IRON AGE AND ROMAN ARABLE PRACTICE IN THE EAST OF ENGLAND

Volume 1

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Kate Parks (BA, MSc)

School of Archaeology and Ancient History,

University of Leicester

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Abstract

Arable Practice in the Iron Age and Roman East of England.

Kate Parks.

This thesis provides an interpretation of Iron Age and Roman arable practice in the East of England, using data on carbonised plant macrofossils recovered during excavation as its primary data. Choice of crop, strategies employed in cultivation, and the ways in which crops were processed, stored and utilised are explored and linked to wider social and economic changes over time.

Spelt and barley are confirmed as the major crops of the region/period, with localised emmer cultivation well attested in the Middle Iron Age; bread wheat cultivation was rare. Investment of sufficient labour/resources to maintain reasonable crop-yields is revealed as the normal attitude to cultivation throughout the region and period. Small-scale handling of crops was the norm until the Middle Roman period, when increased scale of production, along with malting, use of chaff as fuel, and concern with efficiency of crop-storage/transport suggest a switch from subsistence production to participation in a more market-oriented economy.

Middle Iron Age emmer cultivation (alongside spelt) and investment in large-scale production indicate surplus production on the Isle of Ely, suggested to have been enabled by inter-settlement co-operation or exchange of labour for grain by settlements pursuing other economic strategies. Middle Iron Age hillforts are suggested to have had a role similar to that of the classic Wessex examples. Roman small towns are suggested to have been partly self-sufficient, but households are also thought to have imported some (semi-processed) grain. By contrast, clean grain was supplied in bulk to Early Roman Colchester through large-scale local cultivation. The Middle Roman surge in production is suggested to have met the demands (rent, taxation) of new systems of land ownership, but also to have contributed to supplying townspeople and/or the army in the region and beyond.

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1. Introduction and Research Context

1.1. Introduction

In this thesis I investigate arable practice in the Iron Age and Roman East of England, considering the cereal crops grown, the strategies employed in their cultivation, and the ways in which harvested crops were processed, stored and utilised. I achieve this through analysis of existing (published and unpublished) data on carbonised plant macrofossils recovered during archaeological excavations of appropriate period and location.

This introductory chapter is divided into four sections. Firstly I set out the background and objectives of this research (Section 1.2). This is followed by a physical description of the study region (Section 1.3), and then by reviews of current understanding of the Iron Age and Roman East of England (Section 1.4), of Iron Age and Roman arable practice (Section 1.5), and of the archaeobotanical methods available for investigation of arable practice (Section 1.6).

1.2. Background, objectives and structure of this research

1.2.1. Why study Iron Age and Roman arable practice?

Agricultural production was probably the occupation of the majority of the population throughout the Iron Age and Roman period (e.g. M. Jones 1996; Dark and Dark 1997: 93; Fulford 2004). Because of its centrality to everyday practice and subsistence needs, it was also the economic base of British societies in these periods and a major factor in their social and political organisation. The wider social changes attested in the archaeological record must therefore have affected, and been affected by, changes in agricultural practice.

Much of the current understanding of British Iron Age and Roman arable practice is based on studies in central southern Britain, supplemented by information from the north-east of England. These studies reveal variation in arable practice both between and within these regions (Sections 1.5.4.2-1.5.4.3). Across most of the rest of Britain, (varying amounts of) archaeobotanical information exists mainly as individual site reports with little attempt at broader syntheses (Van der Veen *et al*. 2007). The notable exceptions are the English Heritage Regional syntheses, but these are neither complete nor available for all regions.

The need for regional synthesis is recognised (Van der Veen *et al*. 2007; Medlycott 2011). Its lack is part of a wider tendency in British archaeology, exacerbated by site-specific funding, for site narratives and archives to be viewed as ends in themselves, resulting in the amassing of large quantities of data without regional interpretation or the development of clear conceptual frameworks (cf. Pitts and Perring 2006; Taylor 2007: 1).

1.2.2. The scale of the research project and the selection of a study region

The amount of archaeobotanical data available precludes a Britain-wide investigation of Iron Age and Roman arable practice in a research project of this scale, necessitating the selection of a study region. The anachronism of using modern geographical constructs to define an area for archaeological study is acknowledged. However, as the territorial boundaries of the Iron Age and Roman period are not clearly known (Section 1.4.4), it is considered appropriate to select a broad, if arbitrary, region with the aim of identifying variation which may contribute to their clarification. The use of county boundaries to define the study region has facilitated the identification of relevant data, and will be advantageous if the opportunity arises to link this study with future studies of neighbouring regions.

The selected region is the East of England (Fig. 1.1), comprising the counties of Norfolk, Suffolk, Essex, Cambridgeshire, Bedfordshire and Hertfordshire, and covering an area of 7380 square miles (DEFRA 2000). Recent debate has confirmed this region as central to the understanding of social/political developments in the Later Iron Age (Section 1.4.6.2-1.4.6.4), and it has long been known as one of the most heavily influenced by Roman presence (Section 1.4.7). Furthermore, social/political variation within the region is attested both chronologically (not least that associated with the Roman Conquest) and geographically.

Good availability of archaeobotanical data in this region has been identified (Glazebrook 1997; Brown and Glazebrook 2000; Murphy and de Moulins 2002; Van der Veen *et al*. 2007; Medlycott 2011), and the need for its synthesis and the characterisation of crop-related behaviour has been noted (Murphy in Going 2000; Medlycott 2011).

1.2.3. Research objectives

The aims of this research are to increase understanding of Iron Age and Roman arable practice in the East of England, and to explore the implications of that practice for consideration of the region's wider social, economic and political development.

The first stage in achievement of this aim is the compilation of a database of all available information on carbonised plant macrofossils of appropriate date and source.

The second goal is analysis and interpretation of the gathered data to shed light on Iron Age and Roman arable practice. This is divided into three principal objectives: (1) identification of the crops which were cultivated; (2) characterisation of crop-processing, -storage and -utilisation, including assessment of the scale on which these activities were carried out; and (3) identification of *how* crops were cultivated, considering the strategies employed and the amount of effort and resources invested, as well as determining whether crops were grown separately or as mixtures (maslins). Each of these objectives is pursued through analysis of the archaeobotanical data and interpretation in the context of the current understanding of the study region and period, as set out below (Sections 1.3-1.5). To this end, variation is sought in each aspect of arable practice between samples of different dates, from different locations (separated by physical or cultural/political attributes) or from sites of different natures.

Finally, it is intended that consideration of arable practice in the context of the region's wider archaeological record will allow insight into aspects of social, political and/or economic developments in the Iron Age and Roman East of England.

1.3. Physical description of the study region

1.3.1. Preface

Variation within the Iron Age and Roman archaeobotanical assemblages of the East of England may result from differences in physical or meteorological characteristics rather than from social/cultural/political/economic disparities among its inhabitants. It is therefore necessary to give a brief description of the region and its climate.

1.3.2. Relief, drainage and drift geology

The East of England is low-lying, mainly below 60m OD (DEFRA 2000; Countryside Agency 1999). Its highest elevation (275m OD) is on the plateau-like dip-slope of the Chilterns in the south-west, and the lowest in the fenland which lies at/below sea level, excepting islands of gravel-capped clay (up to 20m OD). The eastern clay-till plain is flat in the north but undulating in the south, reaching a maximum elevation of 130m OD in central Suffolk. The region drains via the Great Ouse and Nene into the Wash, via the Lee into the Thames estuary, and via a series of east-flowing rivers (including the Yare, Bure, Alde, Ore, Deben, Orwell, Stour, Colne and Blackwater) into the North Sea.

Glacial clay-till overlies Cretaceous chalk across much of the region, with alluvial sand and gravels along river valleys (Figs. 1.2 and 1.3). The London Clay is exposed in the south-east, with silt, sand and gravel deposits along the coast. A broad band of Cretaceous chalk is exposed, flanked by Greensand and Gault, running from the south-west to the north of the region. Areas of Oxford clay and limestone are exposed in the west, and small areas of Crag in the north-east.

The fen basin occupies the north-west of the region. Its Flandrian deposits and palaeogeography are discussed by Waller (1994) and Hall and Coles (1994: 13-24), and are summarised by Wiltshire and Murphy (1999). Successive layers of organic peat/ inorganic clay and silt in the southern fens represent a succession of freshwater and marine conditions. The silt beds of the northern fens were deposited under marine conditions prior to marine regression in the early centuries AD. The fen-margins (and coastline) are known to have fluctuated during the study period, with expansion to the south and east (but drier conditions in the southern fens) toward the end of the first millennium BC.

In considering spatial variation in crop-related behaviour, I divide the study region into eight zones (Fig. 1.4) guided by geology, relief and drainage and broadly based on Natural England's National Character Areas (Countryside Agency 1999).

1.3.3. Climate

The modern climate of the East of England is much influenced by its low relief (Shirlaw 1966; DEFRA 2000; Met Office 2000) and easterly location (DEFRA 2000). Mean summer temperature is *c*. 15-18^{o}C; mean winter temperature is *c*. 4-4.5^{o}C (Met Office

2000). Annual rainfall averages 606mm, among the lowest in Britain (Met Office 2000). There is little variation between summer and winter rainfall, but variation with relief is discernable, with less than 600mm/year in the fens and Essex, and over 1000mm/year in the Chilterns (DEFRA 2000).

There are several schemes (reviewed by Essenwanger 2001) for the classification of modern European agro-climatic zones (considering humidity and frost-free periods as well as rainfall and temperature), but few detailed enough to distinguish variation within the British Isles. In specifically British considerations, summers in the study region are characterised as hot and dry (Shirlaw 1966: 20; DEFRA 2000). Winters are agreed to be dry, but have been described as both the coldest in Britain (Shirlaw 1966: 20), and mild (DEFRA 2000, consistent with Met Office data)[1].

Britain's climate in the second millennium BC was warmer than today's, but between 1000 and 750 BC the overall mean temperature fell by slightly less than 2^{0}C (Lamb 1981), accompanied by an increase in rainfall (Turner 1981; Bell 1996), probably linked prevailing westerly winds (Lamb 1981; Turner 1981). A widespread wet/cold period *c*. 800-4/300BC has been confirmed by more recent research, and explained as a result of reduced solar activity at this time (e.g. Plunkett and Swindles 2008). The climate then became gradually drier and warmer, though with further fluctuations, reaching conditions similar to today's by the first century AD and continuing to improve until the fourth (Lamb 1981; Turner 1981; Dark and Dark 1997: 18-21; Meyer and Crumley 2011).

Lamb (1981) states that Early Iron Age climatic downturn would have reduced the growing season by more than five weeks; Shirlaw's (1966: 22) formula suggests a

[1]Met office data are based on average figures for the period 1971-2000, post-dating Shirlaw's (1966) publication.

reduction of three weeks. The effects of climatic change would have been different in different parts of Britain (cf. Moore and Armada 2011). Murphy (1984) suggests that increased rainfall may have allowed agricultural expansion in (extremely dry) Breckland.

1.4. Archaeological context: the Iron Age and Roman East of England

1.4.1. Preface

In this section I set this project in context by reviewing current understanding of Iron Age and Roman archaeology in the East of England. Beginning with an overview of the theoretical approaches taken in these disciplines (Section 1.4.2), I move on to look at the chronological and territorial subdivisions of the study region (Sections 1.4.3-1.4.4) and the development of different types of settlement within it (Section 1.4.5). I then explore different models of Iron Age society and the transition to Roman rule (Sections 1.4.6-1.4.7). Finally, I consider evidence for population increase in the light of its probable relationship to increasing demand for arable produce (Section 1.4.8).

1.4.2. Current theoretical approaches in British Iron Age and Roman archaeology

Since the 1990s, British Iron Age studies have been influenced by anthropological models (e.g. Collis 2011) and largely post-processual in approach (e.g. Hill 1995). They frequently emphasise the lack of distinction between the ritual and mundane, and the structuring of everyday activities by belief and identity. Where this approach is taken, ‘common sense’, functionalist and geographically/environmentally determined interpretations are rejected or relegated to secondary significance. However, some papers (e.g. Pope 2007) argue that functionality and symbolism need not be mutually exclusive, and interaction of people and environment underlies the ‘historical ecology’ approach taken in some studies of the European Iron Age (e.g. Meyer and Crumley

2011). Themes of interest have included identity, regionality, processes of change, and the ways in which people lived within landscapes, settlements and buildings (cf. Haselgrove *et al*. 2001). An alternative (culture historical) approach, much influenced by linguistic models and documentary sources, and concerning itself more with political and economic aspects of Iron Age ('Celtic') society, is evident in some continental studies (e.g. Karl 2008; 2011) and still dominates the standard work on the British Iron Age (Cunliffe 2005).

Identity has become a key theme in Romano-British studies following review (Millett 1990) and subsequent abandonment of 'Romanisation' as a model for understanding social and cultural change (e.g. Taylor 2001a; Creighton 2006: 10; Mattingly 2006: 14). A review of national research priorities undertaken over a decade ago (James and Millettt 2001) emphasises the multiplicity of identities in Roman Britain and advocates interpretation of material evidence in terms of how it structured, and was structured by, the identities of its creators (also Creighton 2006: 76-78). Urban, rural and military communities are generally considered separately (e.g. James and Millett 2001; Mattingly 2006), but the emphasis is on understanding variation within, and links between, them.

1.4.3. Iron Age and Roman chronology

The chronological subdivision of British later prehistory is not straightforward (e.g. Moore and Armada 2011): there is a large degree of regional variation, and the ceramics on which many dates are based are not intrinsically datable but rely on systematic correlation to context and artefact associations, supported where possible by absolute dates (Willis 2002).

The British Early/Earlier Iron Age is agreed to cover the period 800-400/300 BC, with the Earliest Iron Age (800-600 BC) sometimes considered separately as part of the Late Bronze Age to Early Iron Age transition. Persistence of coarse ware pottery types may have resulted in a bias against the identification of Early Iron Age sites in the study region (e.g. Bryant 1995; Dawson 2000; Knight 2002; Brudenell 2011).

There are two current chronological models for the period 400/300 BC-AD 43. One (e.g. Cunliffe 2005) divides it into Middle (400/300-100 BC) and Late (100 BC-AD 43) sub-periods, consistent with the evidence from central southern Britain and the south-east, including the southern part of the study region (modern Hertfordshire, Essex and southern Suffolk, Cambridgeshire and Bedfordshire). The other (e.g. Haselgrove and Pope 2007; Haselgrove and Moore 2007) recognises that the Late Iron Age is distinctive only in those regions, and consequently recognises a continuous Later Iron Age (400/300 BC-AD 43). This allows discussion of specific developments within their own timeframes.

For the purposes of this research, a three-fold division into Early (800-400/300 BC), Middle (400/300-100 BC) and Late (100 BC – AD 43) Iron Age (EIA, MIA and LIA) is considered appropriate. This recognises the distinction of Middle and Late Iron Age apparent in the south of the study region, and allows the potential for recognition of such a distinction in the archaeobotanical record of the north.

The transition from Late Iron Age to Early Roman should not be viewed as a clear-cut change occurring in AD 43, but as a gradual process (e.g. Davies 1996; Creighton 2000; 2001; 2006; Burnham *et al*. 2001; Pitts and Perring 2006; Medlycott 2011). Change within the period of Roman rule was likewise gradual. Although the Early, Middle and Late Roman periods are often referred to, their dates are not consistently defined. For the purposes of this research, a practical subdivision of the Roman period in Britain is into Early (later first century AD), Middle (second and third century AD) and Late (fourth century AD) periods (ER, MR and LR; after Van der Veen *et al*. 2007; 2008).

1.4.4. Social/political subdivisions

1.4.4.1. Nature of Iron Age identities and social units

Recent considerations of Iron Age identities suggest that they were complex and changeable, based on perceptions of kinship, gender and status (e.g. Moore 2011). Individuals are considered to have lived within fluid and fragmented groups, forming many interacting networks, with no coherent social model for the whole of Britain.

However, models in which people are seen as members of tribes (groups perhaps subject to a chieftain, occupying bounded territories and producing a distinct material culture) remain evident in several works (e.g. Cunliffe 2005). The idea of groups linked to specific territories has proved particularly resilient, though the nature of those groups is frequently undefined (Moore 2011). The persistence of this model in considerations of the study region is demonstrated in the recently published *The Iron Age of Northern East Anglia: New Work in the Land of the Iceni* (Davies 2011). In its opening paragraph, this volume states that "*The Iceni were a people who lived in the east of England during the Iron Age and into the Roman period"*, that they were "*... one of several groups mentioned by classical writers"*, and that "*their territory occupied a substantial part of northern East Anglia…* [though] *precise tribal boundaries are unclear and… almost certainly shifted over time*". Fig. 1.5 shows the tribes (Iceni, Trinovantes, Catuvellauni and Corieltauvi) usually identified as occupying the study region (after Cunliffe 2005; fig. 8.1).

Although the tribes of this model are usually named only in the LIA, similar territorial subdivisions are sometimes suggested (based on material culture) to have existed throughout (e.g. Hawkes 1959), and even before (suggestions cited by Martin 1999), the Iron Age. The recent volume mentioned above (Davies 2011) includes considerations of the region from the Late Bronze Age onwards, apparently equating the *Iceni* with the whole of the region's Iron Age. Others postulate MIA origins, resulting from population expansion and movement (e.g. Davies 1996; Hill 1999; 2007; see Section 1.4.8.2).

In keeping with more recent concepts of Iron Age identity, a third school suggests that 'tribes' were short-lived results of Roman influence and indigenous response, causing the coalescence of new political entities after the mid-first century BC (e.g. Creighton 2000; Moore 2011). Pitts and Perring (2006) go so far as to suggest a Trinovantes Client Kingdom in this period. They also describe the area north of this as the 'Icenian polity', suggesting political and cultural cohesion, and cite Evans' (2003a) suggestions that individual settlements on the boundary between the two were affiliated with one or the other.

1.4.4.2. Roman territorial divisions and land ownership

The territories often ascribed to LIA tribes more accurately reflect the Roman *civitates* constituted around the region's major towns: *Colonia Vitricensis* (Colchester) in Trinovante territory, *Verulamium* (St Albans) in the lands of the Catuvellauni, *Venta Icenorum* (Caistor St Edmund) in the Iceni area and possibly *Durobrivae* (Water Newton; Medlycott 2011) in Corieltauvi territory (Fig. 1.5). 'Iceni territory' was maintained until AD 60/1 as a client kingdom, and parts of it may have remained under long term state control following its absorption (Section 1.4.6.2). An ER Catuvellauni Client Kingdom has also been suggested (Mattingly 2006: 137, 270, 278).

With the exception of Client Kingdoms, British land belonged to Rome after the Conquest and would have been quantified, surveyed, assigned legal ownership and subjected to demands for taxation or tribute (Mattingly 2006: 361-2). The transfer from military to civilian administration (which would have occurred early in the study region) meant the attachment of land, directly or indirectly through taxation, to Britain's major towns. Transfer of additional land to direct control of *Colonia Vitricensis* may have contributed to Trinovantian participation in the Boudican revolt (Mattingly 2006: 354). Sale of land into private ownership meant acquisition by veterans and other 'outsiders' – from the Continent and from other parts of Britain. This affected occupancy to a lesser extent than ownership: native farmers may have been put off their land, but are more likely to have found that they had become tenants of (often absentee) landlords and subjects to new legal and financial rules (Mattingly 2006: 354-5, 362).

Following LR sub-division of the British province, the study region was probably divided between *Flavia Caesariensis* (north) and *Maxima Caesariensis* (south), though the extents of both are uncertain (Mattingly 2006: 228-229).

1.4.5. Settlements

1.4.5.1. Overview of Iron Age settlement-types

Throughout the Iron Age, most settlements were agricultural. Open settlements, usually large agglomerations (probably representing settlements which shifted over time, rather than very large contemporaneous spreads; cf. Woodward and Hughes 2007), are known throughout the study region, except in the eastern/central fens (e.g. Davies 1996; Hill 1999; 2007). These remained the norm in the north of the region throughout the Iron

Age, but in the south complex (incorporating several subdivisions of the landscape) and discrete, enclosed settlements dominate in the MIA and LIA. Discrete, enclosed settlements are rare in the north and are seen only in the MIA in the west of the study region (e.g. Bryant 1995; 1997; Davies 1996; Hill 1999; Dawson 2000; Taylor 2007: fig. 4.2, 49).

1.4.5.2: 'Hillforts'

In the extreme south-west of the study region (northern Chilterns), there are hillforts similar to the classic examples of central southern Britain, though lack of excavation makes their dating and function unclear. Across the rest of the study region, classic hillforts are absent, though sites with some physical similarities do exist in Cambridgeshire (known as ringworks), Essex and Norfolk (often referred to as 'hillforts'). In Essex and Cambridgeshire, some of these sites were occupied in the MIA and/or LIA (and beyond) but others, like the MIA 'hillforts' of Norfolk appear to have been unoccupied; their functions remain unclear (Davies 1996; Sealey 1996; Hall and Coles 1994; Evans and Knight 2002; French 2004).

1.4.5.3. New Late Iron Age settlement-types

In the south of the study region, the LIA saw the enclosure of large areas of settlement, the emergence of dense areas of enclosed and small, open settlement elements, and the development of dense, nucleated settlements (Hill 2007). The most extreme examples of these new settlement types (at Colchester, St Albans, Baldock, Braughing, Welwyn and in the Bulbourne Valley) have evidence of high status and/or distinctive funerary/ritual/trading/industrial activity; minting is attested at Colchester, St. Albans and Braughing. These sites have been discussed as potential *oppida* (e.g. Hawkes and Crummy 1995; Bryant and Niblett 1997; 2001; Bryant 2007). Pitts and Perring (2006) describe both *Camulodunum* and the nucleated settlement at Heybridge as urban foundations of the pre-conquest period, and suggest that they (and others like them) were occupied largely by immigrant communities.

LIA settlement nucleation is also represented by systems of linear settlement enclosure in the west of the region and a degree of nucleation in agglomerated settlements in the north-east and west (Taylor 2007: 50; Dawson 2000).

1.4.5.4. Overview of Roman rural settlements

Roman rural settlement in the East of England was dominated by dispersed rural settlements, usually set within single or (especially in the northern and fenland areas) multiple enclosures (Taylor 2007: 49-50). Roundhouses were scarce, while rectilinear buildings (including villas except in the fenland) were the norm (Taylor 2007: figs 4.7-4.9). Some LIA nucleated settlements developed as small towns (Burnham and Wacher 1990: 282; Burleigh 1995), while others continued as nucleated rural settlements (Taylor 2007: 28, 50).

New, non-settlement sites in the Roman period include temples/shrines and rural industrial complexes.

1.4.5.5. The development and nature of towns

As well as developing from LIA nucleated settlements, small towns developed from *vici* associated with early forts (e.g. Burnham and Wacher 1990: 81; Wacher 1995: 208), independently on the sites of the forts themselves (Plouviez 1995), and in other roadside locations. There are more than forty potential small towns in the study region (cf. Drury and Rodwell 1980; Burnham and Wacher 1990; Plouviez 1995; Gurney 1995; Going 1996; 1997) in addition to the three/four major administrative towns (Section 1.4.4.2).

Burnham and Wacher (1990: 44-45) suggest small towns were agriculturally self-sufficient, at least some of their inhabitants being engaged in cultivation either of small plots within the towns, or (possibly as hired labour, rather than land-owners) in fields outside them. However, they admit that evidence of these practices is lacking. Conversely, Taylor (2007: 117-118) notes that Roman small towns are known primarily from the parts of Britain which also attest diverse patterns of rural settlement. He suggests that this reflects the dependence of towns on rural development to produce a large enough arable surplus to feed them (assuming insufficiency of any in-town/out-field cultivation to meet subsistence needs), and on the integration of rural settlements into the wider market economy to allow the distribution of that surplus.

Roman towns, and their LIA precursors, must be understood in the context of their relations with surrounding rural settlements (e.g. Millettt 2001; Burnham *et al*. 2001; Taylor 2001). However, Pitts and Perring (2006) emphasise that towns cannot be understood as market places as seen in later periods, and that the supply/demand relationships between towns and the rural land which surrounded them are not yet understood.

In the study region, expansion of towns (large and small) seems to have ended in the mid second century AD, at which time earthwork ramparts were constructed around several of them (Going and Plouviez 2000). This change is accompanied by apparent impoverishment, though punctuated with evidence for concentrated wealth (Taylor 1999). More generally, across Britain, the fourth century AD saw changes in the use of Roman towns, including increasing agricultural activity within them and abandonment/changed use of buildings/areas. Late Roman towns must be interpreted as functioning settlements in their own right (e.g. Esmonde Cleary 2004; Mattingly 2006: 326-331), not as degenerate versions of their Middle Roman predecessors or precursors to fifth century abandonment (cf. Going 1997; Going and Plouviez 2000).

1.4.6. Hierarchy and prestige in Iron Age societies

1.4.6.1 Early-Middle Iron Age social/political models

Economically based models of political power and social organisation in Iron Age (central southern) Britain have focused on hillforts as centres for the gathering and redistribution of agricultural produce and other goods (e.g. Gent 1983; M. Jones 1984a; Cunliffe 1995: 98-103; 2005: 590-591). These have been criticised for their separation of economic from social/ritual aspects exchange (Sharples 2010: 106), but also for their assumptions of social hierarchy and the existence of permanent elites (Hill 2006).

Sharples (2010: 106-172) sets out a model for Wessex whereby social relationships were forged and regenerated by competitive exchange of labour and resources in the construction of EIA settlement-boundaries. He argues that in the MIA this system developed, to maintain bonds between occupants of hillforts and dependent settlements through symbolic re-construction of hillfort ramparts in seasonal community-efforts (provisioned by the dependent settlements), creating monuments to coherent group identity. By the end of this period, this consumption of labour became insufficient for the reiteration of shared identity, and gifts of material goods were instead exchanged between hillfort-dwellers and occupants of surrounding settlements.

This model is not (directly) relevant to the largely hillfort-free study area. Hill (2006) suggests an alternate exchange- and competition-based model of a non-hierarchical Iron Age society in which short-lived elevated social status was gained through the acceptance of obligation. By increasing labour input a household could produce an arable surplus, which could be used (e.g. through the provision of feasts) to enhance its social standing, without incurring obligations. However, the life-cycle of the household and lack of long term agricultural strategies meant that this enhancement was also short-lived.

Van der Veen and Jones (2006) build on this model, suggesting that some MIA groups became able to sustain their role as feast-providers (presumably by controlling surpluses produced by others or by changing their cultivation strategy), thus maintaining their elevated social position, resulting in an increasingly hierarchical society. It is suggested that, in Wessex, these feast-givers moved into the developed hillforts. Ralph (2007) identifies 76 Iron Age feasting sites, potentially relevant to this model, within the study region (excluding Bedfordshire), though her identification-criteria may not exclude other interpretations.

1.4.6.2. New identities and new elites in the south of the study region

The LIA saw the rise of a distinct regional identity, emphasising individual wealth/power/prestige/status, in the south of the study region. This is evidenced by the adoption of coinage and development of inscribed coins, new settlement forms (Section 1.4.5.3), new and imported items of personal ornamentation, new cremation rites, and import and manufacture of new pottery forms associated with new ways of eating and drinking (Hill 2007; Cool 2006: 155-168). Strabo (Geography 4.5.3) mentions British import of Roman luxury items. There are three current models, reflecting wider debate over the nature of identity in the LIA (Section 1.4.4.1), explaining the rise of new elites embodying this new identity.

Hill (2007) suggests roots in the second century BC, in population movement and expansion of settlement which ended a period of isolation between the nascent Trinovantes and Iceni populations (cf. Martin 1999), coupled with arrival of continental migrants and/or influences. He does not give detail of how these meetings of people/ideas gave rise to the new behaviours attested. In Wessex, Sharples (2010: 170-172) also suggests indigenous origins for new LIA behaviours, with the exchange of objects becoming divorced from reinforcement of social ties and a barter economy developing.

Others see post-Caesarean Roman/Continental influence on and support for Trinovantes/Catuvellauni rulers as the major influence in the rise of the new identity. As well as ideas brought to the area by elites returning from time spent in Rome (Creighton 2000: 82-89; 2001), this model recognises manoeuvring by members of indigenous society to take on/create those aspects of Roman social behaviour which could increase their own power-bases (Moore 2011). Pitts and Perring (2006) suggest a Trinovantes Client Kingdom as the end product of this process.

Van der Veen and Jones (2006) note the LIA abandonment of hillforts (feast-locations) in central southern Britain and concurrent disappearance of storage pits[2]. In a model reminiscent of Haselgrove's (1982) core-periphery theory, they extend their MIA social model to suggest that feast-provision ceased in the LIA, with arable surpluses instead being exported[3] in exchange for prestige-giving luxury items. Campbell (2008) notes that disappearance of grain storage pits need not imply decreased grain storage: greater political stability may have encouraged above-ground storage.

Pitts (2005) suggests that feasting (particularly communal drinking) *was* important in LIA society in the south-east of the study region (based on associations between new types of drinking-vessels/table-wares and indigenous settlements). His analyses suggest that the imported goods seen in the LIA of this region were not intrinsically prestige-giving, but that they could enhance social-standing when used in existing practices of

[2] A phenomenon noted in the study region (Medlycott 2011).
[3] As recorded by Strabo (Geography: 4.5.2).

prestige generation (i.e. feasting and communal drinking; Section 1.4.6.2). This does not necessarily preclude a decline in the practice of feasting from the MIA to LIA.

Ralph (2007: 111, 132-136) identifies more feasting sites in the LIA than in the MIA, and suggests that competitive feasting was a driver of LIA social/political/economic change.

1.4.6.3. Changes in the north of the study region

Social change has also been suggested in the north of the study region from the mid-first century BC (Davies 1996; 1999; Hutcheson 2007; Hill 2007). This change is less pronounced than in the south and is differently attested, lacking the imported goods, inscribed coins and new pottery styles which indicate Roman/Continental influence in the south (Hill 2007). Davies (1996; 1999) suggests continuing regionalism within 'Iceni' territory throughout the Iron Age and beyond.

1.4.6.4. Identity and land rights

Hill (1999; 2007) suggests that the later Iron Age dominance of enclosed settlement in south and open agglomerations in the north of the study region (Section 1.4.5.1) reflect different control of land rights. Noting increasing concern with personal prestige in the south, and inferring links between personal identity and specific land parcels from the adoption of cremation burial-rites, he suggests land rights held by households or lineages, contrasting with communal authority in the north. Sharples (2010: 94) suggests that such household ownership did not exist in the first millennium BC.

1.4.7. The transition to Roman rule

Two of the models (Section 1.4.6.2) explaining LIA developments in the south of the study region also account for the beginnings of the social and political changes which began the transition to Roman rule. This transition is suggested by some to have been largely achieved through development and reinforcement of the changes to social identity initiated in the post-Caesarean era. For example, the structuring of space in *Verulamium* and *Venta Iceninorum* (and elsewhere) is suggested to have been designed to reinforce the authority of emergent elites through conspicuous visual reference to their authority in a mythic past (Creighton 2006: 123-156; Moore 2011).

However, even this continuity from the latest part of the Iron Age must be seen in the context of the massive changes inevitably caused by conquest, influx of military (and civilian) population, the demands of new towns, the imposition new systems of landholding and taxation, and integration with a market economy (Taylor 2001a; 2007: 118; Mattingly 2006: 358).

The, already Rome-influenced, south-east of the study region appears to have been brought under more direct state control after AD 43, with the absorption of Pitts and Perring's (2006) putative Trinovantes Client Kingdom (Section 1.4.4.2) and founding of *Colonia Vitricensis* (rather than a *civitas*-capital, as in other regions; Mattingly 2006: 269). By contrast, the Claudian invasion saw the founding of the Iceni (AD 43-60/1) and posited Catuvellauni (Mattingly 2006: 137, 270, 278) client kingdoms.

1.4.8. Population increases and demand for agricultural produce

1.4.8.1. Population size

The size of the Iron Age and Roman populations of the study region is not known. Estimates for the whole of Britain include two million for the end of the Iron Age and four-five million for the Late Roman period (Fowler 2002: 17), and two million for the Roman period (Mattingly 2006: 356). Whatever the numbers involved, any increases in population would have entailed increasing demand for arable produce.

1.4.8.2. Middle Iron Age population increase

Population increase in the MIA/LIA is attested by the expansion of settlement from the river valleys, fen edges (Bryant 1997; Martin 1999) and light soils of Breckland and north-west Norfolk (Davies 1996) into previously marginal areas including the fen edges/islands (e.g. Pryor 1984; Evans and Serjeantson 1988; Evans 2003b) and Middle Ouse Valley bottoms (Dawson 2000; 2004), as well the clays of eastern Norfolk and Suffolk, Hertfordshire and Essex (Davies 1996; 1999; Hill 2007). Caution must be exercised however in accepting this model: recent review of the later prehistoric ceramic sequence of Norfolk (Brudenell 2011) suggests that its clay areas may not have been as empty in the EIA as has been supposed.

1.4.8.3. Roman population increase

Incoming population

The influx of soldiers and their dependents (cf. James 2001), along with administrators, traders and service providers in AD 43 began another wave of population increase. With the transfer of land from military to civilian administration came the opportunity for purchase (Section 1.4.4.2). Although many of Britain's new landowners would have been absentee landlords, others – veterans, but also other 'outsiders' (Section 1.4.4.2) − would have settled on their new lands (Mattingly 2006: 354).

Fulford (2004) poses the question of whether the increased demand for grain resulting from this immigration was met from new/existing surplus production or whether grain was imported to Britain to feed the incoming population. Tacitus' (Agricola 19) account of reforms to systems of tribute suggests local supply of grain to meet state requirements. However, he also records famine among the native population in the immediate aftermath of the Boudican revolt, resulting from a failure to either sow their own fields or seize Roman supplies (Annals 14.38). If taken as literal truth, this implies that Roman supplies had a different source to native crops, but they could equally be stored grain, already taken in tribute/taxation.

New, large-scale crop-processing (corndriers and water mills) and storage (granary buildings) features suggest greatly increased arable production to meet the new demand for food, and the entrance of agricultural producers into the province's new market economy (Section 1.5.3). The spread of (previously unattested) insect grain pests in Roman Britain also suggests increased storage (in suitable conditions for their proliferation – i.e. large, open grain stores) and movement (to allow survival of a viable metapopulation) compared to the Iron Age (Smith and Kenward 2011).

The withdrawal of part of the British garrison in the mid-third century AD may have resulted in a reduction in overall population (and demand for arable produce) in Britain, but deployment to the Saxon Shore Forts may have mitigated this within the study area. There are several Roman accounts (e.g. Ammianus Marcellinus: 18.2.3) of British grain being exported in quantity to support armies on the Rhine frontier in the mid fourth-century AD (Taylor 1999; Mattingly 2006: 505). It is possible that this grain originated in (or was exported via) the study region, whose coast faces the Rhine mouth (Going and Plouviez 2000), though the combination of port facilities on the Thames and (relatively) central location for overland access may have favoured London as the point of departure for such exports (cf. Mattingly 2006: 511).

Settlement expansion

Roman colonisation of the fenland may be interpreted as expansion of agricultural production onto marginal land as a direct result of population increase and rising demand for produce. The Roman fenland has been seen as state-controlled resource (e.g. Salway 1970; Potter 1981; 1989; Jackson and Potter 1996; King 2004), based on its resources and desirability; on its colonisation over a relatively short period (as part of a centrally planned Hadrianic initiative); on the scale of road, canal and drainage programmes; and on the probable fate of Iceni lands in the aftermath of the Boudican revolt (cf. Tacitus: Annals 14.31). The absence of villas (present across the rest of the study region) has been seen to support this interpretation, and the distinctive settlement at Stonea has been suggested as an administrative centre for the area (Jackson and Potter 1996). Mattingly (2006: 385) suggests that the fenland may alternatively have been an *ager publicus,* settled by native Britons in return for levies of products (e.g. salt, meat, hides, grain) required by the state.

Millett (1990: 120-123) counters that native communities were sufficiently organised to reclaim the fens on the scale indicated by the archaeological evidence and that absence of villas is neither very unusual nor indicative of central-administration. Furthermore, the palaeoenvironmental evidence indicates a more gradual colonisation of the fenland (first to third centuries AD; Taylor 2001b), and piecemeal systems of land division suggest a varied settlement process, consistent with gradual, independent colonisation (Millett 1990: 120-123; Taylor 2001b).

1.5. Arable farming in Iron Age and Roman Britain

1.5.1. Preface

In this section I review the established understanding of Iron Age and Roman arable practice in Britain. I begin with consideration of the relationship between pastoral and arable farming (Section 1.5.2) and a summary of the technology of arable farming in these periods (Section 1.5.3). I then summarise what is known of arable practice in the best-studied parts of Iron Age and Roman Britain (central southern Britain and north-east England/south-east Scotland; Section 1.5.4), as well as the current understanding of arable practice within the study region (Section 1.5.5).

1.5.2. Relationships between pastoral and arable farming

1.5.2.1. Overview of pastoral farming

Extensive crop-mark systems in several parts of southern Britain date to the Bronze Age, Iron Age and Roman period. Within the study region, these frequently represent combinations of fields and droveways (e.g. Pryor 2001; Taylor 2007: 66), suggesting pastoral farming.

Iron Age pastoral farming is often characterised as sheep-dominated, in contrast to Roman cattle-dominance (e.g. Fowler 1981: 198; 2002: 223; Cunliffe 2005:420). This is largely based on evidence from central southern Britain, but regional variation is acknowledged in the Roman period (Fowler 2002: 223). Within the study region, there is a need for further assessment and synthesis of faunal remains (Murphy in Going and Plouviez 2000; Medlycott 2011), but a broad trend of increasing dominance of cattle- over sheep-husbandry through the Roman period is recognised (Murphy in Going 1997).

Pig bone is also present throughout the study period and across the study region, but concentrations at Roman military sites are thought to indicate their raising specifically for military provisioning (Murphy in Going 1997). Sheep bone assemblages from Colchester have been interpreted as possibly representing a meat-rearing strategy specifically for the provisioning of the town (Luff 1993).

1.5.2.2. Interdependence of pastoral and arable farming

Arable and pastoral farming strategies are frequently interlinked and interdependent; neither can be fully understood without reference to the other (cf. Varro I.II: 15-16, cited by Luff 1993: 139). It has been suggested that Iron Age agricultural strategies on the heavy clay soils of the study region were exclusively pastoral, with livestock traded for grain from other areas, such as the fen-edge (e.g. Medlycott 2011; Section 1.5.5.4).

Cultivation of grass as fodder, using implements such as the hay-fork recovered at Stonea Grange, has been suggested in the Roman fenland (Fowler 2002; 223). Hulled barley and/or oats and brome have been suggested as fodder-crops in the Iron Age (Van der Veen 1992: 75; Campbell 2000), and crop-processing by-products may also have been used as fodder (e.g. Hillman 1981; Grant 1984; Campbell 2000). Arable products may have made further contributions to the diet of livestock through grazing of stubble between harvest and ploughing (Campbell 2000) and/or of young cereals to promote tillering (Hamilton 2000). Direct application of manure by grazing livestock would replenish soil nitrogen, improving arable crop yields, provided that this was not the animals' only source of nutrition.

Cunliffe (2005: 420) suggests Iron Age sheep-husbandry in central southern Britain as a means of maintaining the fertility of arable fields but Van der Veen and O'Connor (1998) suggest that sheep were inadequate to this task. They suggest that the larger amount of manure provided by cattle facilitated expansion of arable production in Roman Britain. They also note the use of oxen for ploughing. Unusually large cattle remains, with pathologies consistent with traction, in the MR faunal assemblage from Great Holt's Farm, Boreham, Essex, may represent beasts imported (or bred) specifically for the tillage of heavy soils (Murphy *et al.* 2000). Spring-ploughing (and sowing), may have necessitated better feeding of oxen over winter, perhaps entailing increased reliance on fodder crops and/or increased grazing of harvested fields (with implicit direct manuring) (Hamilton 2000).

1.5.3. Technology of cultivation, harvesting and processing

1.5.3.1. Digging and hoeing

A variety of hand-held spades, forks, mattocks, hoes and weeding tools, made in iron, wood and antler, are known from Roman Britain (Rees 1979: 304-331; Fowler 2002: 170-171). A far smaller variety is attested in the Iron Age, though it is possible that wooden implements or unmodified animal bones/antlers were used for a variety of similar purposes (e.g. cattle scapulae as shovels), or that tools recognised as adzes and axes actually had a wider range of functions (Rees 1979: 304; Robinson and Lambrick 2009).

1.5.3.2. Ploughing

The 'ploughs' of the Iron Age and Roman period were mostly ards (as defined by Fowler 2002: 182, 320). An ard comprises a wooden frame which allows a wooden share to be dragged by animals through the ground thus disturbing it sufficiently (though perhaps requiring two perpendicular passes) to allow planting. Iron-tipped shares are relatively common finds in Britain from the Iron Age onwards. Socketed iron share-tips first occur in the Iron Age, becoming more common and increasing in length over time, to the point of Roman examples in which the entire share is made of iron (Rees 1979: 48-59; Fowler 2002: 188).

An ard may also incorporate a coulter, a blade positioned in front of the share, to cut the ground vertically prior to horizontal disturbance by the share. Ards incorporating coulters and asymmetric shares, allowing deeper ploughing of heavy soils, came into use in Britain in the third/fourth century AD (Rees 1979: 59-61). However, they may have been confined to the agriculturally richer, or heavier soiled, parts of Britain, e.g. Gloucester and Somerset (Fowler 2002:184).

True ploughs have both a coulter and a share, but also incorporate a mouldboard, which turns the soil completely following its cutting, and thus greatly facilitates cultivation of heavy soils. It is possible that mouldboard ploughs were used in Late Roman Britain (M. Jones 1981; Fowler 2002: 184), though this remains unproven (Booth *et al.* 2007: 288).

Robinson (1992) identifies two sites (Drayton, Oxfordshire, and Warren Villas, Bedfordshire) at which changes in ploughing practice may relate to changes in the technology available. In both cases the marks of Early Roman cross-ploughing are sealed by deposits which were then disturbed by later Roman uni-directional ploughing. Weed seeds preserved by waterlogging in the cross-ploughed soil at Warren Villas indicate cultivation of extremely wet ground.

1.5.3.3. Harvesting

Short, crescent-shaped sickles occur throughout the Iron Age and differ from their Bronze Age predecessors only in being made in iron (M. Jones 1981; Robinson and Lambrick 2009). They are varied and were probably used in different ways (e.g. for cutting the cereal ear only, or for reaping lower on the stalk), perhaps not solely for cereal harvesting (Robinson and Lambrick 2009; cf. Reynolds 1981). Balanced sickles are known from the LIA onwards with large examples known in the fourth century AD (M. Jones 1981).

1.5.3.4. Milling

Saddle querns are known throughout the Iron Age and into the Roman period, while rotary querns (which can grind larger quantities of grain with less effort) appear consistently by the third/second century BC. Watermills and (rare) donkey-mills (cf. Williams-Thorpe and Thorpe 1988) were an innovation of the Roman period (Van der

Veen 1989; Van der Veen and O'Connor 1998; Taylor 2007: 115, 118). These new milling facilities would have increased the amount of grain that could be ground in a given amount of time/with a given amount of labour. This may suggest a re-deployment of labour, away from purely agricultural tasks: a mill would require investment of both labour and resources for construction but, once running, may have created time for other tasks (Booth *et al*. 2007: 298).

Concentrations of Roman Mayen lava quern stones (from the Eifel region of Germany) are known within the study region (Peacock 1980), but a variety of British outcrops, including Hertfordshire Puddingstone (Moore *et al*. 1988), were also used.

1.5.3.5. Drying and malting

Roman corndriers are known throughout southern, central and eastern Britain, including several examples in the study region. Experimental work (Reynolds and Langley 1979) suggests that these may have been better suited to malting than to drying of grain, but archaeobotanical analysis of carbonised plant macrofossils from several corndriers found evidence of both uses (Van der Veen 1989). Whether used for drying, malting or both, corndriers attest large-scale processing, suggesting increased scale of arable production (e.g. Van der Veen 1989; Taylor 2007: 115). Large-scale malting implies specialist production of a commodity (beer) for sale (Section 1.6.4.3). The need for large-scale drying prior to storage or consumption may also be linked to market production, or to taxation and military supply networks (Van der Veen 1989; Van der Veen and O'Connor 1998).

1.5.4. Archaeobotanical investigations of Iron Age and Roman arable practice in other parts of Britain

1.5.4.1. Preface

In recognition of regional variation, no overview of Iron Age and Roman arable practice in Britain is attempted. Such accounts appearing in syntheses of British Iron Age and Roman archaeology (e.g. M. Jones 1981; Dark and Dark 1997: 109-110; Fowler 2002; Fulford 2004; Cunliffe 2005: 407-443; Mattingly 2006: 365-366) tend to draw heavily on the evidence from the well-investigated regions of central southern Britain and (to a lesser extent) north-east England. The following sections summarise current understanding of arable practice in these regions (Sections 1.5.4.2 and 1.5.4.3), and in the East of England (Section 1.5.5).

Because of the variety of different methods used to formulate interpretations of arable practice, some critique of methodology is necessary within this summary. A structured assessment of the methods which can be used for archaeobotanical investigation of arable practice follows in Section 1.6.

1.5.4.2. Central southern Britain (Wessex and the Thames Valley)

<u>The studies</u>

As with other aspects of British Iron Age life, understanding of arable practice has been based largely on the large amount of published and synthesised work carried out in this region, which extends to the south-west boundary of the current study region.

Much archaeobotanical work was carried out by M. Jones in the 1970s and 1980s, and published in syntheses of Iron Age and Roman agriculture in southern England (1984a; 1988a; 1995), or in Britain, drawing heavily on evidence from this region (1981; 1985; 1988b; 1989; 1996). Interpretation in these syntheses was tied into that of the area's wider archaeological record, particularly the rise and development hillforts and the use of storage pits, in models of EIA and MIA social/political authority (e.g. Cunliffe 1995: 98-103; 2005: 418-429, 590-591). Further work has been carried out in Wessex by Campbell (2000; 2008) as part of the Danebury environs programme. In the Thames valley, recent syntheses by Booth *et al*. (2007: 277-299) and Robinson and Lambrick (2009) include review of M. Jones' identifications and interpretations, as well as consideration of material from more recent investigations.

Crop species

Spelt (*Triticum spelta*) and hulled six-row barley (*Hordeum vulgare*) were the dominant cereal crops of the Iron Age and Roman period (M. Jones 1981; 1984b; Campbell 2000; 2008; Booth *et al*. 2007: 281, 293; Robinson and Lambrick 2009). Emmer (*T. dicoccum*) is also present, but is thought to represent a contaminant of spelt crops except in the later Roman period of the Thames Valley (Campbell 2000; 2008; Robinson and Lambrick 2009; Booth *et al*. 2007: 281, 293). This range of cereal crops differs from that seen in other parts of Britain and across the Channel in northern France (where spelt occurred only rarely after the Early La Tène period and emmer and barley were the dominant crops, replaced by bread wheat in the Early Gallo-Roman period; Matterne 2001: 109).

Oats (*Avena fatua* and *A. strigosa*) occur with increasing frequency through the Iron Age (M. Jones 1981; Campbell 2000) and may have been cultivated in the Late Iron Age and later Roman period, but probably not in the earlier Roman period (Booth *et al*. 2007: 281, 293; Robinson and Lambrick 2009). Campbell (2000) suggests that putative oat-cultivation in the Late Iron Age may indicate the replacement of brome (*Bromus sp*.) as a fodder-crop, but also offers an alternative interpretation of both as incidental contaminants of other crops. Rye (*Secale cereale*) is known from a small number of

Iron Age and Roman sites (M. Jones 1981; Green 1981; Booth *et al*. 2007: 293), but there is no clear evidence that it was cultivated in its own right.

Bread wheat (*T. aestivum*) is present in LIA and Roman assemblages, but is not now thought to have been a crop in its own right (Campbell 2000; Booth *et al*. 2007: 281; Robinson and Lambrick 2009), except possibly at high status settlements in LR Wessex (Campbell 2008). MIA examples from the Thames Valley region may actually be atypical spelt grains (Robinson and Lambrick 2009).

<u>Scale of production</u>

Increasingly dense carbonised cereal deposits, and decreasing occurrence of wild species, in the Late Bronze Age and EIA indicate increased scale of arable production (M. Jones 1984b), contrasting with continued exploitation of wild resources alongside large-scale arable production across the English Channel (Matterne 2001: 82-82). M. Jones (1981) suggests that this was followed by stagnation in the MIA, leading to soil exhaustion (confirmed by Booth *et al*. 2007: 278) in some areas.

The ER period is considered to have seen increasing intensity of agricultural activity and increased agricultural production. In the Thames Valley it is not clear whether this did more than keep pace with increasing population levels (Booth *et al*. 2007: 285). In Wessex, Campbell (2008) suggests that LIA and ER increased incidence of dense grain deposits signify increased scale of production/handling (Section 1.6.4.3), consistent with a move away from subsistence farming and towards production for exchange and participation in a market economy.

<u>Cultivation of marginal land</u>

The dominance of spelt in this region from the early first millennium BC has been interpreted as a response to climatic downturn (M. Jones 1981), as spelt is hardier than emmer, and gives higher yields in years with cold winters (Van der Veen and Palmer 1997).

Alternatively/additionally, its dominance may signify cultivation of the damp and clayey soils onto which settlement spread during this period (M. Jones 1981; 1984b). This is based on spelt's supposedly higher tolerance than emmer for such soils, though Columella (II, IX.3) suggests that emmer (*Far adoreum*) is suited to such conditions, and cultivation experiments have shown that it can tolerate them (Robinson and Lambrick 2009). Though no full autecological study (Section.1.6.5.2) has been carried out, carbonised weed seeds confirm cultivation of wet (*Eleocharis palustris*), clayey (*Anthemis cotula*) and acidic (*Chrysantemum segetum*) soils in the MIA (M. Jones 1981; 1984a; 1984b; 1988a; 1988b; 1995; 1996).

M. Jones (1981) suggests that temporary absence of *E. palustris*, combined with widespread cutting of drainage ditches indicated mitigation of damp conditions in the LIA and earlier Roman period. Robinson and Lambrick (2009) note evidence for cultivation of consistently damp floodplains throughout this period at some Thames Valley sites. In other instances, abandonment of cultivation on damp floodplains in the earlier and later Roman period may have been accompanied by expansion onto higher ground and heavier clay soils (Booth *et al*. 2007: 284, 298).

Increased representation of oats (tolerant of acidic and nutrient-poor soils) as a crop-contaminant, along with increased representation of leguminous weeds and decreases in nitrogen-loving species, is cited as further evidence of the farming of poorer soils throughout the Iron Age and earlier Roman period (M. Jones 1981). Robinson and Lambrick (2009) confirm these trends in the Thames Valley, but also note evidence for manuring (pottery scatters) in the Iron Age and earlier Roman period, and suggest that changes in sowing-time may be behind these changes in weed flora. Campbell (2000; 2008) suggests manuring of fields in the Danebury area from the Late Iron Age onward.

Sowing regimes

Interpretations of sowing-time (spring/autumn) and the combinations in which crop species were sown in this region are interlinked.

Robinson and Lambrick (2009) suggest cultivation of a spelt/emmer maslin (i.e. a mixed crop) in the EIA. They point to cultivation experiments showing that autumn-sowing of such a maslin will lead to almost entire displacement of emmer by spelt (while spring-sowing will lead to displacement of spelt by emmer) over a five year period. They thus suggest that an increase in the autumn-sowing of emmer-spelt maslins explains the dominance of spelt, and lack of evidence for emmer-cultivation, in the Iron Age Thames Valley. Roman spelt and barley are considered to have been both spring- and autumn-sown (Booth *et al*. 2007: 285).

The presence of *Galium aparine* in carbonised assemblages is cited (e.g. Carruthers 1995; Robinson and Lambrick 2009) in support of the interpretation of autumn-sowing in this region. This is based on its autumn-germination. However, there is disagreement over this species' germination-time, and it cannot therefore be relied on as an indicator of autumn-sowing (Van der Veen 1992: 133; Campbell 2000).

Campbell (2000; 2008) suggests autumn-sown spelt/barley maslins in the EIA and MIA, a shift to autumn-sown spelt and spring-sown barley monocrops in the LIA and Roman period, and a possible return to spelt/barley maslins in the fourth century AD. Identification of maslins is based on the presence of spelt and barley in roughly equal proportions in stored grain deposits (see Section 1.6.3). Assessment of sowing-time is based on traditional sowing times for spelt and barley – an approach criticised by

Hillman (1981) and Van der Veen (1992: 130) as inappropriate to considerations of prehistoric practice – but also on increasing frequency of oats (whose later flowering time is consistent with spring-sowing) and decline of brome.

Harvest

Based on the presence/absence of rhizomes and tubers, Campbell (2000; 2008) suggests EIA and MIA harvest by uprooting in the Wessex area but later use of sickles for reaping. The presence of low-growing weeds in Iron Age assemblages from the Upper Thames Valley suggest reaping very low on the stalk (Robinson and Lambrick 2009).

Crop movements and crop-processing

At Danebury, differing proportions of grain, chaff and weed seeds in storage pit assemblages have been interpreted as signifying deposition of (burnt) 'refuse' from different stages of crop-processing in different pits. The weed assemblages indicate presence of harvests from several growing environments in each pit (M. Jones 1984b). A model has thus been constructed whereby coarse-sieved harvests were brought to Danebury for bulk completion of processing, followed by underground winter-storage at the hillfort (M. Jones 1984a; 1985; 1995). There is some confusion as to whether this grain was then used as seed, further processed for consumption, or redistributed outside the hillfort (compare M. Jones 1985: 122 and 1995: 48, 49).

At other Iron Age sites in the Danbury area, Campbell (2000) identifies stored spelt spikelets and semi-clean barley grain, winnowing and threshing by-products and fine-sieving by-products. Early stage crop-processing at these sites is consistent with the above model, but it appears that at some sites crops were stored and further processed, and not sent to Danebury. There is evidence for use of winnowing and threshing by-products to fuel spelt-parching in the EIA.

Assemblages from non-hillfort sites in the Upper Thames Valley have been interpreted (on the assumption that loss of grain to fire is most likely where its economic value is lowest) as evidence of arable production and consumption at sites on the second and first gravel terraces, respectively (M. Jones 1985; 1996). The same patterns of grain/chaff/weed representation have also been interpreted as evidence of household and community level organisation of crop-processing and grain storage (Stevens 2003a), though there are concerns over the methods used to arrive at this interpretation (Van der Veen and Jones 2006).

Roman corndriers (including ER examples in the Thames Valley) are found throughout this region, signifying increased scale of crop-processing (Booth *et al*. 2007: 289-291; Campbell 2008). They appear to have been used for drying and malting of spelt grain (or malting spelt and barley in one instance), often with spelt fine-sieving by-products used as fuel or tinder.

1.5.4.3. North-east England and south-east Scotland

<u>Sources</u>

Van der Veen's (1992) study of Iron Age and Roman arable practice in the north-east of England was based on all archaeobotanical evidence available at the time (325 samples from 9 sites), and (in contrast to the majority of studies from central southern Britain) was carried out according to a clear and consistent methodology, through which crop species, crop-processing derivation, sites of production and consumption and cultivation practice were investigated.

More recent synthesis from the East Lothian region (*c.* 100km north of the Tyne) is based on samples from excavations carried out in advance of new housing (Huntley 2000) and as part of the research-lead Trapian Law Environs Project (Huntley and

O'Brien 2009). It includes identification of the crops cultivated and some comment on the crop-processing and cultivation strategies, though the latter are hampered by poor preservation and low densities of plant macrofossils.

Crop species

In the Tyne-Tees region, cultivation of emmer, spelt, bread wheat (in the Roman period and at one LIA site), six-row hulled barley and rye (at one Roman site only) was identified. In the Iron Age, emmer dominated over spelt in the area north of the Tyne, but only spelt was present in the Tees lowlands. Barley appears to have been cultivated alongside both species, except at the Roman granary at South Shields, whose spelt and bread wheat assemblage may have been imported to the region.

In East Lothian six-row hulled barley is consistently identified as the dominant crop throughout the Iron Age and Roman Iron Age. Evidence of wheat cultivation is comparatively rare, and may represent import rather than production at some sites. Emmer is better represented than spelt, which is rare in the earlier Iron Age (800-350 BC) but relatively common at some sites in the later periods. Cultivation of oats was identified at one Roman Iron Age site.

Crop-processing

Fine-sieving of glume wheats was the best represented activity in the Iron Age Tyne-Tees region, though by-products from the winnowing and coarse-sieving of barley and (at one site) bread wheat were also present at all Iron Age sites, suggesting that they produced their own crops (Van der Veen 1992: 81-89). The Roman assemblages mostly represented the products of fine-sieving (clean grain), though by-products from the early-processing of rye were also present at one site (suggesting its cultivation at that site).

Specific crop-processing activities were not identified at the East Lothian sites, but the presence of chaff was suggested to indicate cultivation and processing, rather than import (at least of barley), at all sites.

<u>Cultivation practice</u>

Multivariate analysis using weed autecology to consider growing conditions in the Iron Age Tyne-Tees region demonstrated that the difference between the emmer-growing north and spelt-growing south was also apparent in soil conditions and tillage (Van der Veen 1992: 111-116). Two Iron Age arable regimes were thus identified. North of the River Tyne emmer (with barley and some spelt) was cultivated with significant input of labour and resources to till the land and maintain soil fertility. In the Tees lowlands spelt (and barley) were cultivated with lower levels of tillage and less effort to maintain soil fertility, suggesting cultivation of larger areas.

At the East Lothian sites poor preservation hampered preservation and identification of weed seeds. However, those which could be identified were interpreted as suggesting cultivation of nutrient-enriched (possibly through spreading of seaweed) damp soils, as well as some drier sandier soils (neither linked to a specific crop).

1.5.5: Current understanding of Iron Age and Roman arable practice in the East of England

1.5.5.1. Sources

By comparison to the regions described above, food producing strategies in the East of England are currently poorly understood (Cunliffe 2005: 432). Apart from the individual site reports on which this research is based, current understanding of Iron Age and Roman arable agriculture comes largely from the work of Peter Murphy. In addition to characterisation of arable agriculture in the Regional Resource Assessments

(Murphy in Bryant 1997; Murphy in Going 1997), overviews and syntheses include a contribution to Davies and Williamson's (1999) synthesis of the Iron Age in the north of the region (Wiltshire and Murphy 1999) and an unpublished draft of a regional review of plant macrofossils for the Midlands (Murphy and de Moulins 2002), currently being revised and updated (Carruthers and Hunter forthcoming). A review of evidence from Bedfordshire (Scaife 2004) is included in a synthesis of the county's archaeology (Dawson 2004).

1.5.5.2. Woodland clearance and the arable/pastoral balance

Palynological studies indicate continuation of Bronze Age woodland clearance in the Iron Age and Roman periods, with mixed farming on the cleared land also demonstrated by mollusc and plant macrofossil evidence (Murphy in Bryant 1997; Murphy in Going 1997; Wiltshire and Murphy 1999; Murphy and de Moulins 2002). Palynology also indicates Roman increase in arable land at the expense of pasture on the Norfolk clay (Turner 1981; Murphy 1984), and predominantly grassland conditions on the fen-edges/islands (Waller 1994, 93, 94, 100; Murphy and de Moulins 2002).

Mollusc evidence indicates short-turfed grassland in EIA north-west Norfolk and throughout the Iron Age in Breckland, where carbonised plant macrofossils suggest the spread of heath conditions in the LIA and Roman period (Murphy 1984; Wiltshire and Murphy 1999). Murphy (1984) suggests that arable farming would have been possible only on the river terraces in this area of sandy, free-draining soil.

1.5.5.3. Crop species

Spelt, emmer and six-row hulled barley were the principal Iron Age crops, with bread wheat, rye and oats (possibly wild) present in smaller quantities and not necessarily cultivated (e.g. Murphy in Bryant 1997; Wiltshire and Murphy 1999; Cunliffe 2005: 432).

Spelt was already the dominant crop at Springfield Lyons, Essex, by the Middle Bronze Age, but a general MIA trend of replacement of emmer by spelt has been suggested (Murphy in Bryant 1997; Murphy and de Moulins 2002). By the Roman period, spelt was the dominant cereal crop with emmer occurring only within spelt-dominated assemblages, and barley-cultivation continuing on a reduced scale (Murphy in Going 1997; Murphy and de Moulins 2002).

Little evidence has been found for Iron Age or Roman barley-cultivation in Bedfordshire, though this may reflect different crop-processing practices, or taphonomic processes, rather than different crop choices (Scaife 2004).

Non-cereal crops (including pea (*Pisum sativum*), celtic bean (*Vicia fabia*), flax (*Linum usitatissimum*), gold of pleasure (*Camelina sativa*) and woad (*Isatis tinctoria*)) are known, but not common, for the Iron Age (Murphy and de Moulins 2002). In the Roman period, there is a much greater range of non-cereal foodstuffs, mainly herbs, vegetables and orchard fruits, including both newly cultivated and imported species (Murphy and de Moulins 2002; Van der Veen *et al*. 2008). Such remains tend to occur in waterlogged assemblages; they are rare in carbonised assemblages, where there preservation is usually a result of chance contact with fire.

1.5.5.4. Iron Age settlement expansion, production and consumption

As in the Late Bronze Age, and in the Iron Age of other regions (Section 1.5.4.2), wild/gathered plant foods are rare, and cereal cultivation is the best attested source of plant-based food.

Davies (1996) suggests that settlement in Norfolk was confined to Breckland until the MIA, which saw expansion onto heavier soils across the study region. Ease of cultivation is an implied reason for the earlier constriction of settlement, but Murphy and de Moulins (2002) suggest that by the MIA soil impoverishment and summer dryness would have made cultivation unviable in the most free-draining and sandy parts of Breckland and eastern Norfolk. They also suggest that cultivation of the clay soils of Norfolk and Essex would not have been possible in the Iron Age, and that MIA expansion was associated with pastoral (not arable) farming.

These suggestions are supported by near-absence of *Anthemis cotula* (which prefers heavy soils) from Murphy and de Moulins' (2002) Iron Age dataset and by grain-rich assemblages from sites in Breckland and Eastern Norfolk (Wiltshire and Murphy 1999; Murphy and de Moulins 2002). Staunch Meadow, Brandon, has been identified as an arable producer site – i.e. one which may have supplied grain to sites with exclusively pastoral agricultural regimes – on the basis of preserved plough marks and carbonised assemblages dominated by weed seeds (Wiltshire and Murphy 1999).

1.5.5.5. Increased production in the Roman period

Roman increase in agricultural production is attested by increased density and ubiquity of carbonised assemblages (Murphy and de Moulins 2002), as well as by the presence of corndriers (e.g. Taylor 2007: fig. 7.3) and watermills (Going and Plouviez 2000), and increased soil erosion and alluviation (French 1988; French and Pryor 1993). Additionally, LR iron hoards in the study region include sophisticated agricultural implements such as scythes (thought to have been used for hay cutting rather than cereal reaping) and plough coulters (Going and Plouviez 2000).

A. cotula is present in approximately one third of the Roman site assemblages considered by Murphy and de Moulins (2002), suggesting cultivation of heavy clay soils.

1.5.5.6. Crop storage

Iron Age four-post structures and storage pits are present in the region (e.g. Gent 1983; Ashwin 1996). A fused coating of charred grain in a storage pit at Fison Way, Thetford, indicates its use for grain storage and subsequent cleaning; a charred clean grain deposit was found in a similar pit at Rectory Road, Orsett (Murphy and de Moulins 2002). In Essex, four-post structures are associated with charred cereal remains at MIA Uphall Camp, and above-ground storage in ceramic jars and barrels is suggested at Asheldham Camp (Sealey 1996; Murphy and de Moulins 2002). Assemblages from Asheldham Camp and Fison Way, suggest storage of mixed spelt spikelets and barley grain (Sealey 1996; Murphy in Bryant 1997; Wiltshire and Murphy 1999; Cunliffe 2005: 432).

The spatial patterning of deposits recovered from post-extraction pits in a burnt-down Roman granary at Great Holt's Farm, Boreham, Essex, indicate that spelt (clean grain), barley and pulses were stored separately after processing (Murphy *et al.* 2000). As well as indicating the cultivation of monocrops, this may suggest separation in the storage area between human and animal foods (Murphy *et al*. 2000). In contrast, granaries burnt during the Boudican destruction of Colchester, like other urban and military granaries, had more mixed cereal deposits (spelt, emmer and bread wheat), probably indicating the amalgamation of harvests from different sites prior to storage (Murphy 1984).

Carbonised coarse textile fragments associated with sprouted spelt grains in the Culver Street granary are thought to represent a sack of malt (Murphy 1984; Murphy and de

Moulins 2002). Sprouted (spelt) grain is a common occurrence at Roman sites in the region, sometimes associated with corndriers (e.g. Van der Veen 1989). Sites with elaborate malting facilities have been identified at Stebbing Green, Essex (Bedwin and Bedwin 1999), and Beck Row, Mildenhall, Suffolk (Bales 2004).

Pitts (2005) suggests that communal beer drinking, associated with specific vessel forms, was an important practice for the generation of prestige in the LIA and Conquest-period in the south of the study region. No evidence has yet been identified of large-scale malting (or other stages in the brewing process) in these periods to produce the conjectured beer.

1.5.5.7. Crop-processing by-products and integration of arable farming into the wider economy

Roman carbonised assemblages are remarkably consistent in composition (typically spelt chaff and weed seeds) and are interpreted as by-products of fine-sieving, though by-products of earlier crop-processing stages have also been identified at some sites (Murphy and de Moulins 2002). This material is found re-deposited by wind or other agency in pits and ditches (low density deposits), but also in association with evidence of industrial activity (high density deposits), suggesting use as fuel.

Iron Age salt-making in the fens and on the Essex coast is thought to represent seasonal exploitation of natural resources in non-settled areas (Lane 2001: 467), a situation also envisaged for the earliest iron smelting (Morris and Wainwright 1995; Davies 1996). This implies that agricultural regimes did not require constant involvement of the entire workforce. The coincidence of harvest time with the optimum season for salt production may indicate that salt-makers were spared from pastoral regimes (Morris 2001: 62), but integration of arable production into this system is indicated at several sites (including those where local conditions precluded cultivation) by the use of crop-processing by-products to temper briquetage (e.g. Murphy in Morris 2001: 37-38).

This use of crop-processing by-products is also known in the Roman period (e.g. Wilkinson and Murphy 1995; Murphy in Crosby 2001: 110; Percival 2001: 185), when they were also used as fuel/tinder for the salt-making process at some sites (e.g. Murphy 2001a:154). Roman use of crop-processing by-products as fuel has also been noted in corndriers (Van der Veen 1989; 1999; Murphy and de Moulins 2002), and pottery kilns (e.g. Murphy in Plouviez 1989; Murphy and de Moulins 2002), suggesting that they were deliberately conserved, and perhaps traded, for this purpose (Van der Veen 1999). It is possible that the by-products of winnowing and threshing were also used in this manner (Murphy and de Moulins 2002).

1.6. Archaeobotanical context: identifying arable practice

1.6.1. Preface

I begin this section by justifying the choice of carbonised plant macrofossils as the basis of this research (Section 1.6.2). I go on to summarise and review the methods available for elucidating the three key aspects of arable practice (crop species, crop-processing behaviour and cultivation practice) identified in Section 1.2.3 as the principal objectives of this research (Sections 1.6.3-1.6.5).

1.6.2. Choice of material and formation of carbonised archaeobotanical assemblages

Carbonised assemblages have been chosen for this research because they are relatively abundant and frequently comprise the burnt remains of arable crops.

The formation of carbonised archaeobotanical assemblages is influenced by human action: burning of fuel, waste or votive offerings; destruction of diseased plants; cleansing of storage pits; accidents during processing or cooking; or accidental or malicious conflagration during storage (Van der Veen and Jones 2006; Van der Veen 2007). Cereals may become carbonised by any one of these routes, and (along with their contaminants) tend to dominate carbonised plant macrofossil assemblages (Green 1982; Carruthers and Straker 2000; Van der Veen *et al*. 2007). Although cereals may also be preserved by other means (most commonly waterlogging), the taphonomy and preservation-biases involved are different to those in carbonisation: assemblages preserved by different means are not directly comparable.

Archaeobotanical assemblages of carbonised plant macrofossils differ compositionally from the growing plant communities from which they derive. Understanding these differences means that they can be taken into account when using carbonised plant macrofossils to identify past cultivation regimes (Dennell 1974; 1976). Apart from pre-/post-depositional mixing of plant material from different sources, these differences involve the removal, rather than the addition, of components.

Some compositional alteration results from the processes of carbonisation, deposition and recovery. This alteration has been researched experimentally (Boardman and Jones 1990); it is therefore predictable and can be accounted for. Carbonisation favours the preservation of small and dense plant elements (e.g. grains, heavy seeds and glume bases) which drop through the hottest part of a fire and are protected in the ashy deposit at its base (Hillman 1981; Boardman and Jones 1990). Carbonised plant macrofossils can survive in a wide range of burial environments, but are vulnerable to mechanical damage during episodes of redeposition, excavation, sampling and processing (e.g. Pearsall 2000: 80; Guarino and Sciarillo 2004).

1.6.3. Identification of cereal crops

The apparently straightforward question 'which species were cultivated?' (addressed in Chapter 3) is one fraught with methodological concerns centring on the issue of how well-represented a species needs to be in order to be interpreted as a crop.

Species represented by only a few items in a sample may actually be a-typical examples/occasional mutations of another species. There is also a potential for contamination of carbonised assemblages with intrusive material from later periods. A combination of these issues has been suggested to account for most apparent Middle and Late Iron Age identifications of bread wheat cultivation in the Upper and Middle Thames Valley (Robinson and Lambrick 2009: 252-253). Even when small numbers of grains/chaff items are securely dated and correctly identified to species, the possibility remains that they represent incidental occurrences within other crops, rather than cultivation of that species.

On the other hand, archaeobotanical samples are incomplete representations of excavated sites, and excavated sites are incomplete representations of regions considered: species which were commonly cultivated will be well represented in the archaeobotanical record, but rare crops will be represented only infrequently. Every sample analysed has the potential to increase the number of crops recognised.

Where more than one crop species is present in a deposit, an additional difficulty arises in distinguishing between monocrops (single-species crops), mixed during harvesting or at the point of deposition, and maslins (deliberately mixed crops of two or more species), sown to reduce the risk of crop failure by aiming for the success of at least one of the component species (see Chapter 5). Maslins have often been tentatively identified where two crop species are approximately equally represented in a deposit (example in Section 1.5.4.2). Van der Veen (1995) suggests that this logic is flawed, given the purpose of maslin-cultivation; Jones and Halstead (1995) demonstrate that modern-day maslins vary significantly in the representation of their component species. Van der Veen (1995) demonstrates use of multivariate analysis to identify crops which grew separately but were deposited together, and suggests how maslins could be identified using such methods.

1.6.4. Crop-processing and storage

1.6.4.1. What is crop-processing?

Once the factors described in Section 1.6.1 are accounted for, the remainder of the compositional differences between carbonised archaeobotanical assemblages and growing arable crops result from human action in (harvesting and) crop-processing (investigated in Chapter 4).

The removal of some species and plant-elements during harvesting results from both biotic factors (e.g. the absence of plants which do not set seed at harvest time) and human decisions about how to harvest the crop. For example, different weed species will be collected along with the cereal grain according to whether it is ear-plucked, reaped high or low on the stalk, or uprooted (Hillman 1981; Reynolds 1981; Van Zeist *et al*. 1986; Van der Veen 1992: 137; Campbell 2000).

The presumed objective of crop-processing is the systematic removal of chaff and weeds from the desired product (cereal grain). Extensive observation of traditional crop-processing methods in Turkey (Hillman 1984a; 1984b; 1985) and the Aegean (G. Jones 1984) has allowed the reconstruction of a series of crop-processing stages (different for glume wheats and free-threshing cereals), with identifiable products and by-products, characterised by the relative frequency of grain and chaff elements and weed seeds of different characteristics[4]. Comparison of the relative frequencies of these major crop elements in archaeobotanical assemblages to those in ethnographically observed products and by-products thus allows a sample's crop-processing derivation to be identified.

1.6.4.2. Identifying crop-processing derivation

A sample's crop-processing derivation can be determined through calculation of a series of ratios, comparing its composition in terms of major crop elements to that expected in a living crop (allowing for preservation-biases and taking account of the chaff:grain ratio of the species in question). This can be interpreted with reference to the composition of ethnographically observed crop-processing products and by-products (Van der Veen 1992: 82-84). An alternative method uses the characteristics (size, tendency to remain clustered in heads and aerodynamic qualities) which determine the behaviour of weed seeds during crop-processing as the discriminating variables in a discriminant analysis using control groups based on ethnographic data (G. Jones 1984; 1987; Van der Veen 1992: 84-86). Van der Veen (1992: 81-89) demonstrates the complementary use of both methods (Section 1.5.4.3), but notes the value of the former for identifying (rare) early-processing waste of a minor crop constituent (barley), missed by the statistical analysis.

As well as offering insight into the nature of crop-related behaviours (Section 1.6.4.3), identification of samples' crop-processing derivation enables compositional variation

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[4] The use of ethnographic information to elucidate prehistoric practice is justified on the basis that "*in the absence of modern technology there are very few ways of doing any one of the jobs involved in growing and processing any particular crop*" (Hillman 1984a: 8; cf. G. Jones 1984: 46). The similarity of crop-processing practice identified in studies of traditional crop-processing in Turkey (Hillman 1984b; 1985) and the Aegean (G. Jones 1984), and observed in Palestine (Dalman, cited by Hillman 1984b), offers some support for this statement.

caused by differing crop-processing derivation to be eliminated prior to further analysis (e.g. investigation of weed ecology; G. Jones 1984; Van der Veen 1992: 81, 89).

1.6.4.3. Interpreting crop-processing derivation

Scale of activity

Sparse deposits of crop-processing products or by-products are likely to represent multiple depositions of small amounts of material generated and carbonised in the course of small-scale day-to-day activity or (in the case of products) minor accidents during this activity (Van der Veen and Jones 2006; Van der Veen 2007). Generation and deposition of fine-sieving by-products on this scale suggests storage of semi-cleaned crops (i.e. spikelets for glume wheats) after harvest (see below).

Dense assemblages of clean (i.e. fully processed) cereal grain have been interpreted as evidence of producer sites (M. Jones 1985) or of communal grain storage (Stevens 2003a). Following a critical assessment of these interpretations, Van der Veen and Jones (2006) conclude that grain is likely to become carbonised through occasional accidents, rather than regularly, in the course of its day to day use. They suggest that such accidents will occur more often where more grain is present. Frequent occurrence of grain-rich assemblages on a regional scale is thus interpreted as evidence of large-scale production, suggestive of an arable surplus.

The by-products of early-stage crop-processing are ill-suited to surviving the carbonisation process and are rare in the archaeobotanical record (Hillman 1981; Van der Veen 1992: 98). Consequently, archaeobotanical samples rich in chaff and weed seeds tend to represent the by-products of fine-sieving. Dense fine-sieving by-product samples may represent material conserved from numerous small-scale processing events, but are more likely to represent bulk dehusking and fine-sieving.

Nature of activity

Dense clean grain deposits may represent accidents during bulk-processing or storage, deliberate burning of waste (if spoilt), cleansing of (Iron Age) underground storage pits, or malicious acts (Van der Veen 2007).

Bulk fine-sieving may have occurred following the harvest and prior to storage as clean grain, or following spikelet-storage and prior to final use (e.g. culinary preparation). Either way, it would require the mobilisation of labour beyond the resources of a household engaged in subsistence agriculture (cf. Stevens 2003a; Van der Veen and Jones 2006). Its by-products may have been regarded, and disposed of, as waste. Alternatively, Campbell (2000) suggests use (potentially of early-processing, as well as fine-sieving, by-products) as animal fodder, which would leave no trace save scarcity in the carbonised record. Van der Veen (1999) considers the potential of fine-sieving by-products as fuel, i.e. as a commodity in their own right.

Spikelets, sieving and storage

Ethnographically observed practice (Hillman 1981: fig. 5) includes the storage of glume wheats as sieved spikelets and as clean grain. Storage of clean grain implies the availability of sufficient labour to fully process the harvest prior to storage, while spikelet-storage implies less labour at harvest time but increased year-round work-load (cf. Stevens 2003a). The weighting towards year-round labour would be increased by storage of unsieved spikelets.

Germination, malting, and beer

Malting is the process of roasting grain to arrest germination after a release of enzymes has converted the grains' starch to sugar (maltose), but before this has been used to fuel the growth of a new plant. It is a necessary precursor to fermentation in the production of beer. Germination can be identified in archaeobotanical assemblages by the presence of grain shoots (coleoptiles), attached to or detached from grains, or by the hollowed/wasted appearance of grains which have undergone this process.

Malting was suggested by Reynolds and Langley (1979) and confirmed by Van der Veen (1989) as an alternative use to drying/parching for Roman corndriers (Section 1.5.3.5). Large-scale malting, using dedicated ovens and producing large quantities of debris which form dense carbonised deposits, implies production of beer in quantities larger than required for personal consumption.

The presence of germinated grain in a carbonised assemblage is not clear evidence for malting. Germination may occur accidentally in stored grain, especially if harvested damp or becoming damp during storage (cf. Hillman 1981). One way of distinguishing 'spoilt' grain from malt is to consider the proportion of grain affected by germination. In modern malt, a germination level of 70% is normal but this may have been far lower in ancient times (Van der Veen 1989).

A grain store affected by germination may have been considered 'spoilt', and destroyed by fire, resulting in carbonisation. Alternatively, low levels of germination may not have been perceived as spoilage, and so have had no effect on how grain was used or carbonised (cf. Hall and Kenward 2007). There is also a possibility that such grain was parched, perhaps in a corndrier, to arrest germination and prevent further germination/spoilage (cf. Hillman 1981). This means that the combination of derivation from a corndrier and evidence of germination does not prove malting. Malting is thus very difficult to identify archaeobotanically, but deposits with evidence for significant germination occurring in/in association with features such as corndriers warrant consideration as potential evidence of its practice.

1.6.5. Weed ecology and cultivation practice

1.6.5.1. Underlying principles

Some insight into cultivation practice may be gained from archaeological evidence, e.g. plough marks (e.g. Booth *et al*. 2007: 284; Robinson and Lambrick 2009), scatters of abraded pottery representing midden-spreading (e.g. M. Jones 1981; Rogerson 1999), sea shells or seaweed macrofossils representing use of seaweed as fertiliser (M. Jones 1981; Huntley and O'Brien 2009), or chalk quarry pits interpreted as sources of marl (e.g. Cunliffe 2000: 131). However, this type of evidence is not frequently available. More consistent and more definitive characterisations of cultivation practice may be gained through ecological characterisation of the weed seeds in archaeobotanical samples (as in Chapter 6).

As weed species have their own ecological requirements and preferences, the weed flora of an arable crop reflects its growing conditions. This includes both natural conditions (e.g. prevailing climate, nature of the soil) and conditions created through human action in choice of cultivation practice.

1.6.5.2. Methodological approaches: potential and limitations

Three methods have been used to elucidate cultivation practice from weed ecology: phytosociology (identification of plant communities which occur today under specific growing conditions), autecology (interpretation of species' ecological preferences/tolerances) and functional autecology (identification of specific links between plants' characteristics and growing conditions).

Phytosociology (Braun-Blanquet 1964; Westhoff and Van der Maarel 1973 for a detailed English language summary) is based on a hierarchical classification of syntaxa (plant communities of defined floristic composition) identified through analysis of the vegetation occurring in a sample plot. Though it is an appropriate tool for defining modern plant communities, and has been used in several continental archaeobotanical studies, the incomplete nature archaeobotanical samples (Section 1.6.2 and 1.6.4) precludes their accurate comparison with modern syntaxa. Further problems with the application of this approach to archaeobotanical datasets – not least the likelihood that past plant communities differed from their modern counterparts (especially true of arable weed communities under different cultivation regimes; Holzner 1978) – are summarised in Van der Veen's (1992: 101-108) description and critique of the method.

Autecology as a method for studying weed ecology was developed by Ellenberg (1950; 1979), based on assessment of species' tolerance for a range of environmental conditions. A species' presence is seen as indicative of conditions within its limits of tolerance. Species' tolerances of both climatic (light, temperature and continentality) and edaphic (soil moisture, pH and nitrogen content) factors are recorded as indicator values ('Ellenberg numbers') to facilitate interpretation. As climatic variation across a species' geographical range can affect its tolerance for (or ability to compete under) specific edaphic conditions (Holzner 1978; Van der Veen 1992: 106), use of localised autecological studies (e.g. Hill *et al*. 1999; 2004 for Britain) is recommended (Van der Veen 1992: 106, 108).

Some studies explicitly consider only the tolerances of 'indicator species' (those with a narrow range of tolerance for a given environmental factor; e.g. Behre 1986). Others implicitly follow this principal, using those species which have very clear ecological preferences to infer past growing conditions (e.g. Robinson 1981; Van der Veen in Jobey and Jobey 1987; Straker 2000). Autecological studies of past weed ecology involving assessment of all species in an assemblage are rare; Van der Veen's (1992: 111-143) study (Section 1.5.4.3) is the prime British example. This approach eliminates the possibility that apparent indicator species represent contamination of the archaeobotanical material (Van der Veen 1992: 109; G. Jones 1992; 2002) and prevents erroneous interpretation based on individual species whose (apparent) environmental tolerances have not remained constant over time (cf. Holzner 1978; G. Jones 1992; Van der Veen 1992: 108).

Functional Autecology, specifically the FIBS (Functional Interpretation of Botanical Surveys) approach (Hodgson 1989; 1990; 1991; Hodgson and Grime 1990), relates combinations of genetically determined functional characteristics of arable weeds to specific cultivation practices. Once a relationship between a specific functional characteristic and a specific ecological factor has been identified, any plant having that characteristic can be used to identify the influence of that factor, regardless of location, date, crop, or plant species (Charles *et al.* 2002). The validity of the method has been tested through a series of studies of modern fields (Charles *et al*. 1997; Bogaard *et al*. 1999; 2001; 2002; G. Jones *et al*. 2000). To date there have been only two archaeobotanical applications (Hodgson *et al*. 1999; Bogaard 2004). Measurements of species' functional characteristics, needed for the application of this method, are not yet available outside of the research group which developed it.

Some autecological studies have also taken account of plant characteristics such as typical height (e.g. Van Zeist *et al*. 1986; Van der Veen 1992: 137), perennial root type/regenerative ability (e.g. Van der Veen 1992: 137-138), germination time (e.g. Van der Veen 1992: 132-134), flowering time (e.g. Campbell 2000), and annual/perennial life history (e.g. Van der Veen 1992: 137-138). They thus combine autecology with the principals of functional autecology to good effect, demonstrating that combined consideration of multiple lines of evidence facilitates the linking specific cause to specific effect and so increases the precision of interpretation (Van der Veen 1992: 111-143; Charles *et al*. 1997).

1.6.5.3. Equifinality

Distinction between cultivation practices which have very similar effects on growing environment – e.g. spring-sowing and soil improvement, or manuring, tillage, and other disturbance such as weeding (cf. Van der Veen 1992: 139; G. Jones *et al.* 2000; Bogaard 2004) – remains difficult. As the digging-in of manure may not be separate practice from the turning and aeration of the soil, the effects of manuring and tillage on arable weed assemblages will always be difficult to separate (Van der Veen *pers. comm.* 16/08/2008). On one level, these distinctions matter little, as manuring, tillage and weeding all represent investment to increase crop-yields. However, as the three differ in required level and timing of labour input, inability to distinguish between them limits the potential for linking intensification of arable practice to wider considerations of settlement resources and social organisation.

1.7. Summary

In this introductory chapter I have set out the background to this project and set this research in the context of current understanding of the arable practice and wider society of the study region (and Britain more widely) in the Iron Age and Roman period. I have also set out the project's objectives, which can be summarised as

- Compilation of data on Iron Age and Roman assemblages from the Iron Age and Roman East of England.
- Analysis and interpretation of data to inform understanding of arable practice (the crops cultivated, the behaviours associated with their processing, storage and utilisation, and the strategies employed in their cultivation).

- Consideration of arable practice in light of the region's wider archaeological record to contribute to understanding of wider social/political/economic developments,

The structure of the remainder of the thesis is as follows. In Chapter 2 I describe the methodology of data collection and recording, quantify the data collected, and summarise its chronological and spatial distribution within the study period/region. I also give an overview of the analytical techniques used in subsequent chapters.

In Chapters 3-6, I develop the principal analyses of this research: identification of the cereals cultivated (Chapter 3), identification of behaviour associated with crop-processing, storage and use (Chapter 4) and identification of the ways in which crops were cultivated, specifically whether they were cultivated together or separately (Chapter 5), and the cultivation strategies employed (Chapter 6). In Chapter 7, I present a supplementary analysis of the distribution of non-cereal species of potential economic importance in the dataset. Each of these chapters includes presentation of methodology, results of analysis and interpretation of the crop-related practices represented, as well as assessment of success and limitations and a summary of key findings.

The findings of this research are drawn together and discussed in their wider archaeological context in Chapter 8. This chapter also includes an assessment of the availability and quality of relevant data. Conclusions are presented in Chapter 9.

2. Data collection and analytical methods

2.1. Sources of information

Information was gathered primarily from existing (published and unpublished) archaeobotanical reports. Relevant data was identified by contacting archaeobotanists currently/previously working in the region, and through searches of

- the Environmental Archaeology Bibliography (EAB, Hall 2004) and ArchaeoBotanical Computer Database (ABCD, Tomlinson and Hall 1996, updated information obtained from Allan Hall),
- relevant period- and region-specific journals and report series[5],
- English Heritage Ancient Monuments Laboratory (EH AML) Report series,
- bibliography of the draft English Heritage review of plant macrofossils for the East of England and Midlands (Murphy and de Moulins 2002),
- dataset collected by Van der Veen *et al*. (2008).

Published reports were accessed at the University of Leicester Library, the British Library and the Bodleian Library. Site context information for unpublished archaeobotanical reports was obtained from the archaeological units which had commissioned the work, or through searches of the relevant Historic Environment Records. Permission to use data from non-AML unpublished reports has been given by both the authors of the archaeobotanical reports and the commissioning bodies.

Data was collected from reports on open area excavations only. Data from trial trench (evaluation) projects was not collected, unless incorporated into reports on subsequent

[5] Journals found to contain relevant information: Norfolk Archaeology, Proceedings of the Suffolk Institute of Archaeology and History, Essex Archaeology and History, Hertfordshire Archaeology and History, Proceedings of the Cambridgeshire Antiquarian Society, Bedfordshire Archaeology, Proceedings of the Prehistoric Society, Britannia. Report series found to contain relevant information: East Anglian Archaeology, CBA research Reports, BAR (British Series), Oxbow Monographs.

open area excavations, owing to lack of confidence in the interpretation of dating and site-types for this type of intervention. In addition to existing data, new data was generated through analysis of the plant macrofossil assemblage from a single site at Tunbridge Lane, Bottisham (Nicholson 2008). Data collection ceased in May 2009.

2.2. Recording

2.2.1. Identification and categorisation of records

Each site was subdivided into period-specific ‘records’. Each record was assigned a number. Information pertaining to its location (NGR), date (Table 2.1) and type (Table 2.2), including a note of any evidence suggesting high status or ritual activity, were entered into an Excel spreadsheet, along with its bibliographic reference (Spreadsheet 1, shown in Appendix 1).

Period	**Description**
EIA	800-400/300BC. Includes the Earliest Iron Age (Late Bronze Age/Early Iron Age transition). Also includes records with given dates of Early to Middle Iron Age.
MIA	400/300 - 100 BC. Also includes records with given date of Middle to Late Iron Age, usually applied in areas where ceramics did not change significantly in this period.
LIA	100BC – AD 43. Also includes records with given date of Late Iron Age to Early Roman, usually applied to sites at which ceramic dating cannot distinguish pre/post-Conquest activity.
ER	AD 43 – 100. Also includes records whose dates cannot be refined beyond AD 43 - 200.
MR	AD 100 – 300. Also includes records whose dates cannot be refined beyond AD 100 – 410.
LR	AD 300 – 410.

Table 2.1 Period subdivisions.

Dating information given in source reports was critically assessed before records were assigned to period. More refined period sub-divisions than those given in Table 2.1 (e.g. distinguishing between Middle and Middle to Late Iron Age) would have been preferred, but would have resulted in overly small datasets. Where the date given in the source material fell between the core date ranges given for each period in Table 2.1, the record was included in the earlier of the possible categories (e.g. 'MIA' also includes records whose date was given as MIA-LIA), owing to the lack of clear evidence for the innovations in material culture that would allow it to be considered as part of the later category. The least satisfactory of these decisions was the amalgamation of records with dates of AD 43-200 into 'ER'. However, this affected only six records, and was consistent with the decisions made for other periods, and with the logic above.

A small number of records which could be identified only as 'Roman', 'Iron Age' or 'Late Iron Age – Roman' were also recorded (Table 2.3 and Appendix 1). These were included in analyses to identify crop species (Chapter 3), but proved to be of little significance. They were excluded from further analysis.

Classification of record-types (Table 2.2) was straightforward in some cases, but more complicated in others. Where a site's archaeology suggested more than one type of activity within a period, separated spatially or chronologically, more than one record was assigned. For example, the cemeteries and settlements at LIA North Shoebury, ER Addenbrooke's, ER Vicar's Farm, Cambridge, and MR Rectory Farm, Godmanchester, were assigned separate records. Similarly, samples from features relating to the fort (AD 43-47) and subsequent *Colonia* at Culver Street, Colchester, were assigned to two separate records within the ER period. In practice, it was found that samples from cemeteries related to settlements were either too small for analysis or interpretation, or were similar to those from the settlements: in such cases, these paired records are considered as one in the following chapters. Where burials occurred within settlements but were not spatially distinct, records were classified according to the type of settlement represented.

		Number of records*					
Category	**Comment**	**EIA**	**MIA**	**LIA**	**ER**	**MR**	**LR**
'Hillfort'	Large, ramparted enclosure with evidence of settlement (similar but apparently unoccupied sites are classed as ceremonial).	0/0	2/2	1/1	0/0	0/0	0/0
Discrete enclosed settlement	Enclosure with internal settlement features (or finds evidence to suggest their presence if heavily truncated); no/sparse external features. Can have associated field system but this would have no internal features (i.e. field boundaries only).	0/0	8/5	8/6	3/3	5/5	1/1
Open settlement	Spread of settlement features over a wide area with no evidence of overall enclosure. May be some enclosed elements or other boundary features within the spread. Generally an IA site type.	13/5	8/5	0/0	0/0	0/0	0/0
Complex rural settlement	Settlement features set in multiple enclosures. Generally occur in LIA or Roman period.	1/1	6/3	11/7	11/9	15/14	17/15
Settlement, unclear	Features thought to be part of a settlement extending significantly beyond the excavated area and so of unclear nature/morphology. Category usually applied where area of excavation was small or focused on periphery of settlement.	4/3	5/4	3/3	2/1	4/3	3/2
Field system	Features demarcating boundaries of large plots with no (potentially domestic) structures and no finds evidence to suggest nearby occupation.	0/0	1/1	2/1	6/4	2/2	6/4
Industrial	Site whose main focus appears to have been industrial. Includes pottery production sites, quarries, salterns and metal-working sites. Single industrial features (e.g.) kilns also exist within settlement sites.	0/0	0/0	0/0	5/4	4/3	3/1
Maltings	Sites with evidence of large scale crop-processing activity, identified in source report as malting. Identifications of maltings are scrutinised in Chapter 4.	0/0	0/0	0/0	0/0	2/2	1/1
Small town	After Drury and Rodwell (1980), Burnham and Wacher (1990), Plouviez (1995), Gurney (1995) and Going (1996; 1997).	0/0	0/0	0/0	1/1	6/4	3/0
Major town	One of the three *civitas* capitals in the study region.	0/0	0/0	0/0	5/5	3/3	2/1
Military	From within the walls of a fort.	0/0	0/0	0/0	3/2	0/0	1/1
Burial/Ceremonial	Cemetery sites or spatially distinct burial areas within wider settlements (not used in cases of single burials among settlement features) and sites interpreted as having primarily ritual, symbolic or ceremonial function (e.g. unoccupied 'hillforts').	6/2	2/2	8/3	3/0	3/1	2/1
Isolated features	Individual features/small groups of features with no clear interpretation.	2/0	1/1	3/0	2/1	0/0	1/1

*All records/ records included in Method 2 for crop identification (Chapter 3) and crop-processing analysis (Chapter 4)

Table 2.2 Record types.

The chronological distribution of records by type shown in Table 2.2 is also shown in Figs. 2.1-2.6. This highlights the dominance of complex rural settlement records from the LIA onwards; other rural settlements are more common in the EIA and MIA, but rare in the later part of the study period. It also highlights the greater variety of record-types in the Roman period compared to the Iron Age. This is because of the introduction of new settlement types (small and major towns), as well as sites with new functions (military sites/forts, industrial sites and maltings). Major towns, military sites and industrial sites are particularly well represented in the ER period, and small towns in the MR period. Maltings date to the MR and LR periods only.

Although the numbers differ a little, there is no significant discrepancy in the distribution of record-types when all records are considered and when only those selected for crop-processing analysis are considered.

The spatial distribution of records is shown in Fig. 2.7. Some biases are clearly apparent, most noticeably the scarcity of records on the northern till, especially in the LIA and ER periods. This is partly accounted for by a high incidence of reports from this area lacking full quantification (i.e. using 'abundance scores', see Section 2.3) noted during data collection. The distribution of records also reflects the distribution of post-PPG16 developer funded projects, with concentrations in the areas around Cambridge, Ely, Colchester (also reflecting the known existence and research potential of a major Roman town beneath the modern town), Bedford and Stansted Airport. Less easily recognised is the skewing of the MIA dataset for the south-east toward hillfort-records, which account for two of the six records, and the majority of samples, from this area/period.

2.2.2. Recording of samples

Each sample within every record was given its own number. These were entered into Spreadsheet 2, referenced to the record from which they came (i.e. linked to their date, location and record-type). The content of each sample, identified by taxon and plant-element and quantified as in its source report, was then recorded in Spreadsheet 2. This also included a record of sample volume (or weight if volume not available).

It was not the intent of this study to explore the relationship between feature/context-type and the nature of archaeobotanical deposits. Nonetheless, this information was also recorded (where available) in Spreadsheet 2. Distinctive sample contents/ interpretations identified in subsequent chapters are sometimes linked to, or explained by, unusual or distinctive archaeological contexts; this is commented on as it occurs.

Records and samples are quantified by period in Table 2.3. Their spatial distribution is shown (by period) in Fig. 2.7. The selection of samples for each analysis is detailed in the methodology of the relevant chapter. The necessity and effects of reduction of the dataset for analysis is discussed in the analysis chapters (3-7) and its consequences explored in Chapter 8.

Period	**Records**	**Samples**
EIA	29	171
MIA	33	359
LIA	36	272
ER	41	452
MR	45	715
LR	40	471
Total (datable)	*224*	*2440*
(IA	5	30)
(R	19	85)
(LIA-R	2	44)

Table 2.3. Summary of records and samples

2.2.3. Nomenclature and quantification

All samples were initially recorded using the species-nomenclature of their source report. Synonymic taxonomic labels were then merged. Traditional classifications (Zohary and Hopf 2000: 28, 65) are used for cereal species; nomenclature for other species follows Stace (1997).

The minimum number of elements was recorded for each plant element (seeds, grains, chaff items and others) and taxa. Counts of Fabaceae cotyledons given in some sources were converted to minimum numbers of Fabaceae seeds. Counts of spikelet forks or spikelet bases were converted to minimum numbers of glume bases. Rachises were variously quantified in the source material by number of segments, number of nodes and number of internodes; these categories were combined to give a minimum number of rachis nodes.

Counts of items which are uncountable for analytical purposes (e.g. cereal awn, palea or lemma fragments, nutshell fragments, thorns and buds) were recorded if given, but were excluded from quantitative analyses.

Where counts of seed fragments were given in the source material, it was assumed that a single seed could not be represented by more than three identifiable fragments and a minimum number of seeds was calculated on this basis. Unquantified fragments and items recorded only as ‘present’ in otherwise quantified reports were recorded as single items (i.e. the minimum possible representation). Where these courses of action were taken, the original information was retained in Spreadsheet 2 using a review-comment linked to the appropriate cell. Although somewhat arbitrary, this system allows fragment-count information and the ‘presence’ of unquantified items in otherwise quantified samples to be incorporated into the analyses.

Any information pertaining to the presence or quantification of germinated grain or to the size of items not identified to species level was recorded in Spreadsheet 2 using a review-comment linked to the appropriate cell.

2.2.4. The datasets for analysis

The samples in Spreadsheet 2 were carried forwards for analysis to identify the crop species cultivated (Chapter 3), the ways in which these were processed, stored and utilised (Chapter 4) and the ways in which they were grown (Chapters 5-6). Each of these analyses involved the honing of the dataset to include only appropriate samples which would yield reliable results. Details of these refinements are given in the methodology sections of these chapters.

2.3. Additional records

An additional 114 records were identified which lacked full quantification of plant macrofossils by sample (Table 2.4 and Appendix 1). Some of these included only a text-description of the site assemblage, while others used a system of partial quantification based on 'abundance scores' (e.g. x=1-10, xx=10-100, xxx=100+). Where the existence of fully quantified data was indicated (e.g. in a site archive or EH AML Report), and where the available information suggested a substantial assemblage, this was pursued and incorporated into Spreadsheet 2. In other cases, the presence of species of potential economic importance was recorded separately (Spreadsheet 3) by record (not by sample). Most samples in these records contained only small numbers of items (probably owing, in many cases, to the small sample sizes indicated), but some were larger and would have been worthwhile additions to the main dataset if fully quantified.

Period	Additional records
EIA	19
MIA	19
LIA	20
ER	19
MR	27
LR	9
Total	*113*

Table 2.4. Additional records (lacking full quantification)

These records could not be included in the main analyses of this report, but were incorporated into Chapter 7, which examines evidence for presence and cultivation of non-cereal crops and wild/gathered plants of potential economic importance.

2.4. Analytical methods

2.4.1. Preface

The methods used in each analysis are detailed in Chapters 3-8. Most analyses were straightforward, involving the calculation of percentages (e.g. percentage of all samples in which spelt is present) or ratios (e.g. glume bases: grain). However, in Chapters 4, 5 and 6, correspondence analysis is also employed, to allow consideration of multiple variables in a single analysis.

2.4.2. Introduction to correspondence analysis

Correspondence analysis has previously been applied in the development of the FIBS methodology (Section 1.6.5) for interpreting the relationship between weed ecology and cultivation practice (Charles *et al*. 1997; Bogaard *et al*. 1999; 2001; 2002; G. Jones *et al*. 2000), including a successful application to an archaeobotanical dataset (Bogaard 2004).

It is a multivariate method whose mathematical basis is set out by Shennan (1997: 308-341) and Baxter (1994: 100-133). It is used to synthesise 'composite variables', representative of all variation within a dataset, from existing multiple variables. Each composite variable can be plotted along a single axis. These are ordered so that the greatest variation is expressed by the first composite variable (i.e. seen along the first axis), with ever-decreasing degrees of variation represented by subsequent composite variables. The significant variation within a dataset is frequently expressed within the first two composite variables, and so can be represented in an *x-y* plot of these.

Data may be plotted against these axes either as samples (units whose characteristics have been measured, in this case archaeobotanical samples) or species (the types which occur within those samples, in this case biological species/taxa). As the meaning of variation along each axis is unknown, it must be interpreted/tested by coding the data-points (samples or species) according to their known characteristics, and looking for meaning in the patterning of this information along the axes. The *x* axis (representing the first composite variable) should be read/interpreted first, then the *y* axis (second composite variable).

Samples plotting close to the origin (*0,0*) of the CA plot are of normal/average composition, while increasing distance from this point indicates increasingly unusual composition. Similarly, species plotted close to the origin are common or ubiquitous, and thus offer no discrimination between samples. Species plotted at a distance from the origin occur in some but not all samples, and so offer insights into differences between the samples. Directionality is meaningful in interpretation of distance from the origin of the CA plot, with positive associations between data-points diverging in the same direction from the origin, and negative associations between those diverging in opposite directions.

As CA takes account of all variation in the samples, rare species (those occurring in only a small proportion of samples) have a disproportionate influence on the formation of the composite variables. Variation along an axis may thus result (almost) entirely from the rarity of one species or from the presence of one rare species in a sample. As the presence of such species in archaeobotanical samples is often a matter of chance (and may signify minor sample contamination) this influence is disproportionate to the species' actual significance, and obscures more meaningful variation between the remaining species (Gauch 1982: 214; G. Jones 1991: 68). The exclusion of rare species is thus a necessary precursor to correspondence analysis in archaeobotanical studies.

In previous archaeobotanical and ethnobotanical studies using similar analytical techniques, rare taxa have been defined as those occurring in ≥10% of samples (e.g. Van der Veen 1992: 25; G. Jones *et al*. 1999). Some ecological studies use a 5% cut-off point (Gauch 1982: 214). Details of the limits used in this research are given in the methodologies of Chapters 4, 5 and 6.

3. Crop choice

3.1. Objective and approach

The objectives of this chapter are to identify the cereal crops grown in the region, and interpret variation by period, location, and/or record type. Cereals are the economic plants best represented in the carbonised samples on which this research is based. Other taxa of potential economic importance are less abundant, and their significance less easy to interpret. They are considered separately in Chapter 7.

Different cereal species require different investment of time and resources for cultivation and processing. The species cultivated thus give an insight into the availability and organisation of land, labour and resources. They also have different culinary qualities, which could provide insight into how food and drink were consumed. Furthermore, patterns of variation in the species cultivated may suggest links between, or common influences on, different sites or regions. This chapter serves to identify the cereals cultivated, and any patterns in their distribution.

The difficulties of accurately identifying species which were cultivated, rather than species which were present as contaminants/volunteers of other crops, from archaeobotanical samples have been described in Section 1.6.3. The (contradictory) state of affairs is that we must not give too much weight to species represented by small numbers of items, but that even a small number of items (if accurately identified) is potentially significant. In this study, a dual-method approach to crop identification is used, firstly identifying all potential crop species which are present, secondly identifying those which are present in numbers large enough to be reliably representative. Both methods allow the identification of more than one crop species in a sample. The question of whether these were cultivated together as maslins, or mixed after harvest, is addressed separately (Chapter 5).

Crops were identified on a sample-by-sample basis. The crops identified in individual samples then formed the basis for interpretation of crop-choice on a regional scale. This was done without the 'intermediate' stage of interpreting which species were cultivated in each individual record (cf. Jones and Halstead 1995; Van der Veen and Jones 2006[6]). Its justification is that the probability of a pattern's correctness is increased by the number of samples on which it is based. Combining small numbers of samples for interpretation at 'record level' (and then combining these record interpretations for regional interpretation) thus gives a less reliable indication of which species were cultivated than does combining all samples for interpretation on a regional scale.

The methodologies for these analyses are presented in Section 3.2. Results are presented in Section 3.3, with comments on the chronological distribution of each species' cultivation and an assessment of the two methodologies employed. In Section 3.4 I examine the distribution of different crops according to location and record-type. Section 3.5 comprises an assessment of the success of this analysis, and a statement of its key findings, including a summary of those to be carried forward for consideration in Chapter 8.

3.2. Methodology

3.2.1. Method 1

All samples were included in Method 1, and the presence of a species' grain or chaff was considered as potential evidence of its cultivation.

[6] Recommended for identification of crop-processing derivation.

Definite, 'cf.' and X-type identifications were amalgamated. Items not identified to species (e.g. Cerealia indet., *Triticum sp*., glume wheat, *Triticum/Hordeum sp*.) were excluded, with two exceptions. Firstly, given the absence of *H. distichum* from the dataset, *Hordeum sp.* was treated as *H. vulgare* (which was assumed to be hulled unless otherwise specified). Secondly, all identifications of free-threshing wheat were grouped together in a single category. This was considered justifiable as all source-reports identified either 'free-threshing wheat' or *Triticum aestivum*; no other free-threshing wheat species are known from Iron Age or Roman Britain.

In a small number of source reports, wheat grains were described as a mixture of species (e.g. '50 grains including *Triticum spelta*-type, and *T. dicoccum*-type'), or as being mainly of one species, with other species also present (e.g. '50 grains, mainly *Triticum spelta*-type with *T. aestivum*-type also present'). In Method 1, all species mentioned in such descriptions were considered to be present in the sample. Where identification of cereal items to species level was not possible (e.g. items identified only as 'glume wheat'), these items were excluded from consideration.

3.2.2. Method 2.

Method 2 aimed not to attribute undue significance to items identified tentatively and/or in very small quantities. Identification of crops by this method was based on identification of crop-processing derivation: only those species whose products/ by-products were identified in samples of known crop-processing derivation (i.e. which had met the selection criteria and undergone the processes of item reallocation necessary for that identification, as set out in Section 4.2.1) were considered to have been cultivated.

One of the criteria for samples' inclusion in analysis of crop-processing derivation was presence of ≥50 identified items (to ensure representativeness). Failure to meet this criterion was the main reason for exclusion of samples from Method 2.

The preparation of data for analysis of crop-processing derivation included the reallocation of items with broad identifications to individual species (Section 4.2.1). This meant that items originally identified as 'glume wheat', and so excluded from Method 1, were identified in Method 2 as spelt or emmer, increasing the representation of these species. In a small number of cases this reallocation was not possible, meaning that crop-processing products/by-products of 'glume wheat' are identified in Chapter 4, and that 'glume wheat' is identified as a crop by Method 2.

Of the seven ratios calculated to characterise samples' crop-processing derivation, two were relevant to the identification of crops: Ratios B (rachis internodes: free-threshing grains) and C (glume bases: glume wheat grains), both calculated separately for each relevant species. If multiple species were present in the sample, the less frequently occurring were included in the characterisation of crop-processing derivation (and so identified as a crop) only if they accounted for a significant proportion of the total identifications in the sample. A cut off point of ≥10% of relevant, comparable items was used as guidance in this decision, though the absolute number of usable identifications and the nature (especially susceptibility to destruction during the carbonisation process) of the crop items being compared was also taken into account. For example, where Ratio B indicated the clean barley grain and Ratio C clean spelt grain, the sample would be interpreted as representing cultivation of both species only if both accounted for ≥10% of all grain in the sample.

In several cases where Ratio C indicated a glume wheat fine-sieving by-product, small numbers of barley (or bread wheat) grains were also present. These samples were interpreted as the combined fine-sieving by-product of glume wheat and barley only if the number of barley grains was ≥10% of the number of spelt wheat grains. If barley rachis nodes were also present, interpretation as mixed by-products from the fine-sieving of spelt and early-processing of barley was considered. If the number of barley grains was too small to be considered signficant, the sample was interpreted as the fine-sieving by-product of a spelt harvest in which barley had been incidentally present.

Samples identified as fine-sieving by-products of indeterminate wheat (dominated by small weed seeds but also containing small numbers of indeterminate wheat grains) were considered to represent a free-threshing wheat crop, owing to the absence of glume bases which would have indicated a glume wheat. The few samples of this composition were labelled as fine-sieving by-products of *T. aestivum*, though a degree of uncertainty in this interpretation is acknowledged.

For the identification of crop-processing derivation, wheat grains described as 'mainly' of one/more species or type were re-allocated as *Triticum sp*. if both free-threshing and glume wheats were also present in the sample (Section 4.2.1). This was considered unnecessary for the identification of crop species. Consequently, following the initial identification of crops by Method 2, all occurrences of *Triticum sp*. were cross checked against the original records and were modified to species if appropriate. If wheat grains were described as 'mainly' of more than one species, the modification was made only if the number of grains was sufficient to suggest significant presence of more than one species.

In recognition of their susceptibility to destruction during the carbonisation process, the presence of *Avena sativa/strigosa* floret bases was considered on a case-by-case basis as potential evidence for oat cultivation.

3.3. Cereal crops

3.3.1. The datasets for Methods 1 and 2

Method 1 is based on all 2440 datable samples (Section 2.2.2). Method 2 is based on the 725 samples which were included in analysis of crop-processing derivation. This includes 32 samples whose crop-processing derivation was concluded to be unclear. In most of these crops were identified, but the combination of items present could not be interpreted in terms of crop-processing derivation. The others lacked cereal items on which to base a crop identification; they are included in the total number of samples considered, but no crop identifications are made.

The chronological allocation of these samples is shown in Table 3.1, and the spatial distribution of the records from which they came is shown in Figs. 2.7 (Method 1) and 3.1 (Method 2). Bibliographic references for all records mentioned in the text are given in Appendix 1[7].

Period	**No. of samples (Method 1)**	**No. of samples (Method 2)**
EIA	171	33
MIA	359	78
LIA	273	75
ER	439	136
MR	727	239
LR	471	164
Total	*2,440*	*725*

Table 3.1. Number of samples included in analyses by Methods 1 and 2.

[7] The first mention of each record is suffixed with the record number to allow cross-referencing.

Samples which could be identified only as 'Iron Age', 'Roman' or 'Late Iron Age to Roman' were also analysed, but are not included in the presentation of results below, except where their interpretation makes a pertinent contribution to understanding.

3.3.2. The crops identified by Methods 1 and 2

Methods 1 and 2 produced broadly compatible results, identifying spelt wheat (*Triticum spelta*) and barley (*Hordeum vulgare*) as the major Iron Age and Roman crops of the study region, with emmer wheat (*T. dicoccum*), bread wheat (*T. aestivum*, though see Section 3.3.3.3) and (very rarely) rye (*Secale cereale*) also cultivated.

Method 1 also identified the presence of bristle oat (*A. strigosa*), naked barley (*H. vulgare* var. *nudum*) and possible einkorn wheat (*Triticum monococcum*) in the data set. These were based on just one or two items per period, some of which were only 'cf.' identifications. Some are likely to be misidentified, atypical, grains or chaff elements of other species. This is especially true of the four identifications of possible einkorn wheat, each represented by a single grain or glume base identified as *T. cf. monococcum* or *T. dicoccum/monococcum*. Others may represent incidental occurrence of these species within other crops, but none are considered to represent cultivation.

Cultivated oat (*Avena sativa*) was present in three samples (represented by three, nine and sixteen floret bases) from Asheldham Camp (R29), a MIA hillfort. These numbers were insignificant compared to the numbers of spelt glume bases in the same samples, and are not considered to represent cultivation.

3.3.3. Chronological patterns in crop choice

3.3.3.1. Spelt and barley

Methods 1 and 2 concur in indicating spelt and barley as the main crops cultivated in the Iron Age and Roman East of England (Figs. 3.2 and 3.3). Both methods show trends of increasing frequency of spelt-cultivation and decreasing frequency of barley-cultivation over time.

Method 2 indicates that spelt was cultivated more frequently than barley from the MIA onwards, but Method 1 indicates dominance of barley until the LIA (Figs. 3.2-3.4). While the frequency with which these species were cultivated remains comparable at least until the MR period in Method 1, spelt is clearly indicated as the dominant crop from the LIA onwards in Method 2. Both methods show a similar magnitude of increase in spelt-cultivation (*c.* 30% of samples from EIA to LR).

Decline in barley-cultivation is shown to occur in the MIA and LIA followed by slight recovery in the ER period (Figs 3.2 and 3.3). The overall magnitude of the decline is greater in Method 2 (53%, EIA-LIA, mostly EIA-MIA) than in Method 1 (10%, EIA-MR), i.e. the decline in this species' *presence* is less severe than the decline in its strong representation. This is thought to indicate a decline in barley-cultivation, occurring mostly from the EIA to the MIA (though low sample numbers for the EIA mean that this cannot be stated with certainty), but its continuing incidental presence in other crops.

3.3.3.2. Emmer

Emmer is shown by Method 2 to have been a significant Iron Age crop, cultivated more frequently than barley in the MIA, but declining thereafter, and cultivated only rarely in the MR and LR periods (Figs. 3.3 and 3.5). Method 1 allows emmer less significance, but identifies a similar decline in its cultivation, from the Iron Age and ER period (10-12% of samples) to the MR and LR periods (2-5% of samples) (Figs. 3.2 and 3.5).

Contrary to Murphy's hypothesis (Section 1.5.5.3) that spelt replaced emmer as the major crop in this region from the MIA, emmer is shown to have been cultivated less frequently than spelt by the beginning of the study period. Indeed, the MIA is shown (by Method 2) to have seen a resurgence in emmer-cultivation (Figs. 3.3 and 3.5).

The ratios of samples attesting emmer-/spelt-cultivation according to Methods 1 and 2 show divergence only in the MIA (Fig. 3.5). This is caused by Method 2's identification of a MIA increase in emmer-cultivation of far greater magnitude than the corresponding increase in spelt-cultivation (Fig. 3.3).

3.3.3.3. Bread wheat

Method 1 identifies bread wheat with comparable frequency to emmer in the Iron Age and ER period, and in a considerably higher proportion of samples in the MR and LR periods (Fig. 3.2). However, the *presence* of this species (or items identified as belonging to it) does not necessarily indicate its cultivation (Section 1.6.3).

Method 2 suggests that cultivation of bread wheat commenced and peaked in the MIA (17% of samples, mostly from Wendens Ambo, where bread wheat grain occurred mixed with that of spelt and emmer), being rare thereafter (2% to 7% of samples; Fig 3.3). Examination of the pre-rationalization data (see Section 4.2.1 and Table 4.1) for all samples identified by Method 2 as representing bread wheat cultivation shows that the original identifications were either uncertain ('cf.' or *aestivum*-type), or of very small numbers of items. The process of rationalization has increased both the apparent confidence of its identification and the apparent numbers in which it occurs. Though bread wheat cultivation remains a possibility, this study has not offered definite confirmation of its occurrence in the Iron Age or Roman period of this region.

3.3.3.4. Rye

Method 2 identified rye-cultivation in a single LR sample (Fig. 3.3) and in three samples dated only as 'Roman'. Method 1 recognised rye-cultivation in these samples, as well as in others, dating to all periods but the LIA (Fig. 3.2). These identifications were based on very small numbers of items (less than 5 grains or rachis nodes), or on numbers which were insignificant when compared to the number of spelt wheat glume bases in the same samples.

3.3.3.5. Glume wheat identified by Method 2

Items not identified to species were excluded from Method 1, but 'glume wheat' remained in the Method 2 dataset where reallocation to species proved impossible (Section 3.2.2). The only period for which 'glume wheat' cultivation was identified with sufficient frequency to have any effect on the overall patterns described above was the LIA (17% of samples).

If the LIA occurrences were spelt, the result would be a stronger representation of spelt-cultivation in the LIA than in the ER period. If they were emmer, LIA emmer-cultivation would be approximately as well represented as LIA barley-cultivation, and the decline in the ER period would be sharper. It is likely that both species are present.

3.3.4. Evaluation of Methods 1 and 2

The inclusive approach of Method 1 has, predictably, resulted in its identification of a wider range of potential crops than were identified by the more rigorous Method 2. However, when the species identified at very low frequencies by Method 1 were examined more closely all were discounted as crops (Section 3.3.2), resulting in the same crops being identified by both methods.

While concurring that spelt and barley were cultivated more frequently than the other species, Methods 1 and 2 diverge in their indications of which was more frequently cultivated in the MIA, and of whether barley continued to be cultivated with a frequency even comparable to spelt in the Roman period (Section 3.3.3.1). Caution must be exercised in the interpretation of the Roman samples, as the dominance of fine-sieving by-products over clean grain in the MR and LR period (Section 4.4.1) favours the identification of spelt-cultivation over that of barley-cultivation (owing to the relative invulnerability of spelt glume bases during the carbonisation process). The effects of this bias on Method 1 (which requires only the presence of a single item to identify cultivation) are less severe than those on Method 2. The identification of EIA barley cultivation in a higher proportion of samples by Method 2 than by Method 1, despite the strong representation of fine-sieving by-products in this period (Section 4.4.1), adds validity to the interpretation of barley as the dominant crop of this period.

Methods 1 and 2 differ in their identification of the frequency of bread wheat-cultivation in all periods save the MIA (Section 3.3.3.3). Method 1 identifies bread wheat in a higher proportion of samples than Method 2, suggesting that bread wheat was frequently present in small quantities, probably as an incidental contaminant of other crops. Neither method has offered firm evidence that bread wheat was cultivated in its own right, though there are samples which *suggest* that this occurred occasionally from the MIA onwards.

The two methods also differ in their indications of emmer's significance as a crop in the Iron Age (Section 3.3.3.2). Method 2 consistently identifies spelt- and (in the Iron Age) emmer-cultivation in a higher proportion of samples than Method 1. This is probably an effect of the reallocation and consequent inclusion in Method 2 of large numbers of items identified in the source material as 'glume wheat'. Although this has introduced a small element of doubt into the validity of identifications of spelt- and emmer-cultivation, it has allowed recognition of many instances of glume wheat cultivation which were ignored by Method 1.

Where the methods differ, Method 2 is favoured as the more rigorous of the two for the identification of cultivation (though with constant awareness of the potential for under-representation of free-threshing cereals in fine-sieving by-product samples). Its exclusion of samples potentially too small to accurately represent the deposits from which they were taken and its wariness of items identified insecurely or in very low numbers are considered to make it more reliable than Method 1 for accurately identifying the crops represented by individual samples. The results of Method 2 are used in the following discussion of non-chronological patterning in crop choice (Section 3.4) and in subsequent chapters.

3.4. Other patterns in the distribution of crop species[8]

3.4.1. Representation by record

The chronological distribution of *records* attesting barley-cultivation follows the same patters as the distribution of relevant samples (Fig. 3.6). This indicates that the patterns observed represent a reduction in the number of locations in which barley was grown in the Roman period, rather than the reduction of its status to a minor crop, grown alongside spelt wheat in numerous locations.

The proportion of records attesting spelt-cultivation remains relatively constant over time (Fig. 3.6), despite its representation in an increasing proportion of samples. It is generally represented in a higher number of samples/record in the Roman period than in the Iron Age. This probably results from a combination of higher availability of Roman than Iron Age samples suitable for inclusion in Method 2 (Table 3.1) and the increasing domination of fine-sieving by-products in the MR and LR periods (Section 3.3.4).

[8] Based on Method 2.

The number of records attesting emmer-cultivation is (like the number of samples) higher in the Iron Age than in the Roman period (Fig. 3.6). In the LIA, emmer-cultivation was identified at a higher proportion of records (i.e. in more locations) than barley-cultivation, despite being attested in marginally fewer samples (compare Figs. 3.3 and 3.6).

3.4.2. Spatial patterns

3.4.2.1. Overview

Some sub-regions, and some record-types, had no samples included in Method 2 for some periods; others were represented by very few samples from very few records, preventing reliable interpretation. In the discussion below, only patterns relating to areas and record-types represented by a reasonable number[9] of samples are discussed.

In all periods spelt- and barley-cultivation were attested in all sub-regions for which data existed, with three exceptions for barley (two LIA, one MR) and one for spelt (LR), all from sub-regions represented by very low numbers of samples. Emmer was cultivated less frequently than spelt or barley in most sub-regions in most periods, and was less common in all sub-regions in the Roman period than in the Iron Age.

3.4.2.2. Early Iron Age

Dominance of barley- over spelt-cultivation (Section 3.3.3.1) is explained by particularly good representation in records from the central chalk and western clay (Fig. 3.7). A marginal preference for barley- over spelt- (or emmer-) cultivation at open settlements is apparent (though the glume wheats combined dominate over barley, especially when those not identified as spelt or emmer are also taken into account; Fig.

[9] Preferably more than ten samples, though areas and record-types with fewer samples are commented on where it is judged appropriate.

3.8). These patterns relate almost entirely to the open settlements at Biddenham Loop (western clay; R174) and Fairfield Park A (central chalk; R194).

3.4.2.3. Middle Iron Age

Barley-cultivation is slightly better represented than spelt-cultivation in records from Breckland (Fig. 3.9). Spelt-cultivation is significantly better represented in records from the south-east (Fig. 3.9) – mostly due to its presence in 11 samples from Lodge Farm, St Osyth (R137) – accounting for its overall dominance (Section 3.3.2.1) in this period.

Emmer-cultivation is better represented than that of spelt or barley in samples from the fens (Fig. 3.9); most of these are rural settlements (open, discrete enclosed and complex) from the Isle of Ely (R38, R157, R207). As in contemporary emmer-samples from the two hillforts (Chipping Hill (R156) and Asheldham Camp; Fig. 3.10) in the south-east, emmer- and spelt-cultivation are attested together in most of these samples (though both are also attested alone). Analysis in Chapter 5 (Section 5.3) suggests that samples indicating cultivation of both species represent post-harvest mixing of two crops.

On the central chalk all four crop species are similarly represented (Fig. 3.9). Almost all of these samples are from the open settlement at Wendens Ambo (MIA; see also Fig. 3.10) where the four species frequently occur mixed together. Apart from this site, MIA bread wheat-cultivation is attested at Stansted Airport (R166; southern till) and Bushmead Road (R81; western clay) only.

3.4.2.4. Late Iron Age

Barley-cultivation is better represented than spelt-cultivation on the western clay only (Fig. 3.11). This evidence comes from the complex rural settlement at Biddenham Loop (R175) and discrete enclosed settlements at Brewer’s Hall Farm (R185) and

Beauford Farm (R242; also the only LIA record to attest bread wheat cultivation) (Figs. 3.11 and 3.12).

In keeping with its overall dominance in this period (Section 3.3.3.1), spelt-cultivation is indicated in significantly more samples than barley- (or emmer-) cultivation in the south-east and on the southern-till. It is also attested more frequently than barley-cultivation in the fenland (Isle of Ely and south-west fen-edge).

Emmer-cultivation is attested as commonly as spelt-cultivation in the fens. Most examples of emmer occurring alone (i.e. not mixed with spelt) are from fenland samples (most from Wardy Hill and Haddenham V; R39 and R32). It is attested along with spelt-cultivation in samples from the south-east (Heybridge; R124) and southern till (Stansted Airport and Rayne Roundabout; R146 and R161). There is no evidence for emmer-cultivation on the western clay (Fig. 3.11).

3.4.2.5. Roman

Spelt-cultivation is better attested than barley-cultivation in most sub-regions and most record-types throughout the Roman period (Figs. 3.13-18). The only clear exception is almost equal representation in ER Breckland and central chalk (Fig. 3.13). Although sample numbers are low, better representation of barley- than spelt-cultivation is also conspicuous in the region's two MR major towns (Fig 3.16) and the LR samples from the fort at Caister-on-Sea (R 104; Fig. 3.18).

Scaife's (2004) observation that barley is rare in Roman Bedfordshire is borne out: no barley-cultivation was identified by Method 2 in samples from Bedfordshire. However, very few samples from very few records from Bedfordshire were included in Method 2. Furthermore, only one clean grain sample was identified on the western clay for the MR-LR periods, and there is a bias against the identification of barley (and other free-threshing cereals) in crop-processing by-products. Barley-cultivation *was* attested in samples from other (Cambridgeshire) parts of the western clay, though spelt-cultivation was significantly better represented, and barley was identified by Method 1 (i.e. was present) in six of the twelve Roman records from Bedfordshire.

Spelt-, barley- and emmer-cultivation were similarly represented in ER industrial (pottery-production) records (Fig. 3.14). Evidence for emmer-cultivation, alongside that of spelt and barley, was from Greenhouse Farm (R202; central chalk); spelt and barley were both cultivated at West Stow (R63; Breckland) and Tort Hill West (R67; western fen-edge) (Figs. 3.13 and 3.14). Most of the remaining ER emmer-samples are from *Colonia Vitricensis* (R58, R98, R101-103, R105, R225) or Heybridge (R125) and nearby settlement at Slough House Farm (R11), all in the south-east. Evidence for MR and LR emmer-cultivation on the southern till (Figs. 3.15 and 3.17) comes from just five samples from the complex rural settlements at Stansted Airport and neighbouring sites (R95, R149, R164).

Most of the Roman samples attesting bread wheat-cultivation are from the fens or central chalk (Figs. 3.13, 3.15 and 3.17). Rye-cultivation was attested at the LR complex rural settlement at Brandon Road, Thetford (R229; Breckland), only.

3.5. Summary

3.5.1. Assessment of this analysis

The dual-method approach to interpretation of which crops were cultivated on a regional scale has worked well, circumventing the problems caused by the question of how much significance to accord rare species in archaeobotanical assemblages. The overall consistency of results enhances the credibility of both methods, lending validity to the characterisation of crops presented above. It is considered that use of both methods in combination is appropriate to the identification of cultivation on a regional scale in the carbonised archaeobotanical record.

The results from Method 2 are considered the more reliable for identification of the crops represented by individual samples, and are carried forward for further analyses (Chapters 4-6). Rare crops may, however, be under-recognised by this method, and there is a bias in favour of recognition of glume wheat crops where fine-sieving by-products dominate.

The Method 2 selection criterion of ≥50 identified items/sample led to the exclusion of 70% of the samples used in Method 1. Though extreme, this was considered a necessary step to ensure representativeness of the samples analysed, and so to ensure reliable results (considered preferable to uncertain results based on larger numbers of samples). The causes and impacts of sample exclusion are discussed in Section 8.2.

3.5.2. Summary of significant findings

3.5.2.1. The crops

The principal crops of the Iron Age and Roman East of England were spelt and barley. Spelt-cultivation increased over time; barley-cultivation declined in the later Iron Age, but then remained constant. Emmer was a significant crop in the Iron Age but its cultivation declined so that it was only cultivated occasionally by the MR period. Bread wheat cultivation commenced and peaked in the MIA, being rare thereafter. Rye cultivation occurred very rarely, and only in the Roman period.

Spelt cultivation was more or less ubiquitous, with few patterns discerned in its distribution. Potentially significant aspects of the distribution of barley-, emmer- and bread-wheat cultivation are identified below.

3.5.2.2. Barley-cultivation on the western clay

Barley-cultivation was less well represented than spelt-cultivation for most areas and most record-types in most periods. The only period in which barley was cultivated more frequently than spelt was the EIA, whose evidence relates mostly from two sites: Biddenham Loop on the western clay and Fairfield Park A, on the central chalk.

Barley-cultivation was also more common than spelt-cultivation on the western clay in the LIA (there are too few samples for a MIA pattern to be discerned). Although barley-cultivation was attested in all sub-regions in the Roman period, it was less common than spelt-cultivation on the western clay, though this is likely to be because of the bias against its identification in fine-sieving by-product samples. A change in the use of barley (e.g. increased use as fodder, meaning that it was not brought to the domestic/fire-using areas of settlements and so became carbonised less often) is also possible.

3.5.2.3. Patterns in emmer-cultivation

Emmer-cultivation peaked in the MIA. This was mainly accounted for by samples from Isle of Ely, south-east (mostly from the two hillforts), and Wendens Ambo on the central chalk. Emmer-cultivation was attested alongside other cereals in most of these samples, but alone in a few.

Emmer appears to have been cultivated at prominent sites in the south-east in the MIA (two hillforts) and LIA (the nucleated settlement at Heybridge; also at Wardy Hill 'hillfort' on the Isle of Ely in this period). This pattern may continue in the ER period, with emmer cultivation attested at *Colonia Vitricensis* and the small town at Heybridge.

MR and LR emmer-cultivation is attested in only six records, three of them from the central part of the southern till (where emmer was also cultivated in the LIA).

3.5.2.4. Rare bread wheat-cultivation

Bread wheat-cultivation is indicated at very few sites and remains uncertain. MIA evidence comes exclusively from Wendens Ambo, where it was cultivated alongside other cereals. An ER sample comes from *Colonia Vitricensis*. MR and LR evidence for bread wheat cultivation comes mainly from fenland records and the central chalk.

3.5.2.5. Towns, forts and pottery-production sites

ER industrial (pottery-production) records had a more equal balance of crops (spelt, barley and emmer, the last from Greenhouse Farm only) then most other records. ER cultivation of emmer and bread wheat in *Colonia Vitricensis* and of emmer in Heybridge, have been mentioned above. Better representation of barley- than spelt-cultivation is conspicuous in the few samples from MR *Colonia Vitricensis* and *Verulamium* and the LR fort at Caister-on-Sea.

3.5.3. Key points to carry forwards

Of the two dominant crops, spelt-cultivation was more or less ubiquitous whilst barley-cultivation was particularly well attested on the western clay in the Iron Age. Emmer-cultivation was relatively common in the Iron Age and rare after the ER period. It peaked in the MIA, but was specific to the Isle of Ely, south-east and (along with bread wheat) a single site on the central chalk. It may have been linked to prominent/high status sites in the south-east from the MIA to the ER period. The balance of spelt- and barley-cultivation may have been more equal in towns and forts (and, along with emmer, at pottery-production sites) than at rural sites in the Roman period.

4. Crop-processing, storage and utilisation

4.1. Objective and approach

Following harvest, cereal crops undergo a series of processing stages to prepare them for consumption, re-sowing or other use. Depending on the availability/mobilisation of labour, this processing may be carried out all at once at harvest time, or at intervals with the crop stored between stages. Each archaeobotanical sample comprises the charred remains of a product or by-product of a specific stage of crop-processing, burnt accidentally or deliberately during processing or storage. Analysis of sample composition allows identification of crop-processing derivation. Consideration of why specific crop-processing derivatives occur in specific periods/locations allows identification of activities represented in those times/places, and so gives insight into the actions and decisions of the region's Iron Age and Roman population.

The objectives of this chapter are to determine the activities and processes represented by the samples, and to see how these varied over the study period and with location and/or record-type. This information is then carried forward for further consideration (along with the findings of Chapters 3 and 5-7) in the context of the wider archaeological record in Chapter 8.

As with the identification of crops, analysis was carried out on a sample-by-sample basis and interpretation (initially) on a regional scale. Justification for this approach is given in Section 3.1.

The crop-processing stages recognised are those identified by Hillman (1981) based on ethnographic observation of traditional crop-processing practices. Samples' crop-processing derivations were identified from ratios of major crop components (after Van der Veen 1992: 82-84). This approach was selected over the use of discriminant analysis as being both more straightforward and more apt for the identification of rare early-processing by-products (see Section 1.6.4.2).

Methodology for the identification of samples' crop-processing derivation is given in Section 4.2. This is followed by presentation of results (Section 4.3). Further consideration is then given to the distribution of samples of different crop-processing derivation (Section 4.4) and the species represented in each crop-processing derivative (Section 4.5). More detailed information about the samples' contents (density, occurrence of sieving and presence of germinated grain) and contexts (the types of feature and record from which they derive) is then assessed to allow interpretation of their crop-processing derivation in terms of the human activities and decisions represented (Sections 4.6 – 4.8).

4.2. Methodology

4.2.1. Rationalisation of the dataset

The primary recording of samples' contents (Section 2.2.2) included large numbers of grain and chaff items not identified to species. To allow inclusion of the maximum possible number of samples in this analysis, items with imprecise identifications were reallocated so that all grain and chaff was grouped by species, with analytically useful broader categories retained where further refinement was not possible. The procedure followed in this rationalisation and reallocation is set out in Table 4.1.

Step	**Item-types**	**Procedure**
1	Grain & chaff	Exclusion of items designated 'Cerealia/Poaceae' and uncountable chaff. See Step 7 for exclusion of *Avena* from genus/genus identifications.
2	Grain & chaff	Re-allocation of 'cf.' and X-type identifications: Where definite identifications were present, definite, 'cf.' and X-type identifications were merged. Where no definite identifications were present but the number of 'cf.' and X-type identifications was ≥10, these were reallocated as definite identifications. Where no definite identifications were present and the number of 'cf.' and X-type identifications was <10, these were merged with the closest 'broad' category (e.g. cf. *Triticum spelta* merged with *Triticum sp*.).
3	Grain	Reallocation of 'mainly elongate wheat' to *Triticum sp*. (if free-threshing wheat grain present in the sample) or to glume wheat (if not).
4	Grain	Reallocation of 'mainly aestivum-type' wheat grains to *Triticum sp*. (if glume wheat grain present in the sample) or to *T. aestivum* (if not).
5	Grain & glume bases	Proportional reallocation of glume wheat (grain) and *Triticum sp.* (glume bases) to *T. spelta* and *T. dicoccum*, according to the numbers of each identified in each sample. Where neither was present, the original designation was retained.
6	Grain	Proportional reallocation of *Triticum spelta/aestivum* to *T. spelta* and *T. aestivum*, according to the numbers of each identified in each sample. Where neither was present, these grains were reallocated to *Triticum sp.*
7	Grain & chaff	Proportional reallocation of all genus/genus identifications to the relevant genera (e.g. *Triticum/Hordeum* to *Triticum sp*. and *Hordeum sp.*) according to the total numbers of each genus (i.e. numbers from all species combined) identified in each sample. If relevant genera were not present, these items were reallocated to indeterminate Cerealia. This included reallocation of genus/*Avena* grain identifications (*Avena* grain totals based on definite and 'cf.' identifications, calculated as in Step 2, above). Following reallocation, items designated *Avena sp*. were moved from the cereal grain data set to the arable weed data set.
8	Grain	Proportional reallocation of *Triticum sp*. to individual wheat species (and glume wheat), according to the numbers of each identified in each sample. Where no wheat grains identified to species were present in the sample, but only one species (or 'glume wheat') was represented by the chaff, *Triticum sp.* grain was reallocated to that species. Where reallocation on these grounds was not possible the original designation was maintained.
9	Grain	Proportional reallocation of *Hordeum sp*. to *H. vulgare*. var. *nudum* and *H. vulgare* according to the numbers of each identified in each sample. Where neither was present, *Hordeum sp*. was automatically reallocated to *H. vulgare* owing to the extreme scarcity of *H. vulgare*. var. *nudum*.
10	Grain	Proportional reallocation of indeterminate Cerealia to all cereal species (and glume wheat) according to the numbers of each identified in each sample.
11	Rachis nodes	Proportional reallocation of indeterminate Cerealia and *Triticum sp.* to individual species according to the numbers of rachis nodes and glume bases (modified to give equivalent number of rachis nodes) identified in each sample. Where no relevant species were identified in the chaff assemblage, but only one relevant species of grain was present, rachis nodes were re-allocated to that species. Where no relevant species were present in the grain or chaff assemblage, the original designation was retained.

Table 4.1. Procedure for the re-allocation of grain and chaff items not identified to species.

Items other than grain, chaff and weed seeds (e.g. buds, thorns, stem fragments, tubers and rhizomes, seed heads) were then excluded. Seeds of aquatic plants (defined in

Section 6.2.1) and trees, as well non-cereal species of potential economic significance (see Chapter 7) were also excluded.

Weed seeds were then categorised as large (≥3mm in one or more dimension), small (≤2.5mm in all dimensions) or intermediate (2.5-3 mm in one/more dimension); data on seed size was obtained from Cappers *et al*. (2006) and Stace (1997). In some cases, taxonomic identifications were too broad, or description of size not clear enough (e.g. 'medium Poaceae') to allow this categorisation; these seeds were excluded.

Following this process of rationalisation, any sample containing <50 countable items (and thus considered too small to be reliably representative; cf. G. Jones 1991) was excluded.

4.2.2. Identifying crop-processing derivation

Identification of a sample's crop-processing derivation is dependent on the calculation of its relative proportions of grain and chaff (by species), grain and weed seeds, and large and small weed seeds. The method used was based on that of Van der Veen (1992: 82-84), modified as recommended in more recent publications (Van der Veen and Jones 2006; Van der Veen 2007). It comprised the calculation of a series of ratios, (Table 4.2) designed to quantify the compositional differences between each sample and an unprocessed harvest.

Each ratio was calculated for all samples containing ≥10 relevant items but results based on <25 relevant items were treated with caution and accepted only if individually considered to be robust (cf. Van der Veen 1992: 82, 83). Definition of 'high' and 'low' values was judged on a sample by sample basis, guided (for Ratios B, C and D) by the interpretations of Van der Veen (1992: 83, 205-6). Values and interpretations of Ratios A-F are given for all samples in Appendix 2.

		Sample origin	
Ratio	**Sample variable**	**High value**	**Low value**
A	Cereal straw nodes/grains	By-product from early processing stage	Grain product
B	Free threshing rachis internodes/grains (calculated for each species separately)	By-product from early processing stage	Grain product
C	Glume wheat glume bases/grains	By-product from late processing stage	Grain product
D	Weed seeds/cereal grains	By-product from late processing stage	Grain product
E	Small/large weed seeds	By-product from sieving	Product from sieving or by-product of hand cleaning
F	Number of usable identifications per litre of deposit	Rapid/single event deposition (usually result of accident)	Slow/repeated deposition (usually day-to-day activity)
G	Number of germinated/non-germinated grains	Potential malting residue	Accidental germination in stored grain

Table 4.2 (Table 2 of Van der Veen and Jones 2006 with letter-designations and Ratio G taken from Van der Veen 2007). Ratios calculated for the interpretation of crop-processing derivation.

The greater vulnerability of chaff (especially the rachis nodes of free-threshing cereals but also glume bases) than grain to destruction during the carbonisation process (Section 1.6.2) was taken into account in the designation of values as high or low, for example it was expected that glume bases would be under-represented relative to grains in spikelet samples, and the *presence* of rachis nodes or culm nodes was sufficient to prompt consideration of interpretation as by-products from early processing.

Ratio C was initially calculated for spelt and emmer individually where information allowed (cf. Van der Veen and Jones 2006). However, it was found that they co-occurred within samples almost exclusively as like-products/by-products, and so the categories were merged and Ratio C was calculated for combined ‘glume wheat’ (cf. Van der Veen 1992: 82).

Ratio E was calculated twice, including ‘intermediate’ seeds first as small (following Van der Veen 1992: 207), then as large. In most cases, the interpretation of both results agreed; in the few cases where there was disagreement Ratio E was considered un-interpretable. The interpretation of Ratio E included consideration of the presence of any non-seed large items likely to have originated in the arable crop (e.g. seed heads), as well as the value of the ratio itself.

In some sources, samples were measured by weight rather than volume. In these cases, 1kg of deposit as used as a rough proxy for 1 litre of deposit in the calculation of Ratio F, though it is acknowledged that the weight of a deposit varies according to its moisture content and composition.

In interpretation of Ratio G evidence for germination was considered to be significant if 20% or more of grain of any one species was described as being germinated (following Van der Veen 1989), or if the number of coleoptiles present was equal to 20% or more of the total amount of grain in the sample. However, if the number of germinated grains or coleoptiles in question was less than 10 germination was not considered to be significant. If germinated grains or coleoptiles were identified in the source material as being 'present', germination was not considered to be significant; other qualitative descriptions of their frequency (e.g. 'several', 'frequent') were interpreted on a case-by-case basis.

Interpretation of each sample's crop-processing derivation was based on the combined interpretation of all relevant ratios, taking into consideration the proportion of the whole sample-assemblage accounted for by the items on which each was based.

4.3. Samples' crop-processing derivations

4.3.1. The dataset for this analysis

The 725 samples included in analysis of crop-processing derivation were the same as those used in Method 2 for the identification of crops. Their chronological distribution was set out in Chapter 3 (Table 3.1) and their spatial distribution shown in Fig. 3.1.

Bibliographic references to all records mentioned in the text can be found in Appendix 1[10].

4.3.2 Crop-processing products and by-products

Table 4.3 lists and quantifies the products and by-products identified, as well as giving a summary of the ratios used to identify each one and of its composition. Table 4.4. quantifies these identifications by period.

The most frequently occurring crop-processing derivatives were fine-sieving by-products and clean grain. Combined, these accounted for 69% of all samples included in this analysis (Table 4.3), and for more samples than any other derivative in every period (Table 4.4). Spikelets were also relatively common, accounting for 11% of all samples, as were mixed grain and fine-sieving by-products (6%) and mixed spikelets and grain (5%). Other derivatives each accounted for ≤2% of samples.

Samples with four different compositions were identified as fine-sieving by-products (see subdivisions of Row 3 in Table 4.3). The last of these were samples containing only small weed seeds with very few/no cereal items. These are suggested to be the fine-sieving by-products of free-threshing cereal crops. However, some uncertainty remains over this interpretation, which is scrutinised in Section 4.3.4.3.

[10] The first mention of each record is suffixed with the record number to allow cross referencing.

Row	Crop-processing derivative	No. of samples (% of total samples)	Ratio A	Ratio B	Ratio C	Ratio D	Ratio E	Description
1	Clean grain	158 (22%)	-	Low /	Low	Low	Low	Clean grain with little chaff and few weed seeds (mainly large).
2	Spikelets	77 (11%)	-	-	Intermediate	(Low) (High)	(High)	Approx. equal numbers of glume wheat grains and glume bases. (Some sieved: few weeds). (Some not sieved: many weeds, mainly small)
3	Fine-sieving by-products	349(48%)	-	-	High	High (Low)	High (Low)	Many glume bases and (small) weed seeds, few glume wheat grains. (Some previously sieved as spikelets: few weeds, mainly large; also low numbers of weed seeds compared to glume bases (cf. Van der Veen and Jones 2006)).
			-	High, but low overall numbers	-	High	High	Mainly small weed seeds with some free-threshing cereal grains
			-	High, but low overall numbers	High	High	High	Many glume bases and (small) weed seeds, few glume wheat grains, a few free-threshing cereal grains also present.
			-	-	-	High	High	Mainly small weed seeds, few/no cereal items. Probably fine-sieving by-products of free-threshing cereals.
4	Spikelet sieving by-products	14 (2%)	-	-	Intermediate or Low	High	High, and high overall numbers	Many small weed seeds with a few glume wheat grains and/or glume bases.
5	Early-processing by-products	8 (1%)	High	-	-	High	High/low	Mainly weeds and culm nodes, few other items: by-product of threshing.
			-	Low	-	High	High/low	Mainly rachis nodes and weeds: by-product of coarse sieving.

6	Spikelets mixed with free-threshing cereal grain	36 (5%)	-	Low or intermediate	Intermediate	(Low) (High)	(Low) (High)	Glume wheat and free-threshing cereal grain. Fewer rachis nodes than in a live crop and approximately equal numbers of glume wheat grains and glume bases. (Some sieved: few weeds, mainly large). (Some not sieved: many weeds, mainly small, sometimes with frequent rachis nodes also present)
7	Glume wheat fine-sieving by-product mixed with free-threshing cereal early-processing by-product	11 (2%)	-	High	High	High	High	Mainly (small) weeds, rachis nodes and glume bases.
8	Free threshing cereal grain mixed with glume wheat fine-sieving by-product	47 (6%)	-	Low	High	(Low) (High)	(Low) (High)	Free-threshing cereal grain with few/no rachis nodes but many glume wheat glume bases. (Clean grain mixed with fine-sieving by-products previously sieved as spikelets: few weeds, mainly large) (Grain not fine-sieved and/or fine-sieving by-products not previously sieved as spikelets: more weed seeds (mainly small) than grains)
9	Glume wheat grain mixed with early-processing by-product of free-threshing cereal	3 (<1%)	-	High	Low	High/low	High/low	Glume wheat grain with few/no glume bases but with free-threshing cereal rachis nodes and weed seeds.
10	Glume wheat spikelets mixed with early-processing by-product of free-threshing cereal	1 (<1%)	-	High	Intermediate	High	High/low	Approximately equal proportions of glume wheat grain and glume bases with free-threshing cereal rachis nodes and weed seeds.
11	?: Free threshing	8 (1%)	-	Low	-	High	High	Free-threshing cereal grain with few/no rachis

	cereal grain and (small) weed seeds							nodes compared to a live crop but with abundant (small) weed seeds. See text.
12	?: Glume wheat and free-threshing cereal grain and (small) weed seeds	10 (1%)	-	Low	Low	High	High	Glume wheat and free-threshing cereal grains with few/no rachis nodes or glume bases but with abundant (small) weeds; lack of glume bases suggests that weed seeds originate in free-threshing cereal crop. See text.
13	?: Glume wheat grain and (small) weed seeds	3 (<1%)	-	-	High	High	High	Mostly small weed seeds with a few glume wheat grains and no glume bases.
	Total	*725*						

Table 4.3. Quantification and description of crop-processing derivatives.

Row	Product/by-product	EIA	MIA	LIA	ER	MR	LR
1	Clean grain	11	32	23	42	26	24
2	Spikelets	3	7	12	15	16	24
3	Fine-sieving by-products	11	29	30	49	140	90
4	Spikelet-sieving by-products	1	1	1	0	6	5
5	Early-processing by-products	0	0	1	1	6	0
6	Spikelets & cereal grain	0	4	4	5	17	6
7	Fine-sieving by-product & early-processing by-product	0	1	0	6	2	2
8	Grain & fine-sieving by-product	5	2	1	10	21	8
9	Grain & early-processing by-product	0	0	0	1	1	1
10	Spikelets and early-processing by-product	0	0	0	1	0	0
11	Cereal grain (free-threshing only) & small weed seeds	1	0	1	3	1	2
12	Cereal grain (free-threshing & glume wheat) & small weed seeds	1	2	2	2	2	1
13	Cereal grain (glume wheat only) & small weed seeds	0	0	0	1	1	1

Table 4.4. Quantification of crop-processing derivatives by period.

4.3.3. Comment on mixed samples

Rows 1-5 of Tables 4.3 and 4.4 describe samples originating from a single stage of crop-processing, whether from a single act or the combined results of several similar acts.

Rows 6-10 describe samples containing mixtures of material from two different processing stages. Potential interpretations of these mixtures are offered here, but mixture of material from different sources at the point of charring/deposition is also possible in all cases.

Row 6 may represent crops combined for storage after completion of early stages of processing. Row 7 represents mixed by-products, potentially burnt together as waste or as fuel.

Rows 8-10 may represent deliberate use of by-products to fuel the drying or malting of grain/spikelets (with some accidental loss of the intended product). The samples described in Row 8 are dominated by glume bases, but the numbers of free-threshing cereal grains present are large enough to be considered significant. This balance is consistent with the interpretation given here: the burning of glume bases was intended, while the carbonised grains represent accidental loss and so are fewer. In the samples described in Rows 9 and 10, glume wheat grain/grain and glume bases (i.e. spikelets) outnumber the rachis nodes and weed seeds which represent the early-processing by-product component. This is consistent with the high susceptibility of rachis nodes to destruction by fire, and so with the interpretation given above. However, alternative interpretation as contaminated grain/spikelets is also viable.

The origin of samples described in Rows 11-13 is unclear. All three potentially represent clean grain contaminated (perhaps at the point of disposal or burning) with small weed seeds from an unrelated source. Alternatively, Row 11 could represent a free-threshing crop burnt after coarse-sieving but before fine-sieving. The presence of glume wheat grain but no glume bases in the samples described in Rows 12 and 13 is incompatible with this interpretation. The samples described in Row 12 could represent coarse-sieved free-threshing cereal grain, mixed with clean glume wheat grain. This does not make sense as an act of crop-processing and so would presumably have occurred at the point of deposition or burning.

4.3.4 Correspondence analysis

4.3.4.1. Objective of correspondence analysis and principles of interpretation

Correspondence analysis (CA) is used here to clarify the characterisation of samples whose crop-processing derivation is uncertain or mixed. An overview of the technique is given in Section 2.4.

The keys to interpreting CA plots are that samples/species plotting close to the origin (*0,0*) are average/common, while those plotting away from it are distinctive/rare.

Samples/species plotting together are similar, while those plotting at a distance from one another are different; the direction of divergence is meaningful in interpreting that difference. Thus, samples of like-crop-processing derivation should diverge in a common direction from the origin and to plot close to one another.

4.3.4.2. Selection and quantification of species and samples

Species

The primary criterion for inclusion of species was that they should occur in ≥5% of samples. To avoid exclusion of pertinent data, rare taxa were merged (see below) into appropriate broader categories, rather than being excluded. Fifty-eight species categories were retained.

The CA dataset used the same quantifications of cereal items as the ratios analysis, i.e. with imprecise identifications reallocated to species where possible (Table 4.1). As in the calculation of ratios, seeds of trees, aquatics and plants of potential economic importance were excluded. Non-seed weed items (seed-heads, pod fragments, roots, rhizomes and tuners) were considered for inclusion, but all were excluded as rare species. Cf. and X-type weed identifications were merged with definite identifications.

To avoid exclusion as rare species, taxa occurring in <5% of samples were subsumed into appropriate broader categories (e.g. *Persicaria maculosa* and *P. lapathifolia* merged with *P. maculosa/lapathifolia*; small- and large-seeded grass species merged with Small and Large Poaceae). This included the merging of spelt and emmer categories with 'glume wheat' (to avoid exclusion of emmer grain, which occurred in just 3% of samples). Species were amalgamated by taxon, not by size, in recognition of the influence of seed-size on occurrence in crop-processing products/by-products. Where size-specific categories at family level (e.g. Small Solanaceae) remained rare in the dataset, seeds were added to the categories large/small indeterminate weeds, as appropriate. A small number of weed taxa identified only at genus or family level (or not identified at all) are of unknown size, and were grouped as indeterminate weeds of unknown size.

The abbreviations used to represent species in the CA species-plot (Fig. 4.1) are listed in Appendix 3.

<u>Samples</u>

The primary criterion for inclusion of samples in correspondence analysis was that they should contain ≥50 identified items (i.e. all samples included in calculation of ratios were initially included).

After plotting a preliminary dataset, a further 39 samples were excluded. These were all identified as clean grain, most of them indeterminate wheat or mixed wheat species. In the preliminary CA sample-plot, these extended along the positive part of Axis 1 (toward the location of *Triticum spp*. grain, at the extreme positive end of this axis in the species-plot), while all other samples and species lay on/very close to the origin on this axis. Exclusion of these samples allowed observation of further variation in the dataset.

The dataset used in the final analysis included 686 samples.

4.3.4.3. Results of correspondence analysis

<u>Clean grain, spikelets and by-products</u>

Samples characterised by calculation of ratios as having the same crop-processing derivations plot together in the CA-plots (Fig. 4.2). There is a clear separation on Axis 2 (vertical) between clean grain (which plot positively) and by-products (which plot negatively). Unsurprisingly, given their composition, spikelets plot between the two. This distribution reflects the positions of grain and glume bases on Axis 2 in the species-plot (Fig. 4.1).

Crop-processing by-products are differentiated on Axis 1 (horizontal) largely according to relative abundance of glume bases and weed seeds, but also influenced by the position of cereal culm nodes in the species-plot. Samples resulting from the fine-sieving of previously sieved spikelets (dominated by glume bases), cluster at the negative end of Axis 1, while by-products dominated by weed seeds and/or containing culm nodes (early-processing and fine-sieving by-products of free-threshing cereals and spikelet-sieving by-products) lie at its positive end. Other glume wheat fine-sieving by-products occur along the length of this axis.

Most mixed crop-processing derivatives plot as expected, given the cereal items they contain, relative to samples consisting of single products/by-products (compare Figs. 4.2 and 4.3). No further insight into their interpretation is offered.

<u>Atypical clean grain samples</u>

Five clean grain samples plot in the realms of the spikelet or by-product samples (Fig. 4.2). Their atypical positioning is not thought to indicate inaccuracy in their identification as clean grain. Rather, it results from their content of bread wheat or indeterminate wheat grain (rather than glume wheat or barley) or from content of large numbers of seeds of large grasses or *Bromus spp.*. The positions of these samples reflect those of these species (AES GR, TSP GR, POA INDL and BRO SPP) in the species-plot (Fig. 4.1).

Samples containing only small weed seeds

The 11 samples containing only small weed seeds (interpreted in Section 4.3.2 as probable fine-sieving by-products of free-threshing cereals) plot in the same area of Fig. 4.2 as spikelet-sieving by-products and early-processing by-products (negative on Axis 2, positive on Axis 1), where other fine-sieving by-products are also present. Their complete lack of both glume bases and glume wheat grain suggests that they are not spikelet-sieving by-products, or fine-sieving by-products of glume wheat. However, given the high susceptibility of rachis nodes and culm nodes to destruction by fire, they could plausibly be either fine-sieving or early-processing by-products of free-threshing cereals.

Being of uncertain crop-processing derivation, these samples are excluded from further analyses in this chapter.

Samples containing grain and small weed seeds

The samples comprising mixed grain and small weed seeds (Rows 11-13 of Tables 4.3 and 4.4) do not plot as a group in Fig. 4.3. They tend towards the positive end of Axis 1, but are widely spaced on Axis 2.

Those plotting most positively on Axis 2 probably represent clean grain contaminated with small weeds, possibly at the point of burning or deposition but this remains uncertain: the weed seeds were numerous enough to be noticed in the interpretation of ratios, despite being too few to influence the CA plots. The remaining samples plot in the area otherwise occupied by by-products (three samples with free-threshing grain), or in an intermediate position reflecting their weed content. No clearer interpretation of these samples becomes apparent, and it seems likely that they represent mixed material from more than one source.

Being both rare and of uncertain crop-processing derivation, all of these samples are excluded from further analyses in this chapter.

4.3.5. Further analyses

4.3.5.1. Samples included in further analyses

<u>Principles for inclusion</u>

In most of the following analyses, only those crop-processing derivatives occurring in ≥5% of samples are considered. However, early-processing by-products (1% of samples) are given further consideration in Section 4.4.2.5, owing to their acknowledged rarity in the carbonised archaeobotanical record. Spikelet-sieving by-products (2% of samples) are also included in analyses to which they are particularly relevant.

<u>Spikelet samples</u>

The spikelet samples in the all of the following analyses include samples containing mixed spikelets and other crop-processing derivatives (Rows 6, 7 and 11 of Tables 4.3 and 4.4), as their presence is significant regardless of the combinations in which they have been deposited (though this is also commented on where appropriate).

<u>Clean grain samples</u>

Mixtures of grain and spikelets are not included in the clean grain totals as the origin of weeds in these samples is unknown, meaning that the grain component may not have been fully cleaned.

<u>By-product samples</u>

Fine-sieving by-products and early-processing by-product samples in all analyses include those in which the two were mixed. The early-processing by-product samples also include those in which early-processing by-products were mixed with grain. This ensures recognition of all occurrences of these rare archaeobotanical deposits.

Mixed grain and by-product samples

In consideration of broad patterns in the occurrence of the various crop-processing derivatives, mixtures of grain and by-products are of specific interest, potentially representing use of by-products as fuel, and so are included as a category in their own right. Most of these samples are free-threshing grain and fine-sieving by-products of glume wheat, but the few samples comprising glume wheat grain mixed with early-processing by-products of free-threshing cereals are also included in this category.

Other analyses investigate aspects of clean grain and by-product composition (density, species) which are of interest regardless of whether they occur alone or combined (though their co-occurrence is also of interest and is discussed). In these analyses the category 'mixed grain and by-products' is excluded, but the relevant samples are added to both the by-product and clean grain totals, as appropriate. All such samples were added to the fine-sieving by-product totals, but only samples in which the fine-sieving by-product component had been previously sieved (i.e. only those containing very few weeds) were included in the clean grain totals (as the others contained large numbers of weeds of uncertain origin, raising the possibility that their grain component was not fully cleaned).

Product/by-product	**EIA**	**MIA**	**LIA**	**ER**	**MR**	**LR**
Clean grain[1]	11 (12)	31 (31)	23 (25)	45 (49)	26 (43)	24 (35)
Fine-sieving by-products[1]	11 (16)	27 (30)	31 (32)	49 (58)	136 (156)	92(100)
Spikelets	3	11	16	21	33	30
Early-processing by-products[2]	0	1	0	9	9	3
Spikelet-sieving by-products	1	1	1	0	6	5
Mixed grain and by-products	5	4	1	10	22	9
Total	*31*	*74*	*72*	*127*	*229*	*160*

[1]Numbers in brackets are for clean grain/fine-sieving by-products including those occurring mixed together (see text). [2] These include mixtures of early-processing by-products with fine-sieving by-products or clean grain (i.e. samples already included in the totals for these derivatives).
Table 4.5. Samples included in the following analyses.

4.3.5.2. Final note on the excluded samples

The 32 samples excluded from further analyses are those whose crop-processing derivation remains unclear. They comprise either small weed seeds only or mixtures of grain and small weed seeds. Fifteen of these occur in isolation, single samples from single records. The rest occur as small groups in single records, or related records.

Concentrations were noted in records from MIA West Stow (R131, an open settlement in Breckland), from ER *Colonia Vitricensis* (R58, R98, R101, R103, R105, R225), and from the MR south-west fen-edge and fen-island at March.

As the origins of these samples (which may have been varied) remain unknown, the significance (if any) of these clusters is also unclear. The chances of identifying mixtures which occurred only rarely and by chance are probably higher when greater numbers of samples are studied. It may, therefore, be relevant that the total number of samples taken these records was higher than the average (11), though this does not take account of variation in the number features/deposits, or the size of areas excavated.

4.4. Distribution of clean grain, spikelets and by-products

4.4.1. Chronological distribution

From the EIA to the ER period, the most frequently occurring crop-processing derivatives are fine-sieving by-products and clean grain. Fine-sieving by-products dominate in the MR and LR periods. This pattern can be seen in the proportion of samples which *comprise* these derivatives only (Figs. 4.4 and 4.7), in the proportion of samples which *include* these derivatives (Fig. 4.5), and in the proportion of *records* in which these derivatives are present (Fig. 4.6).

The MR increase in fine-sieving by-products was in their occurrence alone, rather than their occurrence mixed with clean grain (Fig. 4.4). It partly reflects an increase in the proportion of records at which these samples are present from the MIA to the MR period (Fig. 4.6; best appreciated if the bars representing fine-sieving by-products alone and mixed with grain are considered in combination), indicating the carbonisation of these by-products in an increasing number of locations. However, there is also an increase across this period in the number of fine-sieving by-product samples per record. This factor explains the higher proportions of samples than records in which fine-sieving by-products are present in the LR period.

The number of samples of a given type (e.g. species or crop-processing derivation) per record is likely to reflect the numbers of samples taken. However, when specific records stand out as having concentrations of a single sample type, it is possible that a real variation in arable practice is also indicated. The increasing number of fine-sieving by-product (but not clean grain or spikelet) samples per record in the Roman period suggests a genuine increase in the quantities in which fine-sieving by-products became carbonised at individual sites.

The occurrence of spikelet samples is relatively consistent across the study period, with peaks in the LIA and (to a lesser extent) LR period (Figs. 4.4 and 4.5). The proportion of *records* which include spikelet samples is also fairly consistent across the study period (though a little lower in the EIA and MIA than in later periods; Fig. 4.6).

4.4.2. Detailed patterns

4.4.2.1. Preface

The distribution of the various crop-processing derivatives by location and record-type is shown in Figs. 4.8-4.20, and discussed below. Low sample numbers hinder interpretation and prevent comment on some periods (especially the EIA), areas and record-types.

4.4.2.2. Early Iron Age

The apparent EIA dominance of fine-sieving by-products over clean grain (Section 4.4.1) largely reflects their dominance at Fairfield Park A (R194), an open settlement on the central chalk; the two are otherwise more evenly distributed (Figs. 4.8 and 4.9).

4.4.2.3. Middle and Late Iron Age

Clean grain

MIA and LIA clean grain samples come almost exclusively from the south of the study region, though the LIA pattern partly reflects the overall distribution of samples (Fig. 4.10).

Twenty-two of the 32 MIA clean grain samples are from single records in the south-east (complex rural settlement at Lodge Farm, St. Osyth; R137) and on the central chalk (open settlement at Wendens Ambo; R72). This accounts for their dominance in these regions and record-types (Fig. 4.11-4.12). These samples represent behaviour in two specific locations, rather than widespread MIA practice.

Fine-sieving by-products and spikelets

Fine-sieving by-products dominate samples from the fenland in the MIA (all but one from Wardy Hill, Watson's Lane and West Fen Road on the Isle of Ely; R38, R157 and R207) and LIA (mostly complex rural settlements on the south-west fen-edge) (Figs. 4.11 and 4.13). They are also more common than other crop-processing derivatives in the LIA south-east, deriving mostly from the nucleated settlement (classed as a complex rural settlement) at Heybridge (R124; Figs. 4.13 and 4.14).

Despite low overall representation, the distribution of spikelets is similar to that of fine-sieving by-products. They are present in two samples from the MIA Isle of Ely, and one from the south-west fen-edge, and are (relatively) well represented at LIA Heybridge (Figs. 4.13 and 4.14). In the MIA they are the dominant crop-processing derivative in samples from the region's two hillforts (Fig. 4.12), both located in the south-east, and also occurred in a small number of samples at the neighbouring sites of Fison Way and Gallows Hill (R14 and R97) in Breckland. In the LIA they occur in records from the central southern till and western clay.

4.4.2.4. Roman

<u>Fine-sieving by-products</u>

Fine-sieving by-products dominate in samples from Pakenham (ER fort and MR small town; R115 and R117) and the small towns at Heybridge (ER and MR; R124 and R125), Godmanchester and Stonea Grange (both MR; R42 and R262-3) (Figs. 4.16 and 4.18).

While this dominance of fine-sieving by-products over clean grain is distinctive in the ER period (Fig 4.16), it reflects the normal distribution of crop-processing derivatives in the MR (and LR) period (Figs. 4.18 and 4.20). This may indicate MR spread of behaviour first practiced in a small number of locations (notably the fort at Pakenham and small town at Heybridge) in the ER period (or even in the LIA at Heybridge).

<u>Clean grain</u>

Clean grain is rare, compared to fine-sieving by-products, in the MR and LR periods and occurs in only a relatively small number of records. In the ER period, the two are equally represented in sample numbers, but clean grain samples are concentrated in a small number of records.

Thirty of the 45 ER clean grain samples are from *Colonia Vitricensis*, and another from the antecedent fort. This accounts for the dominance of clean grain in the south-east (Fig. 4.15) and in major town records (Fig. 4.16). Three mixed grain and by-product samples were also present in records from this town. Clean grain is also the dominant crop-processing derivative from MR major towns (*Colonia Vitricensis* and *Verulamium* (R220); Fig. 4.18).

Clean grain outnumbers other crop-processing derivatives in samples from the ER high status enclosed settlement at Fison Way (R15) and nearby complex rural settlement at Kilverstone (R143), Breckland (Fig. 4.15). It is the only crop-processing derivative in LR samples from northern till (complex rural settlement at Spong Hill and fort at Caister-on-Sea; R57 and R104) though this may reflect low sample numbers from this area (Fig. 4.19).

<u>Spikelets and mixed grain and by-products</u>

In the ER period mixed grain and by-product samples come from *Colonia Vitricensis*, Heybridge and Pakenham, from records with evidence for pottery-production (Addenbrooke's[11], central chalk, and West Stow, Breckland; R213 and R63), from a quarry at Slough House Farm (R11), near Heybridge, and from complex rural settlements on the south-west fen-edge at Earith (R248 and R252; Figs. 4.15 and 4.16). Spikelets occur frequently in samples from the pottery-production site at Greenhouse Farm (R202; close to Addenbrooke's), largely accounting for their strong representation on the central chalk and in industrial records (Figs. 4.15 and 4.16).

Most MR and LR spikelet samples are from the north of the study region (see Figs. 4.32 and 4.33), suggesting that practices allowing spikelet-carbonisation were most common

[11] Classed as a complex rural settlement.

in this area. In the south they were mostly limited to towns in the MR period (*Verulamium*, *Colonia Vitricensis* and Heybridge, but also the rural settlement at Stansted Airport (R164)) but occurred at rural settlements (Great Holt's Farm (R96), Mucking (R151), Stansted Airport (R165) and Strood Hall (R151)) in the LR period.

As well as occurring at MR Pakenham and Heybridge, mixed grain and by-product samples were well represented in MR and LR field systems (Figs. 4.18 and 4.20). Most of these were from Tunbridge Lane, Bottisham (R87 and R88). Though classed as a field system, this site included a suite of MR features centred on two corndriers, thought to have been used for large-scale crop-processing (McConnell *et al*. 2008). Mixed grain and by-products were also well represented in records classed as maltings, with features suggesting large-scale crop-processing activity (MR Beck Row, Mildenhall, and Stebbing Green; LR Hinxton Road, Duxford; R36, R34 and R243).

4.4.2.5. Note on early-processing by-products

Carbonised by-products of the early stages of crop-processing (threshing and winnowing) are rare, owing to the vulnerability of culm nodes and rachis nodes to destruction by fire (Boardman and Jones 1990; Van der Veen 1992: 94). Though few, the early-processing by-products identified here are thus worthy of specific mention. They occurred alone in seven samples, and mixed with other crop-processing derivatives in a further fifteen.

A single MIA sample (mixed spelt fine-sieving by-products and barley early-processing by-products) was identified from Wardy Hill (Isle of Ely). All other samples date to the Roman period (Table 4.6).

Site	Location	Type
Camp Ground, Earith (R248-251)	Fenland	Complex rural settlement
Langdale Hale, Earith (R251-254)	Fenland	Complex rural settlement
Stonea Grange (R262-263)	Fenland	Small town
Tort Hill West (R67)	Fenland	Pottery-production
West Stow (R63)	Breckland	Pottery-production
Pakenham (R115)	Northern till	Fort
Heybridge (R125-126)	South-east	Small town
Lob's Hole, Stevenage (R192-193)	Southern till	Discrete enclosed settlement
Brandon Road, Thetford (R229)	Breckland	Complex rural settlement

Table 4.6. Roman sites with early-processing by-product samples.

A high proportion of early-processing by-product samples are from 'Roman' record-types (towns, forts and pottery-production sites) and from the fenland. This may be a genuine phenomenon, reflecting the ways in which crops were processed, or by-products disposed of, at these sites. Alternatively, it may reflect differences in sampling strategy at different types of site, as rare items are more likely to be identified where more material is examined. Burnt deposits from features such as kilns tend to be well sampled, and the sampling strategies applied to excavations of Roman towns and military sites tend to be more thorough than those applied to rural sites. There are, of course, exceptions to this, and sampling strategies at the complex rural settlements on the Earith fen-edge were also particularly thorough.

4.5. The species represented

4.5.1. Why investigate the species represented in various crop-processing derivatives?

In some cases the species represented by a given crop-processing derivative reflect the physical characteristics of cereal species (e.g. only glume wheats occur as spikelets). In others, patterns in the distribution of a crop-processing derivative by species may reveal differences in the ways that different crops were treated after harvest, reflecting differences in their perception by the region's Iron Age and Roman population.

4.5.2. The species

The species represented by clean grain samples are shown in Fig. 4.21. Glume wheats are shown combined but (as indicated by the data labels) are mostly spelt in all periods. Clean emmer grain occurs in only 13 samples, mostly Iron Age. Given the low representation of bread wheat, and of emmer in the later part of the study period, it is likely that the 'indeterminate wheat' and later 'glume wheat' grain shown in Fig. 4.21 is mostly spelt.

The species represented in fine-sieving by-product samples are shown in Fig. 4.22. 'Glume wheat' may be spelt or emmer in the Iron Age but (given the low occurrence of emmer) is likely to be spelt in the Roman period. Spelt dominates in all periods but the MIA (in which spelt and emmer are approximately equally represented), and more so in the Roman period than in the Iron Age. The overall Roman period increase in fine-sieving by-products (Section 4.4.1) is thus due to an increase in *spelt* fine-sieving by-products.

Fine-sieving by-products of free-threshing cereals are much harder to recognise than the glume base-dominated fine-sieving by-products of glume wheats, and are probably under-represented. Some of those represented in Fig. 4.22 occurred mixed with spelt fine-sieving by-products. This sample-characterisation is tentative; an alternate interpretation would be as spelt fine-sieving by-products in which very small amounts of barley are incidentally present.

Only glume wheats occur as spikelets. Consistent with the species' overall representation (Figs. 3.2 and 3.3), spelt spikelets are more common than emmer (or 'glume wheat') spikelets in all periods (Fig. 4.23). Spikelet species shows no relation to location or record-type, does not affect sample density, and is not related to spikelet-sieving (Section 4.7).

4.5.3. Distribution of the different species

4.5.3.1. Preface

Chronological patterning in the distribution of different species in clean grain and by-product samples is described in Sections 4.5.3.2-4.5.3.5. More detailed aspects of their distribution, i.e. relating to specific records, is described only where potentially significant.

4.5.3.2. Early Iron Age

Barley and glume wheat grain occur in equal proportions of EIA samples (Fig. 4.21); most contain mixtures of the two. In contrast to later periods, clean emmer grain is present in quantities comparable to (though lower than) spelt and barley, though it occurs only in mixtures, while they each also occur alone.

4.5.3.3. Middle Iron Age

Clean glume wheat grain samples outnumber clean barley grain samples in this period. This largely reflects the presence of only spelt in eight of the 11 clean grain samples from Lodge Farm, St Osyth (Section 4.4.2.3). Spelt, barley, emmer and bread wheat grain occurs mixed in the 11 clean grain samples from Wendens Ambo. This is the only substantial representation of emmer (or bread wheat) grain in the MIA, despite strong evidence for its cultivation (Section 3.3.3.2).

By contrast, emmer fine-sieving by-products are well represented in this period (Fig. 4.22), mostly because of high incidence of mixed spelt and emmer (47% of MIA fine-sieving by-product samples). These samples account for the overall strong indication of emmer-cultivation in this period (Section 3.3.3.2). They are from records on the Isle of

Ely, from Stonea Camp (R260), and from the south-east (Asheldham Camp, Chipping Hill and Stanway; R29, R156 and R135).

4.5.2.4. Late Iron Age to Late Roman rural records

Clean grain

Clean glume wheat grain outnumbers clean barley grain in the LIA and ER period. The occurrence of the two is approximately equal in the MR and LR periods (Fig. 4.21). Spelt grain occurs alone more frequently in these periods, but barley grain is well represented mixed with spelt fine-sieving by-products.

The more frequent occurrence of clean glume wheat than clean barley grain in the LIA (Fig. 4.21) is largely explained by absence of barley grain, and frequent occurrence of spelt/glume wheat grain, on the central southern till. This is also a factor in the ER period, though dominance of wheat at *Colonia Vitricensis* (Section 4.5.2.5) mostly accounts for its overall dominance in this period.

All LIA to LR pure clean grain samples include spelt/glume wheat, either alone or mixed with barley. In LIA and ER records spelt and barley occur mixed within the same samples, suggesting that they were stored and/or used together. These samples were too few for investigation of the possibility of maslin-cultivation (Chapter 5). In single LIA and MR and several LR records, spelt and barley clean grain were present as mixtures, but also in separate samples, suggesting that they were cultivated separately but sometimes stored and/or used together.

Clean emmer and bread wheat grain were absent in the LIA and LR period, and rare in the ER and MR periods, represented by four samples from three records. The presence of both at ER pottery-production sites (emmer at Greenhouse Farm and bread wheat at Addenbrooke's) is notable. Clean emmer grain also occurred at Stansted Airport.

Fine-sieving by-products

Most LIA fine-sieving by-products are spelt (Fig. 4.22). Emmer occurred alone only in fenland records; otherwise it was rare and mixed with spelt. Spelt dominates the Roman fine-sieving by-products; the description of Roman fine-sieving by-product distribution (Section 4.4.2.4) thus applies to this species.

Mixtures of spelt and barley fine-sieving by-products are present at a small number of sites, most of which are among those where use of spelt fine-sieving by-products to fuel malting/drying of barley grain is suggested below (Section 4.6.5.5). It is thus possible that these samples represent very small quantities of barley grain (and a few incidental chaff fragments) accidentally carbonised along with (spelt) fine-sieving by-product fuel, rather than genuine mixtures of spelt and barley fine-sieving by-products.

Mixed grain and by-products

Most mixed grain and by-product samples comprise barley grain and spelt fine-sieving by-products. In one ER sample (Slough House Farm) the by-product component also included emmer. Bread wheat grain was mixed with spelt fine-sieving by-products in seven samples, from ER Addenbrooke's (central chalk), MR Parnwell (R82; north-west fen-edge) and LR Camp Ground, Earith (south-west fen-edge).

This category also includes three samples (excluded from Fig. 4. 22) of clean spelt grain mixed with early-processing by-products of barley (ER Camp Ground, Earith), bread wheat (MR Lob's Hole, Stevenage), or barley and rye (LR Brandon Road, Thetford).

4.5.2.5. Clean grain from **Colonia Vitricensis**

Thirty-one of the 45 ER clean grain samples were from *Colonia Vitricensis* (Section 4.4.2.4). Most were indeterminate wheat, though a few were identified as spelt or glume wheat. One sample (identified as malt in Section 4.8.2.4) comprised mixed spelt and barley, and one barley only. This preference for wheat is not evident in the MR phase of the town (represented by only three clean grain samples).

Of the other Roman records noted in Section 4.4.2.4 for strong representation of clean grain, the ER settlement at Fison Way included only barley grain, while the nearby settlement at Kilverstone included only spelt. Both barley and spelt grain were present at LR Caister-on-Sea and Spong Hill. Sample numbers are too low for interpretation of these patterns.

4.6. The scale of production and processing

4.6.1. Significance

Large-scale arable production requires sufficient land to grow a large crop, suitable facilities to store it, and the time and labour to sow, cultivate, harvest and process it. It is only worthwhile if producing more grain than is required for subsistence and safeguarding gives an advantage (social/political or economic) to the producer.

Patterns in the scale on which crops were handled (determined by interpretation of Ratio F, which gives density of plant macrofossils) can thus point to variation in wider aspects of social/economic behaviour. Interpretation of dense and sparse samples in the following discussion follows Van der Veen and Jones (2006; Van der Veen 2007; Section 1.5.3.3). It is not possible to distinguish the nature of activity represented without considering the archaeological context (the nature of the features, deposits and sites from which samples were taken) alongside sample-composition/density.

4.6.2 Distribution and interpretation of dense and sparse samples

4.6.2.1. Chronological distribution

In the EIA, LIA and LR period, there are more sparse than dense clean grain samples; the two are approximately equally balanced in the MR period, and dense samples are more common than sparse in the MIA and ER period (Fig. 4.24).

MR dense and sparse fine-sieving by-product samples are approximately equally represented (Fig. 4.25). Sparse fine-sieving by-products are more common than dense in all other periods, though dense ones are relatively well represented in the MIA and LR period.

4.6.2.2. Small-scale crop-handling

The overall dominance of sparse over dense fine-sieving by-products suggests that dehusking and fine-sieving were generally carried out on a household and day-to-day scale, and were burnt as generated, i.e. as waste. In keeping with this, sparse clean grain samples occur in all records types and all locations where clean grain was present. The MIA and ER, MR and LR periods are distinctive in having significant evidence for large-scale crop-related activity (discussed below; Sections 4.6.2.3-4.6.2.6), but small-scale crop-processing was the norm for most sites throughout most of the study period.

In all periods the majority of sparse clean grain and fine-sieving by-product samples came from uninformative open features (pits, postholes, ditches etc) and layers (deposits which accumulated on the ground surface, rather than in a cut feature) (Figs. 4.26 and 4.27).

Eighteen sparse samples came from contexts (hearths/ovens, ring gullies and middens), consistent with handling/processing of crops on a household scale and in a domestic setting (Figs. 4.26 and 4.27).

A small number of MR sparse clean grain and fine-sieving by-product samples were from corndriers (Figs. 4.26 and 4.27). These may be the remains of fuel and accidentally burnt grain in corndriers, thinned out by cleaning of the corndriers after use. Alternatively, they may represent waste deposited after the corndriers' final uses. Sparse fine-sieving by-products, clean grain and mixtures of the two from kilns (LIA to MR; Figs. 4.26 and 4.27) may have the same interpretation, despite not being identified by their excavators as corndriers. Alternatively they could represent occasional use of crop-processing by-products and spoilt/otherwise unwanted grain as a component of fuel for industrial processes.

4.6.2.3. Middle and Late Iron Age large-scale crop-handling

<u>Grain storage at Lodge Farm (St Osyth), Wendens Ambo and Fison Way</u>

Most of the samples which comprise the MIA peak in dense clean grain samples (Fig. 4.24) are the (mostly spelt) samples from Lodge Farm, St Osyth (Sections 4.4.2.3 and 4.5.2.3). They were from the postholes of four-post 'granary' structures, and are interpreted as representing the remains of burnt grain stores.

The eleven samples of mixed wheat and barley grain from Wendens Ambo (Sections 4.4.2.3 and 4.5.2.3) are of unknown density. However, four were from four-post 'granary' structures and four from storage pits. Although the latter may represent cleansing of storage pits by fire, the interpretation of grain storage in both pits and granaries at this site is considered reliable.

One of the two sparse barley grain samples from Fison Way came from a storage-pit. It included poorly preserved grains which had fused together; the presence of clay fragments was also noted in its source report (Murphy 1992a), where it was interpreted as representing cleaning of the pit using fire between uses for grain storage.

Bulk-processing in the fenland and south-east

One third of MIA fine-sieving by-product samples are dense (Fig. 4.25). These are from the two south-eastern hillforts and three settlements on the Isle of Ely at which emmer is best represented (Section 4.5.3.3). In these two areas, the later stages of crop-processing were carried out *en masse*, in contrast to the normal practice in this period (Fig. 4.28).

Most of these samples are from open (or unknown) features; one is from a ring gully at Wardy Hill, hinting at bulk processing in a domestic context. There is nothing to suggest burning of fine-sieving by-products as fuel.

Only 18% of LIA fine-sieving by-product samples were dense (Fig. 4.25). Five of these six samples were from the south-east (the sixth from the south-west fen-edge; Fig. 4.28), three from the nucleated settlement at Heybridge, perhaps continuing a pattern of bulk late-stage crop-processing at large/prestigious settlements in this region.

4.6.2.4. Early Roman storage and processsing

Grain storage in *Colonia Vitricensis*

Thirty-one of the 34 samples which constitute the ER peak in dense clean grain samples (Fig. 4.25) are pure clean grain from *Colonia Vitricensis*. Several of these samples were taken from open features (e.g. pits), unrelated to the activities represented except as locations of final deposition. Others (including one thought to represent malt; Section 4.8.2.3) were from layers representing large-scale destruction by fire in the Boudican uprising. Both are considered likely to represent burnt stores, possibly removed from their primary contexts in the former instance.

Although large-scale grain-storage probably was more common in *Colonia Vitricensis* than at rural settlements, many (not all) of the relevant samples exist only because of the

Boudican burning of the town (i.e. a malicious act). It is possible that bulk grain-storage was also practiced other settlements but that stores never chanced to come into contact with fire.

Clear evidence of grain storage in the MR period comes only from *Verulamium,* where dense samples from granaries represent storage of clean grain (two samples) and mixed grain and spikelets (three samples; Section 4.7.2.4).

<u>Bulk processing</u>

Fine-sieving at *Colonia Vitricensis* is attested by only one, dense, sample. It is suggested that any crops arriving in the town as spikelets were processed *en masse*, rather than being available to individual households in that form. Heybridge and Pakenham combined account for almost half of the ER dense fine-sieving by-product samples, though they are outnumbered in both records by sparse examples, suggesting that small-scale processing was the norm.

Fine-sieving was carried out on small-scale at most rural settlements, though there is also evidence of large-scale processing in a few cases. Dense fine-sieving by-product samples from Camp Ground, Langdale Hale, Vicar's Farm (R255), North Shoebury (R26) and Strood Hall (R148) are from uninformative open features, though one from Langdale Hale is a mixture of grain and by-products, perhaps suggesting derivation from use of fine-sieving by-products as fuel to dry grain. This practice is more clearly attested by two samples (one dense, one sparse) from kilns at Addenbrooke's, but is otherwise a phenomenon of the MR and LR periods (Section 4.6.2.5).

4.6.2.5. Middle and Late Roman bulk processing and use of fine-sieving by-products as fuel

Bulk dehusking and fine-sieving

Representation of dense fine-sieving by-products peaks in the MR period (46%) and remains high in the LR period (38%; Fig. 4.25). Dense samples are present in high proportions (65% and 63%, respectively) of all records which include fine-sieving by-products (with no pattern in their distribution), suggesting that bulk late-stage crop-processing was practiced at many locations across the region, rather than being confined to a few (as in the ER period).

Nineteen MR samples and 27 LR samples attest bulk dehusking and fine-sieving with no contextual evidence to indicate use of its by-products as fuel. Most of these were from rural settlements, but four were from the MR small towns of Godmanchester and Stonea Grange, where sparse fine-sieving by-products were also present. This suggests both household- and larger-scale late-stage crop-processing in these towns, as at ER Heybridge and Pakenham (where there is evidence only for household-scale processing in the MR period).

Bulk dehusking and fine-sieving with by-products used as fuel

73% of MR dense fine-sieving by-product samples and 29% of LR dense fine-sieving by-product samples are likely to have been burnt as fuel or tinder. This is indicated by derivation from corndriers/similar features or (less securely) from open features on sites where these are present, or by their occurrence mixed with grain (Table 4.7). With one exception, the MR mixed grain and by-product samples were also from corndriers/similar features or nearby open features. A single dense clean spelt grain sample from a corndrier at Barnack (R40; north-west) probably represents a processing accident using fuel other than crop-processing by-products.

Evidence	No. of MR samples	No. of LR samples
Dense fine-sieving by-products	71	38
… comprising mixed by-products and grain	13	3
… from corndriers/similar features (pure-by-product samples)	20	5
…from records where corndriers/similar features are present (pure by-product samples, not from corndriers/similar features)	19	3

Table 4.7. Evidence to support the interpretation of dense fine-sieving by-product samples as fuel.

The samples described in Table 4.7 as having compositional or contextual evidence for burning as fuel are mostly from records located on the fen-edges or in adjacent parts of neighbouring regions. However, other aspects of sample-composition – by-products from the fine-sieving of previously sieved spikelets in areas where sieved spikelets are not attested (Section 4.8.2.4); by-products from the cleaning of malt in records with no other evidence of malting (Section 4.7.2.5) – may indicate import of fine-sieving by-products for this purpose (i.e. trade in fine-sieving by-products) at sites in other parts of the region.

<u>Note on species</u>

Spelt drying/malting with fine-sieving by-products as fuel is less likely to be recognised than that of barley or bread wheat (present in two records), as sample-composition would suggest spikelets or fine-sieving by-products with incidental grain. There are three MR and two LR incidences of spikelets occurring in corndriers/similar features (and three ER, all from Greenhouse Farm). With one exception (MR Snettisham bypass; R113) these samples are sparse. They may indicate drying/malting of spelt grain using its own fine-sieving by-products as fuel; alternatively they could represent drying/malting of spelt spikelets.

4.6.2.6. Other dense samples

The remaining dense samples were from uninformative open, probably secondary, contexts at rural sites. Six Roman clean grain samples were from records where dense fine-sieving by-product samples (included in the sections above) were also present, consistent with bulk-processing. The remaining six Roman samples were mixtures of grain and by-products, possibly the results of processing accidents, removed from their primary contexts.

4.7. Further consideration of spikelets

4.7.1. Interpretation of spikelet samples

4.7.1.1. Density

Because glume wheats may be dried or stored as spikelets rather than grain (Hillman 1981), the density of spikelet samples (interpreted from Ratio F) is considered as an additional indicator of the scale on which crops were handled (Section 4.6.1).

4.7.1.2. Sieving

Close examination of Ratios D (weed seeds: cereal grains) and E (small: large weed seeds) has allowed differentiation between sieved and unsieved spikelets (sieved spikelets contain fewer, mainly larger weed seeds)[12]. The significance of this difference in terms of storage behaviour and the mobilisation of labour is discussed in Section 1.6.4.3.

Spikelet-sieving does not remove the requirement for fine-sieving following dehusking of grain intended for culinary use; further explanation for spikelet-sieving is required. In a particularly weed-infested crop, effective dehusking may not be possible without

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[12] This could only be done where spikelets occurred alone or mixed with fully cleaned grain; where spikelets, grain and weeds occurred together the origin of the weeds is unclear.

prior sieving. Alternatively, spikelet-sieving may have been a precursor to malting[13] or sowing: dehusking can damage the germ area and so prevent germination, but either of these uses would benefit from the removal of weed seeds. Sieving would also reduce the space needed for spikelet-storage/transport. A further possibility is that spikelets were sieved prior to a change of ownership (sale/tribute/taxation), to facilitate efficient transport and/or standardise grain-content by weight/volume (Van der Veen, *pers. comm*. 24/02/10). In this case, sieved spikelets would probably be recovered from the location to which they were transported, rather than the location in which they were sieved.

4.7.1.3. Relevant by-products

The by-products of spikelet-sieving (which contain far fewer glume bases, relative to weed seeds, than fine-sieving by-products) are presumed to be recovered from the locations in which they were generated.

Eventual fine-sieving of spikelets which had already been sieved once produces distinctive assemblages, dominated by glume bases but including fewer (mainly larger) weed seeds than other fine-sieving by-products. Eventual dehusking and fine-sieving of sieved spikelets is inconsistent with spikelet-sieving in preparation for malting or sowing. These samples thus suggest initial spikelet-sieving either to facilitate dehusking or storage, or as a precursor to a transport/change of ownership. Because fine-sieving by-products may have been traded as fuel/tinder in the MR and LR periods, these samples do not necessarily reveal the locations of initial spikelet-sieving, -storage or -processing.

[13] Mentioned here as a possibility only; evidence for malting is considered in Section 4.8.

In considering the distribution of these samples, fine-sieving by-products of free-threshing cereals (which could not have existed as spikelets) and fine-sieving by-products mixed with crop-processing derivatives other than clean grain (in which the derivation of weed seeds in uncertain) are excluded.

4.7.2. Distribution and significance of dense and sieved spikelets

4.7.2.1. Chronological distribution

Sparse spikelet samples outnumber dense ones in all periods (Fig. 4.29). Dense spikelets occur most frequently in the MIA and MR period, consistent with other suggestions (Section 4.6.2) of increased bulk crop-handling in these periods.

The chronological distributions of sieved spikelets (Fig. 4.30), spikelet-sieving by-products (Table 4.8) and by-products from the eventual fine-sieving of previously-sieved spikelets (Fig. 4.31) all indicate that spikelet-sieving was practiced throughout the study period but became more common in the MR and LR periods.

Period	**Spikelet-sieving by-products**
EIA (n=31)	1 (3% - note low sample numbers)
MIA (n=74)	1 (1%)
LIA (n=79)	1 (1%)
ER (n=120)	0 (0%)
MR (n=229)	6 (3%)
LR (n=160)	5 (3%)

Table 4.8. Chronological distribution of spikelet-sieving by-products.

4.7.2.2. Prominent Middle Iron Age sites

Most MIA dense and sieved spikelets are from the hillforts at Asheldham Camp and Chipping Hill (south-east). A small number are from the neighbouring, potentially ceremonial, records from Gallows Hill and Fison Way (Breckland). This suggests that spikelets were treated differently at these prominent hillfort/ceremonial than at other sites; confidence in this interpretation is reduced by low sample numbers, especially for the Breckland sites (Figs. 4.29 and 4.30).

The distribution of by-products from the dehusking and fine-sieving of sieved spikelets is different, with six of the seven samples (all spelt and emmer) coming from the fenland. Mostly from Watson's Lane (Isle of Ely). Only one spikelet sample (sparse and unsieved) was recovered from this record; it is possible that the fine-sieving by-products were not generated *in situ*. Alternatively, behaviour involving spikelets at these sites may have differed from that at the south-eastern hillforts and ceremonial sites, meaning that the spikelets themselves never became carbonised.

MIA spikelet-sieving by-products were found at the discrete enclosed settlement at Stanway (south east) only.

4.7.2.3. Late Iron Age distribution

Four (sparse) sieved spikelet samples came from the nucleated settlement at Heybridge. Five samples (dense and sparse) representing eventual fine-sieving of previously-sieved spikelets came from the same record (and one from the nearby discrete enclosed settlement at Slough House Farm; R10).

This difference in crop-processing behaviour between the Heybridge nucleated settlement and most contemporary sites is of interest, though difficult to interpret. The sparseness of the samples suggests small-scale spikelet-sieving, not mobilisation of labour for mass spikelet-sieving after harvest. Following eventual dehusking most of these spikelets appear to have been fine-sieved on a small scale but a few in bulk.

Whatever the interpretation of this behaviour, it was not unique to Heybridge, and was also seen at a few rural settlements in other parts of the study region, especially the central southern till and fenland (Isle of Ely and south-west fen-edge).

4.7.2.4. Provisioning of Roman towns

Dense samples suggest the storage (alongside the clean grain storage identified in Section 4.6.2.4) of unsieved spelt spikelets in ER *Colonia Vitricensis* (one sample), and of sieved spelt spikelets mixed with barley grain in granaries at MR *Verulamium* (three samples). By-products from the eventual fine-sieving of sieved spikelets suggest the presence of sieved spikelets at LR *Verulamium.*

The sparseness of spikelet samples and (most) fine-sieving by-products from the small towns at Heybridge (ER and MR) and Pakenham (MR) suggest that grain was acquired by individual households in these settlements as spikelets, and that dehusking and fine-sieving (with some accidental carbonisation of spikelets) was carried out on a day-to-day basis. Practice was varied however, as spikelets were present in both sieved and unsieved form, and there is also some evidence for fine-sieving in bulk. At MR Stonea Grange the presence of spikelet-sieving by-products suggests spikelet-sieving within the town (perhaps to standardise grain content by weight/volume prior to sale), rather than to facilitate transport to the town.

Sieved spikelets are also present in the record from the ER fort at Pakenham, where they appear to have been used for malting (Section 4.8.2.3). Sparse, unsieved spikelets with no apparent connection to malting were also present. The by-products from fine-sieving of previously-sieved spikelets are also present; although some represent the cleaning of malt, most do not appear to be connected to malting. This could indicate similar systems of provision to those seen in contemporary small towns.

Other evidence of ER spikelet-sieving was scarce, but included an emmer sample (mixed with clean barley grain) from the pottery-production site at Greenhouse Farm.

4.7.2.5. Spikelet sieving at Middle and Late Roman rural settlements

Preface

Most MR and LR spikelet samples had been sieved prior to carbonisation (Fig. 4.30). Almost all records of these periods which included spikelet samples (mostly rural settlements) included sieved spikelet samples (Figs. 4.32 and 4.33).

Interpretation of spikelet-sieving

Spikelet-sieving by-products were rare. They occur alongside sieved spikelets, or the by-products of their eventual fine-sieving, in three records (MR and LR Camp Ground, Earith and LR Childerley Gate (R172); Figs. 4.32 and 4.33), suggesting spikelet-sieving and subsequent processing without change of location. Spikelet-sieving was probably carried out to facilitate dehusking or allow more efficient storage in these instances. The two occurrences of spikelet-sieving by-products alone (Figs. 4.32 and 4.33) offer less insight into why spikelets were sieved or how they were subsequently used.

Sieved spikelets mostly occur alongside the by-products of their eventual dehusking and fine-sieving (Figs. 4.32 and 4.33). Archaeological context suggests that samples from LR Great Holt's Farm were carbonised during storage, and that those from MR Snettisham Bypass, Valley Belt (Trowse; R133), Tunbridge Lane (Bottisham), Beck Row (Mildenhall) and Mucking were burnt in accidents during drying/malting in corndriers/similar features.

Spikelet-sieving at Snettisham Bypass, Beck Row and Mucking is suggested to have been a precursor to malting (Section 4.8.2.4). Samples from Beck Row representing the dehusking and fine-sieving of previously-sieved spikelets are thought to derive from the cleaning of malt, reused as fuel for the malting process (Section 4.8.2.4). This interpretation may apply to some samples from Tunbridge Lane, but crop-processing practice there seems to have been more varied (Section 4.8.2.4). There is no indication of malting in samples from Valley Belt, where the 'iron smelting furnace' may have been occasionally used to dry sieved spikelets to prevent spoilage, or to destroy (as a component of their fuel) those considered to be spoilt.

All other records with sieved spikelets also included the by-products of their eventual fine-sieving, suggesting that spikelet sieving was not a precursor to malting or sowing. The general absence of spikelet-sieving by-products means that sieved spikelets may have been imported to these locations, with spikelet-sieving carried out to increase efficiency of transport, or to standardise grain-content by weight/volume prior to a change of ownership. It is also possible that spikelet-sieving by-products simply did not become carbonised, and that there was no transport of sieved spikelets; in this case, spikelet-sieving may have facilitated efficient dehusking or storage.

<u>By-products from the fine-sieving of previously-sieved spikelets</u>

The by-products of dehusking and fine-sieving of previously-sieved spikelets occurred alone in several records, and have a wider distribution than sieved-spikelets (Figs. 4.32 and 4.33). Their presence (alone) on the southern till is particularly noticeable in both periods.

It is possible that occurrence of these by-products alone signifies only that sieved spikelets (and the by-products of initial sieving) did not become carbonised in some records. However, presence of unsieved spikelets in some of the relevant records (Figs. 4.32 and 4.33) suggests the alternative interpretation that fine-sieving by-products were sometimes burnt in locations other than those in which they were generated. This is consistent with the suggestion that they were traded in their own right, as fuel/tinder.

Supporting this interpretation of use as fuel, 47% of these samples were dense, and 19% were from corndriers, kilns or similar features.

4.8. Germination and malting

4.8.1. Cautionary note

It is difficult to identify malting with any certainty in the archaeobotanical record (Section 1.6.4.3). Samples with evidence of significant levels of germination ('germinated samples') are considered as potential evidence for malting[14]. However, malting is suggested only where combined evidence of sample-composition (usually based on multiple samples) and archaeological context exist.

4.8.2. Evidence for malting

4.8.2.1. Samples with significant germination

No germinated samples occur in the EIA or MIA, and only one in the LIA. They occur throughout the Roman period, most commonly in the MR (Fig. 4.34; Table 4.9).

Period	Clean grain	Spikelets	Fine-sieving by-products	Grain and fine-sieving by-products	Grain and spikelets
LIA	1	0	0	0	0
ER	1	1	3	1	2
MR	0	1	26	7	2
LR	0	2	11	0	0

Table 4.9. The crop-processing derivation of samples with evidence of significant germination.

Most germinated samples were spelt fine-sieving by-products (Table 4.9). Significant germination was attested by sprouted or 'wasted' grains, and/or by large numbers of detached coleoptiles (Section 4.2.2). The small amounts of grain present in these samples is considered to have been accidentally sieved out of the product along with glume bases and weed seeds. Given the evidence for germination, it is suggested that the spikelets being dehusked and fine-sieved had been malted, and that these samples

[14] Note that it is not certain that evidence of germination was recognised/recorded in all source reports.

represent by-products from the cleaning of malt (prior to its grinding, mashing and brewing). However, it is also possible that sprouted ('spoilt') grains were hand-picked from grain products after fine-sieving and added to by-product material (cf. Fryer 2011).

Spikelets (Table 4.9) are suitable for malting as dehusking may damage the germ areas of grains (Section 4.7.1.2). Furthermore, accidental sprouting is less likely in grain protected within spikelets during storage. Germination was attested in one (LR) pure spikelet sample by detached coleoptiles, but by significant proportions of germinated grain in the others. In the mixed spikelet and grain samples, germination was attested by sprouted grains (of both species where this could be determined); detached coleoptiles occurred only rarely. Coleoptile-detachment may be prevented when grains are enclosed in spikelets.

Mixtures of barley or bread wheat grain and spelt fine-sieving by-products occurred relatively commonly among MR samples with evidence for significant germination (Table 4.9). The interpretation of these samples varies, according to whether germination was attested in the spelt grain, the free-threshing cereal grain, or by coleoptiles (which could have come from either).

4.8.2.2. The Late Iron Age sample

The single LIA germinated sample from Harston (R231) comprised dense clean barley and spelt grain. 20% of the spelt grain, but less than 1% of the barley grain, in this sample was found to have sprouted (i.e. only 5% of all grain). This low level of germination was probably not considered significant by the grain-storers. Germination is considered to be incidental, and unrelated to carbonisation of this deposit (cf. Hall and Kenward 2007).

4.8.2.3. Early Roman malting

<u>*Colonia Vitricensis*</u>

Significant germination was identified in a dense clean wheat and barley grain sample from *Colonia Vitricensis* (Culver Street; R98). The source report (Murphy 1992b) notes approximately uniform sprout-length (suggesting controlled germination), and suggests interpretation as malt. It also suggests that the approximately 10:1 ratio of wheat and barley grains in this sample represents a specific blend, designed to give a desired flavour to beer brewed from this malt. This interpretation is not challenged.

<u>Pakenham fort</u>

Five germinated samples were recovered from unknown features in the ER fort at Pakenham.

Two were sieved spelt spikelets, one mixed with clean barley grain, with significant proportions of germinated grain – 63% and 68% of all grain (of indeterminate species in the mixed sample). These levels of germination approach that seen in modern malts (Van der Veen 1989). It is unlikely that this occurred accidentally (though absolute grain numbers were quite low).

Two samples were spelt fine-sieving by-products, and one mixed clean barley grain and (previously sieved) spelt fine-sieving by-products. Given the identification of malted spikelets at this site, it is considered likely that these samples represent the cleaning of malt, rather than the hand-picking of spoilt grain following fine-sieving. In the mixed sample, germination was attested in the spelt grains only (i.e. in the fine-sieving by-product portion of the sample).

It seems likely that spelt and barley were malted at Pakenham, to produce beer for the soldiers (and others) stationed there. This was not the only crop-processing activity taking place in the fort, as indicated by numerous fine-sieving by-product samples with no evidence of germination. Malting practice at Pakenham differed from that in *Colonia Vitricensis* in the choice to malt spelt as spikelets, not clean grain. Also, the blend of grains is different – spelt-only or an approximate 4:3 spelt:barley mix, in contrast to the 10:1 mix seen at Culver Street.

A single fine-sieving by-product sample (in which 70% of the spelt grains had sprouted), from the MR town at Pakenham is insufficient evidence to indicate the continuation of malting in this period.

<u>Heybridge</u>

The single germinated fine-sieving by-product sample from Heybridge included a large number of coleoptiles (far larger than the number of grains present). Though it may derive from the cleaning of malted spelt spikelets, it cannot be proved that it was not imported to the town (though evidence for commoditisation of by-products comes mainly from the MR period; Section4.6.2.5). There are no further samples to indicate malting in Heybridge.

4.8.2.4. Middle and Late Roman malting

Evidence for malting in individual MR and LR records is shown in Table 4.10.

Record	**Date & Location**	**Relevant contextual information**	**Germinated samples**[1]	**Interpretation**[2]
Malting				
Stebbing Green	MR, central southern till	Features/finds interpreted as malt house, tank for soaking grain to induce germination, malting-ovens, and millstones to grind malt prior to mashing and brewing (Bedwin and Bedwin 1999). Samples from 'flues' and a nearby ditch.	5 x dense FSBP (from previously-sieved spikelets in 4 cases).	Possibly spelt malt combined with FSBP fuel (as Murphy 1999). However, Ratio C indicates FSBP only, suggesting by-products from the fine-sieving of malted spikelets. Given context, probably used as fuel.
Beck Row, Mildenhall	MR, Breckland	Features/finds interpreted as malt house, malting-floor and –ovens, and millstones (Bales 2004).	2 x dense mixed barley grain and sieved spikelets.	Mixed barley and spelt (spikelet) malt.
			4 x dense mixed barley grain and FSBP (from previously-sieved spikelets).	Possibly as suggested by Murphy (1999) for Stebbing Green (above). Possibly malting of barley using by-products from cleaning of malted spelt spikelets as fuel (as Fryer 2004).
			7 x dense FSBP (from previously-sieved spikelets in 5 cases).	By-products from cleaning of malted spelt spikelets (as Fryer 2004).
Snettisham Bypass	MR, extreme north-east fen-edge	Samples from a corndrier.	1 x dense sieved spikelets	Mixed barley and spelt (spikelet) malt (as Murphy 2001).
			1 x dense FSBP (from previously-sieved spikelets)	By-products from cleaning of malted spelt spikelets. Given context, probably used as fuel.
Mucking	LR, south-east	Sample (very large) from a corndrier.	1 x dense sieved spikelets	Spelt (spikelet) malt (as Van der Veen 1989).
Probable malting				
Boxfield Farm (R65)	MR & ?MR, central chalk	One of ten FSBP samples from a corndrier, others have no evidence of germination.	1 x dense FSBP	Germinated grains and coleoptiles present in numbers high enough to draw attention in this analysis (23% of grain and equal to 38% of grain, respectively) but low enough that germination may be incidental.
		Sample from possibly MR fill of an ER well.	1 x mixed bread wheat grain and spikelets	Germinated grain of both species in significant numbers. Probably mixed bread wheat and spelt (spikelet) malt.

Parnwell	MR, north-west fen-edge	Samples from large stone-lined corndrier (and adjacent deposit) interpreted as malting-oven (Druce in Webley 2004).	2 x dense FSBP (from previously-sieved spikelets)	By-products from cleaning of malted spelt spikelets. Given context, probably used as fuel.
			2 x dense mixed bread wheat grain and FSBP (from previously-sieved spikelets)	Germination attested by coleoptiles, no germinated bread wheat grains present. Probably by-products from cleaning of malted spelt spikelets, used to fuel drying (not malting) of bread wheat grain.
Newmarket Road, Cambidge (R244)	MR, western clay	Sample from oven.	1 x dense mixed barley grain and FSBP	Germination attested by coleoptiles which could have derived from either component of the sample. Malting or drying of barley using fuel derived from the cleaning of malted or other spelt spikelets.
Stansted Airport	LR, central southern till	Precise quantification of germinated grain and coleoptiles not available, but indicated to occur 'frequently' (Carruthers 2008).	1 x spikelets	Probably spelt (spikelet) malt.
Possible malting				
Hinxton Road, Duxford	LR, central chalk	Sample from a small oven/kiln set within a chalk-block structure.	4 x dense FSBP (from previously-sieved spikelets in 3 cases).	Possibly small quantities of spelt malt mixed FSBP (as Fryer 2011). However, Ratio C indicates FSBP only, suggesting by-products from dehusking, fine-sieving and hand-cleaning of grain (as Fryer 2011) or by-products from cleaning of malted spelt spikelets. Given context, probably used as fuel.
Tunbridge Lane, Bottisham	MR, central chalk	Record classed as a field system but includes a pair of corndriers suggested to have been used for malting (McConnell *et al.* 2008; Nicholson 2008). Record also includes numerous samples – including other by-products from fine-sieving of previously-sieved spelt spikelets – with no evidence of germination.	5 x dense FSBP (from previously-sieved spikelets).	Possibly by-products from cleaning of malted spelt spikelets. Alternative interpretation is by-products from dehusking, fine-sieving and hand-cleaning of grain.
	LR, central chalk	Corndriers not in use in this phase (McConnell *et al.* 2008).	1 x dense FSBP (from previously-sieved spikelets).	
Stansted Airport and neighbouring sites	LR, central southern till	Precise quantification of germinated grain and coleoptiles not available for 2 samples but indicated to occur 'frequently' (Carruthers 2008).	4 x FSBP (from previously-sieved spikelets)	
Biddenham Loop	MR, western clay	-	1 x dense FSBP (from previously-sieved spikelets).	

Barnack	MR, north-west	Sample from corndrier.	1 x dense FSBP (from previously-sieved spikelets).	
Langdale Hale, Earith	MR, south-west fen-edge	-	2 x dense FSBP (from previously-sieved spikelets).	
Verulamium (R221)	LR, south-west chalk	-	1 x dense FSBP (from previously-sieved spikelets).	
Haddon (R1006)	LR, western clay	-	1 x dense FSBP (from previously-sieved spikelets).	

[1]All fine-sieving by-products (FSBP) and spikelets are spelt. [2]Where interpretation is the same as that given in source report, reference is given – e.g. (as Murphy 1999).

Table 4.10. MR and LR evidence for malting.

Clear evidence for malting comes from only four records (three MR, one LR); malting was recognised (though precise interpretation of sample differed from those given here) in all of their source reports (Table 4.10). There is evidence of probable malting in a further four records, unconfirmed because of low sample numbers or uncertainty as to the exact interpretation of the activity represented. Whether or not the latter are accepted as evidence of malting, the MR period is confirmed as the peak in evidence of malting activity as well as for significant evidence of germination. In contrast to ER occurrence in a fort and a major town only, MR (and LR) malting appears to have been practiced at rural settlements.

It can be seen in Table 4.10 that spelt malt occurs only in spikelet form: malting of clean spelt grain does not appear to have been practiced. Furthermore, most spikelets representing spelt malt have been sieved to remove weed seeds, consistent with suggestions in Sections 4.7.1.2 and 4.7.2.5.

In keeping with this, most by-product samples interpreted as (possibly) representing the cleaning of malted spikelets prior to grinding, mashing and brewing represent the cleaning of *previously-sieved* spikelets. Such samples occur in an additional eight records (four MR, four LR) in which they cannot be shown to represent malting rather than disposal of spoilt grain (presumably hand-picked from a grain product) along with fine-sieving by-products. They are of interest in either case. If interpreted as by-products from the cleaning of malt, it is of interest that they occur in isolation from other evidence of malting activity; this *may* be consistent with the premise that fine-sieving by-products moved between sites as a commodity in their own right (Section 4.6.2.5). If they are unrelated to malting, increased grain-spoilage (accidental germination) in the MR and LR periods is consistent with the premise that grain was more frequently handled in bulk in these periods (Sections 4.6.2.1 and 4.6.2.5).

4.9. Summary

4.9.1. Assessment of this analysis

Only 30% of the samples initially recorded contained sufficient identified items (50) to be included in this analysis (see Section 3.5.1). While use of this threshold has ensured representativeness of the samples used, it is unfortunate that such a large proportion of the original data could not be included in consideration of crop-processing behaviour. Following initial analysis, a further 32 samples were excluded from further consideration as their crop-processing derivation could not be reliably identified.

Assessment of the remaining samples is considered to have been a success. Several aspects of crop-related behaviour have been characterised, and variation within them commented on, for all periods save the EIA (whose dataset was reduced to just 28 samples). The patterns identified are of interest, and have the potential to contribute to understanding of variation in wider social and economic behaviours in this region and period (Chapter 8).

4.9.2. Summary of significant findings

4.9.2.1. Early Iron Age

Low sample numbers prevent comment on most aspects of Iron Age crop-processing behaviour. This prohibits comment on whether the patterns identified in the MIA represent new or established behaviours. Clean emmer grain is represented in a more records in the EIA than in later periods. This may indicate a change in how emmer was perceived and handled.

4.9.2.2. Middle and Late Iron Age

Treatment and storage of clean grain

Variation in the ways that clean grain was treated in the MIA and LIA is indicated by its occurrence almost exclusively in the southern half of the study region. This suggests differences in behaviour which resulted in contact between grain and fire being more common in the south than in the north.

Storage of wheat and barley grain in four-post granaries and/or storage pits is attested at two MIA rural settlements. It is assumed that grain storage was not an unusual activity; circumstantial evidence for it (storage structures and pits) has been noted in other studies (e.g. Murphy and de Moulins 2002; Section 1.5.5.6). It is the *scale* of storage at Lodge Farm and Wendens Ambo which is considered significant: destruction of such large stores by fire cannot have been a common occurrence; its detection suggests that large-scale grain-storage was practiced frequently enough for an improbable event to occur (cf. Van der Veen and Jones 2006). It is possible that detection at these sites was enabled by storage practice which was in some way atypical, e.g. location of grain stores closer to domestic areas where fire was frequently used.

Crop-processing.

The distribution of MIA fine-sieving by-products contrasts with that of clean grain, as more than half are from the Isle of Ely. Most are dense, and most include emmer; some represent the fine-sieving of previously-sieved spikelets. As well as cultivation of a different crop, the Isle of Ely is thus distinctive in carrying out fine-sieving on a larger scale, and burning its by-products more frequently, than was the norm in the MIA. Cultivation of emmer and frequent disposal of the by-products from its (now small scale) fine-sieving by burning continued in the fens (south-west fen-edge) in the LIA.

Dense fine-sieving by-product samples, some including emmer, are also present at the two hillforts (Asheldham Camp, also the only MIA record with clean emmer grain, and Chipping Hill) in the south-east of the study region. These records were also distinctive in the presence of spikelets (rare in this period), including most dense and sieved examples. Spikelet-sieving by-products were absent, but were present at Stanway (a discrete enclosed settlement *c.* 19km from Chipping Hill).

Low sample numbers make interpretation tentative, but it appears that spikelets were treated differently at these prominent sites in the south-east than at other sites. A model may be cautiously suggested whereby crops cultivated at rural settlements underwent early-processing (sometimes including spikelet-sieving), before being transported to the hillforts, where they underwent further bulk-processing, with an end product of clean grain.

In the LIA, the nucleated settlement at Heybridge (south-east) is distinctive in strong representation of fine-sieving by-products (mostly sparse, including some emmer) and spikelets (sparse, sieved and unsieved). This assemblage is similar to that of the ER period (Section 4.2.9.3) possibly suggesting similar provisioning strategies. Similar assemblages are identified in a few rural records from the central southern till and fenland.

4.9.2.3. Early Roman

<u>Towns and forts</u>

Storage of wheat in *Colonia Vitricensis*, and carbonisation when the town was burnt during the Boudican rebellion, explains the high representation of dense clean grain in the ER period. Fine-sieving by-products (thought to have been carbonised following processing events, rather than in the burning of the town) are rare, but all examples are dense, suggesting bulk fine-sieving. Spikelets are present in just one (dense) sample. Grain may have usually arrived in the town fully cleaned; however, on at least some occasions it arrived as spikelets which were (sometimes) stored for a short time before being fine-sieved in bulk. Grain would thus have been acquired by individual households clean and ready for culinary preparation.

Clean grain is absent from the small town at Heybridge and rare at Pakenham fort, where it occurs only in sparse samples (though these settlements were never destroyed by fire to preserve any grain stores they may have had). Fine-sieving by-products (mostly sparse), some representing fine-sieving of previously-sieved spikelets, dominate and spikelets (sparse, sieved and unsieved) are also present. It appears that grain arrived in the town and fort in spikelet form, sometimes sieved (perhaps for more efficient transport or as a means of standardising grain content by weight/volume prior to sale), and was acquired by individual households in this state, with further processing mostly carried out as required, on a day-to-day basis.

ER malting is attested only at *Colonia Vitricensis* and Pakenham. Though the evidence is limited, malting practice seems to have differed between the town and the fort, with spelt malted in spikelet form (and subsequently cleaned) at Pakenham, but as clean grain in *Colonia Vitricensis*. Tastes also appear to have differed, with a 10:1 spelt:barley malt blend used at *Colonia Vitricensis*, but examples with both more barley and no barley identified at Pakenham.

<u>Pottery-production sites</u>

Four sites with evidence for pottery-production had distinctive assemblages. Spikelets (emmer as well as spelt) were unusually well represented at Greenhouse Farm; these included an example of spikelet-sieving, a practice mostly attested in town/fort records.

Mixed grain and by-products, rare in this period but occurring at Heybridge, Pakenham and *Colonia Vitricensis*, were present at Addenbrooke's (where the grain component was also distinctive in indicating bread wheat-cultivation) and West Stow, where rare early-processing by-products (barley) were also present (mixed with fine-sieving by-products). The only occurrence of mixed spikelets and early-processing by-products (barley) was at Tort Hill West.

<u>Rural settlements</u>

In records from ER rural settlements, sparse grain and by-product samples remain the norm, suggesting small-scale crop-handling. Large-scale fine-sieving is attested at a small number of complex rural settlements. Dense deposits of clean grain occur only alongside dense fine-sieving by-products, suggesting (not proving) accidents during processing, rather than destruction of stores, although this suggestion is supported by archaeological context (derivation from a kiln) in only one case.

4.9.2.4. Middle and Late Roman

<u>Scale of fine-sieving and use of by-products as fuel</u>

Spelt fine-sieving by-products dominate in the MR and LR periods. A high proportion of these are dense, indicating bulk fine-sieving, which was more common in the MR period than any other, being represented in all record-types across the study region. Its frequency declined a little in the LR period. There is evidence indicating frequent re-use of fine-sieving by-products as fuel/tinder in the MR period. There are also suggestions that by-products became carbonised in this manner at sites where they were not generated, suggesting their commoditisation. These practices continued in the LR period, though less frequently.

In contrast to this evidence of widespread bulk fine-sieving, sparse samples from the MR small towns of Pakenham and Heybridge suggest acquisition and small-scale fine-sieving of spikelets (sometimes previously-sieved) by individual households. This type of supply is also suggested in the small towns at Godmanchester and Stonea Grange, but there is also evidence for bulk fine-sieving in these cases. At Stonea Grange, spikelet-sieving by-products suggest that spikelets were sieved within the town (rather than to facilitate transport to it).

<u>Storage and malting</u>

Clean grain samples are relatively scarce in the MR and LR periods. Dense clean grain samples are as common as sparse ones, but few records have sufficient dense samples combined with contextual evidence to indicate grain storage. Barley grain and spelt spikelets were present in granaries at MR *Verulamium*, and spelt and barley grain samples from the LR fort at Caister-on-Sea may also represent burnt stores. A potential increased incidence of grain spoilage (accidental germination) in these periods would be consistent with increased bulk grain storage.

It is notable that in these periods, dense clean grain occurs almost exclusively mixed with fine-sieving by-products (barley) or in records where dense fine-sieving by-products are also present (spelt/wheat and barely), and that barley grain does not occur at all except where spelt/wheat is also present.

MR and LR spikelet samples are mostly from records in the north of the study region. Most MR exceptions to this were from Heybridge and *Verulamium*; LR exceptions were from Mucking (related to malting) and Great Holt's Farm (representing a burnt store); sparse spikelets also occurred on the central southern till in both periods. This pattern suggests variation in practice resulting in more frequent exposure of spikelets to fire in the north (and in MR towns) than (generally) in the south. This may indicate bulk storage and accidental destruction (though contextual evidence is lacking) or more frequent drying of spikelets using fire (with ensuing accidents).

Spikelet-sieving was more common in the MR period than in any other, and remained common in the LR period. It appears to have been carried out to facilitate transport/change of ownership, or to increase the efficiency of dehusking and reduce space needed for storage, in most cases. In a small number of records, it was a precursor to malting, which is best represented in the MR period but also occurred in the LR period.

4.9.3. Key points to carry forwards

There is evidence of distinctive behaviour on the MIA Isle of Ely, incorporating emmer-cultivation, bulk fine-sieving and frequent disposal of its by-products by burning. Also in the MIA, spikelets appear to have been gathered in bulk at the south-eastern hillforts, subsequently undergoing bulk fine-sieving. This may be consistent with gathering and redistribution or consumption of crops at these prominent sites. There is also evidence of large-scale grain-storage in the MIA.

In Roman small towns (and the ER fort at Pakenham and LIA nucleated settlement at Heybridge), grain appears to have been acquired by individual households in spikelet form, with further processing carried out on a day-to-day basis. This contrasts with provisioning at *Colonia Vitricensis*, where grain was either brought to the town fully-cleaned or fine-sieved in bulk on arrival in spikelet form, prior to acquisition by individual households. Roman grain storage is best attested at ER *Colonia Vitricensis* (owing to burning of grain stores in the Boudican revolt), but also at MR *Verulamium* and (possibly) the LR fort at Caister-on-Sea.

Small-scale crop-processing was the norm at rural settlements in the ER period, but large-scale fine-sieving is well represented in the Middle and LR periods. By-products from this process appear to have been burnt (and traded) as fuel, especially in the MR period. Malting was practiced only at Pakenham fort and *Colonia Vitricensis* in the ER period, but at several rural settlements in the MR and LR periods.

5. Maslins or monocrops?

5.1. Objective

This chapter explores whether crops in the Iron Age and Roman East of England were always grown as monocrops, or whether the growing of maslins (Section 1.6.3) was part of the cultivation strategy in some periods and/or locations. Cultivation of maslins reduces the risk of total crop failure in the event of adverse weather conditions such as drought or extreme cold (Van der Veen 1995). Identification of maslins in the archaeobotanical record could thus help identify times and places in which such risk-buffering was considered necessary. In the context of the region's wider archaeological record (Chapter 8), this insight into the attitudes of Iron Age and Roman farmers towards their crops may contribute to understanding of wider social and economic fluctuations.

5.2. Methodology

5.2.1. Background and samples

The cereal crops cultivated in the Iron Age and Roman East of England are identified in Chapter 3. In most samples a single crop species was identified by Method 2. Grain/chaff of other species present in some of these in very small quantities was considered to be incidental. These samples represent the cultivation of monocrops. 223 samples were interpreted as containing more than one crop species. Of these, 102 were of mixed crop-processing derivation (e.g. barley grain and spelt fine-sieving by-products). They are considered to represent post-harvest mixing of monocrops.

In the remaining 121 samples, two or more crops of the same crop-processing derivation were identified (Table 5.1). It is possible that these were cultivated separately (i.e. as monocrops) and mixed for storage, use or disposal. Alternatively, these samples could represent the cultivation of maslins.

Crop-processing derivation and species	EIA	MIA	LIA	ER	MR	LR
Fine-sieving by-products						
Spelt and emmer	1	13	7	1	2	3
Spelt and barley	3	1	1	1	17	8
Barley and indet. wheat	0	0	1	0	0	0
Spelt and bread wheat	0	0	0	1	1	1
Clean grain						
Spelt and barley	0	4	6	2	4	4
Spelt and emmer	0	1	0	0	1	0
Spelt and bread wheat	0	0	0	0	0	2
Barley and indet. wheat	0	0	1	0	0	0
Barley and glume wheat	3	0	1	1	0	2
Emmer and barley	2	1	0	0	0	0
Spelt, emmer and barley	1	1	0	0	0	0
Barley and bread wheat	0	1	0	0	0	0
Barley, bread wheat and spelt	0	2	0	1	2	1
Barley, bread wheat, spelt and emmer	0	8	0	0	0	0
Bread wheat and glume wheat	0	0	0	1	0	0
Spikelets						
Spelt and emmer	0	2	4	0	0	0

Table 5.1. Samples representing more than one crop of the same crop-processing derivation.

Most of these mixtures are quite rare in the dataset (Table 5.1). It is unlikely that specific maslins were cultivated across the region and throughout the study period (e.g. that spelt and emmer were always cultivated together – there is plenty of evidence from single species samples for their being cultivated separately). Single-record datasets used to determine practice at individual sites during specific periods would be the preferred scale for this analysis. Failing this, period-specific analyses may yield useful results.

Four mixtures occurred with reasonable frequency within specific periods. These are MIA spelt and emmer fine-sieving by-products (13 samples from three records on the Isle of Ely and two in the south-east), MR (17) and LR (8) spelt and barley fine-sieving by-products, and barley and wheat grain (10 samples: spelt and bread wheat, with emmer in two cases) from MIA Wendens Ambo.

5.2.2. Correspondence analysis

Distinguishing maslins from post-harvest mixing of monocrops is notoriously difficult. The method used here is based on Van der Veen (1995). Her study pre-dates the development of correspondence analysis and instead employs principal component analysis to identify associations between cereal crops and their weed floras. This investigation uses correspondence analysis to the same end. The principles of interpretation are the same: taxa (crops and weeds) which grew together should plot close together in the species-plots; taxa which grew separately, under different conditions, should plot at a distance from each other. In the sample-plots there may be a spatial discrepancy between samples representing post-harvest mixing and those representing maslins if both are present.

The datasets used to distinguish between maslins and monocrops are based on the mixtures identified in Table 5.1 and are described in Table 5.2. All samples are of known crop-processing derivation, and so include ≥50 identified items.

Dataset A (MIA fine-sieving by-products) initially included the thirteen samples listed in Table 5.1, as well as five (from two records on the Isle of Ely) in which only emmer, or 'glume wheat', was identified as a crop.

Dataset B (MIA clean grain) initially included all eleven clean grain samples from Wendens Ambo (the ten noted in Table 5.1 and one whose crop was identified as spelt and emmer only, but in which a very small number of barley grains were also present). Wheat was entered into the analysis as a single species as numbers of grains for individual species were unavailable.

Given the comparative difficulty of recognising barley fine-sieving by-products (Chapter 4.5.2) Datasets C and D also initially included samples in which small amounts of barley were present but not considered (by Method 2) to represent cultivation.

In all datasets, samples containing fewer than 3 weed seeds were excluded (as the method is dependent on identifying patterns in weed assemblages); this very low cut-off point is necessitated by very small datasets. Samples which plotted as outliers in preliminary datasets, obscuring other variation, were also excluded.

Species are usually included in a dataset for correspondence analysis if they occur in more than a given proportion of samples (5% and 10% limits have been applied; Section 2.4.2). Cut-off points for species inclusion were set individually for each of these very small datasets (Table 5.2) to exclude truly rare species, but retain a species assemblage resembling the original sample compositions. Unidentified weed seeds were excluded.

The codes used to identify weed taxa and cereal items in the species-plots (Figs. 5.1, 5.3, 5.5 and 5.6) are explained in Appendix 3.

Dataset	**Period**	**Records**	**Mixture**	**No. of samples**	**No. of species**	**Species cut-off**	**Comments**
A	MIA	Isle of Ely: Watson's Lane (R38), Wardy Hill (R207), West Fen Road (R157). South-east: Chipping Hill (R156), Stanway (R135).	Spelt and emmer fine-sieving by-products	14	21	≥19% (three samples)	No. of samples less than no. of species, may give unreliable results.
B	MIA	Wendens Ambo (R72).	Barley and wheat clean grain (see text above)	11	4	Irrelevant (see comments)	Small dataset, very few species. This reflects sample composition and does not result from exclusion of rare species.
C	MR	Mostly Tunbridge Lane (Bottisham; R87); and Beck Row (Mildenhall; R36); 1-2 samples from 10 other records.	Spelt and barley fine-sieving by-products	35	22	≥12% (five samples)	Samples from 12 records: increases potential for variation with causes other than differences in cultivation regimes for spelt and barley.
D	MR	Tunbridge Lane (Bottisham).	Spelt and barley fine-sieving by-products	14	12	≥19% (three samples)	Small dataset.
E	LR	Mostly Tunbridge Lane (Bottishsam; R88), also Hinxton Road (Duxford; R243), Langdale Hale (Earith; R254), Vicar's Farm (Cambridge; R257) and *Verulamium* (R221).	Spelt and barley fine-sieving by-products	13	13	≥21% (four samples)	Small dataset.

Table 5.2. Datasets used in correspondence analysis for identification of maslins and monocrops.

5.3. Middle Iron Age spelt and emmer cultivation in the south-east and on the Isle of Ely (Dataset A)

Spelt and emmer glume bases plot separately in the species-plot of this dataset (Fig. 5.1; Table 5.2 for dataset description). Each plots together with a group of weed taxa (and other cereal items); glume wheat grain (which could be spelt or emmer) plots between the two groups. This pattern was observed in Dataset A (Fig. 5.1) and remained unaltered (i.e. the same weed taxa associated with the two cereal species, though slightly less clearly) in two experimental datasets (not shown) from which outlying samples were excluded. This suggests the existence of two different weed floras, one associated with spelt, the other with emmer, implying that the two were cultivated separately in the MIA on the Isle of Ely and in the south-east of the study region.

Weeds plotting with spelt glume bases	**Weeds plotting with emmer glume bases**
Phleum spp., Bromus spp., Trifolium spp., Carex spp., Avena spp., Persicaria maculosa/lapathifolia, Atriplex spp., Avena/Bromus, Medicago luplina, Vicia/Lathyrus, Eleocharis spp.	*Polygonaceae indet., Chenopodium spp., Chenopodiaceae indet., Fallopia convolvulus, Bromus hordeaceus/secalinus, Tripleurospermum spp., Cladium mariscus*.

Table 5.3. Weeds associated with spelt and emmer in Fig. 5.1.

Reflecting the positions of the two groups observed in the species-plot, the samples are divided into two groups: the samples from the south-east of the study region and Wardy Hill, and one from Watson's Lane, fall in the 'emmer area'; the remaining samples from Watson's Lane and West Fen Road fall in the 'spelt area'. This pattern was also seen in the two experimental datasets (not shown). The two outlying samples in Fig. 5.2 (excluded from the experimental datasets) are the two identified only as glume wheat. Consistent with their location in the sample-plots, samples from the south-east and Wardy Hill contain more emmer than spelt glume bases; the sample from Watson's Lane which plots with these is the only emmer-only sample in the dataset. In the remaining samples from Watson's Lane and West Fen Road spelt glume bases were more common than (or as common as) emmer glume bases; the one samples in which this is not the case switches groups in the experimental datasets (not shown).

It thus appears that one group of weeds is associated with spelt and Watson's Lane/West Fen Road and another with emmer and Wardy Hill/the south-east of the study region. However, the weeds plotting in each group also occur in samples from the other group. It is *not* suggested that crops from the two regions were mixed to form the deposits from which samples were taken. However the record-associations are interpreted, it seems that spelt and emmer were cultivated separately, as monocrops, in the south-east and on the Isle of Ely in the MIA.

5.4. Middle Iron Age wheat and barley cultivation at Wendens Ambo (Dataset B)

Analysis of Dataset B (Table 5.2 for dataset description) proved inconclusive. This was probably because very thorough grain cleaning had removed all weeds other than *Avena spp*. and *Bromus hordeaceus/secalinus*, meaning that the only variation in the weed assemblages which could be assessed was relating to these two species. In the species-plot (not shown), the wheat and barley grain plotted either side of these weeds (which occupied a similar position) on Axis 1. There was no pattern observed in the sample-plot (not shown), save that the single sample in which barley was not considered to have been a crop plotted at the negative end of the range on Axis 1 (closest to the position of wheat grain in the species plot). The question of whether wheat and barley were cultivated as maslins or monocrops at MIA Wendens Ambo remains unanswered.

5.5. Middle Roman spelt and barley cultivation (Datasets C and D)

Spelt glume bases plot very close to the origin of the species-plot for Dataset C (Fig. 5.3; Table 5.2 for dataset description), reflecting their dominance in the fine-sieving by-product samples. Barley rachis nodes occupy a similar position on Axis 1, but the two are separated on Axis 2. Grain of both species plots closer to barley rachis nodes than to spelt glume bases on Axis 2, but the direction of their separation is the same as that of the chaff items (spelt plots more negatively); they are also separated on Axis 1 (spelt plots more positively). Most weed taxa plot in the area between spelt glume bases and barley rachis nodes, but some appear to be more strongly associated with spelt and a few more strongly associated with barley (Table 5.4).

This pattern in the species-plot suggests that spelt and barley were cultivated as monocrops, each with an associated weed flora, and only became mixed after harvest. The 'fuzziness' of this separation is probably caused by similarities in the weed floras associated with the two.

Weeds more strongly associated with spelt	**Weeds more strongly associated with barley**	**Other weeds**
Bromus hordeaceus/secalinus, Festuca/Lolium, Large Poaceae (indet.), small Fabaceae (indet.), Avena spp., Vicia/Lathyrus, Fallopia convolvulus	*Chenopodiaceae (indet.), Polygonum aviculare, Tripleurospermum spp., Chenopodium spp*	*Rumex spp., Anthemis cotula, Cladium mariscus, Asteraceae (indet.), small Poaceae (indet.)*

Table 5.4. Weeds associated with spelt and barley in Dataset C.

In the sample-plot (Fig. 5.4), samples from Beck Row (and the single samples from Ruxox and Snettisham Bypass) and Tunbridge Lane (and single samples from Parnwell, Biddenham Loop and Rectory Farm) form two groups separated on Axis 1. It appears that variation on Axis 2 relates to differences in weed ecology between records, rather than between crops.

Tunbridge Lane was the only record to have sufficient relevant samples to attempt a single-record investigation of whether spelt and barley were grown as maslins or monocrops in the MR period. The species-plot for Dataset D (Fig. 5.5; Table 5.2 for dataset description) resembles that of Dataset C, with spelt and barley separated by a small margin on Axis 2. Ten of the weed taxa included in Dataset C were excluded as rare from Dataset D. Of the remainder, those associated with spelt in Dataset C remained so in Dataset D. All taxa associated with barley in Dataset C were excluded from Dataset D, but all of those whose association was unclear in Dataset C were more strongly associated with barley in Dataset D. Spelt and barley are considered to have been cultivated separately, as monocrops, at MR Tunbridge Lane, Bottisham.

5.6. Late Roman spelt and barley cultivation (Dataset E)

As in Datasets C and D, spelt glume bases plot close to the origin in the sample-plot of Dataset E (Fig. 5.6; Table 5.2 for dataset description), reflecting their dominance in LR fine-sieving by-product samples. Barley rachis nodes occupy a similar position on Axis 1, but plot more positively on Axis 2. Most weeds appear to be more strongly associated with spelt, apart from *Chenopodium spp*. which is more strongly associated with barley; *B. hordeaceau/secalinus* and Asteraceae (indet.) plot between the two. This pattern suggests that spelt and barley were cultivated separately in the LIA.

Variation on Axis 2 appears to relate to variation in weed ecology between records, rather than between crops, with more variety evident at Tunbridge Lane than in other records.

5.7. Comment on investment in different crops

The investment of labour and resources in cultivation is a principal aspect of the characterisation of cultivation regimes, addressed in Chapter 6. However, the crop-weed associations identified in this chapter offer an opportunity to explore (time/place specific) differences in the levels of investment between different crops. Table 5.6 shows the mean Ellenberg N values (after Hill *et* al. 1999; defined in Section 6.2.1) for the weeds (those identified with sufficient precision for meaningful values to be obtained) associated with spelt, emmer and barley in the MIA, MR and/or LR periods.

	Mean N value		
Period	**Spelt**	**Emmer**	**Barley**
MIA (south-east and Isle of Ely)	6	5.4	-
MR	5	-	7
LR	6	-	8

Table 5.5. Mean Ellenberg N values for weeds associated with specific crops.

For the MIA south-east and Isle of Ely there is no significant difference in the levels of investment suggested for spelt and emmer. However, the Roman evidence suggests that the barley component of mixed samples was cultivated with higher levels of investment than the spelt element. It is noted that the reliability of this characterisation is affected by the very small datasets on which it is based.

5.8. Key points to carry forwards

This analysis was hampered by small datasets. This results from the relatively small number of samples in which multiple crops of like crop-processing derivation were identified. However (as stated in Chapter 3.4.2) it is considered preferable to use these crop identifications in this attempt to distinguish between maslins and monocrops, rather than basing this analysis on all samples in which more than one cereal species was *present*, regardless of its abundance (i.e. on Method 1). It is considered that this alternate approach would produce unreliable results.

Despite the low sample numbers, this analysis has been successful, showing that spelt and emmer were cultivated separately in the MIA in the south-east of the study region and on the Isle of Ely – the only areas in which emmer-cultivation was well represented. It has also shown that spelt and barley were cultivated separately in the MR and LR periods (though occasional maslin cultivation has not been ruled out); barley appears to have been cultivated with higher levels of investment than spelt. This is not to say that maslins were never cultivated in the Iron Age or Roman East of England: limitations of the data mean that the question has not been tackled for most of the Iron Age and ER period, or for mixtures other than spelt and barley in the MR-LR period.

6. Weed ecology and cultivation practice

6.1. Objective and approach

Chapter 6 focuses on the characterisation of the conditions under which crops were cultivated and interpretation of the different cultivation practices which contributed to them. In the context of the region's wider Iron Age and Roman archaeological record (Chapter 8), this allows insight into the relationship of arable production with fluctuations and movements of population and changes in social organisation.

Each of the weed species growing in an arable crop has its own preferences/tolerances for soil and environmental conditions, as well as its own life-history characteristics. Because of this variation, weed species either thrive or fail in arable plots cultivated under different regimes. A full list of the weed taxa identified in quantified samples is given in Appendix 3. In this chapter I use the preferences/tolerances and life-history characteristics of weed taxa in the archaeobotanical samples to elucidate the conditions in which crops grew, and so to characterise the cultivation strategies employed.

This is a complex undertaking, approached in two ways. Firstly, I plot the frequency with which weeds representing specific growing conditions occurred over time, confirming and clarifying the patterns observed through direct observation of the data. Secondly, I look at the combinations in which different growing conditions are represented using correspondence analysis, a multivariate technique which reduces multiple variables to a small number of composite variables (Section 2.4.2). This second approach facilitates identification of samples representing similar/different growing conditions, allowing characterisation of the cultivation practices employed in different records/record-types/areas/periods.

I begin by identifying weed characteristics which have the potential to elucidate growing conditions, and explaining the potential significance in terms of each in terms of cultivation practice (Section 6.2). I then describe the datasets and methodology employed in the direct approach (Section 6.3), before presenting the results of this analysis (Section 6.4). The datasets and methodology for correspondence analysis (CA) are described in Section 6.5; preliminary findings and the honing of the datasets are discussed in Section 6.6. The results of CA are discussed in Sections 6.7-6.9, divided by chronology and crop-processing derivation. In Section 6.10 I summarise the findings of the analyses and comment on their successes and limitations.

6.2. Characterising the weeds

6.2.1. Autecology: soil conditions

The approach taken to analysis of weed ecology in this research is largely autecological (Section 1.6.5.2). Each weed taxon was categorised according to its preferences/tolerances for the factors of soil moisture, nitrogen-content and reaction (acidity/alkalinity). These are defined by the British 'Ellenberg values' (Section 1.6.5.2) identified by Hill *et al*. (1999; 2004), as set out in Table 6.1.

Assessment was also made of the weed taxa's preference/tolerance for heavy clay soil. Those commonly occurring on a limited range of soil-types including heavy or clayey soils were differentiated from those occurring on a wide range of soil-types, or on a limited range of soil-types excluding heavy/clayey soils.

Attempts were also made to investigate preference/tolerance for soil salinity, but this was hampered by lack of available information. Most species investigated by Hill *et al*. (1999; 2004) do not occur today in saline soils in the British Isles, but it is not clear whether this means that they have no tolerance for such soils, or that information regarding their tolerance is simply unavailable (as assumed by Fitter and Peat 1994).

Factor & source of information	**Significance**	**Values**	**Previous studies**
Soil moisture (F value). Hill *et al*. (1999).	Taxa with high F values indicate cultivation of arable plots which included very wet areas (perhaps at the plot-edges, or in low-lying parts). Such conditions are not optimum for cereal cultivation and such plots can be described as marginal land. Their cultivation suggests that drier land was insufficient/ unavailable.	F1: extremely dry. F2: between 1 and 3. F3: dry. F4: between 3 and 5. F5: moist (average dampness). F6: between 5 and 7. F7: constantly moist/damp (not wet). F8: between 7 and 9 F9: often water-saturated, badly aerated. F10: periodic presence of shallow standing water. F11: plant rooting underwater [1] F12: submerged plant [1]	Van der Veen (1992: 124)
Soil nitrogen content (N value). Hill *et al*. (1999).	The nitrogen content of soil determines its fertility. Taxa with high N values indicate soil improvement; taxa with low N values indicate cultivation of soils whose nitrogen levels had not been maintained.	N1: extremely infertile. N2: between 1 and 3. N3: infertile. N4: between 3 and 5. N5: intermediate fertility. N6: between 5 and 7. N7: .richly fertile. N8: between 7 and 9. N9: extremely rich.	Van der Veen (1992: 122-129)
Soil reaction/ acidity (R value). Hill *et al*. (1999).	Acidic soil is an indicator of soil exhaustion, due to leaching and/or over-exploitation. Taxa with low R values indicate cultivation of soils whose nutrient levels had not been maintained.	R1: extremely acidic. R2: between 1 and 3. R3: acidic. R4: between 3 and 5. R5: moderately acidic. R6: between 5 and 7. R7: weakly acidic to weakly basic. R8: between 7 and 9. R9: basic.	Van der Veen (1992: 122-129)
Soil clayeyness Preston *et al*. (2002).	Heavy clay soils are difficult to cultivate. Such soils are considered as marginal land, whose cultivation suggests that areas of lighter soil were insufficient/ unavailable.	Clay preference. No clay preference.	M. Jones (1981; 1984a; 1984b; 1988a; 1988b; 1995; 1996), Murphy and de Moulins (2002)

[1]Taxa with Ellenberg F values F11 and F12 were excluded as their need to root or grow underwater suggests that they are more likely to be present as a result of post-harvest mixing or sample contamination than to have originated as arable weeds.

Table 6.1. Information used to classify weed taxa by edaphic tolerances/preferences.

Table 6.1 explains the categories used to classify weeds' edaphic preferences/tolerances, and states the source of information used in this categorisation. It also outlines the significance of each of these factors for interpretation of cultivation practice, and gives references to previous archaeobotanical investigations which have included their consideration.

6.2.2. Autecology: climatic conditions

Investigation of the weed taxa's preferences/tolerances for light was attempted, but the range of Ellenberg L values present was too narrow (one species with a value of L6, indicating partial shade to well-lit locations, and one with a value of L9, indicating full sun, and the rest with L values between the two) to indicate variations in cultivation practice.

No information was available on preferences/tolerances for Ellenberg's other climatic factors (temperature and continentiality) under British conditions. Furthermore, their exclusion from this analysis is justified on the grounds that (1) their measurement in the oceanic climate of the British Isles was considered by Hill *et al*. (1999) to be unreliable; (2) they are unlikely to have varied much within the (relatively small) study region; and (3) neither temperature nor continentiality was found to be a significant or meaningful cause of variation in the weed flora of arable crops in Iron Age and Roman north-east England (Van der Veen 1992: 122).

6.2.3. Life history characteristics

Other, non-ecological, weed characteristics with the potential to provide insight into growing conditions were also used in these analyses. Table 6.2 identifies these characteristics, explains their significance for the interpretation of cultivation practice, and explains the categories used in analysis. It also states the source(s) of information for each, and gives references to previous archaeobotanical studies in which they have been analysed.

Factor & source of information[1]	**Significance and source of information**	**Values (after Hill *et al.* 2004)**	**Previous studies**
Perennation and ability to regenerate from fragments Grime *et al.* (1988); Hill *et al.* (1999).	Perennial species cannot tolerate frequent soil disturbance; their presence indicates low levels of disturbance (e.g. weeding, hoeing, digging-in of manure or digging-over for aeration, deep or repeated ploughing). Annual species survive better in disturbed conditions. Perennial species able to regenerate from fragments, or spreading by means of rhizomes or stolons, are also able to survive frequent soil disturbance. These are included in the category 'annuals'. The presence of perennial weeds suggests infrequent soil disturbance; their absence suggests more regular disturbance in the course of cultivation.	Annual. Perennial. Varied.	Van der Veen (1992:137-138), Bogaard (2004: 125-126)
Onset and duration of flowering period. Fitter and Peat (1994); Hanf (1983)	Taxa with long flowering periods tolerate disturbance well and so will be common where cultivation involves frequent disturbance or spring sowing (and associated ploughing). Late-flowering taxa may set their seed late and compete poorly in autumn-sown crops, especially if these are harvested relatively early. Taxa with early and short flowering periods are well developed by the time of spring ploughing (and sowing), and so unable to recover from its effects before their flowering period is ended. They are more common in assemblages from autumn-sown plots.	Early/intermediate, short flowering (Jan-Jun, 1-3 months). Early/intermediate, long flowering (Jan-Jun, 4 months +). Late, medium flowering (July/later, 3-4 months). Varied or non-diagnostic.	Bogaard (2004: 123-129).
Germination time Fitter and Peat (1994); Hälfinger and Brun-Hool (1968-1977).	Autumn-germinating weeds are at a disadvantage in spring-sown crops, owing to the disturbance caused by spring-ploughing. Spring-germinating weeds are at a disadvantage in autumn-sown crops, which create shaded growing conditions. Spring-germinating species also favour fertile soils. It is difficult to adequately distinguish between the effects of soil fertility and the effects of sowing time.	Spring-germinating Autumn-germinating Varied or unclear.	Van der Veen (1992: 132-134), Bogaard (2004: 122-123)
Maximum height. Fitter and Peat (1994).	The height of weed taxa may indicate how a crop was harvested: short taxa will be present only if it was reaped low on the stalk or harvested by uprooting (in which case very short taxa and rhizomes may also be present). No patterns were identified for this factor.	Short (0-30cm) Medium-short (30-60cm) Medium-tall (60-100cm) Tall: >100cm (& *Bromus hordeaceus/secalinus*) Varied.	Van der Veen (1992: 137).

[1] Where more than one source is cited, the second was used only where information was unavailable in the first.

Table 6.2. Information used to classify weed taxa by life-history characteristics.

6.2.4. Specificity of taxonomic identification

Investigation of weed ecology requires that the ecological preferences/tolerances and life histories of weed species are known and uniform within each taxon. Weeds with very broad taxonomic identifications (e.g. identification to family, or to more than one possible genus) were excluded, as these factors varied too much within the species potentially represented. Identifications to genus, or to two/three species within a genus, were considered individually; only those which (excluding species indicated by Stace (1997) or Hill *et al*. (2004) to be recent introductions to Britain) were sufficiently consistent in most characteristics to allow meaningful interpretation were retained.

Where taxonomic identifications broader than a single species resulted in a range of similar Ellenberg values (N, R or F values) the mean of these values (rounded to the nearest whole number) was used; where a wide range of values was indicated, the taxon was excluded. Where broad taxonomic identification resulted in inconsistent descriptions of perennation, flowering period, germination time or maximum height, this was recorded as ‘varied’.

Some disagreement was noted in the literature in the assessment of germination time for some taxa; these were recorded as ‘unclear’. This may relate to responses to local climatic variations (cf. Van der Veen 1992: 133), but it adds an element of unreliability to analysis of this characteristic.

6.3 Methodology and dataset for basic analysis

6.3.1. Dataset

Comparison of weed assemblages in samples of varied crop-processing derivation cannot be reliably used to identify differences in growing conditions because of the selective removal of weed taxa according to their physical characteristics at each stage of crop-processing (G. Jones 1984; Van der Veen 1992: 81, 89)[15].

To avoid confusion between variation caused by crop-processing and cultivation practice, only samples of like crop-processing derivation were analysed. As both the most frequently occurring crop-processing derivative (Section 4.3.2), and one of those in which weeds are most likely to occur (i.e. a by-product), fine-sieving by-products (not mixed with any other crop-processing derivatives) were selected for consideration. This analysis was based on the proportion of all seeds accounted for by relevant taxa. It included all (332) fine-sieving by-product samples in which weed seeds were present.

6.3.2. Analyses

Five key weed characteristics, each (relatively) unambiguous in its significance in terms of cultivation practice, were selected for consideration by this approach (Table 6.3). These were investigated individually by the plotting of the frequency with which weeds representing each one were present in each period. Direct interrogation of the data was then used to clarify and confirm these patterns, and to identify records/record-types/areas at which the growing conditions in question were particularly well represented.

[15] Nonetheless, the weed-content of the all samples of known crop-processing derivation has been checked to verify that it does not contradict the broad trends observed in the fine-sieving by-product samples (Section 6.4), i.e. that the patterns observed result from variation in growing conditions, not (unspecified) variation in crop-processing practice causing differences in the taxa ending up in fine-sieving by-products.

Cultivation practice	Investigated by determining distribution of
Cultivation of very wet soils (marginal land)	Taxa with Ellenberg values F8-F10.
Cultivation of heavy clay soils (marginal land)	Taxa with a preference for heavy clay soils.
Cultivation of nutrient-poor and acidic soils (little effort at soil improvement)	Taxa with Ellenberg values N2-N4 and R3-R5.
Cultivation involving low levels of soil disturbance (little effort at soil improvement)	Perennial taxa.
Cultivation of nutrient-rich soils (investment in soil improvement)	Taxa with Ellenberg values N7-N9.

Table 6.3. Aspects of cultivation practice investigated using the direct approach.

6.4. Patterns in the representation of specific growing conditions

6.4.1. Samples used in these analyses

The 332 fine-sieving by-product samples included in these analyses were from 91 records. Their chronological distribution is set out in Table 6.4 and their spatial distribution is shown in Fig. 6.1. Bibliographic references to all records mentioned in the text are given in Appendix 1[16].

Period	Samples	Records
EIA	11	6
MIA	26	10
LIA	31	14
ER	43	14
MR	134	28
LR	87	19

Table 6.4. Chronological distribution of samples and records included in these analyses.

The low number of samples/record indicated in Table 6.4 means that, in most cases, there is insufficient evidence to confidently suggest record-specific cultivation regimes. However, a small number of records with higher than average sample numbers do stand out for particularly strong representation of weeds with specific, informative, characteristics. Such concentrations in records represented by more than a handful of samples are considered indicative of site-specific growing conditions; where low sample numbers make an interpretation tentative, this is noted. Concentrations in single samples or very small numbers of samples are considered un-interpretable (the more so

[16] The first mention of each record is suffixed with the record number to allow cross referencing.

when these are the sole representatives of a record, with no others available for comparison).

Low numbers of samples and records in all periods hinder interpretation of broader patterns, to the point of prohibiting insight into EIA cultivation practice (this period is consequently excluded from the discussions below –Sections 6.4.2-6.4.6 – unless otherwise stated). The causes and impact of low availability of samples are discussed in Sections 6.10.1 and 8.2.

6.4.2. Cultivation of very wet soils

6.4.2.1. The significance of wet soils and fenland cultivation

Very wet ground is considered marginal for cereal cultivation, and may be more suited to pastoral than arable regimes. Cultivation of such land suggests pressure to produce cereal crops in increased quantities, or non-availability of more suitable land to those who farmed them.

The fenland is defined by its very low elevation and consequent wet conditions (Section 1.3.2). Early settlement was thus largely confined to its edges, with episodes of expansion onto its islands identified in the MIA (Section 1.4.8.2) and, linked to drainage, in the (ER-) MR period (Section 1.4.8.3). The clay-geology of the fen-islands means that soils at an elevation high enough to avoid constant inundation are often heavy and clayey, adding to their marginality for arable farming in the absence of relatively sophisticated plough-technology (Section 6.4.3.1).

Identification of chronological trends in cultivation practice, or in the extent of fenland cultivation, is hampered by very low numbers of EIA and ER fenland fine-sieving by-product samples.

6.4.2.2. Taxa of wetland cultivation

Taxa with Ellenberg F values of 11 and 12 (i.e. plants which only root or grow underwater) were excluded from the dataset for consideration of weed ecology, as they are likely to have origins other than as arable weeds (Section 6.2.1).

Taxa with Ellenberg F values between F8 (constantly damp to wet/water-saturated) and F10 (water-saturated with shallow standing water present some of the time) are considered as potential arable weeds of very wet soils. It is likely that such species occurred in specific parts of otherwise drier arable plots (e.g. at the plot-edges, or in particularly low-lying areas).

Twelve such species occurred in fine-sieving by-product samples. Most were rare, occurring as only a few seeds in only a few samples. The exceptions to this are *Eleocharis palustris/uniglumis*, *Cladium mariscus* and *Montia fontana,* which occur in a significant proportion of samples. *Scirpus spp*. occurs in very few samples, but occasionally in significant numbers.

It has been suggested that *C. mariscus* is likely to be a contaminant of arable weed assemblages, perhaps representing import of marsh vegetation to sites for flooring or animal bedding, rather than an arable weed (e.g. Murphy 2003). Where there is no other reason to assume contamination of crop assemblages with bedding/flooring material, and where site location is consistent with wet conditions, there is no reason why *C. mariscus* should not be considered as a weed growing on the wet margins of arable plots.

Other taxa occurring in samples of known crop-processing derivation have Ellenberg F values of F2-F4 (dry-dry/moist soils, 30 taxa), F5-F6 (moist soils, 48 taxa) or F7 (damp, not wet, soils, 8 taxa).

6.4.2.3. Distribution

Taxa indicative of wetland cultivation account for up to 11% of all weed seeds in fine-sieving by-product samples (Fig. 6.2). They are most common in the LIA and least common in the MIA and ER period.

C. mariscus (all from the Isle of Ely; R38, R157 and R207) is the best represented wetland weed in the MIA, though it occurs only in low numbers/sample. The LIA peak in taxa of wetland cultivation reflects high representation of *E. palustris/uniglumis* (mostly from south-western and western fen-edges, but also from the south-east and southern till – see below), with *M. fontana* also better represented than *C. mariscus*. *E. palustris/uniglumis* is the best represented wetland weed throughout the Roman period, though *M. fontana* is well represented in the ER period and *C. mariscus* in the MR period. Almost all seeds of *Scirpus spp*. are from the MR small town at Stonea Grange (R262-263; Figs. 6.2 and 6.3).

M. fontana (which prefers water-saturated, but not inundated, soils) is relatively evenly distributed across the different areas of the study region (Fig. 6.3). *E. palustris/uniglumis* and *C. mariscus* (which thrive on ground that is not just wet but also periodically under- (shallow) water) are mostly from fenland samples. *C. mariscus* also occurs in samples from the MR and LR western clay (Godmanchester and Rectory Farm; R42, R43, R234 and R236), in samples shown to represent cultivation of heavy soils. Outside the fenland, *E. palustris/uniglumis* occurs mostly in samples from the LIA nucleated settlement at Heybridge (but also from the ER and MR small town which succeeded it; R124-126) and from MIA to MR Stansted Airport/nearby sites (R149, R151, R164).

Rare wetland taxa are mostly Roman and mostly from the fen-edges/islands. Several occurred exclusively in samples from Camp Ground and Langdale Hale (R252-251 and R252-254, both on the south-west fen-edge at Earith), Stonea Grange (on the fen-island at March) and/or Vicar's Farm, Cambridge (R255-258, on the western clay). While this pattern could reflect a genuinely broader range of wetland species at these sites than at others, it must be noted that the sampling strategies at all of these sites were more comprehensive than most.

6.4.2.4. Interpretation

As well as growing in very wet conditions, *C. mariscus* and *E. palustris/uniglumis* are perennials. Perennial weeds are less likely than annuals to recover from damage caused by soil disturbance undertaken in the course of cultivation (Table 6.2). However, *E. palustris/uniglumis* has creeping rhizomes which extend some distance from the parent-plant, meaning that it spreads easily over wide areas, increasing its chance of surviving soil disturbance. This system of vegetative spread also allows it to invade land adjacent to very wet habitats (Booth *et al*. 2007: 292), raising the possibility that it grew in plots which bordered on waterlogged and often inundated ground, but were themselves drier.

It is suggested that samples with *C. mariscus* represent cultivation regimes in which parts of arable plots (probably the edges) were prone to frequent shallow-water inundation. These areas were not frequently tilled or otherwise disturbed, implying that little effort was made to alleviate very wet conditions once they were in place. This is suggested for cultivation on the MIA Isle of Ely, and possibly on the MR to LR western clay.

By contrast, samples with *E. palustris/uniglumis* represent cultivation of very wet land, or plots adjacent to very wet areas, with more frequent soil disturbance. This disturbance may have occurred as part of the cultivation strategy applied to entire plots (e.g. weeding, hoeing, digging-in of manure or digging-over for aeration, deep or repeated ploughing) or in wet/border areas only, perhaps representing efforts to alleviate very wet conditions. This appears to have been the more normal approach to cultivation of plots prone to localised extreme wetness.

6.4.3. Cultivation of heavy clay soils

6.4.3.1. Significance of heavy clay soils

Within the study region, heavy clay soils occur commonly on the western clay, northern and southern till and clay-islands in the fens, as well as where clay deposits overlie the central chalk. The expansion of settlement onto the more easterly of these areas is thought to date to the MIA (Davies 1996; 1999; Hill 2007; Section 1.4.8.2), and it has been suggested that initial settlement of some such areas was by pastoral farmers who imported cereal crops from elsewhere (Section 1.5.5.4).

Heavy clay soils are difficult to till without the use of an ard incorporating a coulter and/or asymmetric shares, which increase the disturbance caused by ploughing, or (preferably) a true plough whose mouldboards ensure that heavy soils are turned, as well as scored. Such refinements to the ard are known in Britain only from the third/fourth century AD, and it is not certain that mouldboard ploughs were used in Roman Britain (Section 1.5.3.2). Heavy clay soil can thus be described as marginal land from the point of view of an Iron Age or Roman arable farmer.

6.4.3.2. Taxa of heavy clay soils

The only species with a preference for heavy clay soils to occur frequently in samples of (any) known crop-processing derivation were *Anthemis cotula* and *Vallerianella dentata* (which also occurs on sandy and chalky soils); a few seeds of others occurred in a few samples. *A. cotula* occurred much more frequently than *V. dentata*.

6.4.3.3. Distribution

Taxa preferring heavy clay soils occur most frequently in the LR period (*A. cotula*) but also more frequently in the MR period (*A. cotula*) and LIA (*V. dentata*[17]) than in other periods (Fig. 6.4).

A. cotula was absent from Iron Age fine-sieving by-products (and from samples of other crop-processing derivation). It occurred in low numbers in a small number of ER samples, mostly from Vicar's Farm, Cambridge (which dates late within this period and probably overlaps with MR activity at most other sites). The low sample and seed numbers make any interpretation tentative, but (given its complete absence from earlier samples) the presence of *A. cotula* suggests cultivation of heavy soils.

In the MR period, *A. cotula* occurred consistently (though mostly in low numbers) in samples from specific records: Vicar's Farm and the small town at Godmanchester/nearby settlement at Rectory Farm (western clay); Watson's Lane (Isle of Ely); and Tunbridge Lane, Bottisham (R87; central chalk). Its LR peak also mostly reflects consistent occurrence in low numbers at specific records: Vicar's Farm and Haddon (R1006; western clay); Tunbridge Lane (R88), Stansted Airport/nearby sites; and Prickwillow Road (R141; Isle of Ely). It was also present in larger numbers in a

[17] The only noteworthy occurrence of this species is 48 seeds in a single sample from a mid-first century AD (classed as Late Iron Age) high status burial from Folly Lane (R48), just outside *Verulamium*. The significance of this single sample is unclear, the more so given its funerary context and the species' success on sandy and chalky, as well as clay, soils.

small number of samples (three out of four) from Hinxton Road, Duxford (R243; central chalk).

6.4.3.4. Interpretation

It seems likely that Iron Age cultivation in areas of predominantly clay geology was confined to the lighter soils of the river valleys. The chronological distribution of *A. cotula* suggests possible (late) ER expansion of arable farming onto heavy clay soils at Vicar's Farm. The evidence from the MR and LR periods is clearer, though still mostly in the form of small numbers of seeds/sample (i.e. *A. cotula* was part of the weed flora of some crops, but did not dominate). Cultivation of heavy clays appears to have been practiced at a small number of sites in each period, rather than being widespread in areas of predominantly clay geology. However, caution must be exercised in this interpretation as it is possible that *A. cotula* was not introduced to Britain until the Roman period (Section 6.10.2.2).

LR presence of *A. cotula* LR Tunbridge Lane (also MR) and Hinxton Road (in unusually high numbers) is of interest. Neither is situated on clay soils, though these lie within *c*. 3km of both, possibly indicating short-distance movement of crops after harvest.

6.4.4. Cultivation of poor soils

6.4.4.1. Significance of poor soils

In this section I examine the distribution of taxa which thrive on acidic (Ellenberg values R3-R5) and nitrogen-poor (N2-N4) soils. These characteristics are likely to develop in soils which are affected by leaching. Some soil-types (especially free-draining sandy soils) are naturally more vulnerable than others to this process, but it will also occur on soils subjected to cultivation regimes not including investment of labour and resources in replenishing or maintaining soil nutrients.

6.4.4.2. Taxa of poor soils

Twenty-eight taxa occurring in fine-sieving by-product samples have Ellenberg values N2-N4, indicating low levels of soil nitrogen. Twelve of these, and an additional three, have Ellenberg R values R3-R5, indicating acidic-moderately acidic soils. However these include six taxa which also have high Ellenberg F values (F8-F10), indicating that they grow in extremely wet conditions. These probably had a localized distribution within arable plots (e.g. field margins, low-lying areas), and indicate that soils were nitrogen-poor and acidic only where they were also very wet. As they do not reflect the general soil conditions in arable plots, they are excluded from the consideration of species distribution (Section 6.4.4.3).

Most taxa of nitrogen-poor and acidic soils are rare, occurring as only a few seeds in only a few samples. The exceptions to this are *Bromus hordeaceus/secalinus* (N4), *Plantago lanceolata* (N4) and *Rumex acetosella* (N3, R4). The N4 value of the first two of these is consistent with low-intermediate soil fertility, not with extreme nitrogen-depletion (Table 6.1). This suggests cultivation regimes without significant, intensive investment to maximise soil productivity, but not a complete lack of effort to maintain reasonable crop-yields.

6.4.4.3. Distribution

Taxa of nitrogen-poor soils are most common in the LIA and least common in the MR period (Fig. 6.5). The LIA peak is caused by concentrations of rare taxa (*Vallerianella dentata* and *Sherardia arvensis*) in the Folly Lane burial sample, whose relation to arable practice is unclear (see Section 6.4.3.3). Disregarding this sample, the LIA frequency of weeds of nitrogen-poor soils is similar to that of the ER period, and mostly accounted for by *B. hordeaceus/secalinus.* This is by far the most common weed of nitrogen-poor soils, accounting for most seeds in all periods but the ER; it occurs widely, not concentrated in any particular area or record.

R. acetosella – indicative of genuinely poorer and more acidic soils – is the best-represented weed of poor and acidic soils in the ER period (Figs. 6.5 and 6.6). This is largely explained by very strong representation (along with relatively high numbers of rarer weeds of nitrogen-poor and acidic soils, notably *Scleranthus annus*) in a single sample from the pottery production site at West Stow (R63; Breckland). Taxa of poor and acidic soils also occurred consistently (though in low numbers, apart from *B. hordeaceus/secalinus*) in samples from the ER fort at Pakenham (R115), and *B. hordeaceus/secalinus* was particularly well represented at ER Heybridge.

R. acetosella is also relatively well represented in the MIA (due to strong representation at the open settlement at West Stow; R131) and LIA (mostly from Heybridge), but less so in the MR and LR periods (Figs. 6.5 and 6.6).

6.4.4.4. Interpretation

The dominance of *B. hordeaceus/secalinus* in this analysis suggests that it was more common for soils to be 'not rich' (i.e. cultivated without intensive investment) than for them to be particularly poor (i.e. cultivated without any investment). Lower representation in the MR period may indicate increased investment in soil improvement at this time.

A few records stand out as having evidence of genuinely poor and acidic soils, suggesting little/no effort to prevent soil exhaustion. It is notable that these include both MIA and ER records from West Stow (the latter represented by just on sample), perhaps explained by the vulnerability of the light soils overlying its sand/gravel-over-chalk geology to leaching, as well as ER town and fort records.

6.4.5. Cultivation with infrequent soil disturbance

6.4.5.1. Taxa indicating infrequent soil disturbance

Perennial weeds are worse-affected than annuals by episodes of soil disturbance, and so are likely to occur more frequently where cultivation regimes do not involve frequent weeding, hoeing, digging-in of manure, digging-over for aeration, or deep/ repeated ploughing. However, they may also grow at the edges of arable plots, where such disturbance is less consistent.

Twenty-three perennial taxa[18] were present in fine-sieving by-product samples. Eight have Ellenberg F values F8-F10; these are suggested to have had a localised distribution (probably on field margins and in low lying areas) and not to reflect growing conditions in the wider plots. They are excluded from this investigation. Most of the remaining 15 taxa are rare, occurring as only a few seeds in only a few samples. The exceptions to this are *Rumex conglomeratus/obtusifolius/sanguineus*, *Rumex crispus*, *Phleum pratense/bertolonii*, *Stellaria palustris/graminea* and *Prunella vulgaris*.

6.4.5.2. Distribution

The occurrence of perennial taxa increases over time from the MIA to the LR period, with a slight glitch in the ER period (Fig. 6.7)[19]. They never account for more than 3.5% of all weed seeds/period in fine-sieving by-product samples, but their progress to this level of frequency in the LR period from just 0.6% in the MIA is clear.

[18] Excluding those with characteristics allowing them to survive soil disturbance, which are categorised as annuals – see Table 6.2.
[19] This pattern can also be seen when all samples of known crop-processing derivation are considered (i.e. it is not linked to the increasing dominance of fine-sieving by-products over time, but is a genuine reflection of growing conditions).

Perennials are very scarce in the MIA, but all are from the Isle of Ely (Watson's Lane and West Fen Road). They remain rare in the LIA with no clear pattern to their distribution. Despite being marginally scarcer in the ER period, they occur (in very low numbers) in most records.

The increased frequency of perennial weeds in the MR period is largely explained by concentrations (>50 seeds, accounting for 6-9% of weed seeds in fine-sieving by-products from each record) at Vicar's Farm, Parnwell (R82; north-west fen-edge) and Langdale Hale. The Late Roman climax in the representation of perennials is also due to concentrations (>35 seeds, accounting for 7-8% of weed seeds in fine-sieving by-products from each record) at Vicar's Farm and Langdale Hale; perennials are also better represented at Camp Ground (adjacent to Langdale Hale) than at other LR sites.

6.4.5.3. Interpretation

The very low numbers of perennial weed seeds which occur in all periods are not thought to be indicative of general growing conditions or cultivation regime; they are likely to represent plants growing on the fringes of cultivated ground. The MIA distribution is intriguing, perhaps related to unusually low levels of disturbance at plot edges (already shown – Section 6.4.3.3-6.4.3.4 – to have been very wet in places) on the Isle of Ely, but the number of seeds involved is too low for further speculation.

The MR and LR concentrations of perennial weeds suggest cultivation with infrequent (or inconsistent, allowing perennials to survive in some areas) soil disturbance at Vicar's Farm, Langdale Hale and (MR only) Parnwell. The evidence from Vicar's Farm, where Roman cultivation of heavy soils has already been identified (Section 6.4.2.3-6.4.2.4) is intriguing, implying that these were cultivated with basic ards, rather than more sophisticated models which would allow greater soil disturbance (co-occurrence of *A. cotula* and perennial weed seeds within samples suggests this interpretation rather than identification of mixed crops from two sources, one with heavy soils, one with low levels of disturbance).

6.4.6. Cultivation of nitrogen-rich soils

6.4.6.1. Significance of nitrogen-rich soils

In this section I investigate evidence for cultivation regimes including significant investment in soil improvement, attested by weed taxa which thrive only in rich soils (Ellenberg N values N7-N9). Such investment in soil fertility suggests the focusing of resources to maximize the productivity (i.e. crop-yield) of a given piece of land, rather than taking a more *laissez-faire* approach (but possibly increasing the land under cultivation). It represents an intensive, rather than extensive, approach to cultivation (cf. Van der Veen and O'Connor 1998).

6.4.6.2. Taxa of nitrogen-rich soils

Twenty-one taxa occurring in fine-sieving by-products had Ellenberg values N7-N9. Most (including the only N9 species) occurred as small numbers of seeds (often single seeds) in small numbers of samples. The exceptions to this were *Chenopodium spp.*, *Atriplex spp.*, *Polygonum aviculare*, *Persicaria maculosa/lapathifolia* and *Rumex conglomeratus/obtusifolius/sanguineus*.

6.4.6.3. Distribution

Taxa of nitrogen-rich soils are best represented in the ER period, but also relatively well represented in the MIA (Fig. 6.8). There is a clear trend of decreasing representation through the Roman period, with occurrence in the LR period lower even than the EIA. In all periods weeds of nitrogen rich soils occur in most records, but most occurrences are of only a few seeds/sample.

MIA weeds of nitrogen-rich soils (mostly *Chenopodium spp.*) were well represented in most records. Chipping Hill hillfort (R156; where 81 seeds accounted for 46% of all weed seeds from fine-sieving by-products, though only three samples were available) stood out as having particularly high representation. They continue to occur in most LIA records, but in smaller numbers, with no notable concentrations.

The ER peak in weeds of nitrogen-rich soils is accounted for mostly by two large samples, both dominated by these taxa (one accounting for 68% of ER seeds represented in Fig. 6.8, the other for 12%), from West Stow and *Colonia Vitricensis* (Head Street; R225). If these samples are excluded, taxa of nitrogen rich soils would account for just 7% of seeds in ER fine-sieving by-products, reflecting widespread occurrence in very low numbers and possible concentrations at Heybridge and Pakenham.

Similarly, 66% of the MR seeds represented in Fig. 6.8 are from a single sample from Vicar's Farm; other samples from this record show no particular concentration of taxa of nitrogen-rich soils. Discounting this sample, taxa of nitrogen rich soils would account for just 5% of seeds in MR fine-sieving by-products, reflecting widespread occurrence in very low numbers and concentrations from Parnwell and Langdale Hale. LR weeds of nitrogen-rich soils occurred widely, but in low numbers; there were no notable concentrations but the numbers per sample were highest at Langdale Hale.

When the unusual concentrations of weeds of nitrogen-rich soils in single ER and MR samples are discounted, the overall chronological trend is one of steady decrease from the MIA to the MR period, with slight (probably insignificant) recovery in the LR period.

6.4.6.4. Interpretation

The general pattern is of taxa of nitrogen-rich soils being present consistently, but in low numbers in all periods. This may indicate inconsistent conditions in arable plots (as already suggested with regard to frequency of soil disturbance), allowing these taxa to thrive in some areas, but not to dominate in entire crops. Decreasing representation of these taxa over time may indicate declining levels of investment in soil improvement.

The suggested inconsistency of soil conditions within plots would account for ER Heybridge and Pakenham being noted for weeds indicating both nitrogen-rich and nitrogen-poor (Section 6.4.3.3-6.4.3.4) soils. An alternate interpretation of this would be the application of different cultivation regimes to different plots and/or different crops.

The atypically strong representation of taxa of nitrogen-rich soils in three large ER and MR samples may result from contamination of fine-sieving by-products with weeds pulled from a dung-heap/midden or other nitrogen-rich context, rather than indicating cultivation practice.

6.5. Methodology and datasets for correspondence analysis

6.5.1. Weed characteristics investigated

In addition to the weed ecological and life-history characteristics investigated above (Sections 6.3-6.4), the CA investigation includes investigation of weeds' germination time and flowering period which have the potential to be informative about the season in which crops were sown (see Section 6.2.3). However, both must be treated with caution as they are not independent of soil nitrogen-content and/or frequency of soil disturbance.

6.5.2. Datasets

6.5.2.1. Description

To ensure that the patterns identified result from variation in weed ecology, and not from differences in crop-processing between samples (Section 6.3.2), CA was carried out using samples of like crop-processing derivation. For Datasets F-I these were fine-sieving by-products (not mixed with other crop-processing derivatives). Dataset J represents an additional analysis carried out using clean grain samples, the only other single crop-processing derivative to occur frequently enough for analysis.

CA datasets are described in Table 6.5. The process of selection of the samples and species is detailed in Sections 6.5.2.2-6.5.2.4.

Dataset	Sample-types	Period	No. of records	No. of samples	No. of species
F	All Fine-sieving by-product samples	All periods	68	211	14
G	Fine-sieving by-product samples, excluding those which had been previously sieved as spikelets*	All periods	47	104	14
H	Fine-sieving by-product samples, excluding those which had been previously sieved as spikelets*	EIA-ER	26	63	14
I	Fine-sieving by-product samples, excluding those which had been previously sieved as spikelets*	ER-LR	23	45	11
J	Clean grain	LIA-LR	34	61	16

*See Section 6.5.2.2.
Table 6.5. The CA datasets.

6.5.2.2. Sample selection

The requirement that samples include 50 identified items (to ensure representativeness) was applied by default to selection of samples for CA (smaller samples do not have known crop-processing derivation).

Ideally, to further ensure compositional representiveness (cf. G. Jones 1991: 67), a limit would have been set on the minimum number of weed seeds required for samples to be included in the analysis. However, a stringent limit would have reduced sample numbers to the point where meaningful analysis was no longer possible. A minimum requirement of 30 weed seeds (cf. Bogaard 2004: 62) would have reduced the dataset to just 57 samples[20] before the application of any further selection criteria (e.g. exclusion of rare species, chronological subdivision). In the interests of maintaining a large enough dataset, a minimum requirement of just three weed seeds (after species-selection) was used.

In interpreting the CA sample-plot for Dataset F, it became clear that (among other factors) the difference between samples deriving from the processing of sieved and un-sieved spikelets (Section 4.7.1.2) was influencing the distribution of samples (Section 6.6.1). Both had been included in Dataset F in the interest of maintaining sample numbers, but those derived from previously sieved spikelets were excluded from subsequent analyses (Datasets G-I) in keeping with the principle of comparing samples of like-crop-processing derivation.

Initial analysis of clean grain samples of all periods (not shown) demonstrated that EIA and MIA clean grain samples plotted as a tight cluster at the origin of the sample-plot. Like the examples from MIA Wendens Ambo (Section 5.4), these contained few weed seeds other than *Avena spp*. and *Bromus hordeaceus/secalinus*. For this reason, they were excluded from Dataset J, which consequently includes only samples of LIA and Roman date.

[20] A minimum of 20 weed seeds would have left 95 samples, and a minimum of ten would have left 138 samples.

6.5.2.3. Species selection

Both weed taxa and cereal items (grain and chaff) were included in preliminary datasets (not shown). However, it was found that the abundance of cereal items (especially glume bases in the fine-sieving by-product datasets) meant that variation on Axes 1-4 was determined by samples' cereal-content, rather than being influenced by the weed characteristics which are of interest. For this reason, species in the final datasets (Table 6.5) include weed taxa only.

The primary criterion for inclusion of weed taxa in the CA datasets was that they had known and meaningful values for the various ecological and life-history characteristics on which analysis was based (Section 6.2). Taxa identified in insufficient detail to meet this requirement were excluded. Seeds of trees and aquatics (species with Ellenberg values of F11 or F12, which always root or grow underwater) were considered likely to have entered the deposits as a result of post-depositional mixing (cf. Van der Veen 1992: 26) and so were excluded. Taxa of potential economic importance in their own right (Chapter 7) were also excluded.

A further criterion for species-inclusion was occurrence in ≥10% of samples (≥9% in Dataset G and ≥5% in Dataset J). These limits are comparable to those used in previous studies of a similar nature (Section 2.4.2).

6.5.2.4. Exclusion of outliers

In preliminary plots of each dataset small numbers of samples plotted as clear outliers, influenced by exclusive content or unusually high representation of a particular species (which itself plotted as an outlier in the species-plot). These outliers caused other samples to cluster close to the origin on one or both axes, and so prevented the recognition of further variation. They were excluded from the final datasets (Table 6.5).

6.5.3. Interpreting the CA plots

Sample-plots were initially coded according to period, location, record-type, crop species (as identified in Chapter 3, Method 2), evidence for high status activity, evidence for ritual activity/structured deposition, and individual record. Of these, coding by period and by individual record were found to best explain the variation observed.

The codes used to identify weed taxa in the species-plots are explained in Appendix 3, which also summarises the ecological and life-history characteristics of each. Variation in weed ecology was found to be best demonstrated using sample-plots in which each sample is displayed as a pie-chart coded according to the (grouped) values of its weed content for a given ecological or life-history characteristic (e.g. low, medium and high soil nitrogen-content).

6.6. Preliminary analysis of fine-sieving by-product samples

6.6.1. Chronological and crop-processing influences (Dataset F)

In the sample-plot of Dataset F (Fig. 6.10) the contrast between Iron Age samples, almost all confined to the negative end of Axis 2 (i.e. the lower part of the plot), and MR-LR samples, which are ubiquitous, is clear. The spread of ER samples is intermediate, but more closely resembles the Iron Age distribution. This chronological pattern indicates that MR and LR samples varied in ways which earlier samples did not.

This variation may be influenced by the distribution of *Anthemis cotula* (Fig. 6.11), which is present in most of the (MR and LR) samples plotting positive of the origin on Axis 2, and in all of those plotting most positively. In the area negative of the origin on Axis 2 *A. cotula* is present only in a few samples, all MR and LR, all positioned at the negative end of Axis 1 (i.e. left side of the plot).

However, there is a second influence on the distribution of samples in this plot: those deriving from the fine-sieving of previously-sieved spikelets occur throughout the plot, but are concentrated at the negative ends of both axes (i.e. bottom-left of plot; Fig. 6.12). This crop-processing influence affects the patterns already described (most samples plotting negative of the origin on Axis 2 and containing *A. cotula* or dating to the MR or LR periods derive from the processing of previously-sieved spikelets), and hinders recognition of further patterns. This reinforces the necessity of comparing samples of like crop-processing derivation (Sections 6.3.2, 6.5.2.1 and 6.5.2.2).

6.6.2. Clarifying the chronological pattern (Dataset G)

Dataset G excludes samples derived from the fine-sieving of previously-sieved spikelets. The chronological patterning observed in Dataset F can be seen clearly in Dataset G (Fig. 6.14). Iron Age and ER samples plot positively on Axis 2 and (relatively) negatively on Axis 1; MR and LR samples are present in this area but also extend to the bottom-right corner of the plot. The distribution of ER samples is less restricted than that of Iron Age samples but resembles it more closely than that of MR and LR samples. The position of *Anthemis cotula* in the bottom-right of the species-plot (Fig. 6.13) is clearly an influence on the distribution of MR and LR, but not the earlier, samples (Fig. 6.15).

This is interpreted as showing that Iron Age and ER samples are similar to one another, while MR and LR samples can be divided into two groups: those which are similar to the earlier samples, and those that contain *A. cotula*. The significance and distribution of this species is explored in more detail in Section 6.8.

Given that MR and LR samples vary in at least one way which Iron Age samples do not, it is appropriate to split the dataset chronologically prior to further analysis.

Because ER samples have a distribution intermediate between the two groups, they are included in both of the new datasets (H and I). This also has the advantage of boosting the number of samples in each and facilitating consideration of continuity between the earlier and later parts of the study period.

6.7. Iron Age and Early Roman cultivation practice (Dataset H)

6.7.1. Patterns in sample-distribution

The 63 Iron Age and ER samples included in Dataset H are from 26 records; their spatial distribution is shown in Fig. 6.16. Bibliographic references to all records are given in Appendix 1. Fig. 6.17 shows the sample-plot of Dataset H, coded to show samples' period- and record-affiliations. The distribution of samples in Fig. 6.17 is described in Table 6.6, and discussed below (Sections 6.7.2-6.7.6).

Group	**Position in sample-plot**	**Includes samples from**			
		EIA	MIA	LIA	ER
H1	Upper top-right quadrant		Watson's Lane*; Wardy Hill*		
		Fordham Bypass (R245)		Wardy Hill	Eaton Socon (R84)
H2	Bottom-right quadrant	Fairfield Park A (R194)*.	Watson's Lane*; Wardy Hill*; West Fen Road*; Chipping Hill	Heybridge	Heybridge; Pakenham*
			Stanway; Harston (R231)	Tort Hill West (R66); Haddenham V (R32)	Greenhouse Farm (R202); Vicar's Farm
H3	Lower top-right quadrant	Fairfield Park A*	-		Pakenham*
				Camp Ground	
H4	Slightly below origin	-	West Stow		-
			Brewer's Hall Farm (R184)	Biddenham Loop (R175)	
H5	Left side of plot	-	-		
				Folly Lane	Head Street; West Stow

*Other samples from same record in other groups. Shaded records are represented by single samples.
Table 6.6. Spatial distribution of samples in sample-plot (Dataset H).

The records represented in the different groups are not consistently differentiated by period, region or record-type. Rather, they seem to indicate decisions about cultivation taken on a site-specific (or local) basis, though higher sample numbers (i.e. more samples representing more records) would help confirm this observation. Most samples in this group are fine-sieving by-products of spelt, indicating that the patterns observed are not determined by different approaches to the cultivation of different species. Exceptions are discussed as they arise.

6.7.2. Group H1

Initial comparison of the species- and sample- plots (Figs. 6.17 and 6.18) suggest that samples in H1 are influenced by the presence of *Tripleurospermum spp.*. and *Cladium mariscus*. The former is present in all samples in this group, accounting for all indications of medium soil nitrogen-content (Fig. 6.19). The latter thrives in waterlogged soils where shallow standing water is sometimes present and is the only perennial in this dataset; it is present in five of the seven samples in this group (Figs. 6.21 and 6.22). The two samples from which it is absent are very small and the sole representatives of their respective records (EIA Fordham Bypass and ER Eaton Socon); the remainder of this discussion focuses on the other five samples, all from the Isle of Ely. It is the presence of *C. mariscus* (otherwise present only as single seeds in two H2 samples, also from the Isle of Ely) which distinguishes these samples from the other groups, although it is present only in low numbers.

The perennial nature of *C. mariscus* suggests that the wet areas in which it grew (most likely the plot edges) saw little disturbance. Perennials of drier ground from these records (identified in very low numbers in Sections 6.4.5.2-6.4.5.3) have also been interpreted as indicating relatively undisturbed ground along the margins of arable plots.

In two samples (MIA Watson's Lane and LIA Wardy Hill), *C. mariscus* accounts for all indications of low soil nitrogen-content (compare Figs. 6.21 and 6.19); away from the wet margins of the arable plots, soil nitrogen-content was intermediate-high (Fig. 6.19). In the samples from MIA Wardy Hill *C. mariscus* accounts for only a small proportion of the weeds of nitrogen-poor soils, and *Bromus hordeaceus/secalinus* (N4) is common, while taxa of nitrogen-rich soils are scarce. Soil nitrogen-content is therefore characterised as low-intermediate away from the wet plot margins. There is no indication of very poor or acidic soil conditions (Fig. 6.20[21]).

The cultivation represented by these samples took place in fen-island plots prone to extreme wetness along their margins. The contrast in soil nitrogen-content between MIA Watson's Lane/LIA Wardy Hill and MIA Wardy Hill suggests cultivation regimes involving greater and lesser (though not non-existent) degrees of investment in soil improvement. The samples indicating the regime of greater investment represent emmer-only crops, while those indicating lower levels of investment represent mixed spelt and emmer (cultivated separately and mixed after harvest; Section 5.3).

Strong representation of autumn-germinating and early-, short-flowering taxa in all samples (Figs. 6.23 and 6.24) suggest autumn-sowing.

6.7.3. Group H2

6.7.3.1. Overview

There is no period- or regional-unity in the samples included in H2. However, it may be significant that many are from distinctive record-types: Chipping Hill (hillfort), Heybridge (LIA nucleated settlement and ER small town), Pakenham (fort) and Greenhouse Farm (pottery-production site).

This is the largest of the groups identified in the sample plot of Dataset H, both in the area of the plot it occupies and the number of samples it includes. There is no single

[21] The indication of acidic soils in the ER Eaton Socon sample comprises a single seed of *R. acetosella*.

species-/ weed characteristic-influence on all of its samples. However, most of them either have indications of very wet soil conditions (Fig. 6.21) or very strong representation (i.e. dominance of) weeds of nitrogen-rich soils (which are *present* in all samples in this group, but also in most in the dataset) (Fig. 6.19). These features co-occur in only two samples.

6.7.3.2. Isle of Ely

Cladium mariscus is present only in single MIA samples from Wardy Hill (emmer) and West Fen Road (spelt and emmer) plotting at the top of the group. It accounts for their apparent indications of low soil nitrogen-content as well as extreme wetness and perennial taxa (Figs. 6.19, 6.21 and 6.22); disregarding this species they indicate high soil nitrogen-content. They thus suggest the same cultivation strategy (high investment in soil improvement on plots with wet margins) as the MIA Watson's Lane and LIA Wardy Hill (emmer) samples in H1, rather than that indicated by the other (spelt and emmer) MIA samples from Wardy Hill.

The remaining samples from the Isle of Ely (one from Watson's Lane, one from West Fen Road; both mixed spelt and emmer) plot at the bottom of H2 (Fig. 6.17). They are atypical of H2 as they indicate neither extremely rich nor very wet soils (Figs. 6.19 and 6.22). Weeds of nitrogen-rich soils are well represented (not dominant) in these samples; the remainder of their seeds are *Avena spp.*. They thus suggest intermediate-high soil nitrogen-content, and a cultivation regime similar to that described above, though carried out on drier ground. Spring-sowing is a possibility for these samples (and would account for the presence of *Avena spp*. in them but not in others from the Isle of Ely), but the evidence is insufficient to support this conclusion.

Of the samples from the MIA Isle of Ely (from this group and H1), those containing only emmer were consistently from wet-edged plots cultivated with significant investment of labour/resources. However, some samples containing both spelt and emmer (thought to have been mixed at some point after harvest; Section 5.3) represent similar cultivation of similar plots; others represent cultivation with lower levels of investment (at Wardy Hill) or on drier ground (at West Fen Road and Watson's Lane). There is no consistent relationship between crop species and cultivation regime.

6.7.3.3. Other wet soil conditions

All remaining indications of extremely wet soils are *Eleocharis palustris/uniglumis* (Fig. 6.21). Most are in five samples from Heybridge (LIA and ER), where a concentration of this species was also noted in Section 6.4.2.3. These samples plot at the top and right-edge of H2. All five suggest low soil nitrogen-content and two (at the top of H2) also suggest moderate levels of soil acidity (Figs. 6.19 and 6.20). All but one (ER, mixed spelt and emmer) represent spelt crops.

Unsurprisingly, *E. palustris/uniglumis* is present in the single samples from the fenland records of Tort Hill West and Haddenham V; no attempt is made to interpret cultivation practice from these single small samples. It was also present in the one Fairfield Park A sample which plotted in H2 (and absent from those in H3). The Haddenham V and Fairfield Park A samples were the only ones to suggest both very wet plot margins and significant investment in soil improvement. *E. palustris/uniglumis* dominates the sample from Vicar's Farm (discussed along with others from the same record in Dataset I, Sections 6.8.2-6.8.3).

6.7.3.4. Nitrogen-rich soils

Samples forming a tight cluster at the left-edge of H2 (reflecting the position of *Chenopodium spp.* in the species-plot; Fig. 6.18) are dominated by taxa of nitrogen-rich soils (Fig. 6.19) but are not distinctive in other codings of the sample-plot (Figs. 6.20-24). Though present in most samples in Dataset H, taxa of nitrogen-rich soils are dominant only in this cluster, in H5 (Section 6.7.6) and in some of H3 (Section 6.7.4).

The single Hadenham V and Fairfield Park A samples (Section 6.7.3.3) plot at the bottom of this cluster and are the only ones to contain evidence of wet soils. The others are from Chipping Hill, Stanway, Heybridge (LIA and ER) and Greenhouse Farm. These samples are consistent with significant investment in soil improvement to increase crop-yields per unit of land. It is intriguing that five of the six are from hillfort, town and pottery-production records, rather than from rural settlements. The crops represented are mixed spelt and emmer from Chipping Hill and Stanway, spelt from Heybridge and 'glume wheat' from Greenhouse Farm.

6.7.3.5. Heybridge and Pakenham

Two, contrasting sets of growing conditions (nitrogen-rich soils and nitrogen-poor, sometimes acidic, soils with wet plot margins) have been identified in samples from LIA and ER Heybridge. The difference does not relate to crop species, though the single sample which included emmer as well as spelt was from the poorer, wetter soils. Concentrations of weeds of both nitrogen-poor and nitrogen-rich soils were tentatively identified at Heybridge in Sections 6.4.4.3-6.4.4.4 and 6.4.6.3-6.4.6.4.

The spatial separation of the two groups in the CA plot suggests that the distinction between them is real, though low sample numbers must cast some doubt on its significance. The two groups are suggested to represent two approaches to cultivation:

one carried out in plots with wet margins (or adjacent to wet ground) and involving little/no investment to improve crop-yields through manuring or other soil improvement; the other (on drier ground) involving significant investment. It is notable that both putative regimes are identified in both periods, suggesting that cultivation practice did not alter with the transition from LIA nucleated settlement to ER small town.

Given indications of nitrogen-rich soils, the infrequent occurrence of autumn-germinating taxa (Fig. 6.23) is unsurprising in most samples in H2. However, their virtual absence from the poor-soil samples from Heybridge is more intriguing. It is tempting to suggest spring-sowing, perhaps in response to extremely wet winter conditions, but the evidence is not strong enough to confirm this interpretation (and the evidence of flowering time is contradictory; Fig. 6.24).

The two samples from Pakenham which fall in H2 give no indication of wet soil conditions (Fig. 6.21). Their seed assemblages give stronger indications of low than high soil nitrogen-content, though this dominance is clearer in one (which also contains *Rumex acetosella,* suggesting acidic soils) than in the other (Figs. 6.19 and 6.20). These samples are considered further, along with others from Pakenham, in the discussion of H3 (Section 6.7.4).

6.7.4. Group H3

The six samples in this group do not represent any one region, period or record-type (Table 6.6). Two samples from Pakenham and one from Camp Ground plot in this region because they contain only (or are dominated by) *Bromus hordeacues/secalinus* (compare Figs. 6.17-19). The position of the third Pakenham sample is also influenced by this species, but is also intermediate between those of *Chenopodium spp.* and

Tripleurospermum spp. (Fig. 6.18), which dominate its weed assemblage, in the species-plot. Combinations of *Tripleurospermum spp*. and *Chenopodium spp.* or *Atriplex spp*. also determine the positions of the two Fairfield Park A samples (both very small).

Considering all five samples from Pakenham (from this group and H2) together, there is a distinction between two with good representation of weeds of nitrogen-rich soils (mostly *Chenopodium spp*.) and three dominated by weeds of nitrogen-poor/intermediate soils (mostly *Bromus hordeaceus/secalinus* but also *Rumex acetosella* and *Plantago lanceolata*) (Figs. 6.19-20). Concentrations of both were also noted in Sections 6.4.4.3-6.4.4.4 and 6.4.6.3-6.4.6.4). It is possible that, as at Heybridge, two cultivation strategies are attested (both applied to spelt; no other species is represented at Pakenham). However, the small number of samples involved and the failure of CA (this dataset or Dataset I) to separate the two casts doubt on this. Varied conditions within arable plots, suggesting inconsistent investment in soils, are an alternative interpretation.

6.7.5. Group H4

This group comprises single spelt samples from MIA Brewer's Hall Farm and LIA Biddenham Loop (located approximately 10km apart on the western clay) and four samples from MIA West Stow (Breckland). Three of the West Stow samples, including the 'outlier' (Fig. 6.17) are barley, the fourth is spelt.

These samples are distinctive in consistent strong representation of *Rumex acetosella*, indicating moderately acidic soils (Fig. 6.20; also noted Sections 6.4.4.3-6.4.4.4). Other taxa of nitrogen-poor soils are also present, but are balanced in most samples by taxa of nitrogen-rich soils (Fig. 6.19); the exception to this is the spelt sample from West Stow.

The West Stow samples also suggest drier soils than at most other sites (Fig. 6.21), largely owing to (relatively) strong representation of *Fallopia convolvulus*.

The varied indications of soil nitrogen-content in these samples may indicate mixing of crops (though not of different species) from different sources; variation in conditions within arable plots (e.g. between edges and centre) is another possibility. Varied conditions within plots may be consistent with investment in soil improvement (in attempts to improve crop-yields) on soils naturally prone to leaching: West Stow and Biddenham Loop are situated on free-draining sand/gravel geology, while such river terrace deposits lie within 1km of the grid reference given for Brewer's Hall Farm[22]. Breckland is known for its light soils, as well as its low modern-day rainfall, both consistent with the slightly drier than average conditions suggested by the West Stow samples.

The West Stow spelt sample is distinctive in suggesting poorer soils than the barley samples from the same record. This may indicate a genuine difference in the cultivation strategies applied to different crops, but without further samples this cannot be confirmed.

6.7.6. Group H5

This group comprises single samples from three records. All have been noted above (Sections 6.4.3.3, 6.4.4.3 and 6.4.6.3) for distinctive weed composition but (as the sole fine-sieving by-product representatives of their respective records) are considered un-interpretable, possibly representing contamination of crop-processing by-products with weeds from other sources. CA does not overcome this limitation. The nitrogen-rich soil suggested by the Head Street (*Colonia Vitricensis*) sample is inconsistent with the

[22] Note that Brewer's Hall Farm and Biddenham Loop are represented by single samples; interpretations should be treated with extreme caution.

generally poor-intermediate soils suggested by clean grain samples from the town (Section 6.9.2).

6.8. Roman cultivation practice (Dataset I)

6.8.1. Patterns in sample-distribution

The 45 Roman samples included in Dataset I are from 23 records; their spatial distribution is shown in Fig. 6.25. Bibliographic references to all records are given in Appendix 1. Fig. 6.26 shows the sample-plot of Dataset I, coded to show samples' period- and record-affiliations. Samples in Fig. 6.26 form five groups, described in Table 7.3 and discussed below (Sections 6.8.2-6.8.4).

Five species have particularly noticeable influences on sample distribution: *Rumex acetosella* and *Eleocharis palustris/uniglumis* occur mainly toward the negative end of Axis 1(left-side; I3 and I4), while *Anthemis cotula* and Cladium *mariscus* occur mainly toward its positive end (right-side; I1, I2 and I5) (Figs. 6.29, 6.30 and 6.32). *Bromus hordeaceus/secalinus* (the most common taxa of nitrogen-poor soils) occurs with increasing frequency towards the positive end of Axis 2 (top of the plot).

As identified in Dataset G (Section 6.6.2), the presence of *A. cotula* in several Roman samples is the key difference between Dataset I and Dataset H. Reflecting this species' distribution, derivation from clay/other geology is the most readily identifiable cause of samples' groupings in Fig. 6.26. Co-occurrence of *A. cotula* and *C. mariscus* suggests very wet conditions within (probably along the margins of) arable plots on heavy soils. Sites on the western clay appear to have been cultivated with little investment in soil improvement, and soils at Vicar's Farm were particularly poor, while heavy soils on the Isle of Ely (Watson's Lane) appear to have been cultivated intensively.

Most other variation in the dataset appears to reflect record-specific approaches to cultivation. As in Dataset H, samples from Pakenham (fort) and Heybridge (small town) plot together. Samples from Godmanchester (small town) plot separately, influenced by clay geology more than small town nature.

Group	Position in sample-plot	Includes samples from		
		ER	**MR**	**LR**
I1	Bottom-right quadrant	Vicar's Farm*†	Vicar's Farm*; Godmanchester*; Rectory Farm*; Watson's Lane*	Vicar's Farm*
				Prickwillow Road; Paston (R71); Hinxton Road; Strood Hall (R149)
I2	Lower top-right quadrant	-	Godmanchester*; Rectory Farm*; Watson's Lane*	Vicar's Farm*
				Godmanchester; Great Holt's Farm (R96)
I3	Around origin	Vicar's Farm$^{\mathrm{H2}}$*	Vicar's Farm*; Langdale Hale; Biddenham Loop (R176); Watson's Lane*;	Langdale Hale
		Head Street$^{\mathrm{H5}}$; West Stow$^{\mathrm{H5}}$; Stonald Field (R233); Eaton Socon$^{\mathrm{H1}}$	Stebbing Green (R34); Beck Row (R36)	Camp Ground
I4	Lower top-right quadrant, extending into lower top-left	-	Heybridge$^{\mathrm{H2}}$; Langdale Hale*; Pakenham$^{\mathrm{H2,\ H3}}$*	-
			Wixams (R238); Snettisham Bypass (R113)	
I5	Upper top-right quadrant	Pakenham$^{\mathrm{H3}}$*	Rectory Farm*	-

*Other samples from same record in other groups. †Obscured by a MR sample from the same site.
Shaded records are represented by single samples.
$^{\mathrm{Superscript}}$ indicates group of same sample in Dataset H.
Table 6.7. Spatial distribution of samples in sample-plot (Dataset I).

6.8.2. Groups I1 and I2

6.8.2.1. The records and crops

Samples in these groups are mostly from three sites on the western clay: Vicar's Farm (I1, with one LR exception), Godmanchester and Rectory Farm (both in I1 and I2). There are also three samples from the Isle of Ely (two of the five from MR Watson's

Lane and one from LR Prickwillow Road). The crops represented by all of these samples are spelt (mixed with emmer in one sample and with barley in one sample).

6.8.2.2. The soils

These groups are characterised by the presence of *Anthemis cotula* and *Cladium mariscus*. The former is present in all samples but one (a small sample from LR Great Holt's Farm[23]), accounting for higher proportions of weed seeds in I1 than in I2 (Fig. 6.32); the latter is well represented in all but two (Great Holt's Farm and the LR outlier from Vicar's Farm) samples in I2, and present, though relatively scarce, in three from I1 (Fig. 6.31). Outside of I1 and I2, these taxa are rare: *A. cotula* occurs only in I3 (including two samples from Watson's Lane and one from ER Vicar's Farm), *C. mariscus* in I3 (one Langdale Hale sample) and I5 (an outlying Rectory Farm sample). *Eleocharis palustris/uniglumis* is also present in four I1 samples (none of which contain *C. mariscus*).

Sample composition indicates cultivation of heavy clay soils (consistent with the geological derivations of all samples but one[24]). Very wet conditions (probably around plot margins) are attested in samples from Godmanchester/Rectory Farm, Watson's Lane and ER Vicar's Farm, but not those from MR and LR Vicar's Farm; these probably reflect the poor drainage qualities of clay soils, though locally high water tables may also be a factor.

Indications of nitrogen-poor soils in most samples are *C. mariscus* or *E. palustris/uniglumis* (compare Figs. 6.28 and 6.31), reflecting conditions only on the wet margins of arable plots. Most other indications are of intermediate soil nitrogen-content, reflecting the preferences of *A. cotula*. The perennial *Rumex*

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[23] *A. cotula* was present in samples of other crop-processing derivation from this record.
[24] from Hinxton Road, Duxford; discussed in Section 6.4.3.4

conglomeratus/obtusifolius/sanguineus is not characteristic of these groups (Fig. 6.33) but occurs in small numbers in four samples, all from LR Vicar's Farm. Three of these also include indicators of low soil nitrogen-content outside of the wettest areas of the plots represented. Concentrations of perennial weeds (taxa excluded as rare from Dataset I) from both MR and LR Vicar's Farm were noted in Section 6.4.4.4.

6.8.2.3. Cultivation practice

The dominance of *A. cotula* and/or *C. mariscus* allows little comment on soil nitrogen-levels, but there is no evidence to suggest significant investment in soil improvement. Strong representation of perennial taxa at MR and LR Vicar's Farm suggest cultivation with only cursory ploughing/other tillage, suggesting that the ards used did not incorporate features allowing them to efficiently break or turn the soil (Section 6.4.3.1; Section 1.5.3.2). Under these circumstances, the soils farmed at this site should be considered marginal.

The strong representation of autumn-germinating taxa in I1 and I2 (Fig. 6.34) reflects the autumn-germination of *A. cotula* (compare Figs. 6.32 and 6.34). As this species' dominance in these samples is considered to result from the type of soil cultivated, this pattern should not be interpreted as strong evidence of autumn-sowing (though there is nothing to suggest that these crops were spring-sown).

6.8.3. Group I3

6.8.3.1. The records and crops

Most samples in this group are from the fens or western clay. Best represented are MR and LR Langdale Hale (and the single LR sample from neighbouring Camp Ground). Samples from Watson's Lane and Vicar's Farm (both of which also have samples in I1/I2) are also included (Table 6.7). All samples in this group represent cultivation of spelt only. No further insight is offered into the composition of the West Stow and Head Street samples from H5 (extreme left of I3) or Eaton Socon sample from H1; they are not discussed again.

6.8.3.2. Composition and growing conditions

The interplay of soil nitrogen-content, acidity, moisture and disturbance (Figs. 6.28, 6.29, 6.31 and 6.33), and its interpretation in terms of growing conditions, is summarised in Fig. 6.36.

Most I3 samples represent cultivation of land which was extremely wet in places, probably along plot margins. The taxa indicating this wetness are also responsible for much of the indication of nitrogen-poor soils, suggesting that these did not extend outside of the wettest areas. However, genuinely poor (and acidic) soils are indicated in samples on the far-left and middle-right of I3. In the latter these occur mixed with indications of nitrogen-rich soils, but all of these are *Rumex conglomeratus/obtusifolius/sanguineus*, which also suggests low levels of soil disturbance.

R. conglomeratus/obtusifolius/sanguineus also occurs (as a smaller proportion of seeds) in samples on the left of I3; these contain significant numbers of other seeds of nitrogen-rich soils, but also include *Rumex acetosella* (which thrives on acidic and nitrogen-poor soils).

Three samples in the bottom-right of I3 are dominated by *Eleocharis palustris/uniglumis* and *R. conglomeratus/obtusifolius/sanguineus*, otherwise containing only a few seeds indicating intermediate soil nitrogen-content.

6.8.3.3. Sowing time

Autumn-germinating weeds are scarce in several I3 samples, potentially consistent with spring-sowing (Fig. 6.34). However, some autumn-germinators are present in most samples (their relative scarcity compared with I1 and I2 is explained mostly by the absence of *Anthemis cotula*), and those most dominated by spring-germinating taxa are also those in which nitrogen-rich soils (preferred by many spring-germinating species) are best attested. Late-flowering taxa are present in a small number of I3 samples (and others in this dataset) but these are not concentrated in any specific record or area and are insufficient evidence to suggest spring-sowing.

6.8.3.4. Cultivation practice

<u>Langdale Hale</u>

The Langdale Hale samples which dominate I3 account for most samples in the two clusters with mixed indications of soil fertility. Variation in growing conditions is indicated within samples as well as between the two clusters, but it is possible that the difference between the clusters (unambiguous evidence of nitrogen-rich soils in one, stronger indications of low disturbance and nitrogen poor/acidic soils in the other) indicates approaches of greater/lesser levels of investment in spelt cultivation. This would be consistent with the concentrations of both perennials and taxa of nitrogen-rich soils (both including taxa other than *R. conglomeratus/obtusifolius/sanguineus*) noted at this site in Sections 6.4.5.3 and 6.4.6.3. It seems likely that crops cultivated under two regimes are represented, but that conditions within both sets of arable plots varied (e.g. between the edges – also suggested to have been wet in places – and centre).

Vicar's Farm

One of the ER Vicar's Farm samples in I3 contains taxa of intermediate to nitrogen-rich soils and also includes *A. cotula* (Fig. 6.32), the other suggests wet ground (6.31); both include *R. conglomeratus/obtusifolius/sanguineus* (Fig. 6.33), suggesting low levels of soil disturbance. Along with the sample from I1, these samples suggest cultivation strategies similar to those of the MR[25] and LR periods at this site (Group I1), though applied on soils more prone to extreme wet conditions.

Watson's Lane

A. cotula is also present in two of the three I3 samples from Watson's Lane (Fig. 6.32), confirming interpretation of its I1 and I2 samples as representing cultivation of heavy soils – i.e. different land to that cultivated from this site in the MIA (at least 400 years earlier; Sections 6.7.2-6.7.3). The absence of perennials (other than *C. mariscus*) suggests frequent soil disturbance, perhaps suggesting use of ards incorporating third-fourth century AD developments which allowed efficient ploughing of heavy soils (Section 1.5.3.2). This investment of effort would be consistent with indications of intermediate-high soil nitrogen content (outside of the wettest parts of arable plots) in this record. A change in crop choice (from spelt and emmer to spelt alone) since the MIA at the site may also have facilitated the cultivation of heavier soils.

Other records

The absence of *A. cotula* from both MR Biddenham Loop samples (and from two others excluded from Dataset I) is potentially interesting, suggesting continued cultivation of lighter river-valley soils, rather expansion onto the heavier soils of the western clay.

[25] The single MR Vicar's Farm sample in I3 is dominated by *Atriplex spp.* (800 seeds), contrasting with the composition from others from the same record (Group I1). The possibility that it includes seeds of non-arable origin has been suggested (Section 6.4.6.4).

Single samples from MR Beck Row, Mildenhall, and Stebbing Green indicate high soil nitrogen-content. This is of interest given the interpretation of both records as malting sites. Other fine-sieving by-product samples from these records contain few weed seeds (owing to previous-sieving as spikelets, which has also meant their exclusion from Dataset I) but almost all are indicative of high soil nitrogen-content.

6.8.4. Groups I4 and I5

These groups mainly comprise the three ER Heybridge samples and five ER Pakenham samples already described and discussed in Groups H2 and H3 (6.7.3 and 6.7.4). The remaining samples are single outliers from MR Rectory Farm and Langdale Hale (which do not contradict the interpretations already given of cultivation at these sites) and single (uninformative) samples from Snettisham Bypass and Wixams.

6.9. Indications of cultivation practice in clean grain samples (Dataset J)

6.9.1. Patterns in sample-distribution

The 61 samples included in Dataset J are from 34 records; their spatial distribution is shown in Fig. 6.37. Bibliographic references to all records are given in Appendix 1. Fig. 6.38 shows the sample-plot of Dataset J, coded to show samples' period- and record-affiliations. The distribution of samples in Fig. 6.38 is described in Table 7.4 and discussed below (Sections 6.9.2-4).

Bromus hordeaceus/secalinus is common in samples in this dataset and has a significant influence on their distribution. Several samples (plotting in the same position with only one from *Colonia Vitricensis* clearly visible in Fig. 7.30) contain no other weeds, reflecting thorough crop-processing.

Samples from ER *Colonia Vitricensis* plot separately (Group J1) from almost all others. Otherwise, there is no clear or consistent period, region or site-type influence on sample distribution (the juxtaposition of single samples from Heybridge and Pakenham in this dataset reflects only their very high content of *B. hordeaceus/secalinus*), which is thought to reflect localised/site-specific cultivation decisions: samples from the same records tend to cluster together. As in Dataset H, more samples from more records would help confirm this interpretation of variation.

Group	**Position in sample-plot**	**Includes samples from**			
		LIA	**ER**	**MR**	**LR**
J1	Top-left quadrant		*Colonia Vitricensis**		Caister-on-Sea (R104)*
				Colonia Vitricensis;	
J2	Bottom-left quadrant (extending into top-left)	Slough House Farm (R10); Stansted Area*†	Orton Longueville (R37); *Colonia Vitricensis**	Wedens Ambo (R74)	Wendens Ambo (R75); Great Holt's Farm*; Spong Hill (R57)†
		Harston (231); Heybridge; Beauford Farm (R242)†; Tort Hill West†	Pakenham	Tunbridge Lane†	Great Holt's Farm*†
J3	Right side of plot	Stansted Area*	Fison Way (R15); Kilverstone (R143)	Camp Ground	Spong Hill*; Caister-on-Sea*
		North Shoebury (R25)	Greenhouse Farm	Stonea Grange; Stansted Area; Lob's Hole (R193)	Stansted Area; Kempston (R93); Camp Ground

*Other samples from same record in other groups. †Obscured by sample from *Colonia Vitricensis* (see text). Shaded records are represented by single samples.
Table 6.8. Spatial distribution of samples in sample-plot (Dataset J).

Most samples represent spelt, glume wheat or indeterminate wheat crops. Most in J1 (*Colonia Vitricensis*) represent indeterminate wheat. Barley is best represented at the top and bottom of Group J2 and in samples spread throughout J3. Only three samples indicate emmer cultivation, positioned on the left edge of J3 and centre of J2. No clear link between specific crop and specific cultivation practice is identified.

6.9.2. Group J1

Almost all samples in J1 are from ER *Colonia Vitricensis* (mostly from Balkerne Lane (R58), but also from Head Street (R225) and Cups Hotel (R103)); the other two are from the MR phase of the town and the LR fort at Caister-on-Sea.

J1 forms a line extending diagonally up and left from the position of *Bromus hordeaceus/secalinus* (Ellenberg value N4) in the species-plot (compare Figs. 6.38 and 6.39). The position of samples within J1 reflects the balance of this weed and *Agrostemma githago* (N5), best seen as the balance between indicators of nitrogen-poor and intermediate soils in Fig. 6.40. The only other species to influence J1 samples in this plot are *Avena spp*. (N6), which is rare by comparison, and nitrogen-loving *Galium aparine* and *Polygonum aviculare*, occurring in very low numbers in samples dominated by *A. githago*. Further samples from *Colonia Vitricensis* (Balkerne Lane as well as civilian and military features at Culver Street) contain only *B. hordeaceus/secalinus* and so plot at the top of J2.

Dominance of these large-seeded taxa reflects thorough grain cleaning, but the varying balance between them may reflect cultivation practice. Though the difference between Ellenberg values N4 and N5 is slight, the presence of nitrogen-loving taxa only alongside the latter, may indicate a real difference in soil fertility between samples plotting closer to/further from the origin. However, there is no indication of very low soil nitrogen-content or acidic soil conditions (excepting a single seed of *Danthonia decumbens* in the MR sample), or of the low-levels of soil disturbance which might be expected if a completely *laissez faire* attitude was taken to cultivation (Figs. 6.1 and 6.43). Rather, these samples suggest cultivation without significant investment of effort or resources to maximise productivity per unit of land, but with sufficient input (possibly varying between different plots) to maintain reasonable crop-yields.

The single ER fine-sieving by-product sample from *Colonia Vitricensis* which was dominated by nitrogen-loving *P. aviculare* (Section 6.4.6.3 and 6.7.6) contrasts with this interpretation. It has been suggested that it represents contamination of fine-sieving by-products with weed seeds from another source. It is also possible that it represents a second, intensive, cultivation regime (such a regime would be consistent with small-scale cultivation within the town itself; cf. Wacher 1995: 125), but secure interpretation of a single sample is not possible.

6.9.3. Group J2

This group includes most LIA samples but also several from a variety of Roman rural settlements and ER *Colonia Vitricensis*. At the top of the group, several samples containing only/almost only *Bromus hordeaceus/secalinus* form a tight cluster, several of them occupying the same position (Table 6.8). With increasing distance from this cluster, samples contain less of this taxon and more *Avena spp*., reflecting the positions of the two in the species-plot (Fig. 6.39). Other weeds are rare, reflecting thorough cleaning of grain. Most samples in this group are spelt (or glume wheat); barley cultivation is attested at both ends of the group, in samples dominated by *Bromus hordeaceus/secalinus* and by *Avena spp*..

The balance of *B. hordeaceus/secalinus* and *Avena spp.* in these samples may be interpreted as indicating more fertile soils (i.e. more effort at soil improvement) in samples toward the bottom of J2 than in those toward the top (though neither very rich nor very poor in either; Fig. 6.40). Alternatively, it could represent a difference between autumn- (top) and spring- (bottom) sowing (Fig. 6.45). The limited range of weed taxa in these samples (though not unusual for clean grain samples) precludes definite interpretation. No link is suggested between crop species and growing conditions or cultivation practice.

6.9.4. Group J3

6.9.4.1. Overview

The records represented in J3 have no one factor in common, and cannot be used to suggest broad patterns in cultivation practice based on region- or settlement-type. Some records are represented by single samples, precluding interpretation. Both the Earith fen-edge (MR and LR) and Stansted Airport area (LIA, MR and LR) are represented by samples of more than one period, allowing comment on cultivation practice over time, and the ER samples from Fison Way and Kilverstone allow comment on Breckland cultivation in this period.

The weed assemblages of J3 are more diverse than those in J1 or J2 (reflecting the distribution of species in Fig. 6.39). J3 contains indications of cultivation of damp soils and land prone to waterlogging and shallow-water inundation, probably along plot margins (Fig. 6.42). Late-flowering taxa are relatively well represented (Fig. 6.45), mostly *Avena spp.* towards the bottom-left, and *Fallopia convolvulus*[26] towards the top-right of the group. Perennial weeds and those which thrive on moderately acidic soils are also better represented than in J1 or J2, though neither is common (Figs. 6.41 and 6.44). Weed ecology does not indicate uniform growing conditions for samples in this group, but comment is possible on growing conditions and cultivation practice in the better-represented records/record-groups.

6.9.4.2. Stansted Airport area

LIA samples from the Stansted Airport area of the southern till have indications of lower soil nitrogen than most in J3, including taxa indicative of acidic, as well as

[26] This species is ambiguous in its relationship to sowing time: late-flowering suggests that it should compete better in spring-sown than autumn-sown crops, but autumn-germination suggests that the disturbance associated with spring-sowing would disturb its growth and so set it at a disadvantage (see Table 6.2)

nitrogen-poor soils (Figs. 6.40-1). Two further samples from this area (plotting in J2) are consistent with this interpretation. Small proportions of the seeds in these samples indicate very wet soil conditions (Fig. 6.42), probably along plot margins. The single MR sample from Stansted Airport resembles the LIA samples, but the single LR sample suggests higher (though not very high) soil nitrogen-content and includes no evidence of extreme wetness.

Strong representation of the wetland weed *E. palustris/uniglumis* in MIA-MR samples from this area was noted in Section 6.4.2.3, and strong representation of *A. cotula* (excluded from Dataset J as a rare species) in LR samples from this area in Section 6.4.3.3.

It is suggested that the soils cultivated from the MIA to the MR period in this area were lighter river-valley soils, prone to wetness along their margins and possibly to leaching of nutrients (accounting for indications of acidity). In the LR period cultivation is suggested to have shifted, possibly accompanied by increased investment in soil improvement, to the heavier clay soils of the southern till.

6.9.4.3. The Earith fen-edge

Two samples from MR Camp Ground, one from LR Camp Ground and one from LR Langdale Hale are consistent with the interpretation of cultivation practice at Langdale Hale (MR and LR) given in Section 6.8.4.3, suggesting that the cultivation regime did not vary between the two sites or from the MR to LR period

6.9.4.4. Early Roman Breckland

ER cultivation in Breckland is represented by three samples from Fison Way and two from Kilverstone, plotting in the upper part of J3. All suggest intermediate-high soil nitrogen-content, possibly higher at Fison Way than at Kilverstone (Fig. 6.40), suggesting investment of effort and resources to improve crop-yields per unit of land. Little else is revealed about cultivation practice at either site.

The strong representation of nitrogen-loving weeds in the single fine-sieving by-product sample from ER West Stow (Sections 6.4.6.3-4, 6.7.6 and 6.8.2) is consistent with this interpretation of Breckland cultivation practice. However, this sample also contained strong indications of acidic and nitrogen-poor soils (Section 6.4.4.3-4). This may suggest (inconsistent) efforts at soil improvement on soils prone to leaching (as suggested from MIA West Stow (Section 6.7.5), but it without further samples no clear interpretation is possible.

6.10. Summary

6.10.1. Assessment of analyses in this chapter

6.10.1.1. Understanding low sample numbers

The number of samples which could be included in the analyses in this chapter was low: 332 (91 records) in the basic analyses of distributions and just 45/63/61 (24/26/34 records) the three CA datasets (H-J). Fig. 6.46 shows the process of elimination by which these numbers were reached. In addition to previous sample-culling to meet criteria necessary for identification of crop-processing derivation (Sections 4.2.1 and 4.9.1) the key causes are the necessity of analysing samples of like crop-processing derivation, the exclusion of rare species[27] from the CA datasets and the chronological subdivision of the CA datasets. None of these could have been avoided.

[27] Without excluding rare species only 10 samples would have been lost to meet the criterion of >3 weed seeds. Although a limit of 10% was used to define rare species in Datasets H and I, use of a 5% limit would not have resulted in the inclusion of more samples; use of any cut off lower than this would have resulted in a lot of ‘background noise’ making the plots uninterpretable.

The 'problems' thus lie in the dataset itself, rather than in the methods employed in analysis. They are (1) the size of the dataset available following crop-processing analysis (more samples of known crop-processing derivation would mean more of like crop-processing derivation and more of any given period) and (2) the composition of the weed assemblage, which included a wide range of species in very low numbers. Both of these factors can be linked to small sample sizes (though the second may also reflect the actual compositions of arable weed floras): larger samples would have contained more items (allowing characterisation of crop-processing derivation for more samples) and more weed seeds (most likely increasing the numbers in which many species was represented, rather than further increasing the range of species). Sample sizes are discussed in Section 8.2.3.2.

6.10.1.2. The implications of small sample sizes and low sample numbers

The impact of low sample numbers was greater for some periods than for others. No comment has been possible on weed ecology, growing conditions or cultivation practice in the EIA (represented by just 11 samples in the basic analyses).

The limited number of samples from most records and limited number of items in many samples, has meant that most of the patterns identified (in both the basic analyses and the CA plots) relate to practices at individual sites (or clusters of sites) – those with more and larger samples. This is not to say that the interpretations of these patterns given are invalid, just that it is not possible to tell whether they are representative of widespread practices which the data is too poor to show, or whether (as it appears) they represent site-specific or local approaches to cultivation.

6.10.1.3. Comparing the basic and correspondence analyses

Plotting of the frequencies with which weeds with different ecological/life-history characteristics occurred over time allowed the identification of broad chronological trends in growing conditions. Direct interrogation of the data allowed differentiation between widespread growing conditions, low level (incidental) occurrences of relevant weed taxa, and conditions/practices specific to certain areas or records. It also allowed identification of (and correction for) isolated large samples which skewed the frequency plots but could not be clearly interpreted. However, all interpretations based on this direct observation are heavily reliant on the author's recognition and judgement of what is/ is not significant.

Because of the complexity of the dataset (not least the wide range of species represented by very small numbers of seeds), this approach allowed investigation of the five selected aspects of weed ecology/life history separately but only very limited attempts were made to draw links between them. CA remedied this problem, allowing an integrated consideration of weed ecology and life-history. However, interpretation of the interplay of weeds' various characteristics remained complex in some instances (necessitating the creation of an extra figure (Fig. 6.36) for clarification in one case).

CA allowed consideration of aspects of life-history (germination and flowering) potentially indicative of sowing time but which can only be interpreted in light of the growing conditions suggested by other characteristics. However, this consideration had only limited success. Autumn-sowing is suggested in most cases. Spring-sowing is only identified tentatively, and only in a few cases: its two indicators were frequently inconsistent, and it was not possible to definitely distinguish the influences of sowing-time from factors of soil fertility and disturbance.

The (necessary) exclusion of rare species from the CA datasets reduced the resemblance of the analysed data to the samples' true weed-composition. In some cases, this prevented recognition of certain aspects of cultivation practice (e.g. cultivation of clay soils in the LR Stansted area, low levels of soil disturbance at MR and LR Vicar's Farm) as the pertinent taxa were (individually) too rare to be included. Comparison of interpretations based on CA and the more basic analyses has remedied this oversight, but it is possible that further relevant information contained in the dataset's rare species has gone unrecognised by both approaches.

CA has the clear advantage of allowing easy visualisation of weed-composition on the by-sample (using pie-charts) and by-record (based on positioning of samples) scales on which variation in cultivation practice has been identified. The grouping of samples has revealed patterns (similarities between samples) which could not be recognised by the plotting of frequencies or direct observation of the data. This includes recognition of dual-strategy approaches to cultivation in certain records/areas where direct interrogation had recognised inconsistencies in the growing conditions attested (e.g. MIA Isle of Ely, LIA and ER Heybridge and, less certainly, ER Pakenham and MR-LR Langdale Hale). CA also has the advantage that the shape of its plots are not determined by the absolute numbers in which species occur, lessening the potential influence of many-seeded taxa on intereptation.

6.10.2. Summary of findings

6.10.2.1. Preface

In this section I summarise the key findings of this chapter, drawing together the results of basic analysis and analyses of the three principal CA datasets. These findings relate to the timing and nature of cultivation of the region's heavy clay soils and patterns in the levels of investment made in to improve/maintain soil fertility.

6.10.2.2. Cultivation of clay soils

Clear patterning in the chronological distribution of *Anthemis cotula* suggests that the region's heavy clay soils were cultivated in the MR and LR periods only, with possible evidence for slightly earlier (late ER) expansion at one site (Vicar's Farm). However, the possibility has been raised (Robinson 1981) that *A. cotula* was a Roman introduction to Britain; in this scenario the timing of its appearance in the study region would not necessarily reflect the timing of arable expansion onto heavy soils though its presence in MR and LR samples would still be a useful indication of cultivation of heavy clays.

The ABCD (1996; updated information obtained from Allan Hall) lists fifteen British sites at which pre-Roman (Bronze Age or Iron Age) examples of this species have been identified, though the dating of the only sample in which more than ten seeds are present is questionable. Further examination of the material (and context records) from these sites would be necessary to prove the pre-Roman occurrence of *A. cotula* in Britain. The timing of arable expansion onto clay soils in the East of England thus remains open to question.

It is suggested that MR and LR cultivation of heavy clay soils was confined to few records, rather than being ubiquitous in predominantly clayey areas (though this could also result from piecemeal spread of a newly introduced weed). This may reflect the limitations of the dataset, but there is evidence of continued cultivation of lighter (probably river valley) soils in the MR period (as in earlier periods) in the Stansted area of the southern till (where expansion onto the clays is attested in the LR period) and at Biddenham Loop (southern part of the western clay). Low record-representation also prevents comment on whether variation in growing conditions attested on heavy soils (see below) reflects regional or site-specific differences in cultivation strategy.

At Vicar's Farm, indications of poor-intermediate soils occur alongside perennial weeds, suggesting that only basic ards (not capable of significantly disturbing or turning heavy soils) were employed in cultivation. Perennials are not well represented at Godmanchester (though they are present) or Rectory Farm, but soils are indicated to have been relatively poor, and prone to extreme wetness (probably along plot margins). It is thus suggested that spelt cultivation on the heavy soils of the western clay can be accurately interpreted as exploitation of marginal land.

This is not the case on the Isle of Ely (MR Watson's Lane) or in the LR Stansted area, where perennials are absent and evidence of high soil nitrogen-content suggests investment in soil improvement to increase crop-yields. The crops represented in both cases are spelt (mixed with emmer in some samples from the Stansted area) despite growing conditions apparently ideal for bread wheat (e.g. M. Jones 1981).

Cultivation of heavy clay soils is indicated at Tunbridge Lane, Bottisham (MR and LR), and Hinxton Road, Duxford (LR), despite their locations on lighter soils. Both lie within *c.* 3km clayey land, and both have evidence of large-scale crop-processing activity (corndriers – MR only at Tunbridge Lane - and dense archaeobotanical deposits[28]), potentially consistent with import of crops over short distances.

[28] Malting is possible at Hinxton Road, but considered an unlikely interpretation of the Tunbridge Lane assemblages (Section 4.8.2.4).

6.10.2.3. Levels of investment in soil improvement

Trends

Increasing representation of perennial weeds (which never accounted for >3.5% of the fine-sieving by-product weed assemblage) from the MIA to LR period is considered to represent increasing inattention to peripheral parts of fields (a phenomenon confined to the Isle of Ely – where plot margins were also prone to extreme wetness – in the MIA but increasingly widespread thereafter). Cultivation without effective ploughing/other tillage is suggested only at Roman Vicar's Farm (below).

This trend coincides with decreased representation of nitrogen-loving weeds after the MIA. It is possible (not clearly proved) that levels of investment in soil improvement were generally slightly higher in the MIA than in later periods, but concentrations of these weeds suggest atypically high levels of investment at a small number of MIA sites (below), compared to most records.

Indications of nitrogen-poor soils are relatively constant over time (with a dip in the MR period), suggesting that there was no trend of increasing soil exhaustion through decreasing investment per unit of land. Intermediate, mixed, or slightly low (Ellenberg value N4) soil nitrogen-content appears to have been the norm throughout the study period, suggesting strategies of sufficient investment to prevent nutrient depletion and maintain reasonable productivity, but not intensive investment to maximize crop-yields.

No clear and consistent relationship between crop species and investment in soil improvement has been identified. However, at MIA West Stow the evidence hints at higher levels of investment in barley cultivation than in spelt cultivation. In Chapter 5 (Section 5.7) it was suggested that where MR spelt and barley were mixed after harvest, the barley component had been cultivated with higher levels of investment than the spelt component. Increasing dominance of spelt (in the overall assemblage analysed in Chapter 4, but especially in the fine-sieving by-products which form the datasets used in this chapter) in the Roman period coincides with the trends of increasing inattention to plot-margins and decreased instances of intensive investment described above. Together these lines of evidence suggest (but do not conclusively demonstrate) that spelt was cultivated with less investment in soils than barley. This contrasts with the greater investment in spelt/emmer than barley cultivation identified by Van der Veen (1992: 148) in north-east England.

The Middle Iron Age

Taxa of nitrogen-rich soils are more widespread in the MIA than in later periods, but a particular concentration is noted in samples from the hillfort at Chipping Hill, suggesting greater investment in soil improvement than at other sites. Significant investment (with inconsistent effect owing to the natural vulnerability of light soils to leaching of nutrients) is also suggested at MIA West Stow. It also appears to have been one of the two approaches taken to cultivation on the MIA Isle of Ely, where it was applied in dry plots as well as those prone to extreme wetness (probably along their margins). Other plots (prone to wetness) in this area were cultivated with far less investment of resources or labour. The two approaches do not appear to have been consistently related to crop species (mostly mixed spelt and emmer in both).

Roman

Vicar's Farm (MR, LR and possibly ER) is distinctive in being the only site at which cultivation without effective ploughing or sufficient investment to maintain crop yields without increasing the area under cultivation is suggested (Section 6.10.2.2).

The only other concentrations of perennials are from Parnwell (MR) and Langdale Hale (MR and LR, possibly also neighbouring Camp Ground). These records also have the only identified MR/LR concentrations of nitrogen-loving weeds[29]. Too few samples were available for further comment on cultivation practice at Parnwell or Camp Ground (though there are hints that the latter was similar to that at neighbouring Langdale Hale), but variation in the frequency with which taxa of rich and poor/undisturbed soils occur in different samples from Langdale Hale may indicate variation in the levels of investment applied to different arable plots (not related to crop species). Variation within samples may also indicate inconsistent conditions within plots (e.g. between edges and centre).

Heybridge (LIA and ER) and Pakenham (ER) have also been noted for strong representation of taxa of both nitrogen-rich and nitrogen-poor soils, as well as extremely wet conditions (Heybridge only, also in the MR period). At Pakenham these co-occur in the same samples, and may indicate either mixed crops (all spelt) from different sources, cultivated under different regimes, or inconsistent conditions within arable plots. At Heybridge they occur in different samples (separated in the CA plots), suggesting cultivation under two regimes: significant investment to increase crop-yields (spelt) in some plots, but little/no such investment in others (spelt but also emmer in one sample), which were wet along their margins.

ER Breckland records (Kilverstone and Fison Way) stand out as indicating greater than normal investment in soil improvement. Such investment is also suggested (very tentatively owing to low numbers of identifiable weed seeds in the relevant samples) at the MR malting sites of Stebbing Green and Beck Row (the latter also in Breckland).

[29] Though *R. conglomeratus/obtusifolius/sanguineus*, which is both perennial and nitrogen-loving, is present at both sites, it does not account for all occurrences of either phenomenon at either site.

6.10.3. Key points to carry forwards

Low sample numbers have limited the findings of this investigation. Expansion of cultivation onto the region's heavy clay soils dates to the MR period (late ER at one site), though even then some settlements continued to exploit lighter river valley soils in predominantly clay areas. The approach (level of investment) taken to cultivation of heavy clays varied. On other soils, strategies of sufficient, but not intensive, investment in soils were the norm. Strategies of greater investment were mostly of MIA and ER date, and sometimes pursued as part of a dual-approach regime, alongside strategies of less investment. Records/areas standing out for strategies including greater than normal investment in soil improvement include MIA Chipping Hill hillfort, West Stow (probably out of necessity given local soils) and the Isle of Ely, ER Breckland, ER Pakenham and LIA-ER Heybridge.

7. Non-cereal crops and wild plant foods

7.1. Objective and approach

In this chapter I identify the presence of non-cereal plants of potential economic importance in the carbonised archaeobotanical record of the Iron Age and Roman East of England. These macrofossils (excepting nutshell fragments which were commonly disposed of in fires) occur only rarely and by chance in the carbonised archaeobotanical record, which is thus less apt than the waterlogged record for their identification (Van der Veen *et al*. 2008; Van der Veen 2008). The significance of these species' presence is tangential to the main focus of this research. However, patterns in their distribution may help with the understanding of patterns in cereal cultivation when considered in the context of the region's wider archaeological record (Chapter 8).

Because of their very low occurrence, these species are considered on a by-record (not by-sample) basis, and (initially) according to their presence, rather than the numbers in which they occur. This allowed the consideration of records which lack full quantification and were therefore excluded from the main analyses (Chapters 3-6) of this research (see Section 2.3, and Appendix 1).

Van der Veen (2008; *et al*. 2008) has made a comprehensive study of the archaeobotanical (waterlogged, carbonised and mineralised) occurrence of these species in the (Iron Age and) Roman period. This is referred to throughout this chapter. The methodology is set out in Section 7.2, followed by presentation of results in Section 7.3 and summary of key points in Section 7.4.

7.2. Methodology

Assessment of the presence of these items was made on a record-by-record basis. Definite and 'cf.' identifications were combined. The category 'Pisum-type' was amalgamated with *Pisum sativum*. *Rubus sp*., *Rubus* subgen. *Rubus*, *Rubus idaeus/fruticosus* and *Rubus fruticosus* agg. were amalgamated as *Rubus sp*.. *Camelina sp*. was amalgamated with *Camelina sativa,* and *Sambucus sp.* with *Sambucus nigra*.

7.3. The occurrence of non-cereal species of potential economic importance

7.3.1. Occurrence

The number of records per period which included non-cereal species of potential economic importance is shown in Table 7.1.

7.3.2. Imported foods and Roman introductions

Of the more than 50 plant foods identified by Van der Veen (2008; *et al*. 2008) as Roman introductions to Britain, nine were identified in this study (Table 7.1). All occurrences represent single records (each including ≤4 macrofossils) per period, with the exception of ER walnut (two records, both with 11 macrofossils).

The only Iron Age occurrence was four plum/damson stones from MIA Shillington Bury (R89; not included in Van der Veen's dataset). Plum/damson has no wild progenitor native to Britain (Van der Veen 2008), ruling out the possibility of wild fruit being represented. If the identifications are accurate, and if the sampled contexts are accurately dated, these plum/damson stones probably provide (rare) evidence of import of continental goods (rather than orchard cultivation) in the MIA.

Species	**Common name**	**Number of records**					
		EIA	**MIA**	**LIA**	**ER**	**MR**	**LR**
Imports							
Morus nigra	Mulberry	0	0	0	0	1	0
Ficus carica	Fig	0	0	0	0	1	0
Juglans regia	Walnut	0	0	0	2	1	0
Prunus domestica	Plum/damson	0	1	0	1	0	1
Prunus avium/cerasus	Sweet/sour cherry	0	0	0	0	1	0
Anethum graveolens	Dill	0	0	0	1	0	0
Olea europea	Olive	0	0	0	1	0	0
Pinus pinea	Pine nut	0	0	0	0	1	0
cf. Piper nigrum	Black pepper	0	0	0	1	0	0
Wild/ gathered							
Corylus avellana	Hazelnut	17	19	21	19	25	18
Rubus sp.	Blackberry/Raspberry	2	3	2	3	3	1
Fragaria vesca	Strawberry	0	0	0	1	1	0
Rosa sp.	Rosehip	1	1	1	1	0	0
Prunus spinosa	Sloe	2	4	3	8	4	1
Malus -type	Apple/Crab apple	0	1	0	1	0	1
Sambucus nigra	Elderberry	2	2	2	7	10	5
Pulses							
Large Fabaceae	Pulse (indeterminate)	1	3	0	1	10	5
Vicia faba	Broad bean	1	6	0	4	6	2
Lens culinaris	Lentil	0	0	0	0	2	0
Pisum sativum	Pea	4	2	1	7	12	4
Oil-rich seeds							
Papaver somniferum	Opium poppy	1	0	0	0	0	0
Brassica nigra	Black mustard	1	1	0	1	1	3
Linum usitatissimum	Flax	1	2	2	5	2	4
Camelina sativa	Gold of Pleasure	1	2	0	1	1	0
Vegetables							
Daucus carota	Carrot	0	0	1	1	0	2
Total Records Considered		*50*	*54*	*34*	*62*	*73*	*50*

Table 7.1. Number of records in each period including carbonised macrofossils of non-cereal species of potential economic importance.

Walnut (including two ER records each with 11 kernels), plum/damson and cherry were present in the Roman period; with the exception of a plum/damson stone from LR Camp Ground, Earith (R250), they came from military (Pakenham; R115) and town (*Colonia Vitricensis* and Heybridge; R99, R225, R227 and R126) records. Carbonised spines, identified as *Prunus domestica* were present in an additional LR record, indicating the presence of damson branches, as well as fruits – plum has spineless branches (Stace 1997: 364) – in the region by this time, and so suggesting cultivation (consistent with Van der Veen's findings).

Dill (13 seeds) was present in a sample from an ER building at Head Street, Colchester (R225), within *Colonia Vitricensis* (not included in Van der Veen's dataset). These seeds may have been imported, as Van der Veen suggests that this species was cultivated in Britain from the *M*R period.

Fig, mulberry, olive, pine nut and black pepper are considered by Van der Veen to have been imported to Britain in the Roman period but not successfully cultivated here (i.e. as 'exotic' foods). All clear records of these species are from records within *Colonia Vitricensis* (black pepper, fig and pine nut from Head Street, mulberry and olive from Culver Street; R225, R227 and R98). Their presence in a (veteran-populated) major town is consistent with Van der Veen's characterisation of their distribution in Roman Britain.

7.3.3. Wild/ gathered foods

7.3.3.1. Hazelnut

Hazelnut was consistently present in higher numbers of records than other species considered in this chapter (Table 7.1), probably reflecting disposal of its shells in fires. This is a conservative indication of its frequency/distribution, as assemblages including hazelnut shell but lacking the remains of cereals or arable weeds was excluded at the data collection stage of this research.

Records including hazelnut shell accounted for 32-37% of records considered for each period, with no clear pattern over time in their distribution. This consistent occurrence contrasts with Van der Veen's finding that this species' frequency increased from the Iron Age into the

Roman period and from the ER to MR period, but (as her study was based on the waterlogged archaeobotanical record from sites across Britain) the significance of this difference is unclear.

As hazelnut shell was quantified by shell fragment count in 54% of source reports and simply listed as 'present' in 46% (even in otherwise quantified reports), it is not possible to distinguish consistently between records in which hazelnuts represent a significant gathered food resource and those where their presence may have been incidental.

7.3.3.2. Wild/ gathered fruits

Potential wild/ gathered fruits were generally present in two-three records per period, though sloe and elderberry occur more frequently in the Roman period (Table 7.1). Most occurrences are of ≤4 seeds; exceptions to this are discussed below.

Sloe, elderberry and blackberry/raspberry are the most frequently occurring of these species, in the Iron Age. The occurrence of sloe and elderberry increases in the ER period, consistent with Van der Veen's finding that the arrival of new plant foods in Roman Britain was accompanied by a surge in exploitation of wild fruits, but this was sustained only for elderberry.

Rosehip (*Rosa sp*.) was present in single records for each period until the ER period, and not identified thereafter. Wild strawberry (*Fragaria vesca*) was identified in the Roman period only (single ER and MR records).

It is not possible to distinguish cultivated apple (*Malus domestica*), a Roman introduction, from (native) crab apple (*Malus sylvestris*) by seed morphology. The MIA example of this taxon is probably crab apple. It is possible that the ER occurrence represents the cultivated variety (possibly an import) as it is from the same record (Head Street, Colchester) as the dill, fig and pine nut discussed above.

Relatively large assemblages of sloe stones came from MIA Stansted Airport (R166; 23 stones) and the ER small town at Heybridge (11 stones). These represent no more than a handful/double handful of fruit, but this is enough to suggest deliberate gathering.

Other potentially significant occurrences are of 88 elderberry seeds (EIA open settlement at Site 52 on the Willington to Steppingley pipeline; R183), 17 elderberry seeds (ER pottery production site at Greenhouse Farm; R202), 20 blackberry seeds (ER Head Street, Colchester). However, both of these species commonly grow on waste ground near settlements, and need not necessarily represent deliberately gathered resources (Van der Veen 2008). The gathering of fuel for kilns, rather than food, may explain the presence of elder(berry) at Greenhouse Farm, and the presence of carbonised *Rubus sp*. prickles in MR and LR records where their fruits also occur suggests that they were not gathered as food. Furthermore, the large numbers of seeds in a single blackberry/raspberry fruit, or cluster of elderberries means that none of these 'large' occurrences necessarily represents many fruits.

7.3.4. Pulses

Pulses occur in records of all periods (Table 7.1). They occur most commonly in the MR period, but are also relatively well represented in the MIA and ER and LR periods. They were represented in most records by only a few seeds but, given the relatively low carbonisation rate of pulses (compared with cereals), even these low level occurrences may indicate cultivation.

Pea and broad bean are the most frequently occurring identifiable pulses; the indeterminate pulses were probably either broad bean or pea, given the lack of evidence for other species (Table 7.1). Except in the MIA, pea occurs in more records than broad bean.

The only other identified pulse, lentil, occurs as a single seed from MR Stonea Grange (R262), alongside pea, broad bean and indeterminate pulses. Van der Veen considers lentils to have been imported to Britain, but not cultivated here. Stonea Grange is classified in this study as a small town, but may have had an administrative function (Section 1.3.6.3) and so, presumably, a non-British element in its population.

There were three instances of pulse cultivation attested by large numbers of macrofossils from single samples: 4,902 peas from EIA North Shoebury (R24), 87 peas from MR Rectory Farm (R236), Godmanchester, and 192 indeterminate pulses from LR Great Holt's Farm, Boreham (R96).

The pea-rich sample from EIA North Shoebury also contained 34 seeds of gold of pleasure, identified by Van der Veen as a Roman introduction to Britain. Given North Shoebury's coastal location, it is plausible that this pea crop (or the seed store from which it was sown) was imported from the Continent. Gold of pleasure is known from Iron Age records in Scandinavia, Germany and The Netherlands (Murphy 1995).

7.3.5. Oil-rich seeds

Macrofossils representing potential oil-crops were generally present on only one or two records per period (Table 7.1). Most occurrences were of very low numbers of seeds; exceptions are discussed below.

Flax (which may be cultivated for its oil-rich seeds or its fibrous stems), occurs in records dating from the EIA onwards, but is most common in the ER and LR periods (Table 8.1). Of its five ER occurrences, two are from records within *Colonia Vitricensis*, including an assemblage of over 20,000 seeds from Cups Hotel (R103), and a third from the small town at Heybridge. Although flax was not a Roman introduction to Britain, it is possible that the seeds from Cups Hotel were imported, given the presence of gold of pleasure (18 seeds in the same sample), probably representing a contaminant of the flax crop. A second large assemblage of flax seeds (205), potentially representing cultivation, was from the MR complex rural settlement at Camp Ground, Earith (R249).

Black mustard occurred in records of all periods but the LIA. The clearest evidence of black mustard cultivation comes from EIA Biddenham Loop (R174), where one sample contained 381 black mustard seeds, as well as an additional 1,987 seeds identified only as *Brassica/Sinapis*. Contrary to Van der Veen's characterisation of this species (based on the waterlogged record) as occurring almost exclusively in major town and military records in the Roman period, it is present in Roman records only from the complex rural settlements at Camp Ground and Langdale Hale, Earith, and Vicar's Farm, Cambridge (R248-251, R252-254 and R255-R258).

Gold of pleasure occurs in single records in the EIA, MIA, ER and MR Roman periods. Its two large occurrences are interpreted as a contaminant of an EIA pea crop and ER flax crop, both possibly imported from the continent (see above).

Opium poppy, is represented by a single EIA seed, not considered to be significant.

7.3.6. Vegetables

The only vegetable identified is the carrot, which occurs as 1-3 seeds/record in one/two records in the LIA and ER and LR periods (Table 8.1). As wild carrots (not discernable from the domestic variety by seed morphology) are native to Britain, no significance is attached to this low-level occurrence.

7.4. Key points to carry forwards

Two Iron Age records suggest import of food plants from the Continent: peas (contaminated with gold of pleasure) to EIA North Shoebury, on the Essex coast, and plum/damson to MIA Shillington Bury, inland on the western clay.

Records from ER and MR *Colonia Vitricensis* include walnut, plum and apple (potentially representing orchard cultivation), dill and flax (possibly imported), black pepper, fig, pine nut, mulberry and olive (probably imported). This range of non-cereal food plants is far larger than those seen as other settlements (though the large number of investigations carried out in Colchester is probably a factor in this concentration).

There was also evidence of potential orchard cultivated fruits from small towns (sweet/sour cherry from MR Heybridge) and forts (ER walnut from Pakenham), import of lentils to the MR small town at Stonea Grange, and potential flax cultivation (or import, given the coastal location) and gathering of sloes in the ER small town at Heybridge.

The Roman complex rural settlements at Camp Ground and Langdale Hale, Earith, and Vicar's Farm, Cambridge (LR only), have been noted for the only Roman occurrences of black mustard. Camp Ground has also been noted for probable flax cultivation (MR) and the presence of plum/damson stones (LR), possibly representing cultivation. This relatively strong representation of non-cereal species of potential economic importance may result from a combination of low probability of their preservation by carbonisation and extensive sampling strategies employed at these sites.

As well as the cases already mentioned, cultivation of non-cereal crops is suggested at EIA Biddenham Loop (black mustard), MR Rectory Farm, Godmanchester (pea) and LR Great Holt's Farm, Boreham (indeterminate pulses). Other instances are possible, but it is not possible to clearly distinguish between cultivation and incidental presence based on low seed numbers.

8. Discussion

8.1. Introduction

Chapters 3-7 have produced interesting results and raised a number of issues worthy of further consideration. In this chapter I discuss these issues in an integrated manner, using the results of the preceding analyses to address the original objectives of this research (Section 1.2.3). Firstly (Section 8.2), I consider the quality of the data collected and explore the limitations it has imposed on analysis and interpretation. Secondly (Section 8.3), I set out the understanding of arable practice in the Iron Age and Roman East of England gained through this research, with reference to previous understanding and to current understanding of arable practice in other parts of Iron Age and Roman Britain. Thirdly (Section 8.4), I set arable practice in its wider context, and discuss those aspects of the region's wider social/political and economic development to which this research contributes.

8.2. Assessment of the dataset

8.2.1. Preface

The size and quality of the dataset has imposed limitations on analysis and has affected the reliability of some interpretation in the preceding chapters. The limitations of the dataset are explored in this section.

8.2.2. The limitations of the data

All of the principal analyses would have benefited from higher sample numbers. This would have allowed more complete period coverage (e.g. comment on EIA crop-processing practice and cultivation regimes) and greater clarity and confidence in interpretations. It would also have allowed characterisation of cultivation regimes at a regional/period level, rather than the isolated interpretations of local/site-specific practice which have been possible.

Each analysis has had its own selection criteria, designed to ensure reliability of results. These were imposed on the principle that it is better to draw limited conclusions from solid data than to speculate more extensively about the possible interpretations of fallible data. Demonstrating the validity of this principle, more accommodating selection criteria for sample inclusion in analysis of cultivation practice (content of just three weed seeds) allowed the formation of datasets large enough for analysis but meant that interpretation was not possible for some samples and was tentative (compared to other analyses) for others.

Imposition of selection criteria for each analysis meant the exclusion of significant numbers of samples (and of records which included no remaining samples). This was discussed chapter by chapter, but is worth exploring in more detail (Fig. 8.1 and Table 8.1).

Included in analysis of	**Reasons for sample exclusion**	**% of total records (338)**	**% of total samples (2440)**
Crops (Method 1)	Lack of full quantification in source report	66%	n/a*
Crops (Method 2) and crop-processing	<50 identifications (not reliably representative)	47%	30%
Weed ecology (basic analysis)	Not fine-sieving by-products or no weed seeds	27%	14%
Weed ecology (correspondence analysis)	<3 weed seeds after removal of rare species or outlier in preliminary plots	20%	6%

*Unquantified records were not recorded by sample; percentages given in the remainder of this column are of the samples included in Method 1 for crop characterisation.
Table 8.1. Reasons for sample/record exclusion.

The figures are alarming. One third of all records identified lacked full quantification and could not be used in any of the quantitative analyses at the core of this research[30].

[30] These were included only in consideration of other species of potential economic importance (Chapter 7).

Less than half of all records initially identified, and only 30% of the samples from *quantified* records, could be included in any but the most basic analysis (crop characterisation by Method 1), owing to low numbers of identifications/sample.

Exclusions from analyses of weed ecology are even more extensive. In Section 6.10.1, their causes were identified as: (1) the requirement to compare samples of like crop-processing derivation (which meant exclusion of half of the potentially available samples) and (2) the large number of rare weed taxa (which had to be excluded from correspondence analyses, thus reducing the number of usable weed seeds in each sample) in the assemblage. Both phenomena were linked to small sample-sizes.

8.2.3. Exploring the causes of sample-exclusions

8.2.3.1. Lack of quantification in source reports

One third of all the datable records identified ('Overall' in Fig. 8.1) were excluded from the outset because their source reports lacked the data for quantitative analysis. This is partly explained by the decision to collect data from published *and unpublished* reports.

As well as reports 'forthcoming' or 'in preparation' (or languishing at one or the other of these stages), unpublished reports include those from the 'fieldwork archive' (interim) and 'assessment and updated project design' phases of developer funded projects (see MAP 2 guidelines[31]; English Heritage 1998). Archaeobotanical reporting at these stages is intended to inform decisions on how/whether to proceed with further analysis. Given the time- (money-) consuming nature of archaeobotanical

[31] The more recent MoRPHE document (Lee 2006) post-dates most of the reports considered for inclusion in this research (and all of the projects on which they were based); though using different nomenclature, it concurs with MAP 2 in its recommendations on preliminary reporting and assessment prior to publication.

quantification, archaeobotanical assessments are often carried out using 'abundance scores' (see Section 2.3). These preliminary/assessment reports account for 43% of all records excluded for lack of quantified data. The decision to consider this kind of report is not regretted: not all are compiled without quantification (there is apparent variation in policy both within and between archaeological contractors) and 15% of all records included in Method 1 for crop identification were from this source-type.

Almost all the remaining unquantified records were from developer-funded reports in which the decision had been made to publish the archaeobotanical assessment, rather than commissioning further analysis. This probably reflects adhesion to a 'traditional' model of archaeological publication – a report on the site's morphology/ the features revealed by excavation, followed by a full complement of specialists' reports – despite a perception[32] that the archaeobotanical material was not worthy of further investigation.

This is symptomatic of the wider debate on the purpose of archaeological publication (site synthesis or data-provision), an issue much influenced by the site-specific funding of most commercial projects (Section 1.2.1). Differences of objective between regional journal editors (whose publications offer the only publication outlet for many site reports, though this is now mitigated by the OASIS project) and archaeologists

[32] In some cases, incorrect: a fully quantified account of the plant macrofossils may have made a significant contribution to a regional study of arable practice (like this one), if not to the site-report. In others, probably correct: the limited archaeobotanical information would have been better left in the site archive.

(especially finds/environmental specialists), and of opinion within the wider archaeological community, also contribute to this debate.

8.2.3.2. Small sample-sizes

Application of the 50 item cut-off for inclusion of samples in crop-processing analysis (and Method 2 for crop characterisation) meant the exclusion of 70% of all samples and consequently of 29% of quantified records (or a further 19% of all records). These proportions are regrettably high; nevertheless it was considered necessary to exclude potentially fallible data (Section 8.1.2).

Low numbers of identifications/sample would be consistent with either very sparse plant macrofossils in carbonised deposits or low sample volumes. Examination of the sample volumes recorded indicates the latter: 74% of all samples were smaller than the 40-60L recommended by English Heritage (D. Jones 2002: 20; 2011: 12), and 38% represent just one bucket-full or less (≤10L) of sampled deposit (Table 8.2).

Small sample-sizes are also blamed for the very low *numbers* of samples included in analyses of weed ecology (see Section 6.10.1.1). However, the *proportion* of samples included in comparisons requiring like crop-processing derivation reflects the nature of the activity represented and is beyond the control of sampling-strategies.

Sample volume	**No. of samples**
Unknown	474
≤10 L	915
11-39 L	896
40-60 L	121
>60 L	34
Total	*2440*

Table 8.2. Sample volumes.

In 89% of samples 100% of the flot was analysed. Sub-samples appear to have been taken almost exclusively from samples whose overall volume was already low; both decisions are probably explained by visibly high density of plant macrofossils in the sampled deposits. However, the decision to sub-sample (or the portion selected) was frequently inappropriate: the number of identifications made after sub-sampling was >384 (cf. Van der Veen and Fieller 1982) in only 25% of cases; in 42% of cases sub-sampling resulted in <50 identifications being made, and so in exclusion of samples from the principal analyses of this research.

8.2.4. Low sample numbers

There is also a tendency for sites to be represented by small numbers of samples: the mean number is 20 (considering all samples) or 8 (considering samples included in crop-processing analysis), compared to 36 in Van der Veen's (1992) study[33]. Sites/site-clusters represented by significantly higher numbers of samples thus have the potential to dominate period-assemblages and so skew characterisation of arable practice. Care was taken to recognise this where it occurs, with direct scrutiny of data to identify the samples contributing to the period/region/record-type patterns identified.

Rare items are most likely to be identified where most material is examined. It remains possible that apparently distinctive aspects of the archaeobotany at some sites are an artefact of extensive sampling strategies (Table 8.3), and that relatively poor sampling has precluded identification of the same practices elsewhere.

It is also true that higher numbers of samples allow confident recognition of patterns. Sites with higher than average sample numbers thus tend to feature heavily in interpretations of the various aspects of arable practice.

[33] Mean sample numbers are discussed per site (not per record), as this is the number which is under the excavators' direct control (many contexts remain unphased until after the completion of excavation) and could be increased by a change in practice.

Site/site-cluster	**No. of samples (all/included in crop-processing analysis)**	**Bread wheat cultivation**	**Roman emmer cultivation**	**Early-processing by-products**	**Spikelet-sieving by-products**	**Rare wetland weeds**	**ER *Anthemis cotula***	**Imported plants**	**Non-cereal crops**
Colonia Vitricensis	158/46	✓						✓	✓
Camp Ground	232/42	✓		✓	✓	✓			✓
Langdale Hale	89/39			✓		✓			✓
Vicar's Farm	36/18			✓		✓	✓		✓
Stonea Grange	177/22	✓		✓	✓	✓		✓	
Stansted area	206/70		✓	✓					
Heybridge	60/37		✓	✓					✓
Pakenham	123/35			✓					✓

Table 8.3. Rare items and unusual sample characterisations in sites/site-clusters with high sample numbers.

8.3. New understanding of Iron Age and Roman arable practice in the East of England

8.3.1. Preface

In this section I draw together the principle findings of this research and compare them with pre-existing understanding of Iron Age and Roman arable practice in the East of England (Section 1.5.5). This new understanding is also compared with the known arable practice of other regions (Sections 1.5.4.2 and 1.5.4.3) in these periods. Arable practice is considered in three parts, consistent with the structure of this research: the crops cultivated (Section 8.3.2), the ways in which they were processed, stored and utilised (Section 8.3.3), and the strategies applied to their cultivation (Section 8.3.4).

Patterns and variations in these aspects of arable practice have been identified according to the periods and places which samples represent. The type of record has a more limited influence. Differences are identified between rural settlements and the 'new' types of site which emerged in the LIA and Roman period, as well as within the latter group, but (with the exception of MIA hillforts) the layout of rural settlements (enclosed, open, complex) is not shown to be linked to variation in any aspect of arable practice.

8.3.2. The crops

8.3.2.1. The principal crops

Spelt, emmer and six-row hulled barley are confirmed as the principal Iron Age crops of the East of England. The suggestion that spelt replaced emmer as the preferred wheat crop in the MIA (Section 1.5.5.3) is upheld across most of the study region, but there are localised exceptions (Section 8.3.2.2).

Consistent with previous findings (Section 1.5.5.3), cultivation of spelt is better attested than that of any other species in the Roman period. However, the apparent decline in barley-cultivation may be augmented by the bias in favour of glume wheat identification in fine-sieving by-products, which dominate in the MR and LR periods. Other cereal crops were rare in the Roman period: emmer and bread wheat were cultivated occasionally (Section 8.3.2.2) and rye very occasionally (one securely dated record). Oats were present in several samples, but there is no indication of their cultivation.

The dominance of spelt and barley is consistent with crop choices in central southern Britain and the Tees Lowlands; it contrasts with the dominance of emmer north of the Tyne and barley in East Lothian. In contrast to central southern Britain, (time/place-specific) cultivation of both emmer and bread wheat is attested in both the Iron Age and Roman period (Section 8.3.3.2), both peaking in the MIA. These similarities and differences confirm regional variation in crop-choice (Section 1.5.41), highlighting the (now well recognised) folly of generalising about crop-choice, or other aspects of arable practice, on a Britain-wide scale, based on the central southern British evidence.

8.3.2.2. Patterns in distribution

<u>MIA replacement of emmer by spelt</u>

Contrary to the norms of the period, emmer-cultivation was as well attested as spelt-cultivation on the MIA Isle of Ely, and also well attested in the south-east (where most evidence comes from the hillforts at Ashledham Camp and Chipping Hill). In the south-east, this forms part of a MIA-ER pattern of emmer-cultivation being attested at unusual settlements, specifically those where people may have gathered (i.e. MIA hillforts and the LIA nucleated settlement and ER small town of Heybridge). The possibility that these sites were in receipt of crops from others enhances the likelihood of rarely cultivated crops (i.e. emmer) being identified. It is also possible that traditional, but no longer commonplace, crops were reserved for (or grown specifically for) special occasions, such as gatherings.

MIA Wendens Ambo is also striking in its evidence for cultivation of both emmer and bread wheat alongside spelt and barley. This wider than normal range of crops remains unexplained.

Although spelt and emmer can be productive on a similar range of soil types, spelt gives higher yields than emmer, especially when winters are cold (Van der Veen and Palmer 1997). The switch from emmer to spelt in this region (and in other parts of Britain) may thus have been an economically based decision in response to increasingly cold and wet weather (Section 1.3.3). However, this does not account for continuing MIA emmer-cultivation in the south-east or on the Isle of Ely, or in other regions (e.g. north of the Tyne; Section 1.5.4.3).

Two scenarios (based on cultivation experiments) have been put forward whereby a shift from emmer to spelt may have resulted from changes in the cultivation regime under which spelt-emmer maslins were grown, rather than conscious decisions to change crop. Van der Veen (1995; 1997; and O'Connor 1998) suggests that extensive cultivation strategies (i.e. less investment in soils) benefit spelt at the expense of emmer, which would eventually disappear. Robinson and Lambrick (2009) suggest that autumn-sowing has the same effect.

In the current dataset, there is no evidence for extensive cultivation in the MIA, but autumn-sowing appears to have been the norm (Section 8.3.4.1). Analysis shows that spelt and emmer were cultivated separately in this period *in the south-east and on the Isle of Ely* – the two regions in which emmer-cultivation remains well attested. Too few samples were available from other records/areas for analysis, but I suggest that spelt and emmer may have been cultivated as autumn-sown maslins, leading to the disappearance of emmer by the MIA.

<u>Barley on the western clay</u>

Scaife's (2004) observation that barley is rare in Iron Age and Roman Bedfordshire is not confirmed. Considering the western clay (within which Bedfordshire falls), barley-cultivation is particularly well represented in the EIA (though most samples are from one site) and LIA. It is rarer in the Roman period, but this is attributed to the dominance of fine-sieving by-product samples (in which free-threshing cereals are much harder to recognise than glume wheats) in this region, rather than a genuine pattern in crop-choice.

Crop choice and the Roman palate

The balance between spelt and barley cultivation was more equal at ER pottery-production sites than was normal in the Roman period. Cultivation of emmer (otherwise seen only at Heybridge) was also attested at Greenhouse Farm, and of bread wheat at Addenbrooke's (classed as a complex rural settlement but including evidence of significant pottery production). Allaying previous uncertainty (Murphy in Going 1997; Murphy and De Moulins 2002), emmer *was* cultivated (very occasionally) in the MR and LR period, mostly in the Stansted area of the southern till. Rare cultivation of bread wheat was attested mostly in fenland records in the MR and LR periods.

The numerous clean grain samples from ER *Colonia Vitricensis* suggest a preference for wheat (probably of mixed species but dominated by spelt) over barley, but strong representation of barley-cultivation is notable in the (fewer) MR samples from this town and *Verulamium*, as well as the LR fort at Caister-on-Sea. This may reflect differing tastes among the urban/military population over time, or different intended use (e.g. food/fodder) of the stored crops.

The evidence that bread wheat-cultivation remained rare in this region throughout the study period may be indicative of palate (bread wheat lacks the 'nutty' flavour of spelt; Hoagland 1998) or culinary preferences. Matterne (2001: 106) suggests that the Gallo-Roman shift from emmer to bread wheat in northern France was the result of a Roman-influenced shift of preference from gruel to bread[34] as the preferred mode of grain-consumption. The lack of an equivalent shift in culinary preference might help explain continuing preference for spelt in the study region (and in central southern Britain). In north-east England, bread wheat cultivation is attested only at the Roman fort at South

[34] The higher gluten-content of bread wheat allows loaves to rise and stay risen. Spelt and emmer can be used to make bread, but the resultant loaves tend to fall and are heavy compared to bread wheat loaves.

Shields (where Roman culinary preferences are hardly surprising and grain may have been imported; Van der Veen 1992: 73, 74, 154) and in a very small number of LIA contexts; it is not attested at all in East Lothian, beyond the northern frontier of Roman Britain (Section 1.5.4.3).

8.3.2.3. Other crops, imports and gathered foods

The non-cereal crops, imports and wild/gathered foods identified in Chapter 7 are of interest but, as only carbonised material was considered, are unlikely to form a comprehensive list of plant foods consumed in the Iron Age or Roman East of England. No new species are idntified, but the locations/timings of some occurrences are of interest (though see Section 8.1.4).

MIA plum/damson at Shillington Bury and peas contaminated by gold of pleasure at EIA North Shoebury may represent Continental imports. North Shoebury is located on the coast, but Shillington Bury lies well inland. These records' artefact assemblages do not give any other indications of Continental trade (Brown 1995; Major 1995; Dawson 2004: 371-440, 491-494).

Roman orchard fruits/nuts, dill and exotic plants are almost exclusively from *Colonia Vitricensis*; other occurrences are from Pakenham (fort), Stonea Grange (small town) and Camp Ground, Earith (complex rural settlement). Flax from *Colonia Vitricensis* was contaminated with gold of pleasure, and may have been imported, but cultivation seems likely at Heybridge and Camp Ground.

8.3.3. The scale of crop production and distribution

8.3.3.1. General trends

Throughout the period, small-scale day-to-day crop-processing activity, incorporating minor accidents in which grain or spikelets were lost, was the norm. However, the MIA and Roman periods stand out as also seeing larger-scale crop-processing and/or storage activity. In the MIA and ER periods, this activity relates to specific areas and/or site-types, but crops appear to have been handled in bulk at a wide range of rural sites in the MR and LR periods.

8.3.3.2. Middle Iron Age

MIA evidence of small-scale handling and day-to-day use of crops is punctuated by evidence of large-scale grain-storage at Wendens Ambo and Lodge Farm, St Osyth[35]; bulk processing of glume wheats on the Isle of Ely; and spikelets being gathered and processed in bulk at hillforts in the south-east. These records/areas (except Lodge Farm) are the same as those noted for evidence of MIA emmer-cultivation.

The evidence from the Isle of Ely and south-eastern hillforts appears to represent specific local or regional practices, different to the norms of the East of England. It is not clear how widespread the bulk-storage attested at Lodge Farm and Wendens Ambo was: it seems likely that it represents ‘pockets’ of behaviour, rather than otherwise undetected norms across the entire region.

These examples of bulk crop handling suggest arable production on a scale larger than that seen at other sites in this period, or at any in the EIA or LIA. This contrasts with the MIA ‘stagnation’ of arable farming posited by M. Jones (1981; Section 1.5.4.2) for central southern Britain. It may relate to settlement expansion (Section 1.4.8.2), and/or may have more complex causes linked to variation in economic strategies on newly settled land (Sections 1.5.2.2; 1.5.5.4) or the maintenance of social/political structures (Section 1.4.6.1). These possibilities are discussed further in Section 8.4.2. The gathering and bulk-processing of spikelets at the two south-eastern hillforts is

[35] It is the scale (not the act) of grain storage which is significant (Section 4.9.2.2). This evidence differs in character and significance from the evidence of grain storage previously identified (Section 1.5.5.6).

reminiscent of the collection and processing of coarse-sieved harvests suggested to have occurred at Danebury (M. Jones 1984a; 1985; 1995; Section 1.4.3.2). Its interpretation and significance is considered further in Section 8.4.2.3.

8.3.3.3. Early Roman

<u>Normal practice at rural sites</u>

Small-scale, day-to-day handling of crops remained the norm throughout the LIA and at most ER rural settlements. The only LIA exception was Heybridge, where the practices attested resemble those of the ER small town (see below). There was some evidence of crop-handling on a larger scale at some ER rural settlements; this appeared to represent large-scale processing, rather than large-scale storage, perhaps suggesting that crops did not remain on these sites once processing was complete.

<u>Varied practices in towns and forts</u>

There is a clear contrast between the characterisation of samples' crop-processing derivation at *Colonia Vitricensis*[36](almost exclusively clean wheat grain with some dense fine-sieving by-products) and at Heybridge and Pakenham (sparse spikelets, sometimes sieved[37], and fine-sieving by-products, mostly sparse). This suggests that grain arrived fully processed, or was bulk-fine-sieved on arrival, in *Colonia Vitricensis*, and was acquired by households in that form, while grain was distributed in spikelet form at Heybridge (as in the LIA) and Pakenham and further processed as required, on a day-to-day basis.

The only evidence for malting in the ER period comes from *Colonia Vitricensis* (previously recognised; Murphy 1984; Murphy and de Moulins 2002; Section 1.4.4.6)

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[36] Samples are mostly from Balkerne Lane, situated outside the town wall, but also from inter-mural sites. Several relate to the Boudican burning of the town, but others do not: clean grain dominates in both groups.
[37] See Section 8.3.3.4.

and Pakenham, suggesting that (large-scale) beer production was first carried out by soldiers (or other fort-occupants; cf. James 2001; Mattingly 2006: 170-173) and veterans (or other town-dwellers) to meet their own requirements. The putative beer consumed for the generation of prestige among the native population of the LIA and ER south of the study region (Pitts 2005; Section 1.5.5.6) must have been produced on a small scale, not using specialised malting ovens and not generating identifiable carbonised waste.

These practices represent new insight into the place of towns and forts in the ER economy (further discussed in Sections 8.4.4). This is hardly surprising as the results of the many excavations at *Colonia Vitricensis* have not previously been brought together, and the Heybridge and Pakenham samples are reported in the EH AML series[38], whose reports tend to be strong on sample-detail but weak on (site-specific, let alone inter-site) archaeological context[39].

Something different about pottery-production sites

ER pottery-production sites have already been mentioned as having better than normal representation of crops other than spelt. They were also distinctive in the presence of spikelets (mostly from Heybridge and Pakenham in this period), including sieved examples, and mixed grain/spikelets and by-products (rare in this period).

[38] An interim report on the archaeology of the former has been published (Atkinson and Preston 1998) and full publication is planned.

[39] For example, determining the relationship of the Pakenham samples to the fort (whose excavation remains un-reported apart from brief summaries in an article on Roman Suffolk and Suffolk small towns; Moore *et* al. 1988: 22-25; Plouviez 1995) was complicated by the reporting of the samples along with those from an adjacent site (sampled for palaeoenvironmental reconstruction) and the labelling of the report with the county HER reference to that site only. Many thanks to J. Plouviez (*pers. comm*. 17/05/12) for resolving the confusion.

8.3.3.4. Middle and Late Roman

Overview

It comes naturally to summarise MR and LR crop-processing behaviours together, as they differed in several aspects from those of earlier periods. Large-scale crop-handling was common, especially in the MR period, with bulk processing, rather than bulk storage, represented in most instances. This evidence comes from a variety of rural settlement sites, suggesting that bulk processing was normal practice in the MR and (to a lesser extent) LR periods. It is consistent with evidence from other sources (including the spread of technology for large-scale grain-processing and the of insect grain pests in Britain; Sections 1.4.8.3, 1.5.3.4-1.5.3.5), in suggesting increased arable production at this time.

Increased Roman arable production had previously been recognised in the study region (Section 1.5.5.5), but this research has identified it as MR-LR, rather than earlier. It thus post-dates the increase in the scale of arable production suggested in central southern Britain (Section 1.5.4.2). Its relationship to population increase and the market economy is discussed in Section 8.4.5.

Chaff as a commodity

Compositional/contextual evidence suggests that 73% of MR dense fine-sieving by-product samples became carbonised as a result of use as fuel; this figure is 29% in the LR period. This use is unattested in earlier periods, with possible exceptions at ER pottery-production sites. It represents new behaviour which partly accounts for the dominance of (dense) fine-sieving by-products in these periods.

This use of fine-sieving by-products was previously attested anecdotally at individual sites (Section 1.5.5.7), but this research confirms it as widespread, particularly in the

MR period. There are hints that fine-sieving by-products moved around the region in both periods independently of crop-products, becoming carbonised away from the sites where they were generated. This is consistent with suggestions that they were a trade commodity in their own right (Van der Veen 1999).

Spikelet-storage

Spikelet samples have been characterised as sieved/not sieved. Reflecting this difference, fine-sieving by-products have also been characterised as representing the processing of spikelets which had/had not undergone previous sieving. This has been made possible by comparison of the chaff and size-specific weed content of a large number of samples, and is an improvement on Murphy and De Moulins' (2002) characterisation of 'typical' Roman carbonised assemblages as glume wheat chaff and weed/other seeds representing fine-cleanings from crop-processing (Section 1.5.5.7).

Spikelet-sieving was markedly more common in the MR and LR periods than previously. It appears to have been carried out to reduce the space required for storage in some cases and, possibly, to facilitate transport or change of ownership in others. In a small number of records it has been identified as a precursor to malting.

There is markedly northern bias in the spatial distribution of MR and LR spikelets. It is not clear, however, whether this indicates that spikelet-storage was more common in the north, giving the opportunity for conflagration by chance, or that parching of spikelets over fires (resulting in accidental burning) was more common in the north[40].

Germination, malting and storage

Malting is best represented in the MR period, and declined in the LR (though this may be an aberration of the data, given the very small number of records). It is notoriously

[40] Archaeological context offers support for neither interpretation, but burnt deposits may well have been removed from their primary contexts.

difficult to identify with confidence (Section 1.6.4.3) and is identified tentatively ('probable malting' in Table 4.10) in as many records as it is identified confidently. The most confident identifications of malting are those already recognised in their site reports, but recognition of further probable instances was made possible by comparison of evidence of germination (and context) from such a large number of records. In contrast to the ER period, MR (and LR) malting appears to have been carried out at rural sites, some with apparently specialised facilities.

Evidence of germination which could not be clearly associated with malting ('possible malting' in Table 4.10) also peaked in the MR period. Alternative interpretation of this phenomenon is of accidental germination during storage, adding to the evidence of increased large-scale grain storage in this period.

8.3.4. Cultivation practice

8.3.4.1.Normal practice

Autumn-sowing is suggested to have been the norm in all areas throughout the study period. No evidence for cultivation of maslins (mixed crops) has been identified, but low numbers of samples appropriate for analysis means that assessment was only possible for a very limited range of periods and records/areas. (Unverified) cultivation of autumn-sown spelt-emmer maslins (which would favour propagation of spelt) has been suggested as an explanation for the MIA decline of emmer across most of the study region (Section 8.3.2.2).

Throughout the Iron Age and Roman East of England, the normal approach to cultivation appears to have been sufficient investment of labour and resources (in ploughing, manuring, weeding etc) to prevent soil nitrogen-depletion/exhaustion/ acidification and the survival of perennial weeds, but not the intensive investment required to significantly enrich soils. This strategy would have been aimed at ensuring reasonable crop-yields, consistent with production for subsistence and safe-guarding, but does not suggest efforts to maximise crop-yield per unit of land or produce a significant arable surplus. It is consistent with what Saller (2005) calls "satisficing" (the seeking of safe return on minimal investment, rather than any attempt to maximise productivity/profit) and with Van der Veen and O'Connor's (1998) characterisation of agricultural production in subsistence economies (limited goals and a preference for leisure over maximising output). It is possible that, within this general approach to crop production, spelt was typically cultivated with less investment of labour and resources than barley.

This research has revealed nothing similar to the consistent geographical differentiation of cultivation regimes of greater and lesser investment identified by Van der Veen (1992: 111-116) in north-east England. Though this is thought to suggest a genuinely more consistent, and more 'average', approach to cultivation (with a few exceptions) than in that region – perhaps suggesting less pressure on production – it is possible that low sample-numbers (Section 8.2.3) have prevented recognition of more complex patterns.

8.3.4.2. Trends and exceptional sites

The overall trend is one of decreasing investment in soil fertility over time (resulting in poorer – though not very poor – soils and better survival of perennial weeds). However, this largely reflects the nature of activity at a few sites which differed from normal practice (Section 8.3.4.1) rather than a directional shift in normal practice.

Suggestions (made with limited confidence due to low sample numbers; Section 8.2.3) of consistent policies of intensive investment in soil improvement came from MIA

Chipping Hill (south-eastern hillfort; discussed in Section 8.4.2.3) and West Stow (Breckland open settlement). In the latter case, this strategy is suggested to have been an attempt to counter the soil's natural tendency to leaching and maintain viable crop-yields, rather than an investment to produce a significant surplus. This is consistent with previous suggestions (Murphy and De Moulins 2002) that light Breckland soils were becoming exhausted by the MIA, but not with the extrapolation that this prevented their cultivation (Section 1.5.5.4).

At ER Fison Way and Kilverstone (both in Breckland and located on free-draining sandy soils) indications of soil nitrogen-content are also surprisingly high. This may be consistent with either intensive investment in soil improvement, or (as suggested by Murphy and De Moulins (2002) on the basis of a few samples 'composed largely of grain' at Fison Way) with import of grain to these sites from (unspecified) areas of better soil[41]. The potential high status/ceremonial functions suggested for both records – Fison Way as a ceremonial centre of the Iceni Client Kingdom (Gregory 1992: 199), Kilverstone as possibly including temples/shrines (alternatively interpreted as raised granaries; Garrow *et al*. 2006: 163) – may support the latter interpretation. However, crop-processing by-products were present at Kilverstone, suggesting that if crops were imported it was not as clean grain.

Significant investment in soil improvement is also suggested at MIA Watson's Lane and West Fen Road (Isle of Ely) and formed part of a dual-approach cultivation strategy at nearby Wardy Hill (see Section 8.4.2.4), as well as at LIA and ER Heybridge and (possibly) ER Pakenham (see Section 8.4.4.2). These dual-approach strategies involved significant investment of labour and resources to maximise crop-yields in some plots,

[41] No quantified archaeobotanical data was available for the Staunch Meadow, Brandon, suggested by Murphy and De Moulins (2002) as a Breckland 'producer-site', though the plough/ard marks identified do suggest cultivation.

but less such investment (more normal levels) in others. These different approaches were not consistently associated with specific crops at any of these sites. The MIA Isle of Ely and LIA-ER Heybridge are also the only instances in which spring-sowing has been suggested (with great caution; it is certainly not considered definite that it occurred), associated with investment in soil improvement at Watson's Lane and West Fen Road, and with the approach of minimal investment (carried out on plots prone to extreme wetness: spring-sowing may have been a response to very wet winter conditions) at Heybridge.

A similar dual-approach cultivation strategy, with less clear-cut differentiation, is also possible at MR and LR Langdale Hale, but the regime at this site may be better characterised as involving inconsistent investment both within and between arable plots.

As the scale of production (Section 8.3.3.4) was not increased by maximising production per unit of land in the MR-LR period, it is suggested that more land was cultivated than in earlier periods. Evidence of arable *expansion* (cf. Van der Veen and O'Connor 1998) onto soils not previously farmed is discussed below (Section 8.2.4.3). Cultivation of more/larger plots in other areas is also suggested, though the evidence does not indicate that this was coupled with a decline in the care taken to maintain soil nutrient-content (which would suggest an *extensive* cultivation regime; Van der Veen and O'Connor 1998).

8.3.4.3. Roman cultivation of heavy soils

<u>Expansion and distribution</u>

The expansion of cultivation onto the region's heavy clay soils has been dated to the MR and LR period, though this remains uncertain owing to the possibility that *Anthemis cotula* was not present in Britain before the Roman period (Section 6.10.2.2). This refines Murphy and De Moulins (2002) suggestion of a Roman date for this expansion, and confirms it took place several centuries later than in central southern Britain (MIA; Section 1.5.4.2). *Anthemis cotula*, the weed which indicates cultivation of heavy clay soils, is also present in much lower numbers in a few ER samples, mostly from Vicar's Farm, Cambridge (see also Section 8.2.4), which dates late within the ER period.

In the MR and LR periods, cultivation of heavy soils appears to have been confined to a few sites, rather than being widespread on areas of clay geology. This cannot be confirmed owing to the small size of the dataset available for characterisation of growing conditions, but there is evidence that cultivation of lighter river valley soils continued in the MR period in the Stansted area (southern till) and at Biddenham Loop, on the Great Ouse (western clay).

<u>Marginal land or exploitation of a new resource?</u>

Cultivation of spelt on the western clay appears to have been carried out without significant investment in soil improvement. At Vicar's Farm there are also suggestions that heavy soils were being cultivated without ards incorporating features which would allow efficient tillage (Section 1.5.3.2), despite the presence of such implements in Britain by this time (Rees 1979: 59-61; Fowler 2002: 184), including in the East of England (Going and Plouviez 2000) and within 10-15km of this site (Fig 8.2). In these circumstances, the heavy soils of the western clay can be accurately described as marginal, and their cultivation interpreted as suggesting pressure to increase arable output and/or non-availability of more suitable land to the cultivators.

By contrast, the heavy soils cultivated on the MR Isle of Ely and in the LR Stansted area appear to have had (relatively) high nitrogen-content and there is no evidence that they were not effectively ploughed. This cultivation strategy suggests that these instances of expansion onto these heavy soils should be characterised as positive investment to exploit a newly available (owing to advances in plough-technology) resource, rather than a 'forced'/necessary move onto sub-prime/marginal land.

Given these strategies of investment in soil improvement it is striking that the crop cultivated in both cases was spelt (with occasional evidence for both barley- and emmer-cultivation in the Stansted area) and not bread wheat, which thrives on heavy soils under such regimes (M. Jones 1981). However, choice of spelt over bread wheat is consistent with the choices made elsewhere in the study region and other parts of Roman Britain (Section 8.3.2.2).

<u>Note on wetland cultivation</u>

In contrast to heavy soils, very wet soils (those prone to waterlogging and/or inundation, at least along their margins) were exploited from at least the MIA. It is not possible to say whether this represents MIA expansion onto such soils[42], as in central southern Britain (Section 1.5.4.2). From the MIA onwards, where sample numbers have allowed detailed characterisation, the arable practice identified on the fen-edges and islands suggests focused deployment of resources and labour, often allowing large-scale arable production. It would be more helpful to consider the wet soils of the fens as a 'specialised environment' than as 'marginal land'.

By contrast, cultivation of plots prone to extreme wet conditions at LIA and ER Heybridge appears to have been associated with a strategy of minimal investment, while more effort and resources were expended on cultivation of drier plots. This may indicate extensive farming on poor/marginal land and intensive farming on more desirable land.

[42] There are samples from fenland records in the EIA and wetland weeds are present in EIA samples, but low sample numbers mean that it has not been demonstrated that crops were cultivated, rather than imported, to these sites and conditions on any cultivated land has not been explored.

8.3.4.4. Transport of crops

The suggestion that crops were imported to ER Kilverstone and Fison Way has been discussed above (Section 8.2.4.2). This was previously considered probable (Murphy and De Moulins 2002), but this research suggests that possible is a better assessment.

A stronger suggestion of crop-transport comes from Tunbridge Lane, Bottisham (MR and LR), and Hinxton Road, Duxford (LR), where *Anthemis cotula* suggests cultivation on heavier soils than those on which the sites are situated. Such soils exist within *c.* 3km of both sites, and short-distance transport of crops seems likely. There is evidence of large-scale crop-processing at both sites.

Trade in crop-processing by-products was mentioned in Section 8.3.3.4. The movement of crop-processing by-products away from the sites where they were generated is suggested (not proven) by the occurrence of samples suggested to represent the cleaning of malted spikelets at sites with no other evidence for malting, and of those representing the fine-sieving of previously sieved spikelets at records where only un-sieved spikelets are identified. Further, circumstantial, evidence comes from the frequency with which these by-products appear to have been used as fuel, and the supposition that their marketability as such would have been recognised.

8.3.4.5. Comment on pastoral farming of clay areas

Suggestions that the region's heavy clays were dominated by pastoral farming strategies in the Iron Age (e.g. Murphy and De Moulins 2002; Medlycott 2011; Sections 1.5.2.2 and 1.5.5.4) may be borne out by the presence of *Anthemis cotula* only in the MR (possibly late in the ER) and LR periods (though see Section 6.10.2.2). Economic strategies not including arable farming may be indicated in the carbonised archaeobotanical record by samples which, despite adequate volume (i.e. 40-60L or more; D. Jones 2002: 20; 2011: 12), contain very few or no plant macrofossils.

The current dataset is not truly suited to identifying such samples as those containing no plant macrofossils were excluded at the data collection stage (if they were shown in source reports). Additionally, site geology was not recorded for each record. However, comparisons have been made between samples from the region's heavy clay areas (209 samples of known volume from the northern till and western clay) and the study region as a whole (1973 samples of known volume).

Sample volumes from the clay areas were similar to those from the region as a whole (Table 8.2), i.e. only a small proportion (*c*. 7%) are over 40L: it would thus be impossible to determine whether low numbers of items/sample resulted from genuine absence or from low sample volumes. However, neither the mean number of items/litre of deposit nor the proportion of samples categorised as dense (containing >25 items/litre of deposit) was lower for clay areas than for the whole region for the Iron Age (or any part thereof) or for the period as a whole. No comment is therefore offered on the possibility of solely pastoral farming strategies on the region's clay soils.

8.4. New insights into the wider economic, social and political context of arable farming

8.4.1. Preface

Analysis and interpretation of crop choice, crop-processing behaviour and cultivation practice has allowed the characterisation of arable practice given above. Though broad interpretations of normal practice are given, detailed understanding relates to specific sites/areas and specific periods. It is this understanding which can be best interpreted in terms of wider economic/social/political life. The text below thus focuses on specific areas and periods, rather than attempting an arable-practice-informed narrative of social/political/economic development in the Iron Age and Roman East of England.

8.4.2. Population expansion, prestige and integrated economies in the Middle Iron Age

8.4.2.1. Population expansion and increased scale of production

Increased bulk-crop handling and (unusual) cultivation regimes involving significant investment in soils in the MIA are consistent with population increase suggested by settlement expansion (Section 1.4.8.2). The evidence does not suggest simply 'normal' production practiced at more sites than in the EIA or LIA (i.e. increased aggregate production), but increased *scale* of production and attempts to maximise crop-yields per unit of land, i.e. increased production per-head of crop-cultivating population (cf. Saller 2005). This fits with suggestions that not all the settlements associated with expansion produced their own crops, and that some had economies based on pastoral (or even wild) resources, and depended for their grain on surplus arable production at other sites (Sections 1.5.2.2 and 1.5.5.4).

Consistent with previous observations (Sections 1.5.2.2 and 1.5.5.4), there is no evidence that the region's heavy clay soils were cultivated at this time, supporting the inference that their settlements were crop-importers (though all evidence from these area comes from river-valley soils, and no assemblages were characterised as imported crops). Suggestions that cultivation of light Breckland soils was unviable by this time (i.e. that crops were imported to settlement in this region; Section 1.5.5.4) are not supported, though at West Stow cultivation apparently required significant investment in soils to *maintain* (not improve) soil productivity.

The concentration of evidence for increased production in just a few records/areas is striking (Table 8.4), as is its coincidence with evidence for cultivation of emmer.

Record/area	**Large-scale crop-handling**	**Investment in soils**	**Emmer-cultivation**	**Other**
South-eastern hillforts (Asheldham Camp, Chipping Hill)	✓ (processing*)	✓ (CH only, no AC samples available for weed ecology analysis)	✓ (alongside spelt and barley)	*Bulk gathering of spikelets (some sieved) and semi-clean barley grain[43].
Isle of Ely (Watson's Lane, West Fen Road, Wardy Hill)	✓ (processing, mostly WH)	✓ (WL & WFR; part of 2-approach strategy at WH)	✓ (alongside spelt and some barley)	Processing of previously-sieved spikelets (WL only).
Lodge Farm	✓ (storage)	Grain too thoroughly cleaned for weed ecology analysis.	-	-
Wendens Ambo	✓ (storage)		✓ (alongside spelt, barley and bread wheat)	-

CH = Chipping Hill; AC = Asheldham Camp; WH = Wardy Hill; WL = Watson's Lane; WFR = West Fen Road.

Table 8.4. Distribution of MIA evidence for large-scale production and emmer-cultivation.

8.4.2.2. Lodge Farm and Wendens Ambo

As indicated in Section 8.3.3.2, bulk grain-stores at Lodge Farm and Wendens Ambo are considered to be chance representations of wider practice. Absence of crop-processing evidence from both sites is considered likely to reflect practice (disposal other than burning, perhaps use as animal fodder; cf. Hillman 1981; Grant 1984; Campbell 2000) and/or sampling biases (in favour of dense deposits and potential storage features). It is not seen as sufficient grounds for suggesting solely-pastoral economies or grain-import (cf. Murphy and de Moulins 2002; Medlycott 2011); mixed agricultural economies have previously been identified/suggested at both sites (Sealey 1996; Germany 2007).

[43] Gathering of spikelets and semi-clean barley grain is also potentially represented at the neighbouring Breckland sites of Fison Way and Gallows Hill, both of uncertain but potentially 'ceremonial' function, but the number of samples involved is too small for interpretation with any confidence.

8.4.2.3. The south-eastern hillforts in models of power and prestige

The similarity of crop-gathering and processing at the south-eastern hillforts to the behaviour attested at MIA Danebury was remarked in Section 8.3.3.2. The Danebury evidence has contributed to three different models of Iron Age social, political and economic development in the MIA of central southern Britain – propounded by Cunliffe (1995: 98-103; 2005: 590-591), Sharples (2010: 106-172) and Hill (2006)/Van der Veen and Jones (2006) and summarised in Section 1.4.6.1. In all three, it is considered to represent a development of EIA practices; paucity of EIA evidence prohibits comment on this for the south-eastern hillforts.

The evidence from the south-eastern hillforts is potentially compatible with any one of these models for Danebury. There is no reason to assume that the same practices were occurring in the two regions, and it is re-iterated that Chipping Hill and Asheldham Camp are not 'classic' hillforts (descriptions in Appendix 1; Records 29 and 156), as seen in Wessex (Section 14.5.2), nor were they necessarily similar in function to each other (Bedwin 1991).

The number of samples available is too small to definitely state [44] whether crops were gathered from multiple sources (consistent with Cunliffe or Sharples) or grown at hillforts (consistent with Van der Veen and Jones' suggestion that feast-providers were able to move into the hillforts in the MIA). Extensive (but unexcavated) crop-marks in the vicinity of Asheldham Camp suggest cultivation (Bedwin 1991; Sealey 1996) and evidence for investment in soil improvement at Chipping Hill would be consistent with *in situ* cultivation and production of a surplus for feasting. The variety of crops present and the presence of both sieved and un-sieved spikelets may be consistent with either varied practice at the hillforts or gathering of crops from different sites.

[44] Through demonstration of different weed ecology.

The evidence tells us that spikelets were gathered and processed, but does not indicate whether the grain thus generated was consumed on site in feasts (suggested by Van der Veen and Jones) or during communal labour on rampart re-construction (suggested by Sharples), or redistributed to surrounding settlements (suggested by Cunliffe). Distinguishing between these behaviours would require investigation of samples (quantified and sufficient in both number and size for detailed investigation of both crop-processing derivation and weed ecology) from a range of surrounding contemporary settlements, as well as further samples from the hillforts themselves. No such samples were available for inclusion in this research.

8.4.2.4. The Isle of Ely: specialised economies in a specialised environment

<u>The scale of crop-processing and disposal of chaff</u>

The Wardy Hill source-report interpreted crop-processing there and elsewhere on the Isle of Ely as having taken place on a small scale, day-to-day basis (Stevens 2003b). Sparse fine-sieving by-products are present in these records[45], but in comparison to samples from across the MIA East of England this record-cluster stands out as a concentration of dense samples (the only other being from the south-eastern hillforts) strongly suggesting that the scale of processing at this site was greater than the period's norms. The sparse deposits may represent either additional small-scale processing or scattered/redeposited portions of the material from large-scale fine-sieving.

As well as including dense fine-sieving by-product samples, records from the Isle of Ely were distinctive in accounting for more than half of all MIA fine-sieving by-product samples. This suggests that disposal of these by-products by burning was more common here than elsewhere, though there is no suggestion that they were used as fuel.

[45] and likely that Steven's definition of 'dense' and 'sparse' varied slightly from my own, especially as his characterisation included samples from this record deemed in this research to be too small to be accurately representative.

Risk-buffering

The strategy of investment to increase soil productivity seen at all three sites (the exclusive approach at two) suggests maximisation of crop-yields. The dual strategy at Wardy Hill may represent safeguarding/risk-buffering, especially as (in contrast to the other two sites) *all* cultivation at this site appears to have been on plots prone to waterlogging and inundation along their margins. Similar safeguarding is also suggested by other aspects of arable practice on the Isle of Ely: two wheat species, two types of land (dry and prone to waterlogging on its margins), and, perhaps, sowing in two seasons (at Watson's Lane and West Fen Road)[46]. Analysis has indicated that spelt and emmer were not cultivated as maslins here, but the risk-buffering mindset associated with maslin-cultivation (cf. Van der Veen 1995) is suggested. If one crop/one strategy of investment/one plot/crops sown in one season failed or had limited success, the other may still have been productive.

These were new settlements of this period, part of the wave of expansion on the southern fen-edges/islands identified in Chapter 1.4.8.2. The risk-buffering attitude suggested here, but apparently not across the rest of the study region or (with a few exceptions) in other periods, may reflect the uncertainty of early cultivation in a highly specialised (fenland) environment (e.g. putatively spring-sown crops may have been sown after loss of earlier sowings over extremely wet winters).

Maximisation of production and allaying of risk are potentially consistent with necessary investment to produce enough for subsistence and safe-guarding on a limited amount of land suitable for cultivation. Alternatively and perhaps more likely, given the large-scale of production, these strategies could have been applied to larger plots

[46] The differences are not between the three settlements and crop-choice did not have a consistent relationship with cultivation strategy.

(which included wet areas out of necessity) for production of a significant surplus. Possibly, the 'risk' being guarded against was low production, rather than total crop-failure – i.e. a threat to economic strategy rather than to subsistence.

Integrated economies and exchange of labour

Both the improvement of soils and the large-scale on which crops were processed would have required greater input of labour and resources than the less intensive and smaller-scale arable production attested across most of the study region.

Conceivably, the occupants of these three closely-spaced sites co-operated, exchanging labour[47]. In this case, spikelet-sieving at Watson's Lane may have been carried out quickly, to reduce the space required for temporary storage while the Watson's Lane farmers helped with bulk dehusking and fine-sieving at the two other sites, later receiving reciprocal help with their own bulk-processing. Similar exchange of labour may also have occurred for manuring and other agricultural tasks.

In this scenario, the more diverse cultivation strategy at Wardy Hill (i.e. the cultivation of some plots without significant investment) may have increased crop-yields without significantly increasing labour-input, i.e. without incurring obligations towards the other sites. This may have allowed its increase in status by the Late Iron Age (cf. Hill 2006; Van der Veen and Jones 2006), giving it the leverage to command/coerce the labour required for the elaboration of its ringworks and other features (cf. Evans 2003b: 260).

Alternatively, the extra labour mobilised at harvest time (and on-demand throughout the growing season) may have been more usually occupied in non-arable activities. These people may have been resident at the three sites, where there is evidence of livestock

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[47] Though dating is not precise for any of them and settlement may have begun earlier at Wardy Hill than at the other sites.

rearing alongside cultivation (Evans 2003b: 136-138), or they could have been the residents of settlements which did not produce their own grain.

MIA trade of fenland grain for livestock from areas of heavy soil has been suggested by Medlycott (2011) and (without specifying fenland origins of the grain) Murphy and de Moulins (2002) (Sections 1.5.2.2 and 1.5.5.4). Alternatively, other sites established as settlement expanded in the southern fenland (Section 1.4.8.2) may have opted to focus on economic strategies other than the cultivation of wet fenland soils (as at Haddenham V; Evans and Hodder 2006: 276). Such settlements could have traded for grain with hunted/gathered resources, livestock/meat or salt, or with labour spared from economic strategies focused on their production. The possibility of meat import to Wardy Hill is raised in the site animal bone report (Davis 2003:130) and bones of wild game, birds and fish are present, though not common, at Wardy Hill and West Fen Road (Davis 2003: 126-127; Higbee 2005: 95).

8.4.3. Developments (or lack thereof) in the Late Iron Age

The general lack of LIA evidence for variety in crop-choice or cultivation practice, or for large-scale production, may suggest that this was not a period of innovation in arable farming, or that arable-produce played no significant role in the region's disparate social and economic development at this time (Sections 1.4.6.2-1.4.6.3).

Alternatively, such practices may have been more common than the evidence suggests, *without their products and by-products coming into contact with fire*. This would be consistent with Van der Veen and Jones' (2006; cf. Haselgrove 1982) suggestion that arable surplus from the south of the study region was exported to the continent in exchange for prestige-giving luxury items (and so would have little chance to become carbonised within the study region). In this scenario, evidence for occasional bulk fine-sieving at Heybridge (a site discussed further in Section 8.4.4.2), where imported luxury items have been recovered, could represent preparation of grain for export (the site lies at the head of the Blackwater Estuary), though excavations have revealed no evidence of a port (Atkinson and Preston 1998).

8.4.4. The economic context of new types of settlement

8.4.4.1. Preface

Insight has been gained into aspects of arable practice in examples of the region's LIA nucleated settlements (Section 1.4.5.3), as well as its Roman towns (small and large; Section 1.4.5.3), forts and pottery-production complexes (Section 1.4.5.5). This is used here to explore their places in the wider LIA and Roman economy, a subject little-discussed in the literature on LIA and Roman Britain (Taylor, *pers. comm.* 25/07/12).

8.4.4.2. The development and nature of small towns

<u>Preface</u>

The clearest insight into arable practice in Roman small towns has been gained at IA-ER Heybridge, in the south-east of the study region. The following discussion is based on that site, followed by comparison to other (later) small towns (from which less consistent insights have been gained).

<u>LIA and ER Heybridge</u>

The nucleated settlement and small town at Heybridge are among the very few records which stand out from the LIA-ER norms of subsistence spelt- and barley-cultivation. Arable practice at this site appears to have been little-affected by the transition from nucleated settlement to small town, suggesting that no significant upheaval of this mundane aspect of day to day life was involved. This continuity may suggest that Heybridge already had town-like characteristics in the LIA (cf. Pitts and Perring 2006;

Section 1.4.5.4), or that it failed to truly develop as a small town in the ER period (consistent with the excavators' suggestion that it would be better viewed as a 'market village'; Atkinson and Preston 1998).

Both agricultural self-sufficiency (Burnham and Wacher 1990: 44-45) and reliance on the produce of surrounding rural settlements (Taylor 2007: 8, 117-118) have been suggested for small towns (Section 1.4.5.5) and some nucleated settlements. Archaeological evidence from Heybridge suggests a combination of the two, with a long-used (Roman and possibly LIA) field-system, incorporating features interpreted as corn-driers[48], located on the northern edge of the town, but an area identified as a market place for local produce within the town (Atkinson and Preston 1998).

Crops were probably cultivated and underwent the early stages of processing (sometimes including spikelet-sieving) in the area north of the settlement (away from the risk of fire and not identified archaeobotanically), before being brought into Heybridge as spikelets in relatively small quantities and subsequently handled only on a small-scale. It is also possible that spikelets were stored in bulk outside the town until they were needed.

The intensive and extensive approaches to cultivation could have been employed by different town-dwellers or at different local settlements supplying the town. A mixed supply strategy, with some grain cultivated by town-dwellers and some imported is also possible.

Some outside supply seems likely if the identification of a marketplace within the town (Atkinson and Preston 1998) is accepted. This research has revealed nothing to suggest

[48] Though archaeobotanical samples were 'un productive' (Monckton 2000).

import of grain over any distance[49], but supply from local settlements remains possible. There is no consistent evidence of increased production at ER rural sites to suggest that they were feeding the region's towns or forts. It is possible that the right rural sites have not been excavated or sampled, or that small samples sizes or lack of quantification precluded their inclusion in these analyses. Of the ER rural settlement records in the south-east, North Shoebury (over 20km from Heybridge) is one of the few with any evidence of bulk-processing (one sample) and samples from Slough House Farm (just 3km from Heybridge) resemble those from Heybridge in attesting emmer-cultivation. Cultivation regimes at both differed from those identified at Heybridge, though this is not definitive evidence that neither ever supplied any grain to the town as archaeobotanical samples represent only a tiny proportion of the crops at any site, and cultivation strategy may have varied from season to season.

MR small towns

Evidence from Pakenham, Godmanchester and Stonea Grange (and the MR phase of activity at Heybridge) suggests that household acquisition of spikelets and further processing as required (i.e. the system attested at ER Heybridge) was normal in MR small towns. Excepting a single lentil at Stonea Grange, the evidence from these towns also suggests that any import of plant-based foodstuffs was on a local scale. However, it must be remembered that small towns are a diverse phenomenon (e.g. Taylor 2007: 8) and samples were available from only a handful of those located in the study region.

Cultivation practice could be characterised only at Godmanchester, where it took place on local (heavy) soils and was shown to have been very similar to that at nearby Rectory Farm. This could be consistent with either supply of the small town from this

[49] No exotic or imported foods were identified, despite Heybridge's estuarine location.

high status rural settlement[50], or cultivation by town-dwellers/under their control not differing significantly from that by their rural neighbours on the area's heavy soils. The presence of wetland weeds at Stonea Grange also suggests local (or at least fenland) provision of the town's grain.

The rural settlement at Vicar's Farm was located <3km from the small town at Cambridge (from which no samples were available). This site has been noted for cultivation of heavy clay soils (possibly beginning towards the end of the first century AD) with minimal investment in soil improvement (as at Godmanchester and Rectory Farm) and without the technology for their effective ploughing. The excavators suggest (cited by Ballantyne 2009) that farming at this site took place under a 'controlling authority' which was lost or replaced at the end of the MR period (Appendix 1; R255-258). This would be consistent with the land being held directly by Cambridge's administrators and its cultivation taking place under their auspices: the people who did the work (perhaps displaced from their own more favourable lands locally) at this site were thus not free to choose which land they cultivated, or to invest in technology which would have made the task easier. If the town's control ceased in the LR period it is, perhaps, surprising that cultivation practice did not change (especially given evidence for local presence of plough coulters; Fig. 8.2); possibly, practice was established by this time, and change prevented by inertia.

8.4.4.3. Iceni territory and military provisioning

<u>A different system in the north?</u>

No towns are suggested to have existed within the ER Iceni Client Kingdom. Cultivation practice at the high status enclosed settlement at Fison Way (whose layout

[50] lack of information on sample-volumes from Rectory Farm meant that the scale of arable production could not be assessed, though relatively high overall numbers of items may suggest dense deposits (assuming that samples were not unusually large) and so large-scale production.

and scale suggest importance even if its interpretation as a 'ceremonial centre' – Section 8.3.4.2 – is rejected) does not appear to have resembled that posited for contemporary Roman small (or major) towns in the south of the study region. Activity at Fison Way ceased around AD 60, interpreted by the excavator as evidence of Roman reprisal following the Boudican revolt (Gregory 1991: 190).

It is possible that this site imported its crops. Wherever they were grown, significant investment was made to improve soils and increase yields of crops that ended up at this site. The same is true at nearby Kilverstone, where ER activity dates to the later first century AD. This hints at continuity of cultivation practice either side of the Boudican rebellion, despite presumed loss of manpower, and a willingness to (consistently) expend more labour/resources than was the norm in the south of the study region. Higher availability of labour may be consistent with Hill's (1999; 2007) theory that land was traditionally held communally in this area, in contrast to household-ownership in the south of the study region in the LIA (Section 1.4.6.4). The evidence is not clear enough for further exploration of this possibility.

<u>Feeding the fort at Pakenham</u>

Samples from the ER fort at Pakenham (a Neronian foundation within the newly absorbed Iceni territory) suggest provision of spikelets to individual households/military equivalent within the fort and subsequent processing on a small scale – a system resembling that seen in small towns and not suggestive of large-scale military supply networks (cf. Thomas and Stallibrass 2008). Investment in the soils on which crops were grown was inconsistent, including evidence of the higher than normal investment seen at native sites in the region. The evidence is insufficient to clearly demonstrate distinct cultivation strategies (consistent with more than one source of grain) rather than 'patchy' investment of labour and resources. Cultivation by the fort's (non-military; cf.

James 2001; Mattingly 2006: 170-173) population is possible, though this option for provisioning the Roman army is not usually discussed (e.g. Mattingly 2006: 511; Bidwell 2007; Thomas and Stallibrass 2008); supply from local sites may be more likely.

As emphasised above, there is no evidence for a general ER surge in arable productivity to feed non-productive elements of the region's population (e.g. soldiers). The only contemporary site close to Pakenham included in this investigation was Kilverstone, where potential granary structures and high levels of investment in crop-yields could indicate surplus production for the fort's provisioning. If this is the case, the level of investment seen was not consistent at all sites involved in supplying the fort's grain. This may represent what Moore *et al*. (1988: 25) describe as a "*variable combination of suppression and economic expansion*" in the wake of the Boudican revolt.

Whether Pakenham fort imported its grain or was (partly) self-sufficient, evidence of malting indicates that its beer was produced 'in-house'. This is also attested at *Vindolanda* fort, in the far north of the British province, where preserved documents refer to the presence of a specialist brewer and include an appeal for more beer to be sent to out-posted soldiers (Mattingly 2006: 163-164). The contrast between this situation and the large-scale malting seen at some rural settlements in the MR period (Section 8.3.3.4) suggests that the rural economy in this area had not, by the end of the first-century AD adapted to take advantage of the demand created by the fort's presence. This is hardly surprising given that the local population was dealing with new subjugation and recovering from defeat (with implied loss of arable work-force) and (possibly) famine (Section 1.4.8.3).

Further consideration of military supply

The only other forts to provide evidence of crop-related behaviour were the early fort at Colchester, where very limited evidence suggests the same practices at in the later town, and the LR Saxon Shore Fort at Caister-on-Sea, where there is possible evidence of bulk grain storage. This is consistent with provisioning by large-scale supply networks (cf. Thomas and Stallibrass 2008), but there is nothing to suggest that crops were not grown locally.

Import of grain to feed the Roman army (cf. Fulford 2004; Section 1.3.6.3) has been claimed at a few sites in other areas of Britain but this research has produced nothing to suggest it within the study region (though few military sites are represented). South Shields is the commonly cited example of grain import after the ER period (e.g. Mattingly 2006: 221; Bidwell 2007: 105-107; Thomas and Stallibrass 2008), though Van der Veen's (1992: 155) characterisation was that the fort's grain was mostly from local sources, and that evidence of long-distance supply of bread wheat was inconclusive. The lack of evidence for this species' cultivation either in the study region or in central southern Britain (Section 1.5.4.2) may suggest that, if it was imported to South Shields, it came from the Continent, rather than from the south of England.

8.4.4.4. Feeding Colonia Vitricensis

There is no evidence of intra-mural cereal-cultivation (cf. Wacher 1995: 125), which would involve investment to maximise the productivity of small plots, at ER *Colonia Vitricensis.* It is possible that other plant-foods (e.g. the dill and orchard crops identified in Section 7.3.2) were grown within the town but other, more exotic, non-staple foods were imported to the town: they are far better attested than in any other part of the study region.

The cultivation strategies employed in providing grain for the town do not appear to have differed significantly from regional norms (Section 8.3.4.1). This consistency of approach is of interest given the assumed transfer of land around *Colonia Vitricensis* to its direct control in the ER period (Section 1.4.4.2). It might imply that the same people were cultivating this land, and that they retained autonomy in their choice of cultivation strategy, despite the change in ownership. However, Saller (2005) suggests that the same strategy of safe return for minimal investment was the normal attitude of Roman landowners throughout the Empire.

As some (most?) of the town's population would not have worked their own land, an increase in arable production per head of productive population in order to meet its grain requirements is assumed (consistent with the bulk grain storage attested). This was probably met by increasing the area under cultivation with an aggregate increase (i.e. the same input per unit of land) in labour (and resources - e.g. manure, perhaps supplied by the extra livestock kept in order to feed the town) to prevent declining soil fertility. As land around *Colonia Vitricensis* was held directly by the town authorities (Section 1.4.4.2), this may have meant the local population being made to work harder (especially as that population is likely to have been reduced by losses during Conquest and the Boudican revolt). Alternatively, some of the town's veteran population may have been directly engaged in cultivation (perhaps of their own, privately owned land) to meet its requirements (cf. de la Bédoyère 1992: 79).

The provision of grain by 'doing more of the same' rather than investing intensively to get higher crop-yields per unit of land is consistent with the attitude suggested by the use of both cows and oxen for traction (rather than a more specialised system of cows for breeding/milk and oxen for traction) throughout the Roman period at *Colonia Vitricensis* (Luff 1993: 60). As well as indicating resistance to specialisation/focused investment (though this is suggested by increase over time in the size of livestock; Luff 1993: 140), this is consistent with the need to plough large areas and with a significant role for beasts of burden in transporting crops to the town. This use of cattle is also suggested by the widespread increase in the representation of cattle in Roman faunal assemblages over time (Taylor *pers. comm.* 12/12/12).

8.4.4.5. Combining arable and ceramic production

Arable practice attested at ER sites where pottery was produced differed from that at other sites in representation of a wider range of crops (Section 8.3.2.2) and a wider range of crop-processing derivatives (Section 8.3.3.3), including species and sample-types which were rare in this period and attested mostly at town/fort records (Table 8.5). It should be noted that Greenhouse Farm and Addenbrooke's are situated close together, raising the possibility that their range of crops is a local, not a pottery related, phenomenon, though it is unattested at other records in the area.

Record	Record-type*	Period of production	Crops	Crop-processing derivatives
West Stow	Industrial (pottery-production)	Late ER (extending into 2nd century)	Spelt, barley	FSBP; grain & FSBP; FSBP & EPBP
Tort Hill West	Industrial (pottery-production)	Late ER (extending into 2nd century)	Spelt, barley	Spikelets & EPBP
Greenhouse Farm	Industrial (pottery-production)	Early ER	Spelt, barley, emmer	Grain; spikelets; grain & spikelets; FSBP
Addenbrooke's	Complex rural settlement; also has evidence of significant pottery-production	Early ER	Spelt, barley, bread wheat	FSBP; grain & FSBP

* As given in Appendix 1. FSBP = fine-sieving-by-products; EPBP = early-processing by-products.
Table 8.5. Arable practice at ER pottery-production sites.

Pottery-producing sites may plausibly have been wholly or partially dependent on trade with other settlements for their grain supply. This would be consistent with the wider range of crops attested, and the presence of both sieved and unsieved spikelets at

Greenhouse Farm. None of these records included sufficient samples of like crop-processing derivation for assessment of cultivation practice which could confirm this claim[51]. Reliance on import (of spikelets/semi-cleaned grain) is plausible at Greenhouse Farm if Gibson and Lucas' (2002) interpretation of pottery-production by itinerant potters, with no permanent occupation of the site, is accepted.

However, on-site cultivation at these sites is also plausible. There is good evidence of a mixed farming economy alongside pottery-production at Addenbrooke's (Evans *et al*. 2008: 126), and the presence of (rare) early-processing by-products at West Stow and Tort Hill West also suggests arable production, though import of un-threshed crops cannot be ruled out.

Integration of arable and ceramic aspects of the Addenbrooke's (and possibly the Greenhouse Farm) economy are suggested by use of kilns for grain-drying, using fine-sieving by-products as fuel (the mixed grain and by-product samples) – a practice not widely attested in the ER period. Use of these by-products to fuel pottery firing is also suggested in the Addebrooke's source report (Evans *et al*. 2008: 131) but (as suggestions were based on small samples) was not confirmed in this research.

8.4.5. Increased arable production in the Middle and Late Roman periods

8.4.5.1. How?

In the MR (and LR) periods, large-scale crop-processing was normal practice across the region (Section 8.3.3.4), and its by-products were frequently burnt (and probably traded) as fuel. There is also evidence of increased bulk crop-storage and (at a handful of sites) for additional processing of grain for large-scale production of beer. The

[51] Though the limited weed assemblages from all hinted at the possibility of varied investment (e.g. a large sample from West Stow was noted in Chapter 6 for distinctive weed-composition including weeds of both nitrogen-poor and nitrogen-rich soils (Sections 6.4.4.3, 6.4.6.3 and 6.7.5), consistent with mixture of crops from different sources, or cultivated in different manners in the same location.

combination of these factors points to a widespread increase in the scale of arable-production. This is not matched by either increasingly intensive (i.e. investment in soils to maximise crop-yields per unit of land) or increasingly extensive (i.e. increasing plot sizes/numbers without increasing aggregate investment of labour or resources) cultivation practices. It is suggested to have been mostly achieved by 'doing more of the same thing' – cultivating more land but using the same strategies as applied throughout the study period.

The choice to increase productivity in this way is consistent with both the range of practices attested in the study region/period (intensive investment is very rare and there is no evidence for strategies which consistently allowed significant nutrient depletion) and Saller's (2005) characterisation of the normal approach to agricultural production by landowners across the Roman Empire (Section 8.4.4.4).

The only clear exception to this approach is the expansion of cultivation onto the heavy soils of the western clay, Isle of Ely and southern till, which would have increased the region's total arable output. As noted in Section 8.3.4.3, this was apprently differently motivated in the western clay (a necessity, with production most likely ensured by cultivating large plots) to on the southern till and Isle of Ely (an investment in newly available land, apparently cultivated with significant investment for maximum crop-yield/unit of land).

8.4.5.2. Who (and when)?

Cultivation of larger areas with the same amount of investment/unit of land would have meant an increase in the overall amount of labour (and resources) required. Although the initial influx of immigrants in/after AD 43 is thought to have consisted mostly of people engaged in pursuits (soldiering, administration) other than agriculture, they were followed by new landowners (though others remained as absentee landlords) when land became available for private purchase (Sections 1.4.4.2 and 1.4.8.3).

New owners who chose to occupy their purchases would have displaced the previous owners, providing a pool of readily available labour which they (and others) could use to increase production. Furthermore, tenant farmers could be pressured to increase production by working harder, though this may be counterproductive over time (Saller 2005).

There is an apparent time lapse between Conquest in AD 43, and the MR (i.e. post 100 AD) surge in the scale of arable production. However, there is evidence of increased scale of production at a handful of ER rural sites, and it must be recognised that archaeobotany is better suited to the recognition of established practices than to identifying their beginnings (Van der Veen 2010). Furthermore, the process of land transfer and displacement of native occupants would have taken some time (cf. Mattingly 2006: 354), as would the establishment of new demand (Section 8.4.5.3); change takes time, even once the necessary preconditions are in place (Meyer and Crumley 2011: 117-119).

8.4.5.3. Why?

<u>Preface</u>

Assuming the sufficiency of each site's arable production to meet its own requirements for subsistence and safeguarding in the earlier part of the study period, the MR and LR evidence indicates production beyond that scale (even with larger workforces; Section 8.2.5.2). The questions thus arise of what the extra arable produce was used for, and what made the extra investment worthwhile?

New demands and participation in a market economy

One consequence of the new systems of land ownership would have been the requirement for the land's existing occupants to pay rent to a landlord and/or taxes to a local authority. Whether paid in kind or in cash, these new demands would have necessitated the attested increase in production if quality of life was to be maintained.

As well as surplus arable production, there is evidence in the MR period of extra processing to increase the value of arable produce (malting and brewing to turn grain into beer) at a few sites. A range of non-cereal crops (flax, pulses, black mustard and possibly plum/damson) are also attested at rural sites[52]. Given the low chances of these being preserved by carbonisation, and their occurrence largely at sites (especially Camp Ground, Earith) where sample numbers were high (Section 8.2.4), it is not certain that these were grown more frequently than in other periods. However, if this was the case, they may represent crops grown for sale rather than own-consumption. There is also evidence in the MR and LR periods for more widespread evidence for concern with efficiency of grain-transport and/or standardisation of harvest by weight/volume (increased spikelet-sieving), and for potential commoditisation of crop-processing by-products (for use as fuel).

The combination of this evidence suggests participation in a market economy (i.e. production for sale and profit) as well as meeting the new necessities of rent and taxation, i.e. involvement in a new provincial economy as well as contribution to the Imperial economy (cf. Mattingly 2006: 493-499). The MR date of this evidence is consistent with documentary evidence suggesting that the Imperial economy (i.e. taxation), and corruptions within it, had been the primary mode of contact between

[52] Orchard crops from town and fort records are of less certain significance and (like the exotic foods at *Colonia Vitricensis*) may have been imported.

producers and consumers of grain in the ER period within the study region (Tacitus, *Agricola*: XIX; Fulford 1989; Section 1.4.8.3).

Participation in market economy would have enabled farmers to meet the demands described above and (assuming successful participation) to invest in their own production. This investment may have been in the form of hired labour to facilitate cultivation of more land (see Section 8.4.5.2) or new technology. On a (relatively) small scale this may have been new ploughing equipment to allow productive cultivation of heavy soils (as suggested on the Isle of Ely and in the (LR) Stansted area, as well as by the recovery of plough coulters in the region; Fig 8.2). On a larger scale it explains the appearance of corndriers and facilities for large-scale milling (e.g. at Langdale Hale) in this period (Section 1.5.3.4-1.5.3.5).

Feeding the region's towns?

The evidence from ER Heybridge suggests partial self-sufficiency in grain supply, though some import from local sites is considered likely. Given continued use of the field-system to the north of the town (Atkinson and Preston 1998), this is unlikely to have changed significantly in the MR period. Although local production is suggested at Godmanchester and Stonea Grange, it is not clear that they produced their own grain, rather than importing it from nearby rural sites. Systems of 'formal attachment' of such sites to small towns (as suggested for Vicar's Farm to Cambridge) are possible, but the small scale and semi-processed state in which grain appears to have entered the small towns may be more consistent with purchase by individual households. Where such purchase would have occurred is not clear: the putative market place at Heybridge is a likely candidate, but there is no archaeobotanical evidence of bulk-import of grain to towns; there is also no direct evidence of bulk grain stores at rural sites.

The occupants of small towns (or some of them) may have formed part of the market for arable produce. Such towns are thought to have reached their zenith in the study region by the mid-second century AD (i.e. the early part of the MR period; Taylor 1999; Going and Plouviez 2000); their early decline (Section 1.4.5.5) may help explain the evidence that neither large-scale production nor the other indicators of market participation were as common in the LR as in the MR period.

The evidence from MR *Colonia Vitricensis* and *Verulamium* suggests grain (and spikelet) storage. It is likely that grain cultivated and processed on a large-scale at rural settlements was transported to, and stored in, these towns but the evidence is too limited to say whether demand from these towns (or *Venta Icenorum* or *Durobrivae*, from which no samples were available) could account for the surge in arable-production.

<u>Supplying the army in Britain and beyond?</u>

Another feature of the period was the ongoing consolidation of the British Province, requiring the presence of many thousands of soldiers who had to be fed. As a relatively stable (by the MR period) and fertile part of the province, the study region is a plausible candidate for providing grain. Fulford (1989) suggests that from the early 2nd century AD onwards the whole of the province was involved in supplying the garrisons of Wales and the northern frontier. The Roman army was also in operation on the Continent, and could have been provisioned via the Rhine-mouth by grain exported from or via the study region, though export through London may be more likely (Section 1.4.8.3).

Unfortunately, this remains speculative. Confirmation would require the identification of the same weed floras typically seen in the study region (though a high degree of variation in these has been noted) in samples from military sites elsewhere in Britain and on the Continent. The only fort of appropriate date in the study region is Caister-on-Sea (LR), where possible grain storage is attested. The weed ecology of its few samples is consistent with production in the study region, but they are too small for further comment about the fort's supply.

Identification of bulk grain-storage or processing (potential preliminaries to shipping) at coastal or estuarine sites would provide circumstantial evidence for grain export, but few such records were identified. The only potential evidence of this nature is ER in date and comprises one dense fine-sieving by-product sample from North Shoebury and two from Heybridge (located on the Thames and Blackwater estuaries, respectively): far too little to support interpretation of grain export.

Changes in the Late Roman period

The evidence shows that concern with efficiency of transport and/or standardisation of grain by weight/volume remained as strong in the LR period as in the MR period, suggesting that transfer of ownership continued to occur frequently. However, other lines of evidence – indications of malting and use of fine-sieving by-products as fuel and (possibly) indications of bulk-crop handling – suggest a decline (not a cessation) in large-scale crop production and market participation in the LR period. This is consistent with Fulford's (1989) suggestion that the British economy was 'run down' by the later fourth century, and with speculation that demand for arable produce decreased after mid third century troop withdrawals from the province (Section 1.4.8.3).

It is important to note that small-scale crop production continued throughout the study period, suggesting that some MR and LR farmers continued with arable strategies little changed from those of their predecessors. This is consistent with the apparent ease with which the British provincial economy collapsed in the early fifth century (cf. Mattingly

2006: 497): with the demand for surplus production gone, it would have been easy to revert to a subsistence mode of production which had never really gone away. Investigation of the nature of fifth century arable practice within the study region (or more widely) and comparison to the results of this research would be illuminating on this point.

8.5. Summary

In this chapter I have reviewed and discussed the quality and limitations of the dataset, and explored the implications of its interpretation for understanding of arable practice, and wider social/political/economic development, in the Iron Age and Roman East of England. In Chapter 9 I will review the success of the project as a whole, assessing whether the individual objectives (Section 1.2.3) have been met and the degree to which I have achieved my wider aims.

9. Conclusions

9.1. Evaluation of this research

The aims of this research were synthesis and interpretation of the disparate archaeobotanical data from the Iron Age and Roman East of England to contribute to our understanding of arable practice, and exploration of the implications of that practice for the region's wider social, economic and political development. These have been achieved, fulfilling a requirement recognised both for this area specifically (Murphy in Going 2000; Medlycott 2011) and more widely by those engaged in the study in of Iron Age and Roman archaeobotany (e.g. Van der Veen *et al.* 2007). Assessment of variation in the composition of archaeobotanical samples from across the entire region and period has allowed insights which are simply not apparent when site-assemblages are considered in isolation or compared (after characterisation) to those of a few other local or prominent sites.

This research will form a valuable resource to aid the interpretation of future assemblages from the region and period and (through comparison with other areas) assessing variation in arable practice across Iron Age and Roman Britain. However, its success has been tempered by the limitations imposed on analysis and interpretation by low sample numbers and small sample sizes. In some cases, these reduced the certainty with which interpretations were made; in others they prevented analysis or interpretation.

9.2. Assessment of individual objectives and suitability of the methods employed

A database of archaeobotanical information from the Iron Age and Roman East of England has been successfully compiled. Uneven distribution of suitable relevant records, both chronologically (very low numbers for the EIA, particularly high numbers for the MR and LR periods) and spatially is apparent. The former reflects the pattern of the wider archaeological record, and is largely due to the difficulty of recognising EIA activity (Section 1.4.3) and the expansion of settlement in the Roman period. The latter (Fig. 2.7) reflects the distribution of post-PPG16 development in the region, as well as the methods (full quantification or use of abundance scores) used for archaeobotanical assessments by practitioners working in different parts of the region.

The goal of characterising arable practice in the Iron Age and Roman East of England was split (Section 1.2.3) into three principal objectives. Identification of the species cultivated was successfully accomplished for all periods. Pragmatic adoption of a two-method approach overcame, on a regional level, methodological problems with the characterisation of crop species.

Characterisation of crop-processing, -storage and -utilisation was also successfully accomplished for the MIA to LR period, though higher samples numbers would have meant greater clarity and/or confidence on some points. Low sample numbers prevented realization of this objective for the EIA. Ratio-calculation was confirmed as a valid and appropriate approach to this aspect of sample-characterisation. Correspondence analysis was also successfully employed to explore similarities and differences between samples.

The objective of characterising cultivation regimes had more limited success. Some comment on both cultivation of single/mixed crops and cultivation strategies extrapolated from identification of growing conditions has been possible, but the very low numbers of samples which could be included in these analyses means that interpretations are of isolated site-specific or local practices, rather than broader regional and/or chronological patterns. Low sample numbers also diminish confidence, often resulting in suggestions, rather than firm indications, of cultivation practice. The practices identified relate mostly to behaviours in the MIA and Roman period, with some comment on a small number of LIA records. The low number of suitable EIA samples precluded interpretation. Correspondence analysis was shown to be a useful tool for exploring variation in weed ecology (allowing clear visualisation of complex data) and it is believed that it would provide valuable and accurate insights if applied to a larger dataset.

Perhaps the limitations of the dataset should have been mitigated by relaxation of inclusion criteria for the various analyses. However, in the instance where this was (out of necessity) done, sample numbers remained low and inclusion of smaller-than-desirable samples meant only increasing uncertainty in interpretation. The objective of reliable though limited conclusions from robust data was preferred.

The final objective of using newly gained understanding of arable practice to contribute to wider narratives of Iron Age and Roman society was achieved, with interesting results, in Chapter 8. The contribution of this research to those wider narratives is summarised in Section 9.3.

9.3. Contributions to wider narratives of Iron Age and Roman society

9.3.1. Preface

This research has provided improved understanding of arable practice in the Iron Age and Roman East of England, especially in terms of variations in the ways that crops were processed, stored and used across the region and period. Low sample numbers prohibited interpretation of EIA arable practice beyond the identification of spelt, emmer and barley as crops. Particularly good insight has been gained into arable practice in the MIA and Roman period. This has been used to contribute to debates on aspects of the regions wider social and economic development, though these contributions have mostly been exploration of possibilities rather than definite interpretation of practice.

9.3.2. Middle Iron Age

Particular insight has been gained into the MIA economy of the fen island of Ely, where a specialised local economy is indicated by (1) continued cultivation of emmer, (2) handling of crops on a larger scale than, and (3) cultivation with greater investment of labour and resources than the regional norms. This has been tentatively linked to MIA settlement expansion in the southern fenland, which is suggested to be better understood as a specialised environment than as marginal land. The distinctive practices attested at these sites are considered to represent production of arable surplus, probably used in trade with (fenland) settlements with other economic specialisations. This production is suggested to have been enabled by either co-operation between sites on the Isle of Ely, or trade of labour for grain by other settlements.

Two hillforts in the south-east of the study region are suggested to have been similar (at least in some respects) to the classic hillforts of Wessex, despite differences in appearance and location. It is suggested that crops were brought to these sites from surrounding settlements for large-scale storage and subsequent bulk processing. This has been shown to be compatible with any of three competing models for the role of Wessex hillforts (Cunliffe 1995: 98-103; 2005: 590-591; Sharples 2010: 106-172; Hill 2006/Van der Veen and Jones 2006), but the limitations of the evidence have prohibited preference for any one over the others.

9.3.3. Late Iron Age and Early Roman

Despite the prominence of these periods in models of the region's social development, this research has suggested that they saw little change in arable practice. Subsistence level cultivation of spelt and barley, as seen across most of the region in the MIA, remained the norm.

The only LIA exception was at the nucleated settlement at Heybridge (where consistent arable practice suggests continuity in mundane aspects of life in this settlement either side of AD 43). As well as evidence for continued cultivation of emmer (unusual by this time), the evidence from Heybridge indicates cultivation under two regimes, potentially consistent with acquisition of crops from more than one source. Crops entered Heybridge in a semi-processed state (as spikelets) and subsequent processing was carried out on a household scale. At least some crops are thought to have been grown in plots just outside the town, but some may have been imported from other settlements in the area.

By contrast, the population of *Colonia Vitricensis* appears to have been supplied with clean grain, which was stored in bulk within the town (attested in deposits carbonised both during the Boudican revolt and later in the ER period). The new demand imposed by this town's population appears to have been met by increasing the area under cultivation, rather than by increasing investment of labour/resources per unit of land to improve crop yields, but there is no indication that growing conditions were adversely affected by this, and a net increase in investment per head of arable-productive population is thus suggested.

It is possible that the approach taken to cultivation in the Iceni Client Kingdom was different (involving higher levels of labour and resource investment) to that in the ER south of the study region, and that this regional difference remained apparent (at some sites) after its absorption into the British Province in AD 60/1. This difference in investment between the north and south would be consistent with different traditions of land-holding between the two areas (cf. Hill 1999; 2007). The Neronian fort at Pakenham (on the edge of the newly absorbed territory) appears to have been supplied locally, but *in-house* beer production suggests that the local economy did not immediately adapt to take advantage of military demand.

9.3.4. Middle Roman

The scale of production increased in the MR period, with bulk handling and storage of crops becoming normal at rural settlements across the study region. Alongside this increase in scale, there is evidence for commoditisation of chaff for use as fuel, as well as for increasing concern with efficient use of space for the storage/transport of semi-processed crops and/or with standardisation of their grain content by weight/volume. Large-scale malting (a necessary precursor to large-scale brewing) is also attested in this period at (a small number of) rural sites, some with specialised facilities. Together these lines of evidence point to participation of the region's rural population in the Roman market economy, producing for sale and profit as well as meeting obligations imposed by Roman systems of land ownership.

The region's towns are a potential market for this arable surplus. Grain (clean and semi-processed) continued to be stored in bulk at both *Colonia Vitricensis* and *Verulamium* in this period. Grain acquisition in small towns (those from which samples were available) appears to have been similar to that described for ER Heybridge, with local supply (if not a degree of self sufficiency) and household acquisition of semi-processed crops. In one instance, it is suggested that a rural settlement positioned on marginal (heavy clay) soils was founded specifically for the provisioning of a small town, and farmed under its controlling authority. Another possibility is that arable surplus was acquired (through sale or taxation) by the army, which was active and in need of supply both within the province and on the Continent at this time.

9.3.5. Late Roman

LR arable practice appears to have been similar to that of the MR period, but with several key aspects (malting, use off chaff as fuel, bulk grain handling) occurring less frequently. This apparent decline in market participation is consistent with the decline of the region's small towns and with the withdrawal of many troops from the province by this period, as well as with suggestions British economy was 'run down' by the later fourth century (Fulford 1989).

9.4. Further work

This research has offered valuable insights into arable practice and wider society in the Iron Age and Roman East of England. Similar studies of neighbouring regions and preceding/subsequent periods would allow that information to be seen in context, allowing identification of spatial and chronological patterns on larger scales. However, within the study region and period improvements in the provision of archaeobotanical data would allow further work, with the potential to refine and enhance the interpretations given here.

Archaeobotanical information was identified from a large number of sites across the region, but the usefulness of much of it was limited by decisions to publish unquantified data, and by small samples sizes (low numbers of items/sample, resulting from low volumes of sampled deposit) and low sample-numbers/record. These factors limited the numbers of samples which could be included in each analysis, decreasing confidence in some interpretations and prohibiting any interpretation in some cases.

Any future work on the arable practice of the Iron Age and Roman East of England (or in other regions) would benefit from the recognition that individual site-reports are not (solely) ends in themselves, but can be valuable sources of data for regional studies (in archaeobotany and other artefact/environmental studies) provided that sample numbers and sizes are adequate and quantified data is published/made available. Consistent observance of existing EH guidance (D. Jones 2002:20; 2011: 12) on sample size, awareness of the number of items required to ensure samples representativeness (Van der Veen and Fieller 1982; G. Jones 1991), and consideration of the number of samples/site (/phase) required for reliable interpretation (cf. Van der Veen *et al.* 2007) would also be a big step forward.

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