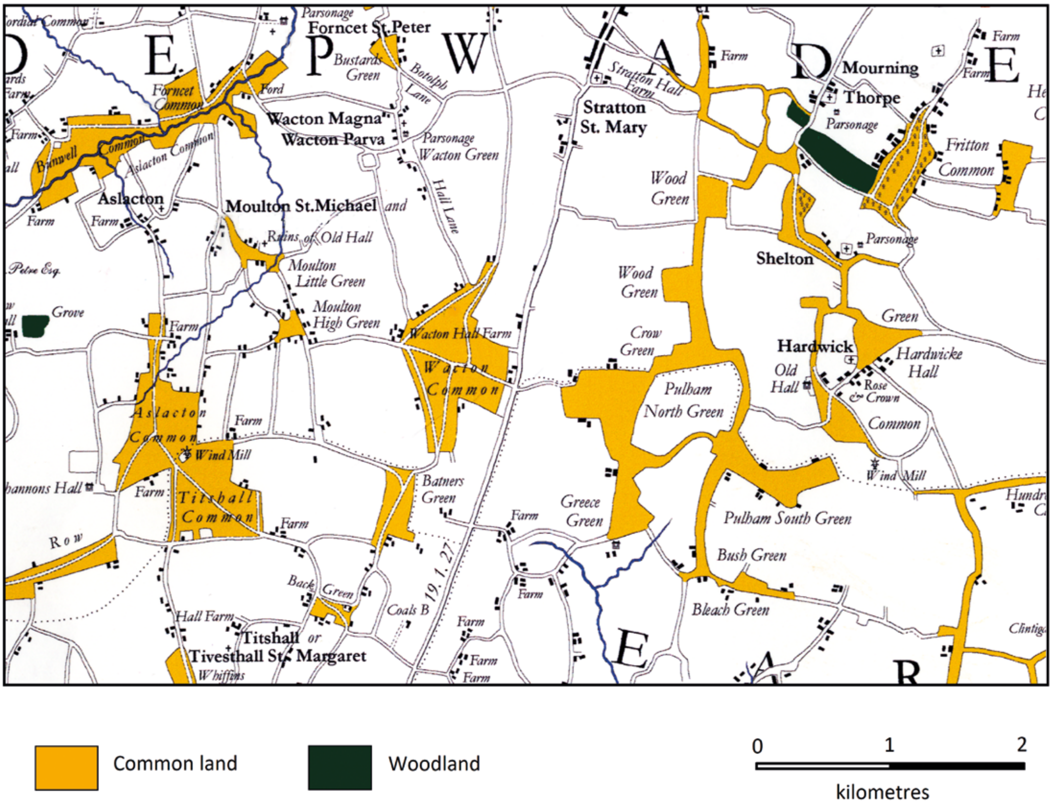
avoid these and other problems, divided land would be allocated in such a way that recipients received scattered portions. It is easy to see how this process, continued over several generations, would have led to the progressive fragmentation and intermixture of holdings in the form of parcels suitably shaped to accommodate the movement of a large plough, i.e., narrow strips. But, in addition, further intermixture of properties would have resulted from the gradual expansion of arable at the expense of pasture, as newly won land was allocated – in a fair and reasonable manner – to those who had formerly exercised common rights over the area in question, and who were involved in reclaiming it.

The subsequent stages of development in such a 'gradualist' model were first elaborated by Thirsk more than five decades ago, in a manner that in many respects remains convincing. Eventually, as fields multiplied whenever new land was taken into cultivation from the waste, and as the parcels of each cultivator became more and more scattered, regulations had to be introduced to ensure that all had access to their own land and to water, and that meadows and ploughland were protected from damage by livestock. The community was drawn together by sheer necessity to cooperate in the control of farming practices. All the fields were brought together into two or three large units. A regular crop rotation was agreed by all and it became possible to organize more efficiently the grazing of the aftermath of the harvest, and the fallows (Thirsk, 1966, 14).

In some cases, the even distribution of strips required by such a system (in which large areas lay uncultivated every second or third year) may have been achieved piecemeal, over time, through exchange or sale. But in many Midland areas it was clearly the consequence of systematic replanning, as indicated by the regular arrangements featuring recurrent sequences of yardlands running through the furlongs. That this final recasting of the fields was, in most if not all cases, a post-Conquest phenomenon, is clear from the fact that the numbers of 'virgates' described in late medieval documents are invariably larger than the number of holdings recorded in the townships in question by the Domesday Book in 1086, usually by a large margin (Williamson et al., 2013, 120–25).

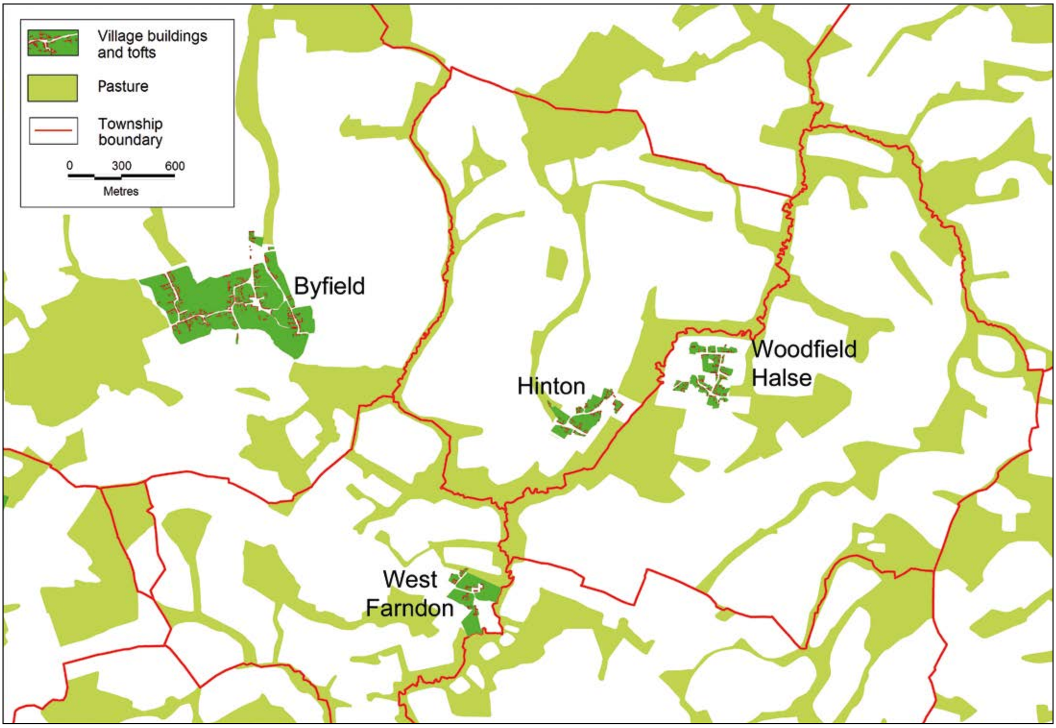
There are some problems with this 'gradualist' model for the emergence of 'champion' landscapes, but the principal alternative – that they were created in their entirety, from scratch, in the eighth or ninth centuries – raises more. It would suggest that villages and fields experienced virtually no subsequent expansion, in spite of the unequivocal archaeological and documentary evidence for very significant growth in population between the eighth and the fourteenth centuries. But a gradualist model also implies that it was only during this period of expansion that 'champion' landscapes, and the various alternatives, slowly diverged. In this context we should note again the shared 'grammar' of medieval landscapes, and the fact that in their early phases of development much settlement in champion areas, like much of that in areas of dispersed settlement, comprised loose scatters of farms around areas of common land. But whereas in the latter regions farms continued to disperse across the land surface as the population grew, often hugging the margins of the dwindling patches of 'waste', in champion districts they remained clustered, with the central areas of common land becoming filled with dwellings (compare Figures 52 and 53). Alternatively, or in addition, they expanded across land already cultivated as arable and divided into strips. Either way, settlements tended to grow *in situ*, developing in time into nucleated villages, with holdings becoming progressively intermixed as the area of cultivated land expanded around them. In other areas, by contrast, farms tended to disperse across the landscape and, while holdings became increasingly intermingled through practices such as partible inheritance and assarting, they did so to a much lesser extent.

The reasons why, in some regions, farms were able to spread fairly freely across the landscape, whereas in others they remained tied to limited areas, cannot be discussed in detail here, but appear to have been largely environmental in character, and to a significant extent associated with the adoption of a heavy mouldboard plough (see Williamson, 2013, 184–206). In the 1930s, the Orwins argued that, as larger and heavier ploughs came into use, farmers were




52 The dispersed settlements and common land around Wacton in south Norfolk (as shown on William Faden's county map of 1797, digitally redrawn by Andrew MacNair).

obliged to dwell in close proximity in order to pool draught oxen and facilitate sharing (Orwin and Orwin, 1938). The problem has always been that co-aration was practised as much in regions of dispersed settlement as in those of nucleated settlement (Homans, 1941, 81; Dodgshon, 1980, 31–33). Yet it is arguable that co-aration may have encouraged settlement clustering in some areas to a greater extent than in others. In particular, nucleated settlements farming extensive open fields were a feature of areas characterized by pre-Cretaceous clays and mudstones giving rise to pelostagnogley or non-calcareous pelosol soils, which are particularly susceptible to compaction when ploughed wet (Williamson, 2013, 196–201). These soils posed a serious problem because compacted soils not only exacerbate seasonal waterlogging but also dry to a hard, brick-like mass, reducing germination rates and militating against the emergence of seedlings. Where such soils were prominent in drier and more populous regions, such as the Midlands, they may have encouraged the clustering of farms in order to facilitate the rapid mobilization of ploughs and teams to make the best use, especially




53 Reconstruction of medieval settlement areas, and unploughed pasture, in the 'champion' of western Northamptonshire, around Byfield and Hinton (compare with Figure 52).

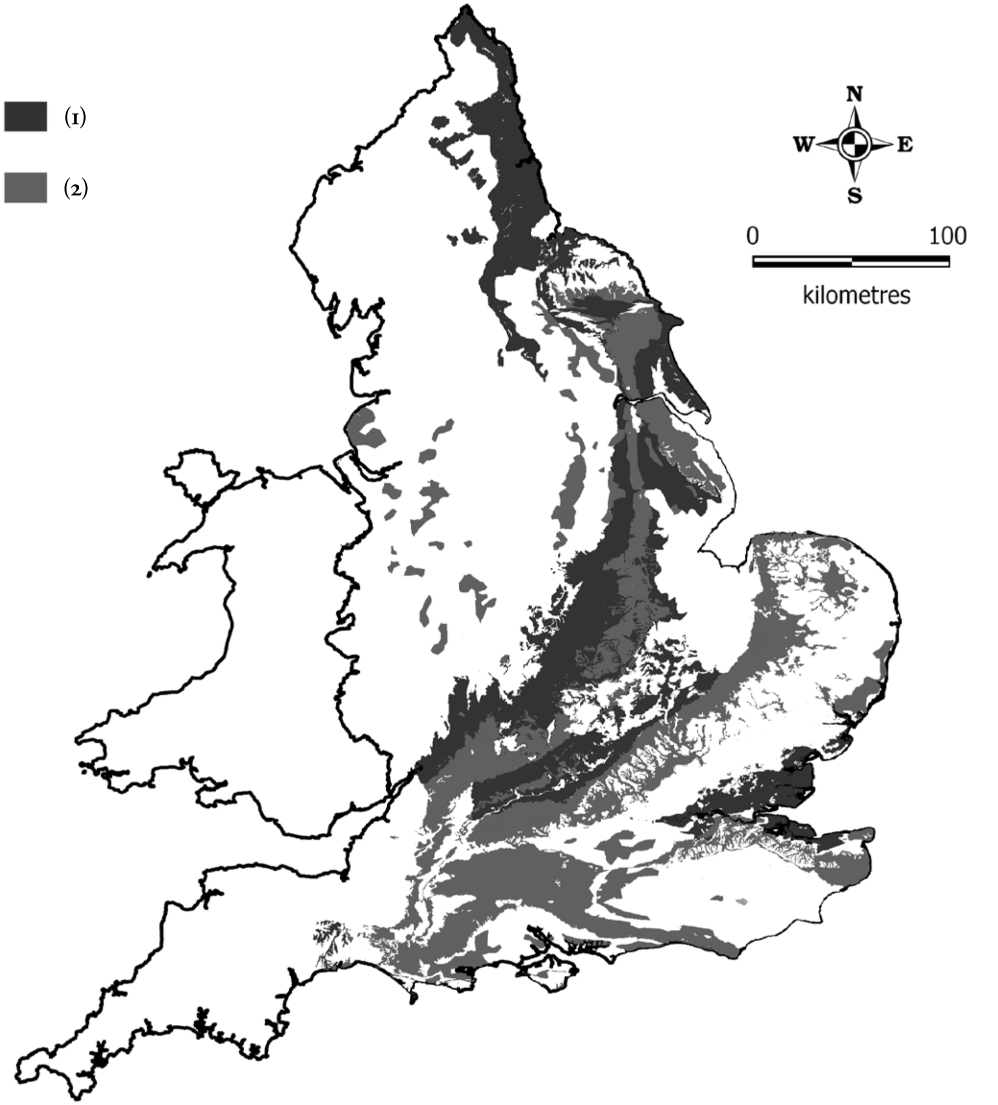
in the spring, of short windows of time during which the land could be safely cultivated. It is possible that this need also encouraged the final recasting of intermixed holdings in highly regular forms, which would ensure that, as the shared ploughs worked through the fields, the lands of all those who contributed to them had an equal likelihood of being ready for seeding at the proper time.

But 'champion' landscapes were also a particular feature of light land, especially of areas with a chalk geology, and here other environmental factors may have been important. The close-folding of sheep, so necessary on soils rapidly leached of nutrients, would have been a difficult and labour-intensive procedure if carried out on an individual basis, each cultivator moving his own sheep every day from the pastures to his own diminutive fold. In addition, as Kerridge has commented, the farmer would also have had 'all the lambing and shearing to attend to. All this would have preoccupied him to such an extent as to leave him little time for growing cereals' (Kerridge, 1992, 26). Communal organization may have encouraged proximate living. But in addition, farms also clustered near springs and other water sources, and dispersal was discouraged by the difficulties of obtaining water elsewhere. In fact, this was also a problem on some of the more impervious of pre-Cretaceous clays just discussed, which simply shed water directly into surface watercourses, rather than absorbing it deep into the ground: groundwater supplies are thus limited to the bases of narrow intercalated formations of pervious strata (Figure 54). Indeed, there is a strong correlation between the distribution of the 'champion', and that of classic 'scarp-and-vale' countryside.

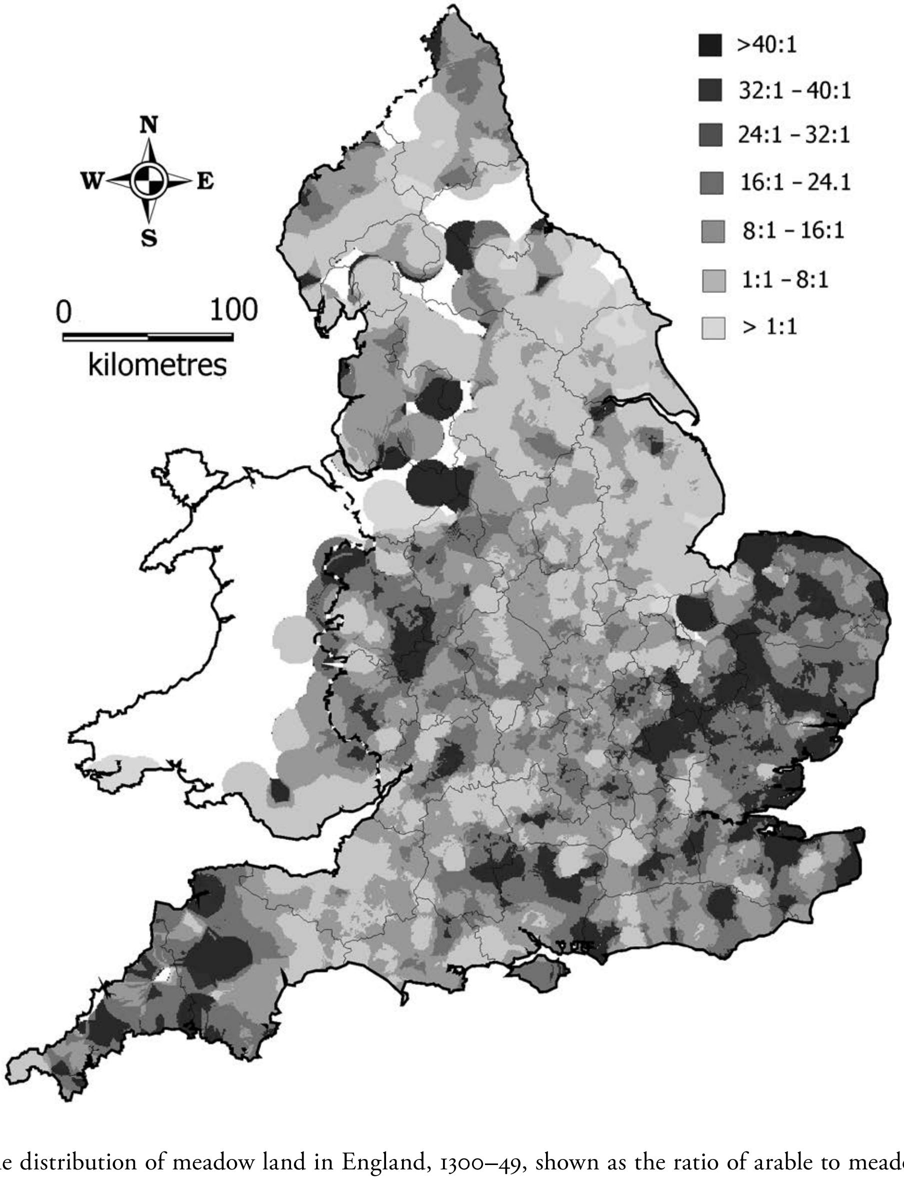
Other factors probably encouraged the clustering of farms. The adoption of a heavy plough put a particular premium on fodder supplies, required to ensure that oxen were kept in good condition through the winter, ready for spring ploughing. It is surely no coincidence that evidence from places like Yarnton in Oxfordshire indicates that floodplains were being more intensively managed, as hay meadows, from the eighth century, just as mouldboard ploughs were coming into widespread use (cf. papers in this volume by Forster and Charles, and Holmes). Good-quality meadows require alluvial soils, preferably overlying gravel, and where sluggish flows lead to the formation of valley peat they are less productive or viable. It is striking that meadow land was, by the thirteenth century, generally present in larger and more concentrated blocks across the 'champion' belt of central England than it was in the districts to either side: 'from Somerset and east Devon in the south-west to the Vale of Pickering in Yorkshire's North Riding in the north-east' (Figure 55; Campbell, 2000, 75–76). Hay needed to be cut, repeatedly turned, carted and stacked with great speed: poor weather could ruin the harvest. Where meadows were distributed in large, continuous blocks and provided the majority of winter feed, the need to maximize efficiencies in the organization of labour, and in the use of carts, may have encouraged farms to congregate in nucleations, within an easy distance. Elsewhere, the need for winter feed was supplied from more scattered or less intensively managed sources: from narrow ribbons of meadow in poorly developed floodplains, as in much of Hertfordshire and Essex; or from extensive tracts of pasture or wood-pasture, spared from the plough, which could be used to extend the grazing season, or to provide 'leafy hay'. All these alternative approaches were associated with more scattered forms of settlement, and thus with the development of landscapes featuring less intermixed holdings.

## Extensive and intensive agriculture

The argument set out over the foregoing paragraphs suggests that while there was a connection between the emergence of nucleated villages and extensive open fields on the one hand, and the adoption of the mouldboard plough on the other, it was not a necessary or automatic




54 The distribution of factors which may have encouraged the development of clustered settlement: (1) areas dominated by pelostagnogleys or non-calcareous pelosols and with less than 700 millimetres average rainfall *per annum*; (2) areas of light, freely-draining soils formed in chalk, limestone or sands where close-folding of sheep was of particular importance, and in which dependable supplies of water are limited or concentrated (compare with Figure 50).




55 The distribution of meadow land in England, 1300–49, shown as the ratio of arable to meadow acreage (after Campbell, 2000). Meadow was, in general, more abundant in the 'champion' than in areas to the south-east or west (compare with Figure 50).

one. In some circumstances the new ploughing technology led to the development of 'champion' landscapes, but in others it did not. To some extent the other key elements of the medieval 'agricultural revolution' – the adoption of regular fallows and direct manuring by livestock – are similar, in that these were likewise, by the twelfth century, found everywhere. Yet there are also differences, for (as we have seen) there is some evidence that the emphasis on direct manuring was greater in 'champion' areas than elsewhere. Where holdings lay intermingled in tiny parcels across extensive areas, not only would direct manuring, with or without complex folding arrangements, of necessity loom larger than the dung cart. So too would the communal management of flocks, and the adoption of continuous fallowing systems embracing a third or a half of the arable land of a township; not least because, as holdings became extensively intermingled in small parcels, it became impossible to hedge or fence them, and thus hard to protect cropped land from livestock grazing on adjacent parcels of fallow. It is therefore not surprising that, in regions where settlement was strongly nucleated and holdings extensively intermixed, the maintenance of fertility came to depend more heavily on direct dunging by communally managed flocks and herds, grazing extensive and continuous blocks of fallow; nor that such an emphasis was less pronounced in areas where holdings were less minutely intermingled.

This difference of emphasis may in turn have influenced the relative importance of cattle and sheep in farming systems. Sheep function well as 'mobile muck spreaders'. Their faecal pellets are deposited fairly evenly across the fields or – if close-folded – are incorporated easily into the soil through treading. Cattle, because of their size, cannot be folded, and roaming freely across the fallows, their dung is less evenly dispersed and is anyway most effective as a fertilizer when combined with straw and urine and rotted down to manure in yards. By the sixteenth century, 'champion' areas in lowland England were closely associated with sheep farming, and the various alternatives with cattle, almost regardless of soil type, something which seems to have puzzled Kerridge (1973, 19–20). The distinction is less clear, but already present, by the thirteenth century, at least in regions lying to the south and east of the 'champion'. Manorial accounts suggest that 'cattle assumed a unique prominence' in the agriculture of 'East Anglia and the Home Counties' (Campbell, 1988, 97). But any such distinction was one of emphasis, not absolute, and this applies to most aspects of agriculture, compared across 'champion' and non-champion regions.

Having said this, there were some areas of England, all lying well outside the zone of nucleation and extensive open fields, where the continued proximity of farms and holdings, combined with an absence of strong communal controls on farming, allowed the use of methods which might reasonably be described as 'intensive' in character. As Campbell has shown, by the start of the thirteenth century farmers in parts of Norfolk were producing very high cereal yields through the use of leguminous fodder crops, repeated cultivations and intensive weeding, and the manual spreading of manure from stall-fed livestock. In many parts of eastern Norfolk, year-long fallows had been largely eliminated and peasant holdings were a fraction of the size of those in champion townships; most were below six acres (Campbell, 1983). Similar agricultural systems emerged elsewhere outside the Midlands, in north-east Kent and parts of Sussex, for example (Brandon, 1972). It is noticeable that all were areas of particularly high population density by 1066, although in the case of east Norfolk at least this was in part a consequence of fertile soil and a climate well-suited to cereal cultivation.

## Lordship, landscape and agriculture

It is fashionable to interpret key developments in the history of the medieval countryside in terms of lordly intervention and planned, 'revolutionary' change. In part this is because developments in settlements and field systems spanning decades, or even centuries, can easily become chronologically compressed when distantly viewed in the rear mirror of history. But it is also because many academics buy into a wider but inherently unlikely narrative which plays down the agency of cultivators in favour of the dictates of a non-productive elite. Even in a post-medieval context such an approach is questionable. Some historians of the eighteenth-century 'revolution' still champion the role of enlightened aristocrats like Charles 'Turnip' Townshend or Thomas William Coke, but the evidence leaves no doubt that the innovations with which they are traditionally associated were pioneered many decades earlier by farmers, and usually by ones who were freeholders, rather than tenants subject to the controlling structures of a lordly estate (Wade Martins and Williamson, 1999, 194–203). In a medieval context, the overriding importance of lordly direction in agrarian affairs is even more difficult to sustain.

Leaving aside the question of whether, at the time when the various changes discussed in this chapter first got under way, local lordship of the kind present in the twelfth century even existed (Faith, 1997; 2008), the evidence that large landowners were a major influence on the organization of farms and farming is conspicuous by its absence. There is no sign that regional variations in settlement patterns and field systems were in any way correlated with those in tenurial structures and the strength of lordship. Moreover, major landowners often held properties in both 'champion' and non-champion areas, but there is no indication that any attempt was made to ensure that their fields and settlements conformed to some standardized 'blueprint': they were organized in the same way as those in neighbouring places. It is striking that the few examples of what seem to be direct evidence for the regularization of medieval field systems suggest the active involvement, at the very least, of peasant farmers. An early thirteenth-century extent of Dunstable Priory thus describes the creation of the two-field system at Segenhoe in Bedfordshire in the 1160s as the result of meetings held at the courts of the two manorial lords, overseen by six old men of the township, where 'knights, free men and others … surrendered their lands under the supervision of the old men and by the measure of the perch, to be divided as if they were newly won land, assigning to each a reasonable share' (Fox, 1981, 96). Lordship was one of the influences shaping landscape but it was not the overwhelming or dominant one and it usually operated indirectly, through the responses of farming communities to the exactions it imposed.

Much the same seems to be true of agricultural practices. Mate's study of the estates of Christchurch, Canterbury, showed, for example, that no attempt was made to impose some standardized system of cropping or rotation (Mate, 1985). Each property simply followed local practice, which is hardly surprising given that the reeve who managed the demesne and manorial affairs was here, as was generally the case, one of the local tenants. Karakacili has similarly argued that in thirteenth-century Cambridgeshire and Bedfordshire, working practices varied from manor to manor on the estates of Ramsey Abbey because reeves followed local peasant custom (Karakacili, 2004, 32–34). The critical role of lords in shaping medieval rural affairs is frequently asserted, especially for periods for which we have no good documentary evidence (cf. Faulkner, this volume). But it has never actually been demonstrated, in an English context at least.

## Conclusion

In the period between the eighth and later twelfth centuries, the farming landscapes of lowland England developed in a wide variety of ways, in large measure as a consequence of the interaction of the new ploughing technology with a diversity of environmental circumstances. In some regions, nucleated villages surrounded by extensive and complex intermixtures of holdings gradually emerged. Farmers in such areas were obliged to place a particular emphasis on direct manuring by communal herds in order to maintain fertility. But such landscapes were clearly not 'designed' to reduce labour inputs, for the wide scattering of holdings made for inefficiencies in most other aspects of crop production. In other areas, by contrast, settlement developed in more dispersed forms, and holdings were concentrated closer to farms: 'each man dwelling in the midst of his own occupying', as William Harrison put it in 1577 (Withington, 1900, 21). In such circumstances, while direct manuring and regular fallows were an important part of farming, the movement of farmyard manure to arable plots probably played a greater role than in 'champion' areas, and there are some signs that cattle were accordingly of more significance in the peasant economy. In a few such districts, population pressure, possibly as early as the mid-eleventh century, saw the development, or perhaps elaboration, of truly 'intensive' agricultural systems, in which high yields per unit area were achieved through high inputs of labour, and year-long fallows were effectively eliminated. Such contrasting responses to population growth and expanding markets were not, of course, confined to England. 'Champion' landscapes have their familiar counterparts throughout Europe, but areas of dispersed settlement, some with dense populations practising 'intensive' forms of agriculture, also existed by the twelfth century, such as the 'kouters in bocage' and 'velden' systems in Flanders, defined and discussed by Thoen (2018; cf. Schroeder, this volume).

It is freely admitted that the model briefly outlined in this chapter probably oversimplifies what were, in reality, more complex chains of causality and influence, more subtle interactions of ecology and society. Given the paucity of detailed documentary evidence, the kinds of essentially scientific approaches so ably outlined by others in this volume provide the best way of uncovering what these interactions may have been. But we might make more progress if we abandon assumptions about how different practices necessarily formed parts of single revolutionary 'packages', and if we treat with more scepticism the idea of 'revolutionary' transformations in medieval agriculture directed by a lordly elite.

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