Cereal Husbandry and Settlement
Expanding archaeobotanical perspectives on the Southern Scandinavian Iron Age

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Expanding archaeobotanical perspectives on the southern Scandinavian Iron Age

Radoslaw Grabowski
Dedicated to Elżbieta Grabowska and Sabina Rudź, two remarkable ladies who taught me a lot about life.
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Article 2: Functional interpretation of Iron Age longhouses at Gedved Vest, East Jutland, Denmark: multiproxy analysis of house functionality as a way of evaluating carbonised botanical assemblages

Article 3: Cereal cultivation in east-central Jutland during the Iron Age, 500 BC-AD1100

Article 4: Identification and delineation of settlement space functions in south Scandinavian Iron Age: theoretical perspectives and practical approaches
Abstract

The here presented PhD project explores the phenomenon of cereal cultivation during the Iron Age (c. 500 BC – AD 1100) in southern Scandinavia. The main body of the thesis consists of four articles. These were written with the aim to identify chronological, geographical, theoretical and methodological gaps in current research, to develop, apply and evaluate approaches to how new knowledge on Iron Age cereal cultivation can be attained, and to assess the interaction between archaeobotany and other specialisms currently used in settlement archaeology. The introduction section of the thesis also contains a historical overview of archaeobotanical research on cereal cultivation in southern Scandinavia.

The first article is a compilation and summary of all available previously performed archaeobotanical investigations in southern Sweden. This data is compared and discussed in relation to similar publications in Denmark and smaller scale compilations previously published in Sweden. The main result of the study is an updated and enhanced understanding of the main developments in the investigation area and a deepened knowledge of local development chronologies and trajectories in different parts of southern Sweden.

The second article is a methodological presentation of a multiproxy analysis combining plant macrofossil analysis, phosphate analysis, magnetic susceptibility analysis and measurement of soil organic matter by loss on ignition. The applicability of the method for identification and delineation of space functions on southern Scandinavian Iron Age sites is discussed and illustrated by two case studies from the Danish site of Gedved Vest. Particular focus is placed on exploration of the use of the functional analysis for assessment of taphonomic and operational contexts of carbonised plant macrofossil assemblages.

The third article aims at presenting an Iron Age cereal cultivation history for east-central Jutland, an area identified at the outset of the project as under-represented in archaeobotanical studies. The article combines data from in-depth analyses of material from the sites of Gedved Vest and Kristinebjerg Øst (analysed with the methods and theory presented in the second article) with a compilation of previously performed archaeobotanical analyses from east-central Jutland. The main results of the study are that developments in the study area appear to follow a chronology similar to that previously observed on Funen rather than the rest of the peninsula. Rye cultivation is furthermore discussed as more dynamic and flexible than previously presented in Scandinavian archaeobotanical literature.

The fourth and final article leaves archaeobotany as the main topic. It focuses instead on evaluating, theorising and expanding the multiproxy method presented in the second article by a thorough comparison of the botanical, geochemical and geophysical methods to other techniques of functional analysis currently used in archaeology. These techniques include studies of artefact distributions, assessments of spatial relations between settlement features, and studies of the structural details of dwellings and other constructions. The main result is that there is a correspondence between the functional indications provided by botanical, geochemical and geophysical methods and techniques used in mainstream archaeology. The comparison furthermore shows that a combination of the two data sets allows for more highly resolved functional interpretations than if they are used separately.

The main conclusion of the PhD thesis, based on the discussions in all four articles, is that archaeobotanical questions commonly necessitate the assessment of non-botanical archaeological material. The comparison of archaeobotanical data to other segments of the archaeological record does, however, enable the use of the former as an archaeological resource for addressing non-botanical questions. The increased understanding of (mainly settlement) site dynamics resulting from this integration of methods allows archaeobotanists to address increasingly complex botanical questions. Increased and more structured integration between archaeobotany and other specialisms operating within the framework of settlement archaeology is therefore argued to be the preferred approach to performing both high quality archaeobotany and settlement archaeology.

Keywords: archaeobotany, Iron Age, southern Scandinavia, Sweden, Denmark, settlement archaeology, methodological integration, cereal cultivation, prehistoric agriculture.
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Over the course of the project I have also had the opportunity to interact with colleagues at several archaeological institutions in Scandinavia and further afield.

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I also want to express appreciation to the staff of the Natural Sciences Unit (NNU) at the National Museum of Denmark, for not only for providing a work space but also good company during my extended stay in the Copenhagen-Malmö area.

During my time as a PhD candidate I was also fortunate to have the opportunity to spend several months at the Palaeoethnobotany Laboratory of the Anthropology Department of UC Berkeley. Looking back at the years spent working on the project I can conclude that the time in California was the most productive phase of my studies. I therefore wish to thank Professor Christine Hastorf and the rest of the PEB lab staff for sharing their inspiring work environment and engaging in many inspirational discussions.

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1. Introduction

1.1. Project background

When my education took on a specialisation in archaeobotany I quickly came to realise that even a methodologically straightforward discipline can carry an interpretative complexity that can take a lifetime to get one’s head around. As I was writing a paper based on the analysis of plant macrofossils from the Iron Age central place of Uppåkra in Scania, I became conscious of the significance of the carbonised plant remains before me in terms of archaeological research; namely some of the few remaining material traces of the singularly most common and important occupation of the majority of people living in southern Scandinavia over a six thousand year period, stretching from the Neolithic up to Industrialisation. With this realisation came also the recognition that almost every phenomenon observed in the archaeological record post-dating the introduction of agriculture, should in some way or other be connected to the practice of cereal cultivation, not in the least because cereal cultivation was, and remains, among the most important components of human subsistence.

Much of the practical organisation of the project, and the final shape of the thesis, is an outcome of my cooperation or interaction with archaeological institutions active in the south Scandinavian region.

Horsens Museum has facilitated access to a large segment of empirical material processed in the course of the PhD project, the majority of which derived from the site of Gedved Vest in east-central Jutland, excavated between 2008 and 2010.

In 2012, mid-way through the project, additional material from the site of Kristinebjerg Øst, excavated in 2007-2009 by Vejle Museum, was added to the empirical base.

The remainder of material used during the project has been acquired through cooperation with Moesgård Museum and the SEAD-project (Strategic Environmental Archaeology Database, www.sead.se) at MAL in Umeå, or by assistance of UV-Syd, Sydsvensk Arkeologi (former Malmö Kulturmiljö), UV-Väst, Kristianstad Museum and Lund Historical Museum.

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<td>500-250 BC</td>
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Table 1.1. Chronological nomenclature for the last two millennia of south Scandinavian prehistory.
1.2. Aims and objectives
The formulated aims of this thesis were largely based on the nature of the available empirical material and the perceived state of current research. The explicit aims of the project are:

1) To provide new insights into Iron Age cereal cultivation, mainly from an archaeobotanical perspective. This aim is pursued by:
   a) A summary and comprehensive presentation of the current state of archaeobotanical research on cereal cultivation in southern Scandinavia, and identification of regional trends in cereal cultivation dynamics during the Iron Age.
   b) Identification of areas of research (geographic, methodological and theoretical) where further attention is desirable.
   c) Development, presentation and evaluation of theoretical and methodological techniques to how the identified issues in cereal cultivation research can be practically explored.
   d) Application of the methods and theories on two case study sites, Gedved Vest and Kristinebjerg Øst, both located in east-central Jutland, and interpretation of the results in context of the identified regional issues and development dynamics.
   e) Evaluation of the results and formulation of future research strategies.

2) To attempt to define and analyse relevant issues inherent to the interaction between archaeobotany in the context of cereal cultivation research and other specialisms of archaeology.

1.3. Geographic and chronological setting of the thesis
A common dilemma in archaeological research is the choice between depth and breadth. If a project is too narrowly constrained geographically or in time, it runs the risk of overlooking important perspectives which are only observable at larger spatial and/or temporal scales. If a project is too far reaching in scope it risks instead to attain unconvincing interpretations because the volume of evidence does not allow the researcher to address all the complexity which becomes evident once the record is studied in detail (cf. Hedeager 1992).

In order to establish a workable spatial and geographic starting point for the PhD project, one which hopefully balances the possibility of in-depth studies with larger scale overviews, the investigation area of this thesis has been set to southern Scandinavia, while the chronological frame is defined as the Iron Age, or circa 500 BC – AD 1100. Southern Scandinavia is here defined as all of present day Denmark and the southern tip of Sweden, i.e. the counties of Scania, Halland, Bohuslän, Småland, Blekinge and Öland.

The empirical data actively analysed in connection with this PhD project originate from two relatively adjacent sites in east-central Jutland, Gedved Vest and Kristinebjerg Øst. Cereal cultivation dynamics are therefore addressed primarily for this area.

Methodological studies performed during the project are based on material from Gedved Vest as well as several sites from Halland and Bohuslän.
Figure 1.1. Map of southern Scandinavia, showing the locations of regions commonly mentioned in the thesis introduction chapters and articles. The locations of Gedved Vest (triangle) and Kristinebjerg Øst (diamond), two sites analysed during the PhD project and frequently referred to in the text, are also displayed.
1.4. Outline of the project and publications

The majority of work done over the course of this PhD project is presented in four articles. By the time this text is printed two of these have been published, article 1 in Vegetation History and Archaeobotany, and article 2 in Archaeological and Anthropological Sciences. One paper, article 3, is accepted for publication in Danish Journal of Archaeology, while the fourth article is at time of writing submitted for review in Journal of Archaeology and Ancient History.

The four articles are:


4) **Grabowski, R.** in prep. Identification and delineation of functional spaces on south Scandinavian Iron Age settlements - theoretical perspectives and possible approaches. At time of writing submitted to: *Journal of Archaeology and Ancient History*.

The topics and data explored in these four articles mirror the research process of the PhD project. Article 1 (Grabowski 2011) is a compilation of previously done archaeobotanical analyses in southernmost Sweden. It is modelled on a recent publication with similar scope and aims covering the area of present day Denmark (Robinson et al 2009). Some interpretations of the patterns identified in the compiled data are presented in this paper, but its primary function within the PhD project was to provide a general contribution about the main trends in Iron Age cereal cultivation and to help define currently unresolved research issues as well as spatial and chronological gaps in the currently available archaeobotanical record. Article 1, along with similar publications by other researchers (Engelmark 1992, Robinson 1994a, Robinson et al 2009, Regnell 2002, Viklund 2004), were instrumental for the structuring of the aims, scope and methodological approach applied on the material from Gedved Vest and Kristinebjerg Øst and presented in article 3.

Article 3 (Grabowski in press) is an attempt to formulate a cereal cultivation history for east-central Jutland where the project's case study sites of Gedved Vest and Kristinebjerg Øst are situated. The formulation of a local cereal cultivation history is attempted by two strategies: 1) in-depth studies of cereal cultivation dynamics at the case study sites, and 2) comparison of the material from the case study sites to previously investigated, but largely unpublished, archaeobotanical analyses from the surrounding area.

The data from the case study sites and from previously analysed materials is collectively used to fill one of the spatial/chronological gaps observed in earlier compilation type publications, while the study of cereal dynamics on the case study sites, most distinctly at Gedved Vest, is directed to exploration of issues defined as poorly understood in article 1.

The study of cereal dynamics at Gedved Vest was performed by integrating archaeobotanical analyses with geochemical and geophysical methods which are argued to be instrumental for allowing inference of details of cereal cultivation and processing which are difficult to attain with archaeobotanical analysis alone. The methodological strategy is a continuation of methods de-
veloped at MAL in Umeå over the last 30 years. Article 2 (Grabowski and Linderholm 2013) aims at describing the history of this methodological development and its relevance and applicability under the specific conditions of southern Scandinavian settlement archaeology. In short, article 2 can be seen as a detailed method statement for a large segment of the data presented in article 3.

Article 4 (Grabowski in prep.) leaves archaeobotany as the main point of interest and instead explores how plant macrofossil analysis in combination with geochemical, geophysical and “archaeological” methods\(^1\) can be applied in combination in order to elucidate the functional dynamics of Iron Age settlement sites. Although this article is not mainly archaeobotanical in scope and aims, it is a consequence of thoughts and ideas developed during the assessment of archaeobotanical material at Gedved Vest. Indirectly this last study also acts as an evaluation and extended discussion about the validity of the methods defined in article 2 and applied in article 3.

\(^1\) Mainly studies of artefact distributions, distributions of feature types on settlement sites and assessment of structural details of houses and morphologies of excavated feature types.
2. Archaeobotanical method and material

2.1. Definition of archaeobotany

There has historically been some variation in the definition of what constitutes the discipline of archaeobotany. The Swedish archaeobotanical pioneer Hakon Hjelmqvist (1982:229), for example, stated that:

The discipline of archaeological botany, also called palaeoethnobotany, is a so called cross-discipline, where botany and archaeology in cooperation pursue results of interest to both disciplines.

Hjelmqvist’s definition implies a clear distinction between archaeological and botanical aims, with the essential reason for the existence of archaeobotany being the occasional advantages of disciplinary cooperation.

Viklund (2004:56), in contrast, proposes a more archaeologically orientated definition, stating that archaeobotany is:

[...] not, as often described, a "natural scientific analysis", but rather a form of investigation and a research field specifically adapted and developed for archaeology [my translation].

A similar breadth in definition of the archaeobotanical discipline can also be observed, stated implicitly, in the main body of archaeobotanical publications, which range from biologically and ecologically oriented ones, to studies with distinctly archaeological and anthropological frameworks.

Clearly, archaeobotany is a broad discipline and the specifics of its definition vary correspondingly to the research interests and professional experiences of the archaeobotanically engaged individuals. Because the phenomena involving plants in the past are intrinsically diverse, with links to both the social/cultural and ecological/environmental spheres of material existence, it is perhaps expected that the forms of archaeobotanical practice should correspondingly range in their orientation from predominantly natural scientific to distinctly anthropological and humanistic.

Accepting, however, that the natural and cultural spheres of the human past are ultimately interwoven and inseparable from each other, the most correct definition of archaeobotany, and the one used in this thesis, is perhaps that archaeobotany is:

[...] the analysis and interpretation of the direct interrelationships between humans and plants for whatever purpose as manifested in the archaeological record (Ford 1979:286).

2.2. Archaeobotany of carbonised plant remains

Archaeobotanical research on plants and their relationship to humans in the past relies on direct observation of visible botanical remains, a procedure termed plant macrofossil analysis. This form of analysis requires that the botanical remains are preserved in sufficient detail to enable their identification. In archaeobotanical literature five modes of preservation are commonly listed: 1) carbonisation, 2) waterlogging, 3) desiccation, 4) mineralisation, and 5) imprints (for comprehensive overviews see for example Branch et al 2005, Dincauze 2000, Nesbitt 2006).

Plant macrofossils (i.e. visible plant remains) may be contrasted by microfossils (i.e. remains not visible to the naked eye) such as pollen and phytoliths. Studies of pollen (palynology) and of phytoliths are often performed within the framework of archaeobotanical research and the boundary between these specialisms and mainstream archaeobotany is diffuse. The methodology, scope and/or theoretical perspectives utilised by the researchers working with macrofossils and microfossils respectively tends to vary, resulting in the term archaeobotany commonly carrying connotations primarily to studies of macro-remains.
All of the archaeobotanical material analysed in the course of this thesis, as well as the vast majority of the material referred to throughout the thesis introduction and articles, was preserved by carbonisation.

Plants exposed to high temperatures will normally combust and be reduced to ash. Under low oxygen conditions, with temperatures ranging between 250 and 500°C, plant remains may, however, become charred while remaining sufficiently intact to facilitate their identification thousands of years later. Since carbonised plants are not susceptible to organic decay their survivability in archaeological deposits is mostly dependent on exposure to mechanical damage (Miksicek 1987).

Although carbonisation may occur due to non-human causes, such as forest fires, archaeobotanists rely on a supposition that most carbonised material recovered from archaeological contexts, i.e. on settlement sites, in graves, inside artefacts, et cetera, was preserved due to some form of anthropogenic activity (Hillman 1984, Miksicek 1987, Viklund 1998).

Extraction of plant remains from archaeological contexts does not differ fundamentally from that of most other artefact categories. Relevant strata need to be exposed and documented for future interpretation, and information bearing material culture embedded therein needs to be systematically collected for further study. The main difference is perhaps that plant macrofossils, although visible to the naked eye, are small enough not to be easily identifiable during excavation. At the advent of archaeological research in Scandinavia this fact resulted in few macrofossils being recognised during excavations. When carbonised plants were recognized it was commonly because the macrofossils were large, for example large pieces of burnt wood, or because they were very numerous, for example in the form of burnt grain storages.

Problems of identifying and extracting plant macrofossils may to a large extent be avoided by extensive use of a simple technique known as flotation. Flotation achieves separation between carbonised plants and the sediment in which they are embedded due to differences in density. In short the method entails the collection of soil that presumably contains plants. The soil is thereafter (preferably) dried and poured into a container with water. The heavy mineral fraction of the sediment sinks to the bottom while lighter organic material floats to the surface from where it can be channelled into a sieve with a mesh size suitable for gathering the plant remains of interest to the researcher (Hillman 1984, Miksicek 1987, Nesbitt 2006).

The resulting flotated sample is thereafter visually inspected, usually with the help of magnifying instruments. Identification of plant taxa or specific plant parts is achieved by comparison to modern and/or previously identified reference samples as well as through reference keys and literature (Hillman 1984, Miksicek 1987, Nesbitt 2006).

Identification of plants requires a degree of expertise. Botanical material may change shape and dimensions during the carbonisation process, or may be preserved in a condition that makes identification difficult. As a result some plant remains, normally seeds, fruits and nuts can be determined down to species or even sub-species, while others may be difficult to assess beyond genus or even family level.

The straightforward nature of plant macrofossil analysis may also be contrasted by a high degree of interpretative complexity. This complexity is at the centre of the problems assessed during this thesis, and is presented and discussed in detail in chapters 5, 7, 8 and 9.
3. History of archaeobotanical research in southern Scandinavia

3.1. Early research, c. 1850-1950

The recognition of preserved plant remains as a source material in archaeological research can in Europe be traced back to the mid-19th century when investigations of the Swiss lake dwellings uncovered well preserved, mainly waterlogged, plant macrofossils. Seemingly deposited as a result of subsistence strategies of the Neolithic and Bronze Age inhabitants, these plant remains provided early archaeologists with the first direct evidence about the plant based segments of prehistoric agrarian economies (Heer 1865, Trigger 1997:83f).

In Scandinavia one of the first archaeobotanical studies took place in 1876 when botanist Emil Rostrup investigated an organic crust found inside a bronze vessel excavated at Nagelsti on Lolland in Denmark. Rostrup’s investigation concluded that the crust consisted primarily of cereal chaff with a small admixture of grains, and that the remnants belonged to two plant species: club wheat (*Triticum compactum*) and broomcorn millet (*Panicum miliaceum*). Although the find was small, it put emphasis on two facts which have since been central in Scandinavian archaeobotanical research. Firstly, the find of club wheat, a crop which was neither grown in 19th century Denmark nor recorded as cultivated there in historical sources, illustrated that the plants grown by prehistoric farmers were not the same as contemporary ones. This observation opened up for the possibility that prehistoric agricultural systems as a whole may have been organised according to different principles than those known from historical times, and that they had for some reason changed over time. Secondly, the find of broomcorn millet indicated that not only had cereal cultivation changed over time, but probably also the climatic conditions for agriculture, since millet is not suitable for cultivation in the prevailing weather of contemporary Scandinavia (Hatt 1937, Jessen 1933). Thus, already from the start archaeobotanical research in Scandinavia came to incorporate both cultural as well as environmental, ecological and climatic perspectives.

Due to the specifics of the archaeological methods of the late 19th century, finds of preserved grains and other plants in archaeological contexts had remained limited after Rostrup’s initial discovery. The next important step in Scandinavian archaeobotanical research occurred therefore in 1894 when Frode Kristensen, a teacher and amateur archaeologist, recognised several indentations on Bronze Age pottery fragments as imprints of cereal grains. Kristensen’s discovery identified a previously unknown source from which information on past cereal cultivation could be obtained, and the approach was soon thereafter utilised by archaeologist and botanist Georg Sarauw, who began searching for additional imprints in the collections of the National Museum of Denmark (Hatt 1937, Hjelmqvist 1982).

Sarauw never published his findings in a coherent format, but by the late 1930s enough imprints and direct finds of cereal grains had been discovered to allow Gudmund Hatt (1937) to present a general outline of prehistoric cereal cultivation in present day Denmark, an outline largely based on Sarauw’s work. This work was subsequently expanded upon by Knud Jessen, who combined Sarauw’s identifications of plant imprints with studies of carbonised plant finds which during the first half of the 20th century were becoming increasingly numerous (Jessen 1933, 1939 and 1954). By 1951 Jessen could summarise his investigations in the first archaeobotanical overview written for a region of southern Scandinavia (Jessen 1951).

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3 A summary of Hatt’s book on Danish prehistoric agriculture has also been published in English (Curwen 1938).
In Sweden the first archaeobotanical find, consisting of barley grains (*Hordeum vulgare* coll.), was made in 1874 during excavations of Kungshögarna at Gamla Uppsala. When Sarauw found employment at the museum of Gothenburg, the methods developed in Denmark came into direct contact with Swedish archaeology (Sarauw 1899, cited in Hjelmqvist 1982).

Here they would eventually be used by Hakon Hjelmqvist, who in the 1950s analysed pottery imprints as well as waterlogged and carbonised seeds from numerous archaeological sites; the most famous being perhaps Uppåkra in Scania and Alvastra in Östergötland. Similarly to Jessen’s research in Denmark, Hjelmqvist’s efforts led to the formulation of comprehensive outlines of prehistoric cereal cultivation in the area of present day Sweden (Hjelmqvist 1955, 1960 and 1979).

### 3.2. 1950s – 1980s

Up to the 1950s south Scandinavian archaeobotany can be considered as a primarily descriptive science, with an explicit focus on filling geographic and chronological gaps in the botanical record (Hjelmqvist 1979, Jessen 1933 and 1954). While the data presented in Jessen’s and Hjelmqvist’s overviews did not fill all these gaps, by the time they were published the foundation of Scandinavian archaeobotany had become substantial enough to allow for a broadening of the focus of the discipline from mostly mapping and cataloguing to exploration of possible causes for the observed variation and a deepened consideration of prehistoric cultivation techniques, as well as methodological issues.

This shift coincided with an awakened interest in the economic aspects of past societies and their interactions with surrounding environments in mainstream archaeology of the 1960s. Thus, as archaeobotany was reaching a more established stage where researchers could tackle increasingly complex questions, archaeology as a whole oriented itself toward exploration of issues in which studies of plants from prehistoric contexts had a given place. Within this suitable academic setting two researchers - the already mentioned Hjelmqvist in Sweden, and Hans Helbæk in Denmark - became prominent figures in shaping the direction of Scandinavian archaeobotany.

Helbæk, who was at the forefront of both Scandinavian and global archaeobotany for several decades, with projects in the Nordic countries, the British Isles and western Asia, was a prolific writer. A comprehensive review of his works would therefore require a more historically dedicated text than this one. Within Scandinavian cereal oriented research his contributions include some of the first comprehensive attempts at tracing cereal cultivation not only in Scandinavia, but also in adjoining regions of Eurasia (Helbæk 1952, 1955, 1959a and 1977) and the acknowledgement that the plant macrofossil material may also be used to explore subsistence strategies beyond primary crop cultivation; such as the role of weeds in prehistoric sustenance (Helbæk 1951 and 1959b) and the brewing of alcoholic beverages (Helbæk 1966). Helbæk’s pioneering investigations of the gut contents of the Tollund and Grauballe bog bodies also introduced an additional source of evidence on the presence and consumption of plants in Scandinavian prehistory (Helbæk 1950 and 1958).

In both Helbæk’s and Hjelmqvist’s works one can also trace an increasing preoccupation with the methodological issues of plant macrofossil analysis. The acknowledgement that formation conditions, human handling of plants and modes of preservation can all alter the composition of both carbonised and imprint based botanical assemblages are in Helbæk’s works stated both explicitly (Helbæk 1952:231 and 1955: 638d) and implicitly, the latter interwoven with discussions about the nature of cereal, weed, and other types of botanical finds (e.g. Helbæk 1951 and 1958). Hjelmqvist similarly discussed the distorting effects of charring on cereals and several of his publications show a preference for plant imprints as a way of avoiding the biases associated with carbonised material (e.g. Hjelmqvist 1960 and 1982).
Both Helbæk and Hjelmqvist based large segments of their research on careful spatial and chronological mapping of recovered finds. These efforts were furthermore combined with measurements and statistical analyses of the morphologies of recovered finds, with an underlying theory that the size and shape of cereal grains could provide insights into their physical evolution within the framework of human agriculture (e.g. Helbæk 1952, 1955 and 1977, Hjelmqvist 1955, 1960 and 1979). Occurrences of cereal species were compared to interpreted early (small) and later (larger, similar to contemporary cereals) development stages of identified cereals, in order to propose possible routes and chronologies of introduction into Scandinavia. Neither researcher did, however, adopt a purely diffusionist and evolutionary perspective in assessing the introduction and adoption of crop species. In Hjelmqvist’s work, for example, there are also clear tendencies toward climate deterministic reasoning, for example when he writes about the observed decline of hulled wheats and naked barley at the end of the Bronze Age, and the increase in hulled barley and rye over the course of the Iron Age (Hjelmqvist 1992: 366):

*There is no doubt that the climatic conditions are the principal reason for these changes. The worsening of the climate which took place during the Late Bronze Age meant that emmer was no longer such a profitable crop to cultivate, and the even greater climatic deterioration during the transition to the Iron Age meant that rye gained ground and was no longer simply an occasional admixture; it was gradually to become an important cereal. The decline in naked barley can also be attributed to the climate to a certain extent. As pointed out by Kroll (1975, p. 129), it exhibits a number of less favourable characteristics which may become more noticeable in conjunction with a deterioration in the climate; i.e. poor resistance to disease.*

Although the above quote is a bold climate oriented statement about causal factors in cereal cultivation, Hjelmqvist’s position was not completely rigid. Although never explored in great detail, his works contain references to culturally and socially oriented explanations. For example, in another text with a discussion on the role of naked barley in the Swedish Iron Age (Hjelmqvist 1979: 53), he writes:

*That the naked barley did not entirely disappear in the southern Swedish Iron Age can probably be explained by it being used to obtain a finer bread, and cultivated despite of its [climatic] disadvantages whenever social conditions facilitated a better standard of living [my translation].*

Neither Hjelmqvist nor Helbæk had the possibility to properly explore all the issues they had contributed to put in the foreground of archaeobotanical research, despite being prolific authors of archaeobotanical publications. Most of the issues would instead be addressed by the following generations of Scandinavian archaeobotanists.

### 3.3. 1980s – late 2000s

Scandinavian archaeobotanical research from the 1980s onwards continued to expand upon many of the issues defined in Helbæk’s and Hjelmqvist’s works. New ideas and techniques that had been developed outside of Scandinavia were also increasingly introduced. This broadening of perspectives at least partially matched the diversification of archaeology as a whole during the post-processual reaction against the processual paradigm and the simultaneous processual developments made in its defence. At about the same time the change in southern Scandinavian field methodology, from small but detailed excavations of strategically placed metre-square trenches, to large-scale topsoil stripping, mapping and excavation of settlement sites, coupled with the introduction of flotation on a larger scale, resulted in a significant increase of material available for study. The result of these developments can be seen today in the form of a varied archaeobotanical discipline working within many spheres and levels of archaeology.
One area of research, which has expanded considerably in the last three decades, studies the formational, taphonomic and methodological aspects of plant macrofossil analysis. As argued by Schiffer (1976), most of the archaeological record can only be understood if the life histories of the material under study are taken into account, as most archaeological material is throughout its lifespan repeatedly modified by various transforms\(^4\). Furthermore, archaeological inferences on phenomena in the past have been argued to be unavoidably dependent on analogies to observations made in the present (e.g. Binford 1967, Wylie 1985).

In European and North American archaeobotany significant strides were made in the 1970s and 1980s to both make explicit the analogies used in interpreting botanical assemblages, and to develop investigative approaches which would account for the biases imposed on the material as an effect of C and N-transforms (e.g. Denell 1974 and 1976, Hillman 1973, 1981 and 1984, Jones, G. 1984 and 1990, Jones, M. 1985, Miksicek 1987). Scandinavian archaeobotany was both influenced by, and a contributor to these developments.

The inclusion of experimental archaeology - i.e. the re-enactment and evaluation in the present of techniques possibly used in the past - was one way of obtaining analogous models for the interpretation of archaeobotanical material and for gaining insights into various types of transforms stemming from human handling of plants. These studies included both experiments on the effects of preserving conditions such as charring on different species of plants (Gustafsson 2000, Viklund 1998), and cultivation of cereals observed in archaeobotanical assemblages with prehistoric tools and techniques (Engelmark 1989, Henriksen 1995, Viklund 1998).

The formational and transformational aspects of the material were also studied by in-depth analyses of relationships between different components of archaeobotanical assemblages, for example relationships between cereals and weeds or cereals and chaff, in various types of archaeological features. These studies were frequently performed within theoretical frameworks modelled on historical, ethnographic and ethnobotanical accounts, utilised alongside experimental archaeology as sources for interpretative analogies (Henriksen and Robinson 1996a, Henriksen 2003, Mikkelsen and Nørbach 2003, Robinson & Boldsen 1991, Rowley-Conwy 2000, Viklund 1998).

The discussions on possible causes for changes in cereal cultivation were in the 1980s and onward also expanded to include ecological and functional perspectives, often used in combination in interpretative models (Engelmark 1989, 1992 and 1993, Gustafsson 1995a, Robinson 2003). Increasing focus was also placed not only on the crops and their cultivation, but also on the products for which they were used, and their role in the culinary traditions of prehistoric Scandinavia (e.g. Hansson 2002, Hjelmqvist 1984, Viklund 1998 and 2011), as well as the ritual aspects of cereals, other associated plants, and the thereof derived products (e.g. Engelmark 1984, Gustafsson 1995b, Hansson and Bergström 2002, Jensen et al 2010).

Throughout the 1980s, 1990s, and 2000s the empirical base of archaeological material continued to grow, and the number of active researchers and institutions increased. Consequently, some areas and time periods have received significant archaeological attention (e.g. Andreasen 2009, Engelmark 1992, Jensen and Andreasen 2011, Regnell 2002, Robinson 1994a and 2003, Robinson et al 2009, Viklund 2004).

The growing empirical base of Scandinavian archaeobotany, combined with availability to computerized documentation and statistical processing tools, has also allowed for advanced studies of specific phenomena, such as Mikkelsen’s statistical analyses of rye and barley finds in iron extraction furnaces from Roman Iron Age Jutland (Mikkelsen and Nørbach 2003), and Larsson’s (2013) analyses of flax and gold-of-pleasure from Roman Iron Age Scania.

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\(^4\) Schiffer (1976) termed the individual processes and events which contribute to the interpretative complexity in archaeology by modifying the empirical material as transforms. He furthermore divided them into two categories: cultural transforms (including for example modifications by waste management depositions and re-depositions, chronologically unrelated agricultural processes, movement of soil already modified by human action during new constructions, etc.) and natural transforms (including for example soil erosion, podsolization, bioturbation, etc.).
Figure 3.1. Occurrences of crop species in Denmark during different periods of the Iron Age as understood by archaeobotanical research at two points in time: the 1950s (after Jessen 1951), and the 2000s as summarised by Robinson, Mikkelsen and Malmros (2009). Note that Jessen used a chronological nomenclature that deviates somewhat from that in use today.

Figure 3.2. Occurrences of crop species in Scania during different periods of the Iron Age as understood by archaeobotanical research at two points in time: the 1960s (after Hjelmqvist 1960), and the 2000s as summarised in article 1 of this PhD project (Grabowski 2011).
4. Current archaeobotanical research on cereal cultivation in Southern Scandinavia

4.1. Recent developments
The most significant contributions of late 20th and early 21st century archaeobotany in the field of Scandinavian prehistoric cereal cultivation research can be summarised in five points:

1) The increase in investigated material has allowed for elaboration on the individual histories of several crop species which were initially poorly understood due to insufficient, or chronologically insecure, finds.

2) The increased geographic and chronological resolution of cereal finds has furthermore highlighted that the developments in crop agriculture did not always occur simultaneously in all of the southern Scandinavian area. Whenever a change, such as the introduction of a new crop, is observed in one or several areas other display delayed or diverging developments.

3) The in-depth investigations through which the abovementioned increase in detail was attained, have put to the foreground a myriad of methodological aspects associated with the study of plants from prehistoric contexts. Furthermore, the experimental, historical and ethnographic analogies employed in theory building to counter this complexity have often resulted not only in better understanding of the archaeobotanical source material, but also contributed to outline additional levels of interpretative complexity. It is today not uncommon for archaeobotanical publications to conclude with a call for further method testing and analogy development (e.g. Gustafsson 2000, Henriksen and Robinson 1996a, Viklund 1998:176). Altogether these developments have resulted in a generally cautious and introspective approach to interpretation of archaeobotanical data.

4) Despite the many methodological issues still in need of exploration by future research, significant strides have been made to understand how cereal agriculture may have been practiced in prehistory (e.g. Henriksen 2003, Mikkelsen and Nørbach 2003, Viklund 1998).

5) Despite the cautious stance of most archaeobotanical research, discussions have been initiated about complex plant-human-environment relationships during prehistory. Many of these are currently unresolved, and under investigation and discussion (e.g. Behre 1992, Engelmark 1992, Mikkelsen and Nørbach 2003, Regnell and Sjögren 2006, Viklund 2004).

4.2. Cereal crops during the southern Scandinavian Iron Age
Chapter 4.2 outlines the current state of understanding about the presence of various cereal crops during different periods of the Iron Age.

Article 1 of this PhD project, being a compilation of archaeobotanical finds from southern Sweden performed at the beginning of the project, is integrated in the presentation below.

4.2.1. Late Bronze Age (c. 1100 – 500 BC)
During the late Bronze Age, cereal agriculture in most of southern Scandinavia appears to have relied on crops which had initially been introduced in the Neolithic, i.e. spelt, emmer and naked barley. Einkorn, however, appears to have decreased already during the late Neolithic and its sparse occurrence in investigated assemblages indicates a status as a rarely cultivated crop, or even contamination in other cereals (Engelmark 1992, Robinson 1994a).

A new development during the late Bronze Age was an increase of hulled barley cultivation. This increase was not uniform across all of southern Scandinavia. In Scania the archaeobotanical material indicates a significant breakthrough of hulled barley cultivation, seemingly at the expense of emmer, spelt and naked barley, which on many sites were phased out as primary crops. In Denmark, where the majority of the material originates from Jutland, this transfor-
mation is less pronounced, and although an increase in hulled barley can be observed in the botanical material, naked barley, spelt and emmer still appear to have retained a role as primary crops. The situation in Jutland is somewhat similar to the one observed in Halland, where hulled wheats (almost always not defined to specific species due to poor preservation) and naked barley also appear to have been retained to a larger degree than in adjoining Scania.

A unique trait found in the material from Halland is that significant amounts of oat also appear in the material dating to the end of the Bronze Age (Engelmark 1992, Gustafsson 1998, Robinson 2003, Viklund 2004). Oat (*Avena*) is a problematic genus from an archaeobotanical perspective, since it includes wild species such as *Avena fatua* and *Avena strigosa* besides the cultivated *Avena sativa*. Differentiation between these species can only be made if the glume base is still attached to the grain. This is rarely the case in carbonised material. Outside of Halland undifferentiated oat (*Avena sp*) appears sporadically and in small quantities. These finds are commonly interpreted as a weed presence in other cultivation. Some finds from Halland are, however, substantial enough to consider it as cultivated already during the late Bronze Age (Engelmark 1992, Gustafsson 1998, Robinson 2003, Viklund 2004).

Another crop interpreted as a weed during this period is rye (*Secale cereale*). Rye, although comprising only one species, may grow as a persistent weed with other cereals similarly to the way oat does. Identification of cultivated rye is for that reason difficult, requiring archaeological evidence of intentional cultivation, such as cleaner or larger finds, preferably in storage contexts or other informative settings. None of the late Bronze Age rye finds display such characteristics and all rye during the late Bronze Age has to date been interpreted as weed presence (Behre 1992, Engelmark 1992, Gustafsson 1998, Robinson 2003, Viklund 2004).

4.2.2. Pre-Roman Iron Age (c. 500 – 1 BC)

During the pre-Roman Iron Age, emmer and spelt began to decrease distinctly also in Jutland, but remained in Halland. Hulled and naked barley appears in these two regions to have been of similar importance, and the two crops are found in approximately equal proportions to each other in the archaeobotanical record. In Scania, on the other hand, naked barley decreased even further and must be considered to have assumed a role as a minor crop. The presence of oat in Halland remains high in the material dated to this period, and although the material from this region is not substantial to convincingly assess its overall importance, it does make up as much as a third of the material on two out of five investigated sites (Engelmark 1992, Regnell 2002, Jensen and Andreasen 2011, Robinson et al 2009, Viklund 2004, see also article 1).

4.2.3. Early Roman Iron Age (c. AD 1 – 200)

During the early Roman Iron Age the situation in Jutland and Halland appears to have remained similar to the preceding period, although naked barley is seen as gradually decreasing in the archaeobotanical record. It does, however, still make up a significant portion of the cereals on some sites. Emmer and spelt had probably by this time assumed a role as minor crops in most of southern Scandinavia, although a temporary increase is observed in material from Scania, which is otherwise dominated by hulled barley. Occasional sites in Jutland also begin to display finds of rye in quantities which may indicate intentional cultivation (Engelmark 1992, Mikkelsen and Norbach 2003, Regnell 2002, Robinson et al 2009, Viklund 2004, see also article 1).
4.2.4. Late Roman Iron Age (c. AD 200-400)
By the late Roman Iron Age naked barley, emmer and spelt were probably phased out to sporadic cultivation across the entire region and hulled barley was the dominating cereal. Evidence for rye cultivation, particularly in material from Jutland and Halland, increases in relation to the preceding period (Engelmark 1992, Regnell 2002, Robinson et al 2009, Viklund 2004, see also article 1).

4.2.5. Late Iron Age (c. AD 400 – 1100)
During the late Iron Age the rye cultivation, which began in Halland and Jutland during the Roman Iron Age, appears to have spread to other areas of southern Scandinavia while simultaneously increasing in importance. By the Viking Age it apparently became as important as hulled barley across the region.
Oat, although problematic to assess for all periods of the Iron Age, also begins to appear more commonly in contexts indicating intentional cultivation (Engelmark 1992, Regnell 2002, Robinson et al 2009, Viklund 2004, see also article 1).

Figure 4.1. Distribution of the dominant cereals on sites in Denmark during the Iron Age. Period a: 500-1 BC, period b: AD1 – 300, period c: AD 300-750, period d: AD 750-1150. Red=hulled barley, green=naked barley, blue= rye. Source: Robinson et al 2009.
Figure 4.2. Distribution of the dominant cereals on sites in southern Sweden during the Iron Age. Period I: c. 600-100 BC, period II: c. 200 BC-AD 200, period III: c. AD 100-500, period IV: c. AD 400-800, period V: c. AD 700-1100. Striped white = oat, grey = naked barley, white = hulled barley, black = rye. Source: article 1, Grabowski 2011.
4.3. Main problems and discussions in current research

The cereal cultivation history outlined above shows clearly that numerous changes occurred over the course of the Iron Age. In some areas, such as Jutland, Scania and Halland, the chronologies of these changes are well known and we can convincingly speak of when and where different developments took place. One could, however, argue that the causes and specifics of each development, i.e. the questions of how and why, are still unknown, but under debate, for each of the observed changes.

Most of the discussions in current archaeobotany are complex, touching upon numerous, interrelated, phenomena both within and beyond the main scope of archaeobotany. It is thus often difficult to discuss an isolated phenomenon in cereal cultivation without addressing them all. One may, however, generalize the developments occurring during the Iron Age as belonging to two main themes, occurring roughly during the early and late Iron Age respectively.

4.3.1. Late Bronze Age and early Iron Age: Changing cereal crops

Based on the composition of archaeobotanical assemblages it is evident that cereal agriculture underwent a significant transformation at the end of the Bronze Age and the beginning of the Iron Age; a transformation which may possibly signify the end of cultivation strategies which had prevailed over the two preceding millennia. The near disappearance of naked barley, spelt and emmer, and the simultaneous increase in hulled barley, is archaeobotanically the most obvious result of this change. In relation to this archaeobotanical observation a reoccurring question is: why were the former crops abandoned, and why was hulled barley introduced on such a wide scale as their replacement?

Clearly a diffusionist perspective does not provide a satisfactory explanation. If availability to hulled barley was the only precondition for its adoption in southern Scandinavia then the change from Neolithic/early Bronze Age agriculture to the one known in the late Bronze Age and early Iron Age would have been more coherent across the region. Furthermore, hulled barley had been present throughout most of the preceding prehistoric periods, but not cultivated on a large scale.

Helbæk (1957) and Hjelmqvist (1979 and 1992) complemented diffusionist perspectives with climatically oriented explanations; stating hulled barley’s resistance to humid conditions as a primary factor. This was proposed on the basis of a then commonly acknowledged climatic deterioration believed to have occurred at the end of the Bronze Age. Indirect effects of climate on naked barley cultivation have also been proposed with reference to its higher susceptibility to insect and parasite infections compared to hulled barley (Buxo i Capdevila et al 1997); pests which could have become more common due to climatic change.

Although an overall decrease in temperatures and a shift to more humid weather is currently acknowledged as starting at the end of the Bronze Age, its effects on the development of late Bronze Age and early Iron Age societies and agriculture in southern Scandinavia is still debated (e.g. Berghund 2003, de Jong and Lagerås 2011, van Geel et al 1996, Welinder 2004, Widgren 2005 and 2012). Climate change as a primary cause for changing agriculture may also be questioned on the basis of the asynchrony in cereal cultivation developments in different parts of the southern Scandinavian region. In some areas of Denmark, for example, the breakthrough of hulled barley does not occur until the beginning of the Roman Iron Age, placing it at the start of a period with increasing temperatures during the Roman warm period.

In the context of this discussion, one may thus agree with Widgren’s (2012) argument that climate change should not be seen as a simple causal factor for social change, and his assessment that the specifics of the climatic developments in the middle 1st millennium BC, or their effects on the communities of southern Scandinavia are yet insufficiently understood.

An alternative explanation for the breakthrough in hulled barley, one combining climatic causation with functionality, is Engelmark’s (1992 and 1998) model, where late Bronze Age/early
Iron Age changes are connected to the beginnings of manuring and the emergence of cultivation on fields used more permanently than during the previous periods. In short, Engelmark’s model states that the appearance of hulled barley and the introduction of manuring are interconnected. Hulled barley is argued to have a greater requirement for easily soluble nutrients (especially nitrogen), in order to produce acceptable yields (Engelmark 1992:372), and the suitability of its straw as animal fodder is seen as additional incentive within a system relying on animals for its supply of fertilizer. Measured archaeological evidence in support of this model are an observed increase in manure indicating, nitrophilous weeds in archaeobotanical assemblages, which in Sweden coincides with the increase of hulled barley, and a contemporaneity between the introduction of hulled barley and byre indicating evidence in the settlement-archaeological record.

Arguments against the above model reason that the identification of byres and other stabling indicators in the settlement archaeological record is still an active and unresolved topic, that the susceptibility of hulled and naked barley to manuring is not sufficiently understood and documented, and that the increase in nitrophilous weeds may reflect a change in harvesting and/or processing techniques, or even their use as a food resource, rather than the introduction of manuring (Lagerås and Regnell 1999, Peterson 2006, Regnell and Sjögren 2006, Robinson 2003, Skoglund 1999).

The most significant argument is, perhaps, that naked barley, spelt and emmer are apparently still in cultivation in some areas centuries after the introduction of manuring is indicated by other sources, for example in Jutland, where naked barley, spelt and emmer are still prevalent during the early Iron Age (Robinson et al 2009) while longhouses with clear traces of byres, indicating collection of manure, occur already from the beginning of the Bronze Age (Ethelberg et al 2000, Rasmussen 1999).

Engelmark’s model, which relies on an archaeobotanically measured increase in nitrophilous weeds during late Bronze Age as support for the main argument, has recently also been indirectly questioned by a scepticism of some researchers about whether weed-ecological approaches can attain sufficient resolution to address issues such as the introduction of manuring. An alternative approach, relying on measurement of δ¹⁵N-isotope values in prehistoric grains has instead been suggested as a viable alternative (Bogaard et al 2013, Kanstrup et al 2012, Kanstrup 2013).

In Denmark, a recent PhD project by Marie Kanstrup (2013, Kanstrup et al 2012) has analysed the isotopic signature of 72 carbonised grains from 38 sites distributed chronologically from the 4th to the 1st millennium AD. The results showed that most of the samples which clearly displayed evidence of manuring belonged to the latter part of the investigated time span, i.e. 500-1 BC. The result could thus indicate a breakthrough, or at least intensification, in manuring during this period; a result which corresponds with Engelmark’s model of a late Bronze Age/early Iron Age introduction. However, few of the earlier Neolithic and Bronze Age samples had shown no signs of manuring at all. This result was cautiously interpreted by Kanstrup as possibly indicating that some forms of manuring may have been practiced already during the Neolithic and the Bronze Age, proposing mixed cultivation on manured plots as well as on slash and burn-cleared fields as plausible explanation for the greater variation observed in the earlier samples. The indication that some form of manuring may have been practiced long before the breakthrough of hulled barley thus lends some support to the critique of manuring as a causal factor behind the late Bronze Age/early Iron Age transformation.

Kanstrup (2013) concluded the thesis in which the project was presented with words of caution; calling for further methodological studies and analysis of more cereal grains from a larger

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5 Engelmark’s model was developed within the framework of a multidisciplinary project termed The cultural landscape during 6000 years, or more commonly cited as “The Ystad Project”. In this project changing house designs during periods II and III of the Bronze Age (1500-1100 BC) were interpreted as signifying the advent of animal stabling and collection of manure, and subsequently connected to Engelmark’s archaeobotanical data (Tesch 1991, see also discussion in Lagerås and Regnell 1999)
number of sites. Although this caution is undoubtedly well-founded, and much development remains to be achieved, the new technique may hold the potential of addressing one of the more contested issues in current research on prehistoric cereal agriculture (Bogaard et al 2013, Kanstrup 2013).

Another causal factor discussed in relation to the introduction of hulled barley is that the advent of more efficient iron tools could explain the shift from naked to hulled barley since the grains of the former crop can be lost if harvested too forcefully (Mikkelsen and Nørbach 2003, Viklund 2005). A problem with this explanation is that the new iron harvesting tools, which began appearing at the end of the Bronze Age, were initially comparatively small and not fundamentally different from the flint and bronze tools which had preceded them. Experiments have also shown that a single person can harvest more or less the same area (400m²) per day with both a bronze sickle and the early iron sickles which succeeded them (Pedersen and Widgren 2004:360). Furthermore, a change in harvesting technology does not account for the decrease of the hulled wheat species which coincided with the decrease of naked barley, as these crops display harvesting characteristics similar to hulled barley.

The appearance of short scythes is dated to around 1 BC/AD, followed by a gradual development of harvesting tools which concluded in the Viking Age with a selection of harvesting implements very similar to those used in historical times. The earliest scythes are however interpreted as used primarily for hay harvest. Although their effects on the efficiency of fodder collection, and thus the capacity to feed more manure generating animals, was probably significant for cereal cultivation, the direct effects on the functionality of crop gathering was presumably limited. Longer scythes, which may also have been utilised for harvesting of both hay and cereals, appeared only at the shift between the Viking Age and the early medieval period (Hedeager and Kristiansen 1988, Myrdal 1982, Pedersen and Widgren 2004, Viklund 2009).

Another proposed incentive for the introduction of hulled barley, related to the fact that hulled barley grains stay more firmly attached to the spikes/spikelets after ripening, is that its cultivation would have allowed for a greater flexibility in the timing of the harvest and/or the subsequent transport from the fields to the settlement without risking a loss of grains (Mikkelsen and Nørbach 2003). This cause for a change of crops may however be impossible to substantiate on archaeological grounds.

Active human choices, unrelated to any push-pull factors, provide additional models of explanation, and have in relation to the late Bronze Age/early Iron Age-transformation been discussed in terms of changing food habits. Skoglund (1999), for example, has suggested that the introduction of hulled barley could have been prompted by a shift from a bread oriented diet to one where crushed grain paste was used in the preparation of fat-rich dishes. This change in diet is furthermore proposed to be connected to the introduction of cremation as the main burial custom in the region at the transition from the Bronze to the Iron Age, and the crushing of grains for food rather than grinding them into flour proposed to be a reflection of the treatment of the dead and “a way of conceptualising the world, using daily-life concepts while thinking of religious matters” (Skoglund 1999:158).

The increase in weeds, particularly the nitrophilous Chenopodium genus, in the archaeobotanical material is also discussed by Skoglund, who argues that it reflects the beginning of their use as a food resource rather than solely reflecting functional changes in cultivation and harvesting methods (Skoglund 1999:159). The weed data is proposed to support the dietary change at the end of the Bronze Age and beginning of the Iron Age also signified by the shift to hulled barley cultivation. Behre (2008) who recently presented a study of weed seeds as a food resource, among them seeds of Chenopodium species, also concluded that they had probably been actively collected and maybe even tended or cultivated during prehistory. Behre used strict criteria for classifying weed species as a food resource; the criteria in this case being presence of large and clean storage finds coupled with their occurrence in bog bodies. Skoglund’s assessment in comparison lacks an in-depth discussion about the depositional context of the present-
ed weed finds, resulting in an unconvincing argument where archaeobotanical data is used selectively to support the main argument of a culinary change connected to changing cosmological concepts in the society as a whole.

Lastly, a possible incentive for the introduction of hulled barley, also connected to culinary habits of the population, has been discussed as a growing desire for beer (Pedersen and Widgren 2004, Viklund 2009). That hulled barley was used for beer brewing during the Iron Age has been confirmed by finds of carbonised hulled barley malt, both in Sweden and elsewhere in Europe (e.g., Stika 2011, Viklund 2011). Archaeobotanical finds of brewing products are however sparse, and the currently available material can hardly be used to assess its significance during different periods.

4.3.1.1. Land use practices during the late Bronze Age and early Iron Age

Although the causal link between the disappearance of spelt, emmer and naked barley, the introduction of hulled barley, and the advent of manuring as outlined by Engelmark (1992) has been questioned – often accompanied by arguments for an earlier manure introduction (Kanstrup 2012 and 2013, Lagerås and Regnell 1999, Regnell and Sjögren 2006, Robinson 2003) – the general outline of the probable mode of cultivation during the late Bronze Age and early Iron Age has found more general acceptance.

Scandinavian agriculture, after the introduction of manuring, probably relied on the so-called permanent field-system in which fields are repeatedly manured in order to replace depleted nutrients, allowing for a longer continuity in cultivation than on unmanured fields. These “permanent” fields could not, however, be maintained indefinitely, due to yearly increasing problems with arable weeds and possibly insect pests (Engelmark 1992, Liversage et al 1987). This type of cultivation therefore probably slowly migrated, since no longer productive fields would have been put to fallow after longer periods of cultivation. Suggested cycles are one or more decades of cultivation followed by one to three decades of fallow (Engelmark 1992, Lagerås and Bartholin 2003, Lang 2007).

Besides preserved plant remains, physical traces of prehistoric fields are possibly the most direct evidence of cereal cultivation practices in the archaeological record of southern Scandinavia. For the late Bronze Age and early Iron Age two main types of fossil field systems have thus
far been recognised: 1) the so called *Celtic fields*, occurring in Denmark, Scania and on the island of Gotland in the Baltic, and 2) *stone clearance systems*, found in Halland and the inland of southern Sweden (Hatt 1949, Lagerås and Bartholin 2003, Nielsen 1984, Widgren 1997 and 2010).

The Celtic fields are generally interpreted as used between 800 BC and AD 200\(^6\), while the stone clearance systems have provided dates ranging from late Bronze Age to late Iron Age. Thus, although the clearance cairn systems in Sweden appear to have been in use longer, the two types of fossil fields are at least partially contemporaneous (Hedeager and Kristiansen 1988, Holst 2010: 168, Lagerås and Bartholin 2003, Widgren 1997 and 2010).

The large size of both some of the Celtic field and stone clearance systems has led numerous researchers to conclude that all plots were unlikely to have been in use at the same time. This has prompted a discussion of whether these systems were used extensively, for unmanured cultivation, or more intensively in the form of a slowly migrating, manured, cultivation as outlined by Engelmark (Engelmark 1992, Widgren 1997). In both cases there is now evidence for the latter possibility being more probable. In Denmark, Celtic field plots analysed with a combination of archaeological, pedological and micromorphological techniques show evidence of cultivation for one or two generations followed by extended fallow (Liversage et al 1987), while in Sweden extensive \(^{14}C\) analyses of charcoal fragments recovered from clearance cairns at Hamnedå in Småland indicate clearance cycles of approximately one to two decades (Lagerås and Bartholin 2003).

An additional trait observed in Celtic field systems which may shed some light on the practice of crop cultivation is that the individual plots often show evidence of secondary and tertiary subdivisions. This partitioning of plots has commonly been discussed in terms of land rights and inheritance (Hatt 1937 and 1949, Hedeager and Kristiansen 1988, Holst 2010). It is however possible that the current morphology of the Celtic field systems also reflects functional aspects of the mode of cultivation outlined above (cf. discussion in Lang 2007:96ff). Since it is increasingly assumed that not all plots were cultivated at the same time, the majority being in fallow and possibly used as pastures, the extensive patchwork pattern of some of these systems could reflect a slow back-and-forth movement of permanent field cultivation, while the subdivision of the fields could reflect sub-plots used for secondary crops such as flax, gold-of-pleasure and wheat.

\(^6\) Note, however, that Webley (2008) argues for an earlier phasing out of the Celtic fields, around 250 BC, while Nielsen (1984) argues for an establishment of these systems in western Denmark around 1200 BC, with a shift to more organised and extensive systems occurring around 500-300 BC.
4.3.2. Middle and late Iron Age: The introduction and development of rye cultivation

The second major issue in current archaeobotany is connected to the appearance of rye in southern Scandinavian Iron Age agriculture. The true breakthrough of rye across southern Scandinavia occurred, as seen in the overview above (figures 4.1 and 4.2), during the latter part of the Iron Age. We know with a degree of certainty that it was commonly cultivated together with barley in various types of crop rotation systems already at the beginning of the medieval period. In these rotation types of cultivation rye was commonly grown as an autumn sown crop while barley was sown in the spring (Engelmark 1992, Mikkelsen and Nørbach 2003, Pedersen and Widgren 2004: 385ff). The advantages of crop rotation compared to the early Iron Age permanent field cultivation outlined by Engelmark (1992) are obvious. Cultivation of the less nutrient demanding rye alongside barley would have decreased the need for manure, while retaining comparable grain yields. Regular shifts in seasonality of sowing and tilling would furthermore have disrupted weed infestations in the fields and allowed for longer continuous cultivation than on fields repeatedly cultivated with a single crop (Engelmark 1992, Mikkelsen and Nørbach 2003, Robinson et al 2009).

The timing and circumstances of rye’s adaptation as an autumn sown crop in rotation systems is an important question in archaeobotanical Iron Age research. Retrogressive reasoning makes probable that some of the late Iron Age finds where rye and barley appear in equal quantities represent crop-rotation. This supposition is further supported by the appearance of weeds indicating autumn sowing, such as Agrostemma githago during the late Iron Age and Centaurea cyanus at the shift from late Iron Age to early medieval (Engelmark 1992, Robinson 1994b, Viklund 1998, article 1).

Secure finds of crop-rotation indications, i.e. comparable ratios of rye and hulled barley coupled with finds of weeds indicative of autumn sowing, occur, however, only at the very end of the Iron Age, while rye is present in archaeobotanical assemblages in notable quantities already from the Roman Period.
Little evidence is currently available about the specifics of early rye cultivation, although there seems to be a consensus that rye, contrary to most other cereals, was acculturated locally in northern Europe rather than introduced from elsewhere in Eurasia. Its ability to grow as a weed in other cereals furthermore makes the exact timing of its initial adoption as a cultivated crop less clear than for most other cereals (Behre 1992, Engelmark 1992, Mikkelsen and Nørbach 2003, Robinson et al 2003).

Behre (1992) has proposed the ability of weed-rye to thrive on poor soils as the main reason for its eventual acculturation by north European farmers. The reasoning is that weed-rye would over time have become increasingly numerous on fields with properties better suited to it than other crops, and eventually prompted the farmers to take it into cultivation. A functional component in Behre’s reasoning is that the increasingly efficient iron sickles, developed over the course of the Iron Age, coupled with a change of harvesting technique from picking of the ears only to harvesting close to the ground would also have made weed-rye more difficult to separate from other species even if the farmers wanted to. The initial introduction of rye cultivation in southern Scandinavia is by Behre proposed during the 5th century AD. A subsequent expansion, interpreted on the basis of pollen data, is proposed to have occurred during the 8th century AD onward. The latter event is also interpreted as the most likely timing of the introduction of rye in crop rotation agriculture alongside hulled barley.

Engelmark (1992) also argues for a later autumn-rye introduction based on cereal and weed data from southern Sweden, although he also suggests that rye could at the outset have been utilised as a component in the slowly migrating permanent field agriculture described above; for example on fields which were about to be abandoned after extended barley cultivation.

Contrasting Behre’s and Engelmark’s assessment of autumn sown rye as a late Iron Age phenomenon is Mikkelsen’s (Mikkelsen and Nørbach 2003, Robinson et al 2009) interpretation of cereal finds in iron-extraction furnaces from Roman Iron Age Jutland. Statistical analyses performed on furnaces containing pure barley and rye assemblages showed significant differences in the composition of weed accompanying each crop, and the result was by Mikkelsen interpreted to reflect autumn sowing of the latter.

A subsequent study by Henriksen (2003), also performed on material from iron-extraction furnaces, dated to the transition from Roman to Germanic Iron age, has similarly interpreted identified rye as autumn sown, supporting Mikkelsen’s hypothesis of an earlier introduction in the Roman Iron Age.

A functional aspect cited in relation to the above discussion is a connection between autumn rye and the introduction of the mouldboard plough. These ploughs were, contrary to the ards used throughout most of the Iron Age, fitted with asymmetric shares which turn the soil in order to bring nutrients to the surface. The process also contributes to increased drainage of the fields, an effect which has been suggested as a prerequisite for cultivating autumn sown crops which would otherwise run the risk of frost damage on poorly drained soils. Because the mouldboard plough is commonly interpreted as appearing in southern Scandinavia during the Viking Age, the argument has been proposed in favour of autumn rye being a late Iron Age occurrence (Porsmose 1979; cited in Mikkelsen and Nørbach 2003: 127). Mikkelsen does however argue that this reasoning may be true for heavier, clayey soils, such as those occurring in eastern Denmark and east-central Jutland, but not for southern Jutland where the soils are predominantly sandy and naturally well-draining (Mikkelsen and Nørbach 2003:217f).

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7 In some cases the pits of iron extraction furnaces were filled with un-threshed cereals uprooted from nearby fields in order to support the bog ore and charcoal during the smelting process. Occasionally this material was carbonised in well preserved states. This has allowed for archaeobotanical analysis of a material which has not been modified by the cereal handling, depositional or post-depositional processes which make the interpretation of most botanical assemblages problematic. Because the iron extraction furnaces were single-use constructions the material may on occasion also be reliably interpreted as representing single events rather than mixing from processes occurring over extended periods of time (Mikkelsen and Nørbach 2003, see also discussion in article 3).
Another complication in this discussion is new evidence suggesting that the mouldboard plough may have been introduced in Denmark already during the Roman Iron Age (Larsen 2011).

4.3.2.1. Land use practices and settlement patterns during the middle and late Iron Age

The discussions in settlement and landscape archaeology have a long history in southern Scandinavia, with a correspondingly large volume of published literature. The entire chapter 4.3.2.1 relies therefore on some of the more recent syntheses of current research (Berglund et al 2002, Björhem 2003, Fabech and Ringtved 2009, Hedeager and Kristiansen 1988, Näsman 2009, Pedersen and Widgren 2004, Webley 2008, Widgren 1997 and 2010), with direct references listed for more specific statements.

Two major and probably related developments discussed as occurring during the Iron Age in southern Scandinavia are: 1) the emergence of land use along infield-outfield principles, and 2) the nucleation and spatial consolidation of settlements.

In its most basic definition the **infield** may be described as an intensively used space, commonly adjacent to the main habitation, dedicated primarily to cultivation and possibly fodder production on meadows. The **outfield** may be defined as an area used more extensively, in a region like Scandinavia primarily for the collection of fodder from wetland and woodland biotopes, grazing, and for gathering of forest resources such as wood and wild plants (Christiansen 1978, Fabech and Ringtved 2009, Näsman 2009).

A trait of the infield-outfield systems known from historical times in much of Sweden and Denmark is that the siting of the infield was more or less fixed. Thus, although one may assume that the slowly migrating permanent field cultivation of the late Bronze Age and early Iron Age was also organised according to approximate infield-outfield principles, with arable fields located adjacent to the farmsteads and grazing and fodder collection occurring further afield, possibly to some extent on former arable plots lying in fallow, there is a qualitative difference between the presumed land-use of the early Iron Age and that of the “proper” infield-outfield systems of the medieval and post-medieval periods. The former was a slowly migrating, continuously changeable utilisation of available land, while the latter represents a land-use organisation which may have remained fundamentally unchanged in a given place over periods spanning numerous generations.

The fact that properly established infield-outfields have been documented in parts of southern Scandinavia already at the beginning of the medieval period indicates that this form of land-use must have developed and become established sometime during the Iron Age. The suggested time frames for this development vary from the Roman Iron Age to the Viking period, corresponding with observed local trajectories in the different regions, and also to some extent due to the somewhat loose definition of the infield-outfield concept in archaeological literature.

It is important to highlight that proper infields-outfields were not introduced everywhere in southern Scandinavia. Although dominating in regions such as Zealand and Scania, spatially more flexible forms of land use persisted in some areas into the medieval and later historical periods (Liversage et al 1987, Widgren 1997).
The earliest Iron Age in southern Scandinavia is characterised by habitation consisting of comparatively small farmsteads, either independent or clustered in small villages. These settlements furthermore appear to have been comparatively mobile, changing location at regular intervals, perhaps in connection with generation shifts and the foundation of new households. Overall the settlement pattern of the early Iron Age corresponds well with the model of slowly migrating permanent field cultivation inferred for this period.

The above tradition is commonly discussed as changing during the 2nd century AD in both Denmark and Sweden, when the individual farms became larger and concentrated in fewer but more sizable villages. Although more consolidated than previously, archaeological evidence indicates that settlements were still somewhat mobile, regularly shifting location within their resource uptake area.

At the end of the Roman Iron Age and during the early Germanic/Migration Period many of the settlements which had been established during the preceding periods were abandoned. This coincides with a regrowth of forests in many parts of southern Scandinavia as interpreted on the basis of palynological data (Berglund et al 2002, Hedeager and Kristiansen 1988, Pedersen and Widgren 2004). These developments have been discussed by archaeologists as possibly indicating a period of stagnation or even recession in population and settlement growth; an event termed as the migration period crisis (Näsman and Lund eds. 1988). Increasingly, however, the discussion about changing settlement patterns during the middle 1st millennium AD has shifted from a crisis explanation to one discussing further consolidation of previously dispersed settlements to fewer villages, and the emergence of more defined infields, focusing the settlements to smaller but more intensively used clusters. The partial regrowth of forests is seen in light of an intensification and consolidation of agriculture on the best soils, which allowed for a regeneration of forests in less extensively used outfields.

The later Iron Age, from the 7th century AD onward, is characterised by further consolidation of settlements. Villages became increasingly larger and situated at the locations of historically known settlements. This period also saw the advent of early Scandinavian towns, such as Hedeby and Ribe.

Similarly to the introduction of infields-outfields it is important to highlight that the here described developments in settlement structure are generalisations, and that the processes which

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8 Note, however, that some researchers, for example Webley (2008), have illustrated that the nucleation of settlement may at least in parts of Jutland have commenced already during the late pre-Roman Iron Age.
led to the formation of the historically known villages and towns were intrinsically complex. The single farm, which was common during the early Iron Age, for example, never disappeared from the Danish and southern Swedish landscapes, but rather appears through most periods, presumably filling somewhat different social roles during each period. Layouts of settlements, their transformations over time, or the lack thereof, furthermore show significant diversity in the archaeological record. This complexity must be taken into account when settlement archaeological data is considered during the interpretation of archaeobotanical phenomena.

From historical sources we know with some degree of certainty that the fields of the late Viking Age and Medieval Periods were subject to complex regulation with regards to use and inheritance, and with significant local variation (Myrdal 1999, Widgren 1997). One important development with probable roots in either the late Iron Age or the early medieval period is a shift towards more collective forms of land management within the framework of the now spatially consolidated and increasingly large and numerous villages; manifested by collective organisation of enclosures and land allotment. These organisational forms may have causal connections to functional demands of performing crop cultivation in increasingly complex forms of rotation systems, and an increasing intricacy of balancing the crop cultivation component to that of animal husbandry (Myrdal 1996).

Much less information is available about land use of the middle Iron Age. Previous research has often stated a hiatus, or at least a scarcity, in the fossil field record in large parts of southern Scandinavia between the phasing out of the Celtic fields of the late Bronze Age and pre-Roman Iron Age and the land use forms known from historical periods. This particularly applies to Scania and Denmark (Holst 2010:160, Webley 2008:42, Widgren 1997), areas which have produced most of the archaeobotanical finds.

Through detailed studies of stratigraphies and relationships of settlement features at the site of Nørre Snede in Jutland, Holst (2010) has however observed that what has been documented as a large area overlain with numerous settlement phases represents the ongoing relocation of a few farmsteads within a delineated space. Throughout this relocation process each new farmstead appears to have been placed in accordance to a predetermined plot structure, which Holst interprets as corresponding to an underlying modular field system; i.e. each newly constructed farmstead, with its longhouse, outbuildings and ancillary features, was slotted into a former arable field, while abandoned farmstead plots reverted to fields. Similar patterns are argued by Holst to also be identifiable on other contemporaneous Danish sites, such as Vorbasse.

The interpreted fields furthermore seem to display similarities in size and shape to the Celtic fields of the preceding periods, the main difference being stated as a lack of evidence for secondary division of the fields, and generally more uniform sizes of the middle Iron Age plots compared to the Celtic fields. Both observations are interpreted as possibly indicating a less dynamic system of land use and regulation. Collectively the observations made by Holst at Nørre Snede and other sites are interpreted by Holst from the perspective of land allocation and inheritance systems.

This research is in its early stages, but a fuller understanding of how this possible land division system operated could be of great value to interpretation of archaeobotanical assemblages. Because the plot structures mapped out by Holst occur from the 3rd to the 7th century AD, both their advent and eventual transformation into later forms of land regulation coincide with changes in cereal cultivation proposed by some researchers. The 2nd century AD, for example, is the period when hulled barley assumes the role as the dominating cereal throughout Denmark. Thus, Holst’s proposed decrease in land regulation dynamics could also have connections to a decreased dynamic of cereal agriculture due to a shift towards fewer cultivated species. The transformation of this presumed field system into forms known from Viking Age onwards also corresponds with changes in cereal cultivation, particularly the appearance in the botanical record of secure evidence for autumn rye and crop rotation (Behre 1992, Engelmark 1992).
Figure 4.6. Complete excavation plan of Nørre Snede with all identified structures. Note that the overlapping phases of habitation appear to adhere to an underlying sub-rectangular spatial pattern, interpreted by Holst (2010) as reflecting the field system surrounding the settlement. Source: figure courtesy of Mads Holst, Aarhus University and Moesgård Museum, previously published in Holst 2010.
Figure 4.7. General overview of land use and settlement developments in southern Sweden. Source: reproduced and translated from Berglund et al (2002:172), figure courtesy of Per Lagerås, UV-Syd, Lund.
5. Theory and method

5.1. Complexity of the carbonised archaeobotanical material

As mentioned in the introduction of the archaeobotanical method in chapter 2, plant macrofossil analysis may be perceived as an investigative method with a relatively straightforward practical procedure, but many complex interpretative aspects.

In short the interpretative complexity inherent to studies of archaeobotanical materials may be summarised as stemming from a source material which has been modified by: 1) human handling, 2) variable preservation conditions, 3) depositional processes, 4) variations in post-depositional disturbance and 5) archaeological extraction techniques and strategies (cf. e.g. Dincauze 2000, Hillman 1984, Miksicek 1987, Schiffer 2010, van der Veen 2007).

A fundamental concept in archaeological research is that differences in past events and processes, such as different types of carbonising conditions or variable exposure to mechanical damage, can create biases in source materials which at the outset may have been similar. Similarly the concept of biases resulting either from secondary depositions and re-depositions unrelated to the phenomena under study, or of uneven, random or selective archaeological extraction is always acknowledged by archaeologists. These transforms apply, although in somewhat different ways and degrees, to all archaeological material, and their assessment has a given place in all types of archaeological projects.

The fact that archaeological material created by human handling may include not only the end results but also any stage from a raw material to a finished product, is also an acknowledged phenomenon by most archaeologists working with material culture. This concept is commonly summarised under the term of chaîne opératoire, or operational sequence (Schlanger 2005). Entire operational sequences may furthermore be seen as a component of the C transform (cultural, as opposed to N [natural] transform) concept outlined by Schiffer (1976); a broader notion which also includes anthropogenic modifications of the material unrelated to its production and/or processing.

Although one may question the correctness or necessity of Schiffer’s categorisation of transforms along binary nature-culture lines, the C and N transform concept is still among the most comprehensive for discussing modifications of material culture; encompassing in its definition formational, taphonomic and archaeological extraction biases. For this reason, and because the concepts are presumably familiar to the majority of potential readers, the transform concept is used repeatedly throughout the thesis and articles.

Although the basic concepts for understanding the complexity of the archaeobotanical record are similar to most other archaeological material, in practice the study of plant remains, and particularly their operational aspects, requires numerous considerations and strategies developed specifically for a plant based source material.
Figure 5.1. A schematic model of the life-history of a carbonised archaeobotanical material. At each of the points where the material proceeds from one stage to the next (arrows) there is a probability for modification of the assemblage and for spatial displacement.

5.2. Archaeobotany and inference of crop processing

On the basis of ethnographic studies of “archaic agrarian systems surviving in the present-day”, Gordon Hillman (1984:1) assessed that most crops known from prehistory require up to thirty distinct operations during processing into an edible product.

At each of these stages the material is modified as different plant species, which occur together in the fields, are sorted, or as different parts of a specific plant are separated. Preservation can occur at numerous stages during this process, although the probability of a material becoming preserved varies from stage to stage.

Drawing on the experiences of ethnographic studies Hillman and other researchers working with present-day observations of crop processing among traditional agrarian communities (e.g.,
Jones 1984) have proposed ethnographically based models for interpreting archaeobotanical assemblages in the past. The general theory underlying such models is that:

*Samples of charred remains of crops from archaeological sites commonly exhibit a composition closely similar to that observed in one or other [...] present-day crop product. By reference to modern equivalents, therefore, archaeological samples can produce valuable clues to the husbandry practices of prehistory (Hillman 1984:1).*

These ethnographic approaches may be described as working from the perspective of the present to explore variation in the past. The strategy sets out with a model of a coherent operational whole and thereafter attempts to fit the fragmented past material into its correct place in the operational sequence. But as Hillman himself stressed (1984:7), ethnographic models rely on a degree of uniformity in cereal handling over time and across space, a uniformity which cannot be assumed for all periods and geographic locations.

An alternative approach, initially coherently outlined by Dennell (1972, 1974 and 1976), which does not rely on uniformitarian assumptions, is that inference of crop handling may be attained by a detailed mapping of the compositions of individual archaeobotanical samples on a given site, followed by a subsequent comparison of the observed variation to the presumed functionality of the features or site spaces from which the samples were extracted. This type of strategy is the opposite of the ethnographic approach, utilising the fragmented material record of the past as a basis for reconstructing a once coherent whole. Because there is no known data to which the archaeobotanical material can be directly compared, this approach relies to a high degree on correct interpretation of the non-botanical segment of a site’s archaeological record.

The main strength of this approach is that it is more universally viable since the specific archaeological record in any given area functions as the starting point for reconstruction of plant handling. The drawback of this type of procedure is that interpretation of cereal processing sequences becomes based on speculation and “common sense” assumptions of the interpreting researcher to a larger extent than in the ethnographic approach.

In order to alleviate the uncertainties of this approach Dennell (1972) proposed that the handling processes inferred from the combination of archaeological and archaeobotanical observations should be re-enacted as experiments, and that the outcomes of the tests should be compared to the prehistoric record.

### 5.1.3. Archaeobotanical inference of crop processing in southern Scandinavia

An issue of archaeobotanical research on cereal cultivation in southern Scandinavia is the lack of relevant ethnographic data. Research strategies have therefore predominantly utilised an approach where interpretation is primarily achieved by assessment of the observed variation in prehistoric assemblages, as proposed by Dennell, and supported by comparisons to other types of material culture, experiments, references to historical accounts from the region, and ethnographic data from other parts of the world (e.g. Henriksen and Robinson 1996b, Jensen and Andreasen 2011, Mikkelsen and Nørbach 2003, Regnell 2002, Viklund 1998).

In Denmark much of the theory underlying this work, as well as some supporting experiments, have been performed by researchers at the National Museum of Copenhagen (e.g. Henriksen 1995, Henriksen and Robinson 1996a and 1996b). A specific trait of Danish archaeobotany, which may possibly be a result of the nature of the available botanical material, is a focus on a select number of exceptionally well preserved materials. These studies form a framework in which most other analysis and discussion is undertaken. Examples of this are Henriksen’s and Robinson’s (1996b) analyses of storage finds from the late pre Roman Iron Age site of Overbygård and Mikkelsen’s and Henriksen’s analyses of well-preserved assemblages carbonised inside Roman Iron Age/early Germanic Iron Age iron extraction furnaces (Henriksen 2003, Mikkelsen and Nørbach 2003).
In Sweden, for as yet unknown reasons, few large and operationally/transformationally clearly defined finds have been published for the Iron Age. This has prompted Swedish archaeobotanists to focus on elucidating the significance and methodological complexity of smaller assemblages from settlement contexts to a larger extent than in Denmark. Most of the underlying theoretical work has been performed at the Environmental Archaeology Laboratory in Umeå; a research program which may be traced in a progression of publications dealing with analysis (Engelmark 1981, 1985 and 1989), supporting experiments (Gustafsson 2000, Viklund 1998), and interpretation of analysed material (Engelmark 1992, Gustafsson 1995, Viklund 1998 and 2004). The most comprehensive publication published to date on the role and practice of archaeobotany in Swedish cereal cultivation research, is Viklund’s thesis from 1998. In this publication the primary source material is extensively compared to experimental work and pseudo-ethnographic data based on historical and recent ethnobotanical accounts from the area of present day Sweden.

From the distinctly Danish perspective Henriksen and Robinson (e.g. 1996b and Henriksen 2003) have in several publications stressed that the most valuable source of archaeobotanical information on cereal cultivation is to be obtained from large storage finds of harvested but not further processed cereals; although they also conclude that such material is rare even in Denmark and suggest that finds of refuse assemblages from pits and “cultural” layers may provide an additional complement. While this conclusion is probably correct, one could argue that we should not discount other types of material too early.

5.1.4. Previously inferred crop processing during southern Scandinavian Iron Age

It is probable that crop processing dynamics in the southern Scandinavian Iron Age were just as complex as those observed by Hillman, Jones and others in modern ethnographic records. It is also probable that the archaeobotanical record may never be understood in sufficient detail to account for the full complexity of past cereal operation. Thus, most archaeobotanical researchers in southern Scandinavia today, discuss cereal operation within a framework of a simplified four stage model (Henriksen and Robinson 1996a, Mikkelsen and Nørbach 2003, Viklund 1998):

1) Harvest: The harvesting technique, for example plucking by hand, uprooting or harvest by sickle - either just of the ears or close to the ground to bring in the straw - have by experimentation been acknowledged to result in variable collected assemblages.

2) Threshing: During threshing the straw (if harvested) is removed from the ears. Ears and spikelets are shattered, chaff is sometimes loosened from the grains, and some chaff, awns, weed seeds and cereal grains may be sorted out at this stage.

3) Cleaning: (including flinging, pouring, winnowing and sieving; methods observed historically in different constellations, but not always including all techniques). During this stage most awns, the remaining straw and most of the chaff and weeds are sorted out. Some cereal grains may also (inadvertently) be sorted out during this stage.

4) Storage: As a result of the previous stages stored, cleaned, assemblages retain most of the cereal grains and some remaining weeds. Stored grain may be further fine sieved or hand sorted prior to final preparation and consumption. Note that partially cleaned grain may also be stored.
Figure 5.2. Possible operational sequence of cereal processing during the Iron Age in southern Scandinavia (above), and simplified operational model of cereal processing illustrating the expected movement and separation of plant components (below). Source for upper image: redrawn after Viklund 1998:35 by Sofia Lindholm.

Figure 5.3. The basic morphology of a cereal plant (in this example barley, *Hordeum vulgare*), showing a close-up of the ear. Source: left part of the illustration modified from www.biolib.de under the CC-licence, right picture redrawn after Kaussmann and Schiewer 1989.
5.2. Expanding approaches to inference of crop cultivation and processing on southern Scandinavian settlement sites

Dennell’s (1972, 1974 and 1976) approach to inferring operational aspects of carbonised plant assemblages can be summarised as:

1) Analysis of the archaeobotanical assemblages and identification of variation and patterns.
2) Comparison of the identified patterns to other archaeological evidence on the contexts from which the botanical assemblages were retrieved.
3) Interpretation of functional aspects of the features from which the samples were retrieved which may have relevance for inferring the operational/transformational aspects of the therein embedded botanical material.
4) Inference of operational stages of cereal processing and reconstruction of operational sequences (and also assessment of non-operational transforms imposed onto the botanical material).

One of the main suppositions of this thesis is that the procedure outlined by Dennell may be adapted to infer information about crop operation and other transforms not only from “ideal” contexts, such as unprocessed storage finds, or assemblages carbonised in iron extraction furnaces directly after uprooting from the fields, but also from more ubiquitous sources available for archaeobotanical sampling.

5.2.1. Main feature categories on southern Scandinavian settlement sites

The vast majority of settlements in Iron Age southern Scandinavia were composed of wooden constructions, commonly erected around frames of supporting posts, with other features necessary for the running of a settlement - such as wells, iron production furnaces, enclosures, et cetera - situated adjacent to the houses.

Due to post-settlement processes such as bioturbation, erosion and ploughing most of these sites are today observed as clusters of pits with depths greater than that of post-settlement disturbance, or deposits of soil and/or other matter with thicknesses that allowed them to survive in an identifiable state. The widely used method of exposing settlements by machine stripping of topsoil contributes to this situation as any ephemeral features surviving in the ground are presumably lost during this process (Streiffert 2001, Webley 2008).

The majority of features excavated on southern Scandinavian Iron Age settlement sites belong to one of three feature categories: postholes, pits and the so called “cultural” layers.

Postholes were created when a hole was dug in order to provide support for a wooden post. Once in place the post was fixed with soil and sometimes stones. This material, consciously deposited in the feature by humans, is termed the primary fill. After the active lifespan of the construction had ended the post would eventually disappear, either by active removal, deterioration or a catastrophic event such as a house fire. In all cases the result would be a small hollow into which soil from the surrounding area would quickly erode and seal the posthole. This material may be termed as the secondary fill. Important for archaeobotanical research and other archaeological studies of material culture, is that over the course of the erosion process any present material adjacent to the post would run the chance of becoming deposited along with the secondary fill. If the posthole was deep enough this material could have remained reasonably protected from succeeding disturbance.

Pits are a broad feature category with formation somewhat similar to postholes. They were always created by human action, for example during extraction of clay, establishment of a well (i.e. the digging of a pit below the water table), digging of pits for storage, et cetera. Because of their size, however, the process of infilling after the primary period of use was probably more
complex than for postholes. This is often reflected in the field in the form of intricate stratigraphies inside pits. The material eroding into pits presumably originated from a larger uptake-area than for postholes, as at least larger pits would have remained unfilled for longer spans of time, allowing for the possibility of larger scale erosion processes to come into play.

Due to their simple and general morphology the functionality of pits is often difficult to determine. This is also further accentuated by the fact that most pits may have performed numerous functions throughout their lifespan. An example of this is that wells, even when identifiable as such by presence of wood or stone lining, almost always seem to contain refuse which presumably either eroded into them after they were abandoned, or was purposely deposited as former wells were reutilised as rubbish dumps.

The term “cultural” layer is commonly used to denote a variety of anthropogenically deposited and/or affected sediments. These are often encountered on sites as layers without a clear cut, with colour and texture diverging from the natural subsoil (C-horizon). They also commonly contain inclusions of various types of material culture such as charcoal, bones, and artefacts. The term “cultural” layer is used for a loosely defined archaeological feature category which, although superficially similar, probably represents a wide range of different formation processes, such as trampling by humans and animals, deposition of waste in yard spaces, soil tilling, et cetera.

Discussions relating to the specifics of postholes, pits and “cultural layers” and their analysis by archaeobotanical and other methods are addressed both explicitly and interwoven in other discussions in articles 2, 3 and 4.

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**Figure 5.4.** Schematic illustration showing the formation of a sampled posthole (d). Once the post (a) is removed surrounding floor/yard layers erode into the posthole, forming the secondary fill, also commonly termed as “the post trace” (b). If the posthole is sufficiently deep it may survive subsequent disturbances such as bioturbation and ploughing, and be identified and sampled by archaeologists (d).

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5.2.2. Main problems of archaeobotanical inference on settlement sites from southern Scandinavian Iron Age

Postholes, pits and “cultural” layers are such general phenomena that they may reflect a broad range of prehistoric activities. Consequently, the identification and delineation of their functional aspects for the purpose of elucidating the operational stages and transformational processes of the plant remains embedded in them requires a deeper analysis than just documentation of
basic morphology and spatial distribution. This can be illustrated by the most common type of feature, the posthole.

Postholes in their own right give no indication of function. By assessment of the relationships between individual features, a posthole may be interpreted as belonging to a construction. However, the identification of a coherent construction does not provide any more functional evidence than the individual posthole. Only by assessment of accompanying material culture - such as presence or absence of pottery, distribution of tools, or identification of structural traces which convey more information than the individual posthole - or by analysis with a suitable natural scientific method, may space functions be identified.

With each increase in the detail of the overall functional interpretation, the assessment of any therein embedded archaeobotanical material becomes easier. Historically, archaeobotanical material has however also been used as a major component in functional analyses. Such utilisation of archaeobotanical data is mostly performed by reference to previous interpretations of similar contexts. Thus the use of archaeobotanical material, which needs a functional context to be properly understood, is often itself used to provide that very same context; a problematic situation which may result in circular reasoning.

A related problem, rarely discussed but not uncommon in relation to archaeobotanical investigations, is that botanical evidence is used to support tricky functional interpretations based on other data while still being insufficiently contextualised (e.g. Nicklasson 2001, Wraning 2004). Even more problematic are examples where the archaeobotanical data is used selectively to confirm loosely founded non-botanical interpretations, but ignored when the results are not in agreement (e.g. Nicklasson 2001, cf. also discussion in Filipovic and Obradovic 2013).

An additional problem is that botanical material may be moving through site spaces and features with established functional interpretations along pathways which follow a different rationale than that of the non-botanical record on which the functional interpretation was made. The result may be very complex and indirect links between the functionality of features and site spaces and the operational/transformational aspects of the botanical material. An example of this is the movement of botanical material carbonised around hearths. These features were probably raked out at regular intervals, but there exists little to none publications about what happens to this presumably prevalent source of carbonised plants once it leaves the hearth. If the material was deposited once or in stages during the waste management process it may have deposited botanical traces of hearth-related activities in unrelated functional spaces, for example in the byre, if the material from the hearth was intermittently stored there before being taken out to the fields along with manure. An example explored in article 3 is a pit, probably a well, located outside a longhouse at Locality 9-11 of Gedved Vest. The feature is argued to contain material primarily representative of kitchen activities rather than collection of water in a yard space, most likely as a result of a secondary use of the feature after its intended function had been discontinued.

Thus, in archaeobotanical analysis, one must not implicitly assume any form of simple correlation between specific feature types, as defined by their non-botanical traits, and the operational context of the botanical material. The botanical context must to some extent be obtained independently; a conclusion which is contradictory to points 2 and 3 of Dennell's approach to botanical operational inference.

A fourth problem is the possibility for multifunctionality of any given settlement space or individual feature. Singular documented assemblages of archaeobotanical (or other) material, may in some cases be palimpsests of related or unrelated activities which in turn may have been stable or varying over time. In many cases it may be almost impossible to determine the exact nature of the material.

To these four problems can be added the issues common to all archaeological material; namely variable formation, differences in preservation, and a myriad of possible natural or anthropogenic post-use and post-depositional processes.
5.2.3. Archaeobotany and the organisation of Iron Age settlements

The southern Scandinavian settlement record also displays two more complex traits which should be considered during analysis of plant macrofossil material.

The first is the long and seemingly stable tradition of organising habitation around the concept of the multifunctional longhouse (Hedeager and Kristiansen 1988, Holst 2010, Webley 2008). Contrary to other periods and/or geographic areas, many of the main farmstead functions were during the Iron Age housed within a single elongated construction rather than dispersed in separate buildings. Outhouses do appear throughout the period, but these are commonly situated adjacent to the main longhouse. By assessment of the spatial distribution of longhouses and smaller constructions it is sometimes possible to define which ones belong to specific farmsteads. On occasion this process is made easier by the presence of encircling enclosures (Hedeager and Kristiansen 1988, Holst 1996, Pedersen and Widgren 2004, Webley 2008).

This building tradition is advantageous for archaeobotanical analysis using the approach outlined by Dennell since spaces with different functionality should have been exposed to more similar transforms than if they had been distributed in a larger number of dispersed and/or diverse buildings. An example of this reasoning is that singular house fires in southern Scandinavia should in many cases have affected living spaces, kitchens, byres, storages and cereal processing areas simultaneously, because all of these were presumably located in the longhouses. The longhouse may thus be described as an archaeological object with homogenous constructional qualities within which functions may be sought through heterogeneously distributed material depositions.

The second main trait of the southern Scandinavian Iron Age material, relevant for archaeobotanical studies, is the presumed organisation of Iron Age subsistence production. It is generally believed that agricultural production throughout most of the Iron Age was performed with the household as both the primary producing and consuming unit (Hedeager and Kristiansen 1988, Herschend 2009, Holst 2010, Pedersen and Widgren 2004, Webley 2008). The longhouse, i.e. the physical manifestation of the household, with spaces dedicated for habitation as well as cereal and animal husbandry, was seemingly the framework around which agrarian activities were organised. That this situation was stable throughout much of the Iron Age may be inferred from the fact that when single farms and small villages began to nucleate in the middle of the Iron Age, the longhouse remained a distinguishable primary unit. Houses and their surroundings were often encircled by an individual fences, with private entrances, and byres occurred commonly on most farmsteads (Hedeager and Kristiansen 1988, Herschend 2009, Holst 2010, Pedersen and Widgren 2004, Webley 2008). This evidence indicates household autonomy rather than communal centralisation.

Consequently, some archaeobotanical discussions which are common in adjacent areas of northern Europe, are less relevant for southern Scandinavian research. An example is Roman Age England, where cereal production and operational stages of crop handling are commonly discussed in terms of producer and consumer sites (Jones 1985, Stevens 2003, van der Veen and Jones 2006). Assuming that the Scandinavian household was a relatively self-sufficient and autonomous producer and consumer leads, in contrast, to the expectation of encountering entire operational sequences on single Iron Age sites, with the longhouses acting as a centre points for the different activities.

One should, however, be aware that this supposition, although based on inductive reasoning with a basis in decades of research, is largely theoretical, and that at least the latter Iron Age displays traits of increasing specialisation of production, emerging estate economies, and hierarchisation of land ownership (Hedeager and Kristiansen, Holst 2010, Pedersen and Widgren

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9 Here defined broadly as any social unit inhabiting a farmstead and working jointly to support its existence.
These factors may have imposed increasing complexity on the forms of cereal production. This should be taken into account during assessment of cereal finds, particularly when analysing material from central places or from the towns which began to emerge during the late Iron Age, as these may very well have been importing or taxing agricultural products. With regards to the “common” rural habitation one may however argue that the basic practical procedure of crop cultivation and processing should have remained comparatively unchanged even during the latter Iron Age, as any taxation by an overlord, chieftain or king in a pre-monetary economy would most likely have occurred in the form of a percentage of the household’s production or in labour, and would not have impinged on the practical procedures of cultivation, harvest, processing and consumption.

In summary, the two outlined traits of Iron Age settlements in southern Scandinavia should have resulted in archaeobotanical conditions where: 1) the entire sequence of cereal cultivation, production and consumption probably occurred within the comparatively constricted setting of the individual farmstead, and 2) the material traces of cereal production were formed within the spatial framework of the multifunctional longhouse; a construction type which should theoretically provide favourable conditions for archaeobotanical inference along the principles outlined by Dennell (1972, 1974 and 1976).

Figure 5.5. The multifunctional longhouse throughout the Iron Age in Denmark. Source: Hedeager and Kristiansen 1988:139.
5.2.4. Expanding approaches to inference of crop cultivation and processing by integration of plant macrofossil analysis with geochemical and geophysical methods

It was previously stated that despite numerous difficulties, the more commonly occurring but less securely identifiable archaeological features in terms of function, may provide a valuable resource for archaeobotanical research if addressed by an adapted application of Dennell’s (1972, 1974 and 1976) approach to inference of cereal processing.

The stated adaptation, necessary in order to limit the effects of circular reasoning, vague functional interpretations on basis of both botanical and other data, complex pathways of plant macrofossil movement across settlements, issues of multifunctionality, biases due to N- and C-transforms, et cetera, is to expand the base of functionally indicative data available for comparison against the botanical material; the theory being that inconsistencies in interpretation should be easier to detect with a diversified empirical foundation. There are, presumably, numerous ways of doing this. In this thesis the selected approach is to combine plant macrofossil analysis with the geophysical method of magnetic susceptibility (MS) and the geochemical methods of phosphate analysis, reflecting both organic and inorganic phosphate fractions, and analysis of soil organic matter (SOM) through a procedure known as loss-on-ignition (Linderholm 2010, Viklund et al 2013, and articles 2 and 4 and therein listed references).

The development history and theory of this multiproxy method is the main topic of article 2. Its compatibility with more established archaeological approaches to functional interpretation is further explored in article 4. The reader is thus directed to those texts and therein cited references for in-depth description of the methodological combinations.

In short the multiproxy approach can be used to identify and delineate functional spaces, and to help contextualise archaeobotanical material, by:

1) Providing evidence about whether a construction is burnt or unburnt, or whether a feature was used for heating (e.g. cooking pits). This is achieved by measurement of magnetic susceptibility and interpretation of the concentrations and distribution of carbonised plant remains.

2) Identifying the probable locations of hearths and ovens in unburnt structures by analysis of magnetic susceptibility in different parts of the house and assessment of the distribution of carbonised plant remains.

3) Identifying and delineating kitchen spaces by assessment of inorganic phosphates, soil organic matter and interpretation of the distribution of carbonised food plants.

4) Identifying byres and other spaces where manure was stored by assessment of organic phosphates, soil organic matter, and interpretation of the distribution of fodder plants.

5) Providing indications about the possible nature of the deposits recovered from pits, which under favourable conditions may provide clues about the original function, or at least about the nature of the deposits found within, by analyses with all of the above mentioned methods.

6) Providing indications about the possible formational processes of “cultural” layers and of the origins of the material culture embedded in them by analyses with all of the above listed methods.
The main advantages of the outlined methods may be summarised as:

1) Ease of sampling. Since all of the abovementioned analyses can be performed on sub-samples taken out of archaeobotanical bulk-samples there is no need for separate sampling regimes.

2) Coherence of scale. Due to the fact that plant macrofossil analyses, as well as the geo-chemical and geophysical measurements, are performed on the same samples, there is little inconsistency in the spatial resolution obtained by each respective method. This approach may, for example, be contrasted with comparisons of archaeobotanical material extracted from feature fills to phosphate analyses of samples taken separately in accordance with a pre-determined grid, where the two data sets will result in patterns with variable spatial resolution.

3) Partially comparable functional scope. In many cases the outlined methods can be used to identify the same types of activities. For example: a) kitchens can be identified through compositions of plant remains, assessment of inorganic phosphates and assessment of SOM, b) former location of hearths, commonly presumed to have been primarily located in kitchens, can be identified by concentrations of carbonised plants and MS, and c) byres can be identified by presence of fodder plants, organic phosphates and SOM. Due to the partially overlapping functional scope of the methods the combination may be used to reconstruct more coherent wholes than if they were utilised independently, while simultaneously providing mutual confirmation for the interpretations obtained from each respective method.

Figure 5.6. South Scandinavian longhouses were divided into functional spaces. Samples taken from posthole fills of corresponding areas may be analysed with a variety of methods in order to provide qualitative data on the activities once practiced in the different sections. This figure shows theoretically expected modifications in the botanical record and of chemical and physical soil properties in areas used for different activities. Source: article 2, Grabowski and Linderholm 2013.
6. Material

Two main groups of empirical material were used during the PhD project. The first consisted of previously analysed data presented in the compilation and summary of archaeobotanical investigations in southern Sweden in article 1, the compilation of macrofossil data from east-central Jutland in article 3, and previously performed archaeobotanical, geochemical and geophysical analyses in article 4. This material has in many cases been previously published, or else is described in detail in the respective articles.

The second segment of empirical material used during the project consisted of samples from the case study sites of Kristinebjerg Øst and Gedved Vest. This material was analysed during the project, and thus requires a more in-depth presentation.

6.1. Acquisition of samples

Although the material from Kristinebjerg Øst and Gedved Vest was used in combination for the establishment of the cereal cultivation history of east-central Jutland in article 3, the material from each site was incorporated into the project in different ways.

Gedved Vest was already at the planning stage meant to function as the project’s empirical base, and the fact that I was personally involved in the investigation of the site meant that the sampling strategy could be partially directed in a way that accommodated the aims of the project. The most significant result of this is the fact that sub-samples for additional non-botanical analyses were consistently extracted from every archaeobotanical sample gathered at the site. This allowed for analysis with additional methods, such as those of the multiproxy analysis presented in the previous chapter.

Kristinebjerg Øst was excavated prior to the beginning of the PhD project, between 2007 and 2009. Samples from the site were during the summer of 2009 subject to a preliminary analysis at Moesgård Museum’s department of natural sciences and conservation; an analysis partly performed by myself, at that time employed by Moesgård Museum. The conclusion of these analyses was that only one archaeological context from Kristinebjerg Øst, House DG dating to the Viking Age, contained plant remains in sufficient quantity to allow for more in-depth study. This result was expected as the house was already during excavation interpreted as a probable cereal storage barn due to large amounts of observed carbonised grains (Westermann pers. comm.).

As the analysis of the material from Gedved Vest proceeded, it became increasingly clear that almost all interpretable archaeobotanical assemblages dated to between late pre-Roman Iron Age and late Roman/early Germanic Iron Age, i.e. c. AD 1-600. Because I had at this stage already decided to attempt to construct a cereal cultivation history of east-central Jutland based on the material from the PhD project (the result being article 3), the hiatus in available material for the Late Iron Age was perceived as a major drawback, because, as presented in chapter 4, numerous important changes in southern Scandinavia appear to have occurred after the 5th century AD. Consequently, recalling the Viking Age house assessed at Moesgård Museum, I concluded that it could provide valuable evidence about cultivation during one of the periods which were missing in the material from Gedved Vest, in addition to being worthy of study in its own right.

Although used in a complementary way in article 3, the reader should be aware that the material from the two sites is in many ways fundamentally different.
6.2. Kristinebjerg Øst, House DG

Kristinebjerg Øst is situated a few kilometres from Little Belt, between the towns of Kolding and Fredericia. Excavations at the site resulted in the identification of remains dating to the Neolithic, the Iron Age, as well as the medieval and modern periods. House DG was found in a cluster of settlement remains in the western part of the site where at least twelve houses had once been built, all dating to the Viking Age. No $^{14}$C dates have been obtained for House DG, but the typology of the building, coupled with chronological evidence from surrounding houses and features place it at circa AD 800 (Bjerregård and Iversen 2013).

The house could already at the outset be interpreted as one of the large cereal storage finds that occasionally appear in burnt settlement contexts in Denmark. Because the material clearly derives from a house fire there is little doubt that it represents a singular charring event. It is furthermore probable that the carbonised cereal grains represent a short span of time, possibly a single or a couple of harvests. Since one of the primary functions of house DG is clearly a cereal storage barn the operational context of the botanical material is easy to infer and as such provides excellent conditions for studying a specific stage of cereal handling.

21 archaeobotanical samples were analysed from House DG. Since the material was flotated during excavation, and no sub-samples were collected, only plant macrofossil analysis was performed on this material.
6.3. Gedved Vest

Gedved Vest is situated in east-central Jutland, approximately 10 kilometres north of Horsens and 30 kilometres south of Århus. The site contained predominantly settlement remains, spanning from the late Bronze Age to the Viking Period; with a clear predominance of remains dating to late pre-Roman Iron Age and onward.

Due to the longevity of settlement activities in the area the site was assessed as suitable for analysis within the framework of a PhD project on cereal cultivation dynamics during the Iron Age.

The typologies of houses and artefacts recorded during the excavation indicated already in the early stages of investigation that: 1) the main site could be divided into sub-areas, termed localities, each representing activities from relatively constricted spans of time, and 2) that there was little mixing of unrelated periods within each locality. This was subsequently confirmed by analysis of 144 \(^{14}C\) samples.

The chronological consistency of each locality provided a suitable chronological framework for all archaeobotanical and other analyses on this site. Most localities represent chronological segments of approximately 300 years (see figure 6.2).

A total of 879 archaeobotanical samples from Gedved Vest were analysed. There was significant variation in the amount of samples as well as in the total volume of sampled soil at each locality (see table 7.1).

The material from Gedved Vest differs distinctly from that of Kristinebjerg Øst. The samples derived from numerous features of varying type, and the function of most was unknown prior to analysis. There were also no obvious caches of carbonised plant remains observed during the excavation. The site therefore presented both an archaeobotanical challenge and a suitable case for testing the theory and methods outlined in the previous chapter 5.2.4.

![Figure 6.2. The chronology of settlement traces at the localities of Gedved Vest as interpreted on the basis of typological and \(^{14}C\) evidence. For a plan of the site see figure 7.3 below.](image)
7. An archaeobotanical case study at Gedved Vest: From sample to contextualised botanical material

Samples from Gedved Vest made up the majority of the archaeobotanical material analysed in the course of the PhD project.

As seen in the materials chapter above, the samples from Gedved Vest were not only more numerous than those from Kristinebjerg Øst but were also derived from more diverse archaeological settings, with no beforehand defined operational contexts for botanical remains. This made the material more complex to analyse and interpret.

Article 3 contains a presentation of the results from both Gedved Vest and Kristinebjerg Øst. The data presented therein is, however, only the final result of a longer research process. This particularly applies to the complex material from Gedved Vest.

In this chapter the analysis of Gedved Vest is presented, with focus shifted from detailed description of the results, to the investigative process by which they were attained. The aim is to illustrate how the methodology presented in chapter 5.2.4 and article 2 can pragmatically direct the investigative archaeobotanical process on a south Scandinavian settlement site.

7.1. Aims of analysis at Gedved Vest

On the basis of the available material, and in relation to the main aims of the thesis, two specific objectives were formulated for the archaeobotanical analysis of material from Gedved Vest:

1) To analyse the material in a way that allows for the formulation of a detailed cereal cultivation history of Gedved Vest.
2) To test, on a larger scale, the multiproxy method in which archaeobotany is integrated with geochemical and geophysical methods in order to provide a functional context for the features, constructions and site spaces from which the samples were recovered and preferably establish an operational/transformational context for the botanical material within.

7.2. Defining the operational context of archaeobotanical material at Gedved Vest

7.2.1. Initial assessment of the archaeobotanical material

The first step of the investigation of material from Gedved Vest was plant macrofossil analysis of all samples.

Once analysed the archaeobotanical data could be assessed at two levels of detail, allowing for the formulation of a strategy for additional in-depth analyses: 1) distribution of plant material over time, structured by the chronological framework of the localities (see figure 6.2), and 2) distribution of plant material over time in the different feature types.

Figure 7.1, which displays the distribution of cereals at the different localities, shows that the cereal agriculture at Gedved Vest appears to have been comparatively stable over the course of the Iron Age. The only locality which showed a distinctly diverging cereal composition was Locality 29, dated to period V and VI of the Bronze Age. Spelt, emmer and undifferentiated hulled wheat were the dominant crops present in the assemblage from this locality, while hulled...
barley was a secondary crop. Trace finds of *Avena* sp, i.e. undifferentiated oat, were also observed.

The following periods, starting with late pre-Roman Iron Age at Locality 1a and concluding with Locality 5/6 dating to the late Germanic Iron Age/Viking Period, showed that Iron Age agriculture at Gedved Vest was dominated by hulled barley, with rye as a secondary crop and trace finds of wheat (both hulled and naked, i.e. *Triticum aestivum/compactum*), naked barley and undifferentiated oat.

At this stage two phenomena in Iron Age cereal cultivation at the site were identified as warranting further attention: 1) although rye overall appears to be present in sizable quantities throughout most of the Iron Age, there seems to be a hiatus in its occurrence during the Roman Iron Age, represented by localities 28 and 2, and 2) an occurrence of naked barley greater than the trace finds observed at most localities was “visible” at Locality 19.

As seen in table 7.1, the material from the different localities of Gedved Vest was varied both in sampling intensity - ranging from 1 sample at Locality 29 to 286 at Locality 1a - as well as the concentrations of recovered material in the samples at each locality - ranging from 1 carbonised remain per litre at localities 2 and 3 to 57.5 remains per litre at Locality 21.

A preliminary hypothesis for the causes of the latter variation was formulated as a combination of differences in formation and preservation conditions (for example burnt/unburnt houses) and varying sampling due to differences in identified features as well as the sampling focus of the archaeologists excavating each respective area.

The main conclusion at this stage was therefore that further analysis was necessary in order to assess the importance of rye cultivation on the site during the Iron Age and the causes for the hiatus observed during the Roman Iron Age, to assess the nature of the naked barley presence at Locality 19, and to investigate whether any of the species appearing as minor inclusions in each period had derived from contexts which could in fact indicate small scale cultivation.

![Figure 7.1. Distribution of cereals at the localities of Gedved Vest arranged in chronological order.](image-url)
<table>
<thead>
<tr>
<th>Locality</th>
<th>No of samples</th>
<th>Identified plant remains</th>
<th>Total sample volume (l)</th>
<th>Plant remains/litre</th>
</tr>
</thead>
<tbody>
<tr>
<td>29</td>
<td>1</td>
<td>89</td>
<td>2.5</td>
<td>35.6</td>
</tr>
<tr>
<td>1a</td>
<td>286</td>
<td>1129</td>
<td>934</td>
<td>1.2</td>
</tr>
<tr>
<td>21</td>
<td>11</td>
<td>2501</td>
<td>43.5</td>
<td>57.5</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>73</td>
<td>73.2</td>
<td>1</td>
</tr>
<tr>
<td>1b</td>
<td>19</td>
<td>841</td>
<td>71.6</td>
<td>11.7</td>
</tr>
<tr>
<td>28</td>
<td>119</td>
<td>2957</td>
<td>321.5</td>
<td>9.2</td>
</tr>
<tr>
<td>2</td>
<td>61</td>
<td>613</td>
<td>603.7</td>
<td>1</td>
</tr>
<tr>
<td>9/10/11</td>
<td>77</td>
<td>2464</td>
<td>265.5</td>
<td>9.3</td>
</tr>
<tr>
<td>13</td>
<td>125</td>
<td>3182</td>
<td>296.8</td>
<td>10.8</td>
</tr>
<tr>
<td>19</td>
<td>52</td>
<td>1059</td>
<td>119.3</td>
<td>8.9</td>
</tr>
<tr>
<td>5/6</td>
<td>47</td>
<td>110</td>
<td>89.7</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Table 7.1. Amount of samples, analysed volume, and basic results at the localities of Gedved Vest.

7.2.2. Categorisation by feature type
Categorising the assemblages from each locality according to feature type was the second step in the assessment of material from Gedved Vest. The results of this categorisation are shown in figure 7.2. Selected feature categories were:

1) Longhouses: defined as buildings with four or more roof-supporting post pairs.
2) Outhouses: defined as constructions consisting of only three roof-supporting post pairs, rectangular frames made up of four post in a rectilinear arrangement, or a sub-circular frame of posts enclosing a smaller space (only one example of the latter was encountered).
3) “Cultural layers” and postholes interpreted as belonging to post-built enclosures. These feature types were joined into one category based on a supposition that material in both feature types should represent yard activities outside of the dwellings.
4) Pits and wells. Joined into one category due to the difficulty of separating large pits from wells, as well as the fact that many wells commonly display traces of being transformed into refuse pits after their period of primary use.
5) Iron extraction furnaces.

This categorisation allowed for two additional observations complementing those of the initial assessment: 1) rye appears during all periods predominantly in dwelling contexts, i.e. longhouses and to a lesser degree outhouses, but is rare in contexts associated with yard spaces and possible refuse deposition such as pits and “cultural layers”, 2) the small, but larger than occasional, presence of naked barley at Locality 19 was complemented by a similar presence in the outhouse category at Locality 9/10/11.
Figure 7.2. Distribution of cereals at Gedved Vest categorised by period/locality (x-axis) and feature category from which the material was sampled (y-axis).
7.2.3. In-depth multiproxy analysis

On the basis of the insights attained from the initial assessment selected cases where subsequently analysed by the multiproxy method presented in chapter 5.2.4 and article 2.

The selection of material for in-depth multiproxy analysis was done qualitatively with three main parameters guiding the selection process: 1) sufficient concentrations of plant remains, 2) representative sample coverage (i.e. houses which were sampled along their entire length, and pits/wells and cultural layers where all, or at least a majority, of fills had been sampled) and 3) a suitable archaeological context (i.e. features and constructions not excessively overlain by preceding or successive phases of activity or obviously disturbed by different transforms).

The specific case studies where an operational context could be established for the archaeobotanical material through use of the multiproxy method are presented in detail in articles 2 and 3.

Summarising the outcome, the in-depth analysis resulted in:

1) Interpretation of numerous houses as destroyed by fire, with indications of kitchen and/or cereal storage spaces containing consumption stage cereal finds (clean grain) as well as cereal cleaning areas containing cereal cleaning residues (arable weeds and small cereal grains).
2) Interpretation of a deposit in a pit as resulting from the use of cereal cleaning residues as fuel (arable weeds with inclusions of chaff).
3) Interpretation of a deposit in a large pit, presumably initially used as a well, as containing waste from an adjacent kitchen, and therefore probably containing consumption stage grain (clean grain).
4) Interpretation of a deposit as containing partially cleaned grain stored in an outhouse (grain and arable weeds).
5) Interpretation of numerous deposits as mixed or poorly defined due to sporadic carbonisation during everyday activities inside unburnt houses, deposition and re-deposition during waste management, and post-depositional transforms.

The assessed plant assemblages from contexts belonging to point 1-4 could all be interpreted as belonging to one of three general stages of the simplified cereal processing operational sequence outlined in chapter 5.1.4: 1) cereal cleaning residues (excluding threshing since no straw and almost no chaff was identified), 2) storage and consumption of cleaned grain, and 3) storage of partially cleaned grain.

On the basis of this operationally contextualised material, presented in figure 7.4 and table 7.2, a somewhat different pattern was observed than that seen in the initial chronological overview and the overview based on feature categories:

1) Rye is now seen as predominantly appearing in interpreted cereal cleaning residues. This indicates that it was sorted out of the assemblages meant for consumption. An exception to this pattern is Locality 19 where rye appears in quantities sufficient to warrant an interpretation as consciously cultivated and consumed.
2) The hiatus in rye occurrence observed in the initial assessment of the material is largely confirmed in the contextualised material. The only contextualised assemblage from the Roman Iron Age of Gedved Vest was recovered from a pit interpreted as containing cereal cleaning residue. In this material rye was only observed as a minor inclusion. In rela-

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10 Note that no fixed limit was used during the selection, which was instead purely qualitative. This was done due to the fact that the multiproxy archaeobotanical, geochemical and geophysical analysis was already at the outset known to result in a subdivision of archaeological contexts, such as houses, into smaller units, such as kitchens, byres, cereal cleaning areas, etc. (cf. discussions in articles 2, 3 and 4). As it is impossible beforehand to know which samples will end up in which sub-unit after multiproxy analysis it is also impossible to define strict criteria for plant concentrations. In practice almost all contexts at Gedved Vest, which met criteria 2 and 3 outlined above, i.e. good sampling coverage and a suitable archaeological context, were analysed.
tion to the observations from the preceding and subsequent periods, where rye is found primarily in cereal cleaning residue or partially cleaned grain, this result could be seen as tenuous evidence that it was not cultivated or even inadvertently collected during the Roman Iron Age.

3) The naked barley observed at Locality 19 was shown to belong to a consumption stage assemblage while the occurrence observed at Locality 9/10/11 is no longer “visible” since it did not belong to an assemblage which could be contextualised. Naked barley does, however, now also appear in a consumption stage assemblage from Locality 13. This locality is approximately contemporaneous with localities 9/10/11 and 19. Although present, naked barley is, however, still a minor inclusion in both end stage assemblages. A closer inspection of the individual samples in which these finds were made showed that the find at Locality 13 was only a minor inclusion in the sample from which it derived while at Locality 19 it made up 50% of the material in two adjacent postholes. These results are contradictory as the Locality 13 find indicates sporadic occurrence, possibly due to impurities in cultivated hulled barley, while the one from Locality 19 points toward cultivation.

4) Several separate but contemporaneous consumption stage assemblages, for example from localities 13 and 19, or houses A11312, A11320 and pit A30223 at Locality 9/10/11, display almost identical compositions. This may be an indication that the consumed grain during some periods was essentially similar in composition and was presumably subject to similar cultivation and processing regimes.

5) Wheat was only observed as scattered stray finds on all analysed localities.

6) Undifferentiated oat (*Avena* sp) was only noted in significant quantity in one assemblage, interpreted as a cereal cleaning residue, at Locality 21. This indicates presence of wild oat rather than cultivated *Avena sativa*. This evidence is further supported by the fact that no *Avena* grains were determined as *A. sativa* while the wild growing *A. fatua* was identified in a handful of cases.

Archaeological contexts which were interpreted as representing mixed or operationally/transformationally undefinable plant assemblages showed few interpretable patterns (see figure 7.5 and table 7.2). In comparison to the contextualised material, which shows similarities between spatially and chronologically related materials, this category displays a diversity where assemblages from even superficially similar, spatially related, and contemporaneous archaeological contexts, show completely different cereal compositions. A good example is Locality 1b where four analysed, and superficially almost identical, longhouses showed completely different cereal compositions.

Although not easy to interpret, this material does support some of the observations made during the preceding stages of analysis, as well as those from the contextualised material:

1) Rye, although making up a large percentage of some early assemblages, does only appear in large numerical quantity in House A11071 at Locality 13. Since this context is dated to the late Roman/early Germanic Iron Age this supports the previous interpretation of larger scale rye cultivation commencing around this time.

2) The presence of naked barley during the late Roman/early Germanic Iron Age is also “visible” in longhouse A11323, a context with unknown formation and function. Since this presence is contemporaneous with the contextualised finds of this crop at localities 13 and 19, this tenuously strengthens the interpretation of an unusually late reoccurrence of naked barley cultivation at the site.
<table>
<thead>
<tr>
<th>Locality/Period</th>
<th>Multiproxy analysis cases with inferred botanical operational context</th>
<th>Number on plan (fig 7.3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>21: Early Roman IA</td>
<td>Cereal cleaning residue in burnt outhouse A11402. Partially cleaned grain storage in burnt outhouse A11404. Cleaned grain storage in burnt outhouse A11412.</td>
<td>1</td>
</tr>
<tr>
<td>28: Roman IA</td>
<td>Cereal cleaning residue in small pit interpreted as used a variation of a hearth/cooking pit.</td>
<td>2</td>
</tr>
<tr>
<td>9/10/11: late Roman – early Germanic IA</td>
<td>Cereal cleaning residue in a section of burnt longhouse A11312. Kitchen containing (stored?) consumption stage grain in section of burnt longhouse A11312. Cereal cleaning residue in section of burnt longhouse A11320. Kitchen containing (stored?) consumption stage grain in section of burnt longhouse A11320. Kitchen refuse in pit (former well) A30223.</td>
<td>3</td>
</tr>
<tr>
<td>13: Late RIA/early GIA</td>
<td>(Kitchen?) with evidence of milling containing (stored?) consumption stage grain in unburnt longhouse A11220.</td>
<td>6</td>
</tr>
<tr>
<td>19: Late Roman – early Germanic IA</td>
<td>Cereal cleaning residue in burnt longhouse A11123. Kitchen/living space containing stored consumption stage grain in burnt longhouse A11107.</td>
<td>7</td>
</tr>
<tr>
<td><strong>Locality/Period</strong></td>
<td><strong>Multiproxy analysis cases where botanical operational context could not be inferred</strong></td>
<td><strong>Number on plan (fig 7.3)</strong></td>
</tr>
<tr>
<td>29: late BA</td>
<td>“Cultural” layer A23041, interpreted as containing mixed refuse (including plant remains) from a presumed, but destroyed, settlement.</td>
<td>8</td>
</tr>
<tr>
<td>1B: early Roman Iron Age</td>
<td>Burnt/unburnt? longhouse A11369, containing material presumably mixed during various household activities. Burnt/unburnt? longhouse A?, containing material presumably mixed during various household activities. Burnt/unburnt? longhouse A11383, containing material presumably mixed during various household activities. Burnt/unburnt? longhouse A11382, containing material presumably mixed during various household activities.</td>
<td>9</td>
</tr>
<tr>
<td>28: Roman IA</td>
<td>Unburnt longhouse A11432, containing material presumably mixed during various household activities.</td>
<td>10</td>
</tr>
<tr>
<td>9/10/11: late Roman – early Germanic IA</td>
<td>Unburnt longhouse A11311, containing material presumably mixed during various household activities. Burnt/unburnt? longhouse A11323, containing material presumably mixed during various household activities, or due to mixing due to succeeding settlement activity.</td>
<td>11</td>
</tr>
<tr>
<td>13: Late RIA/early GIA</td>
<td>Well A26380, with unknown formation process and non-contextualised botanical material. Burnt/unburnt? longhouse A11071, with a large cache of grain which may be clean storage or a mixing of unrelat ed assemblages. All evidence sources are ambivalent.</td>
<td>13</td>
</tr>
</tbody>
</table>

Table 7.2. Archaeobotanical assemblages at Gedved Vest analysed with the multiproxy method with an established operational context (upper section), and lacking operational context, i.e. assemblages representing mixing, numerous activities, post-depositional disturbance, etc. (lower section). The numbers in the rightmost column correspond to figure 7.3 below.
Figure 7.3. Plan of Gedved Vest showing the locations of archaeobotanical assemblages from archaeological contexts which were analyzed with the archaeobotanical, geochemical and geophysical multiproxy analysis. Light grey arrows denote archaeobotanical assemblages where an operational context could be attained for the botanical material. Dark grey arrows denote archaeobotanical material interpreted as mixed or where an operational/transformational context could not be attained. The numbers on the plan correspond to those in Table 7.2 above.
Figure 7.4. Distribution of cereals at the localities/time periods of Gedved Vest (x-axis) in assemblages with a functional/operational context interpreted on the basis of a multiproxy analysis by archaeobotanical, geochemical and geophysical methods (y-axis).

Legend: Cereal taxa
- Avena sp.
- Hordeum vulgare coll.
- Hordeum vulgare var. nudum
- Triticum sp.
- Hordeum vulgare var. vulgare
- Secale cereale

ERIA
- Locality 21
- A11401, n=30 [oh]
- A11412, n=101 [oh]
- A11404, n=451 [oh]

Roman IA
- Locality 28
- A35875, n=6 [p]
- A11312, n=15 [lh]
- A11320, n=82 [lh]
- A11312, n=154 [lh]

Late Roman and Early Germanic Iron Age
- Locality 9, 10, 11
- A11330, n=27 [lh]
- A30223, n=30 [w]
- A13020, n=54 [w]

Locality 13
- A11123, n=47 [lh]

Locality 19
- A11107, n=504 [lh]

Outbuilding A11404
- Partially cleaned, stored grain?
7.2.4. Weeds at Gedved Vest

The weeds at Gedved Vest were generally homogenous in composition throughout all periods. The dominating taxa were *Chenopodium* sp (almost exclusively *Chenopodium album*) and *Persicaria lapathifolia*. Almost all weeds indicate cultivation on manured fields; with a smaller presence of weeds preferring sandy, low-nutrient, and low-pH environments, such as *Spergula arvensis*, *Polygonum aviculare* and *Rumex acetosella*.

Most weed taxa only occurred as single or sparse finds in one or a few assemblages. Their presence in the fields was therefore assessed by sorting the weed material collectively into blocks representing different periods of the Iron Age at Gedved Vest. Contextualised assemblages interpreted as cereal cleaning residues were selected as the best source for this assessment because these assemblages are presumed to have retained the most complete representation of the weed flora once present in the fields.

The results, presented in figure 7.6 show that the most significant pattern is a decrease in weeds preferring low nutrient environments between the early and middle Roman Iron Age, possibly indicating that poorer (possibly less-manured, sandier or exhausted) fields were not utilised to the same extent during the latter periods of the Gedved Vest settlement.
Another observation made on the basis of the weed material is that almost all weed taxa indicate cultivation of spring sown crops, with no evidence of either autumn sowing or short-term crop rotation.

Figure 7.6. Frequencies of arable weeds/ruderals in assemblages interpreted as cereal cleaning residues on the basis of a multiproxy analysis utilising archaeobotanical, geochemical and geophysical methods. Note that only three periods of the Gedved Vest material provided material suitable for chronological comparison.

7.3. Inferred cereal cultivation at Gedved Vest

Based on the collective observations made during all stages of the Gedved Vest investigation an outline of the site’s late Bronze Age and Iron Age cultivation history can be formulated.

During the late Bronze Age the cultivation at Gedved Vest still seems to have utilised spelt and emmer to a degree not observed for any of the other periods. Hulled barley was probably also cultivated, but noted in the single assemblage from that period as a minor crop. Because only one sample from this period has been analysed this interpretation should, however, be taken with a significant degree of caution. The sample derived from a “cultural” layer with largely unknown formation history and its representativity for the overall cereal cultivation at the site is impossible to assess.

After the late Bronze Age there is a hiatus in the material until the latter part of pre-Roman Iron Age, after which a large and chronologically coherent material spanning the entire Roman and the early Germanic Iron Age is available.

The material shows that the cereal cultivation tradition at Gedved Vest was overall very stable throughout the assessed centuries, relying mainly on cultivation of manured and spring sown fields. There is some tenuous evidence that either poorer fields were also utilised, or that ma-
nuring was somewhat less intensive during the early Roman Iron Age, a practice which ceased during the middle Roman Iron Age.

Hulled barley is the dominating crop in every Iron Age assemblage from Gedved Vest. Rye is the second most ubiquitous cereal.

The dynamics of rye cultivation, as seen in its distribution in assemblages with inferred operational/transformational context may however be more complex than indicated by its overall presence in the material. The predominance of rye together with cereal cleaning residues indicates that it was - at least during some periods - sorted out of the grain fractions meant for consumption, and possibly not consciously cultivated. At other times it appears in larger quantities in consumption stage grain. Based on this observation it is proposed in article 3 that we may have to re-evaluate the role rye played in the cultivation practices of the Iron Age. Instead of focusing solely on interpretation of whether it was purposely cultivated or occurring as a weed it should perhaps be considered as a flexible resource, utilised adaptably during the middle Iron Age in accordance with the needs and desires of the farming communities.

The absence of any indications of crop rotation or autumn sowing shows that these techniques were probably not introduced during the analysed periods of Gedved Vest, even though they have been inferred on other contemporaneous sites in Jutland (e.g. Henriksen 2003, Mikkelsen and Nørbach 2003). This result accentuates further the picture of a stable cereal cultivation tradition at this site.

The lack of any significant finds of oat and wheat (naked or hulled) at Gedved Vest, despite the large number of analysed samples, indicates that these were not cultivated at the site.
8. Results of the PhD project

This chapter is a summary of the results attained during the PhD project in relation to the aims outlined in chapter 1.2. While the four articles contain in-depth presentations of results corresponding to the specific topics explored in each paper, the here presented results are an overall outline of what was accomplished over the course of the project.

8.1. The current state of archaeobotanical research on cereal cultivation in southern Scandinavia

8.1.1. Compilation of archaeobotanical data from southern Sweden

When the PhD project was initiated in September 2009, no updated compilation of previously performed archaeobotanical investigations of Iron Age material from southern Sweden was available. The only large-scale compilations covering the entire south Swedish region were Hjelmqvist’s (1955, 1960 and 1979) compilation papers, which by 2009 were outdated due to later increase in investigated material, while more recent overviews by Engelmark (1992), Regnell (2002) and Viklund (2004) were constricted in geographic scope as a result of being written within local archaeological projects.

Contrasting the situation in Sweden several compilation type publications had been produced on the basis of archaeobotanical data from present day Denmark; such as Robinson’s compilation from 1994 (Robinson 1994a), based on an accompanying catalogue (Robinson 1994c), and a 2009 article by Robinson, Mikkelsen and Malmros (Robinson et al 2009).

The difference in compilation coverage in Denmark and Sweden was deemed as problematic because it contributed to an uneven basis for discussion and interpretation of developments in cereal cultivation in different parts of southern Scandinavia. An example of this is that while the better geographic coverage of comprehensive publications in Denmark allowed for the identification of significant regional variation, the developments in Sweden were perceived as less complex. Robinson (2003:145), for example, when writing about the appearance of hulled barley in southern Scandinavia, expressed that:

*The situation appears somewhat more complex in Denmark than that described for Sweden. The most striking difference is seen in the behaviour of hulled barley, which becomes massively dominant in Sweden in the course of the Bronze Age, whereas its role in Denmark is much more modest.*

Robinson’s phrasing “than that described for Sweden” is very suitable, because a thorough review of the less comprehensive and less widely circulated Swedish publications, describing local archaeobotanical materials, shows that the complexity observed in Denmark is matched in southern Sweden (e.g. Viklund 2004 and 2005 for Halland; Engelmark 1992, Gustafsson 1995a for Scania). On the basis of such a review one could argue that the perception of less variety and complexity in Swedish cereal cultivation is not a truthful reflection of the archaeobotanical material, but rather an illusion stemming from the fact that most of the discussions in widely circulated Swedish publications have been dominated by presentations of material from spatially constricted areas in Scania, deriving mainly from a few larger projects such as the Ystad-project (Engelmark 1992) and the Fosie IV-excavations (Gustafsson 1995a).

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11 The Ystad project for Engelmark (1992), the west-coast rail link for Viklund (2004) and a number of rescue archaeological projects performed by UV-Syd in Scania for Regnell (2002).
**Article 1** is an attempt to present a publication comparable to Robinson’s, Mikkelsen’s and Malmros’s (Robinson et al 2009) Danish paper. It covers the southern Swedish area in an attempt to provide a more balanced base from which future discussions and research can be directed. For the purposes of comparability this article was largely modelled after its Danish predecessor, particularly with regards to chronological scope, method of compilation, and presentation of data.

The main result of this article is the summarising of a large amount of previously unpublished data, and the highlighting of significant variation in cereal cultivation in different parts of southern Sweden, bringing into a single publication insights which were previously reported in a number of diverse sources.

### 8.1.2. Defining geographic and chronological gaps in the archaeobotanical record

As a result of the uneven availability of empirical archaeobotanical material in southern Sweden, the discussion in article 1 came to revolve mostly around a comparison of developments in Halland and Scania, which were the only areas with a sizable material. Even this comparison was somewhat problematic since the material from Scania was significantly larger than that from Halland.

Although the unevenness in regional coverage limited the interpretations and discussions in article 1, the situation is in itself an important result because it demonstrates geographic and chronological gaps in the current archaeobotanical record. By comparison to Danish publications, such as Robinson et al (2009), by the time article 1 was completed, it was significantly easier than previously to form an opinion about which areas and time periods could best benefit from further archaeobotanical attention.

In southern Sweden, the geographic gaps can be summarised as covering all areas outside of Scania and Halland. Almost no data is available from the inland of southern Sweden, Blekinge, and the island of Öland. Only Scania can be described as chronologically well covered. In Halland only the pre-Roman Iron Age is reasonably represented in the material, with seven substantial previously analysed assemblages. The remaining Iron Age in Halland is represented by only nine additional assemblages, and although these are evenly distributed through time, the low number provides less than a single assemblage per century for interpretation of cereal cultivation.

In Denmark, in 2009, northern, southern and western Jutland were reasonably well covered by archaeobotanical investigations, while Funen, Zealand and east-central Jutland were clearly under-represented. A chronological gap was furthermore observable for the pre-Roman Iron Age in southern Jutland.

### 8.1.3. The limitations of archaeobotanical compilations

While compilation type publications are important in archaeobotanical research for identifying large-scale trends in space and time, their potential contribution to elucidating many of the currently discussed issues is limited, regardless of how well the chronological and geographic gaps are filled with additional data.

Archaeobotanical compilation may be a vital tool for formulating models and hypotheses about complex relationships between prehistoric phenomena and about causal factors underlying change in cereal cultivation. Ultimately, however, these models can only be tested through

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12 Mention should, however, be made of recent archaeobotanical publication of finds from early Iron Age Funen (Jensen and Andreasen 2011) as well as an upcoming study covering the late Iron Age (Jensen in prep, based on report Jensen 2012), which jointly will significantly update and enhance the current understanding of cereal cultivation in this part of southern Scandinavia.
in-depth case studies. New data, which can be incorporated into future compilations, should preferably also be generated during this process.

8.2. Developing archaeobotanical approaches to analysis of material from settlement sites

Mention was made in chapter 5.1.4 that in-depth studies of the processes underlying the formation of cereal assemblages in Denmark have tended to focus on exceptionally well preserved finds, such as granaries and material from iron extraction furnaces, while similar finds are largely absent in Sweden. The best Danish case studies are consequently Henriksen’s and Robinson’s analyses of stored grain at Overbygård (1996b) and Mikkelsen’s (2003) and Henriksen’s (2003) analyses of iron furnaces in southern Jutland, while in Sweden the most informative case studies derive from investigations of postholes and pits from settlement sites (e.g. Engelmark 1993, Gustafsson 1995a, Regnell 2002, Viklund 2004).

The material from Gedved Vest, which was from the outset the used as the empirical foundation of the project, is in most respects more similar to the material previously presented in archaeobotanical publications from Sweden than Denmark. Due to this fact, and because of my affiliation with the Environmental Archaeology Laboratory in Umeå (MAL), where much of the Swedish work has been undertaken, it was natural to address cereal cultivation dynamics at Gedved Vest with the methodological and theoretical tools developed within the framework of Swedish archaeobotany.

Karin Viklund’s PhD thesis (1998) includes a comprehensive review of the theory and method of current Swedish settlement based archaeobotany. Since its publication, however, plant macrofossil analyses performed at MAL have become integrated with geochemical and geophysical methods in a by now standardised multiproxy method. The geochemical and geophysical segment of this multiproxy analysis is based largely on the work of Johan Linderholm and Roger Engelmark (Engelmark and Linderholm 1996, 2008, Linderholm 2010). Although applied on a large number of sites, detailed descriptions of the combined methods have mostly been presented in unpublished reports or in local, less widely circulated, anthologies from archaeological projects.

Article 2 is a result of the above outlined situation. It fills the role of a detailed method statement for the PhD project, but attempts also to address a more far reaching objective by comprehensively outlining the theory, method and interpretative complexity of an investigative approach to functional interpretation of settlement material which for more than a decade has been used on a large number of sites in Sweden and occasionally other areas of Scandinavia and Europe.

8.3. Analysis of archaeobotanical material from east-central Jutland

The results of the analyses of material from Gedved Vest and Kristinebjerg Øst, and their interpretation in context of previously performed archaeobotanical analyses in east-central Jutland, are the main topics of article 3.

8.3.1. Gedved Vest

The archaeobotanical analysis of all samples from Gedved Vest, as well as the in-depth analysis of selected cases with geochemical and geophysical methods for the purpose of defining operational and other transformational aspects of the botanical material, is not only the first application of this multiproxy analysis in Denmark, but also one of the most large-scale applications to date.
As seen in chapter 7 and article 3 the analyses at Gedved Vest resulted in the establishment of a cereal cultivation history for the site, with a comparatively high level of detail for the period AD 1-600.

These analyses have provided evidence that cereal cultivation at the site was more or less stable throughout a large part of the Iron Age. Hulled barley was identified as the main crop, while rye, also observed on the site, was through the definition of operational stages in the investigated assemblages shown to most likely only have been cultivated during and after the shift from late Roman to early Germanic Iron Age. Occasional small finds of oat and wheat (both hulled and naked) could be refuted as cultivated on the site, and were instead interpreted as weeds or impurities in other cultivation. No evidence of crop rotation or autumn sowing was found on this site, and the main mode of cultivation was inferred as spring sowing on permanently manured fields.

8.3.2. Kristinebjerg Øst

The analysis of material from house DG at Kristinebjerg Øst has contributed archaeobotanical data for the Viking Age, a period which was missing in the operationally and transformationally defined material from Gedved Vest.

As previously mentioned, the samples from this site were derived from a comparatively well preserved burnt cereal storage barn. The analysis and publication (in article 3) of this material within the framework of the PhD project has thus added additional evidence about cereal crop storage during the Danish Iron Age based on a well-preserved bulk find. The analysis resulted in observations which, in relation to previous investigations, were both expected and unforeseen. Four different crops were identified in House DG: hulled barley, rye, oat and bread wheat, each stored separately in a respective section of the house. Crop rotation and autumn sowing was clearly identifiable in the material, and the hulled barley and rye was interpreted as cultivated within the framework of a short-rotation system. In combination with the data from Gedved Vest the analysis of House DG indicates that crop rotation and autumn rye may have been introduced in the area sometime between AD 600 and 800.

Autumn sowing at Kristinebjerg Øst was also indicated for the large find of bread wheat, an observation which has previously not been reported in either Denmark or Sweden. This may therefore be early evidence of a previously unknown phenomenon in Scandinavian Iron Age cereal cultivation. Large finds of bread wheat are overall uncommon for all periods of the Iron Age. If more wheat finds are recovered in the future, this material may become an important contribution to the beginnings of exploration of wheat cultivation during Scandinavian Iron Age.

8.3.3. Integrating the results from Gedved Vest and Kristinebjerg Øst into a model of Iron Age cereal cultivation in east-central Jutland

In order to understand the significance of the cereal cultivation observed collectively at Gedved Vest and Kristinebjerg Øst the results were in article 3 integrated with all relevant previously analysed data from the surrounding area.

This material consists of fifteen individual assemblages from a total of ten sites, displaying significant variation in both the type of investigated features and the amounts of recovered plant material. A reasonably convincing operational context had been interpreted for six of these assemblages, two un-threshed finds from iron extraction furnaces and four caches of cleaned grain. The remaining nine assemblages were presumably mixed or distorted beyond interpretation to varying degree by formational, operational and post-depositional transforms on the respective sites.

Three main conclusions were formulated on the basis of the comparison: 1) some trends appear to be consistent across most of east-central Jutland, indicating a coherent agricultural tradition in this part of Denmark, 2) despite similarities in the main trends, there are some minor
differences between individual sites indicating local, settlement-scale, adaptation, tradition or choice, and 3) the developments in cereal cultivation in east-central Jutland followed a somewhat different chronology than those observed in southern, western and northern Jutland, being on the whole more similar to developments observed on Funen than any other part of southern Scandinavia.

In short the Iron Age cereal cultivation history in east-central Jutland has been interpreted as being dominated by naked barley during pre-Roman Iron Age. Hulled wheats were seemingly phased out prior to 500 BC, while hulled barley had not yet made its breakthrough. Around 1 AD/BC a rapid change from naked barley to hulled barley is observed, with the latter crop thereafter dominating Iron Age cultivation until the Viking Age when secure evidence of hulled barley-rye crop rotation appear in the archaeobotanical record. These are the major trends mentioned above.

The most prevalent crop which seems to have been cultivated on a smaller scale is rye. On Gedved Vest there is little evidence of its conscious cultivation prior to c. AD 600. On other, previously analysed sites, rye does however seem to be in cultivation somewhat earlier. Secure finds appear from the 4th century AD, while more tenuous evidence of cultivation, and possibly even autumn sowing, being available from one site from the 2nd century AD. As a consequence of these results cultivation of rye is in article 3 discussed as possibly flexible, adaptive and contingent in relation to the needs and desires of the local farmers during the period after its initial introduction and prior to its adaptation as a component in well-developed crop-rotation systems.

Other crops which were clearly cultivated on a smaller scale, but of which there is less evidence, are oat and naked bread wheat. Oat cultivation is still more or less unexplored in east-central Jutland, although the summary of previously performed analyses shows that all larger finds date to the 9th century AD or later. This possibly indicates an expansion of oat cultivation at the end of the Iron Age. Bread wheat is similarly scarce. It is probably cultivated throughout the Iron Age, but the only significant find in east-central Jutland is the wheat analysed at Kristinebjerg Øst. Future analysis of any additional oat and wheat finds should therefore be a priority of archaeobotanical work in the region.

![Figure 8.1. Developments in cereal crop cultivation in east-central Jutland interpreted on the basis of the analyses of material from Gedved Vest, Kristinebjerg Øst and ten additional previously investigated sites. Source: article 3, Grabowski in press.](image-url)
8.4. Evaluating the methodology of the PhD project

During collegial presentations of the results from Gedved Vest, performed throughout the project in connection with courses, workshops and conferences, I was recurrently asked one specific question: “how do the results of your analyses compare to standard archaeological methods of functional evaluation?”

While I would like to argue that there is no such thing as a “standard archaeological method” - the archaeological discipline being a collective of individuals specialising either in one or other method of studying the traces of past material human existence, or in the interpretation and theorising of the results of archaeological studies - the question did put to the forefront an important issue, namely that the archaeobotanical, geochemical and geophysical multiproxy method had not at any stage been thoroughly compared against other functionally indicative archaeological evidence. Consequently, a theorised and well-structured test, where the multiproxy method is tested against independently attained archaeological evidence, was concluded to be a feasible and interesting way of methodological evaluation. It was furthermore perceived as a way to initiate further expansion and development of the method by exploration of its compatibility to other archaeological sources of functional evidence.

Article 4 is the result of the reasoning outlined above. Because a comparison of the multiproxy method to other archaeological evidence, such as artefact distribution studies, interpretations of the structural composition of houses and other constructions, and studies of the distribution of various features and other settlement components on Iron Age sites, requires the latter to be well understood and published in accessible formats, the material from Gedved Vest could not be used, since no in-depth work-through of the non-botanical material has yet been completed for this site. Instead, article 4 came to utilise previously analysed material from Halland and Bohuslän in south-western Sweden. This material was excavated in the 1990s and early 2000s during the numerous rescue-archaeological projects in the area (the west coast rail link being the main one) and has since been thoroughly analysed, interpreted and published, providing a suitable “archaeological” material for comparison against the results of the multiproxy analysis.

A segment of material from Gedved Vest was used in one capacity in article 4. All geochemical and geophysical results presented in articles 2 and 3, were obtained by analysis of sub-samples extracted from archaeobotanical bulk samples at Gedved Vest. This approach has, however, occasionally been discussed with some scepticism in archaeological publications (e.g. Zimmermann 2001:42). Since I personally perceive that the discussions in these publications have had a significant impact on the perception of phosphate analysis and sampling strategies among colleagues, article 4 also came to include a comparison of two sampling strategies and their applicability in phosphate analysis: 1) sampling and analysis of material from feature fills, extracted as sub-samples from archaeobotanical samples, and 2) sampling along a pre-determined grid, with phosphate samples being extracted from the boundary between the topsoil and subsoil (A and C-horizons).

The results of the case studies in article 4 showed that there is a high degree of compatibility between the results of the archaeobotanical, geochemical and geophysical multiproxy analysis and studies of artefacts and feature morphologies and distributions. In none of the evaluated cases did the two data sets result in inconsistent interpretations which could not be readily resolved by alternative explanations consistent with all data.

One case presented in the article, from Skrea 195 in Halland, selected for its pedagogical qualities, was used to show how the usefulness of the multiproxy analysis can be constricted by a complex stratigraphic situation coupled with a high degree of presumed functional dynamics on a site. In this case study, however, most other functionally indicative approaches were also constricted in their interpretative potential. This result puts emphasis on the fact that plant macrofossil analysis and other methods used predominantly within the framework of environ-
mental archaeology in most respects display the similar potential and limitations to most other forms of archaeological material studies.

The comparison of feature fill sampling and sampling along a pre-determined grid showed that both approaches can be used to attain similarly resolved and viable results.

Sampling along a pre-determined grid, which is not tied to the distribution of archaeological features can, if desired, attain a higher resolution of results than sampling of feature fills. It is, however, significantly more time consuming. This approach may also be used for analysis of site spaces without visible features.

Analysis of feature fills is more time efficient, because both archaeobotanical and other samples are collected at the same time, and may be used to address questions which require analysis of the internal stratigraphies of individual features.

When used in combination for phosphate and other analyses the two sampling strategies are argued to provide a powerful means of evaluating functional aspects of settlement spaces.

The main conclusion of article 4 was that the comparison of the archaeobotanical, geochemical and geophysical methodology to other types of archaeological data is encouraging for the viability of the multiproxy method, but also that that functional evaluation of settlement sites is an inherently complex undertaking, requiring stringent theoretical frameworks defining the possibilities and limitations of the utilised methods. There are no shortcuts or simple universal approaches to functional analysis of settlement sites.
9. Discussion

9.1. The implications of operationally defined archaeobotanical assemblages for cereal cultivation research

9.1.1. The importance of defining operational stages of archaeobotanical material

In article 1, written in 2010 and published in 2011, I stated that:

A storage assemblage consisting of several hundred thousand individual remains [can] provide secure evidence about the single harvest that produced the find. It will however provide considerably less information about the overall composition of the local agriculture than a “randomly” accumulated deposit in the postholes of a house, a type of deposit that represents “average drop off” from activities that are ongoing for several years or even decades (Grabowski 2011:484).

Three years later, on the basis of observations made during the analysis of samples from Gedved Vest, I must modify this statement.

The in-depth analysis, with an archaeobotanical, geochemical and geophysical multiproxy method, of in total 22 archaeobotanical assemblages from the site resulted in the operational definition of twelve of them (figure 7.4) while the remaining ten were interpreted as mixed or undefinable due to the effects of one or several transforms (figure 7.5).

During the interpretation of the operationally defined assemblages the identified patterns could be related to the current knowledge about Iron Age cereal handling, described previously by for example Viklund (1998) and Henriksen and Robinson (1996a).

The mixed or undefined assemblages of Gedved Vest showed no interpretable patterns, and other than demonstrating a presumably major shift in the choice of crops between the late Bronze Age and the Iron Age, contributed little to the understanding of cultivation and processing on the site. One may even argue that the active inclusion of this material in the interpretation of cereal agriculture at the site would only have confused the discussion and blurred the results. The presence of rye at Gedved Vest may be used as an example to illustrate this reasoning:

Rye is present as significant percentages in several of the mixed or undefined assemblages (figure 7.5), for example in longhouses A11369 and A11383 at Locality 1b (early Roman Iron Age) and longhouse A11311 at Locality 9-10-11 (late Roman/early Germanic Iron Age). Without further analysis this relative prevalence could be erroneously interpreted as indicating cultivation and consumption. In the operationally defined assemblages (figure 7.4) it was however clear that rye, although occurring throughout the Iron Age, sometimes in sizeable proportions of individual assemblages, was prior to the late Roman/early Germanic Iron Age only found either in residues resulting from cereal cleaning or, in one case, in partially cleaned grain. Thus, at least the two early Roman Iron Age finds from Locality 1b should be interpreted with caution. The operational stage of the material is unknown and the concentrations of rye may just as well reflect its removal and discarding as cultivation and consumption.

The variation observed in the operationally undefined assemblages at Gedved Vest, and the experiences gained during the process of identification and delineation of functional spaces for purposes of operational definition of botanical material, as described in articles 2, 3 and 4, have

13 Consequently this segment of the material was consciously left out of article 3.
prompted me to re-evaluate the assumption that undefined but seemingly mixed assemblages on settlement sites provide an average botanical signature representative for the overall cereal cultivation. By reference to the operational variations observed at both Gedved Vest (article 3), and on the south-west Swedish case study sites presented in article 4, I would like to argue that the possible circumstances of archaeobotanical formation and deposition are so numerous and diverse that one would need to analyse a much larger material than what is commonly sampled in order to counterbalance the variation imposed onto the material due to human operation and other transforms. The definition of the operational and transformational aspects of the botanical material is therefore absolutely vital for any serious assessment of its significance for understanding events and processes in the past.

9.1.2. The means of defining operational stages of archaeobotanical material

There are several viable ways of evaluating the operational aspects of archaeobotanical assemblages.

In southern Scandinavian archaeobotanical literature almost every researcher acknowledges the importance of understanding the life history of the material. In many cases, the evaluation of the transforms affecting the material is presented implicitly, woven into the general discussions in the respective publications (e.g. Engelmark 1992, Gustafsson 1995a, Jensen and Andresen 2011, Viklund 2004). Discussions about the representativity of the material are sometimes also presented explicitly, for example by Robinson (1994) and Robinson, Mikkelsen and Malmros (Robinson et al 2009), who present a qualitative five-graded assessment-scale as a solution, or by Regnell (2002) who uses detailed comparisons of plant concentrations in various contexts to assess the representativity of the material.

In this project the preferred method of elucidating the transformational histories of the carbonised assemblages has been by comparison to the functional interpretation of the features or settlement spaces from which the material derived, inferred either with an archaeobotanical, geochemical and geophysical multiproxy analysis (article 2 and 3), or a combination of the mentioned multiproxy analysis and other archaeological techniques (article 4).

Without going into a discussion of which approaches are more or less suitable for the specific conditions on prehistoric settlement sites in southern Scandinavia, I would like to argue that the analyses performed at Gedved Vest have emphasised one approach which should under all circumstances be avoided: the assessment of archaeobotanical assemblages based solely on a non-botanical categorisation of the features from which they derived.

A comparison between figures 7.2 and 7.4-7.5, shows that little interpretable information can be gained from a categorisation of the botanical material solely on the basis of sampled feature type. This is probably a result of two factors: 1) the feature categories commonly used in the documentation of settlement sites are broadly defined, and do not in their default definition account for the functional dynamics of the spaces which they represent, and 2) botanical material moving through settlement spaces, simultaneously undergoing transformations along an operational sequence, can be preserved and deposited in such diverse ways that there is little chance of ever developing a feature categorisation which would also encompass the functional/operational aspects necessary for archaeobotanical interpretation. Archaeobotanists must thus accept the fact that archaeobotanical categories have to be established independently, accounting for the specific properties of our material and the specific processes imposed upon it by humans in the past.

14 The same five-graded scale was used in article 1.
9.1.3. The significance of the operationally defined archaeobotanical material from Gedved Vest
As previously mentioned an operational context could be defined for twelve out of the 22 archaeobotanical assemblages from Gedved Vest which were analysed in-depth. The twelve assemblages could be defined as belonging to one of three inferred operational stages: 1) cereal cleaning residues, 2) consumption stage grain in storage or kitchens, and 3) partially cleaned grain storage.

Although this result does not even begin to address the full complexity of cereal processing practiced in the past, which presumably consisted of two dozen or more distinct operations, or even of the simplified operational model used by most archaeobotanical researchers in Scandinavia (cf. chapter 5.1.4), it is nonetheless an improvement upon the operational resolution previously documented in east-central Jutland.

The material from Gedved Vest, and the operationally straightforward assemblage from Kristinebjerg Øst, was in article 3 compared to all other relevant finds reported from the surrounding area. This material consisted of fifteen assemblages from ten sites, of which six had been defined as either pre-threshing assemblages or stored cleaned grain. Thus, the studies presented in this thesis, and in article 3, have tripled the amount of operationally defined botanical material, and added two operational stages which were previously absent in the material: cereal cleaning residues and partially stored grain.

9.1.4. The contributions and interpretative limits of the results from Gedved Vest and Kristinebjerg Øst
In chapter 4.1 five main developments were outlined as characterising contemporary archaeobotanical research on cereal cultivation in southern Scandinavia.

Cereal cultivation was furthermore described in chapter 4.3 as having undergone transformations during the Iron Age that can be broadly divided into two main groups of interconnected phenomena; the first occurring at the beginning of the period, evidenced by the breakthrough and eventual dominance of hulled barley, and the second occurring from the middle of the Iron Age onward, revolving around issues related to the initial acculturation of rye and its subsequent adaptation as a main component of late Iron Age cereal cultivation systems.

The here presented PhD project contributed to several of the developments in contemporary archaeobotany. The analysis of Gedved Vest and Kristinebjerg Øst has added to the resolution of local developments in cereal cultivation, and the inclusion of this material in a local cereal cultivation history has increased the understanding about a region for which comprehensively published data was previously lacking. The inclusion of one of the first large and operationally defined finds of bread wheat has furthermore provided new insights into the cultivation of a crop species about which little had previously been published.

Contributions about the means of cultivation and processing are more limited.

The presentation of rye cultivation dynamics at Gedved Vest, presented in the previous chapters and in article 3, is possibly the most significant addition of this project to the currently ongoing archaeobotanical discussion; the timing and specific conditions of early rye cultivation being at the centre of many questions regarding agricultural and social changes during the latter part of the Iron Age (cf chapter 4.3.2).

Contributions to the discussion about the previously observed changes in cereal cultivation occurring during the late Bronze Age and early Iron Age were not possible on the basis of the material analysed during the here presented project. The operationally defined material from Gedved Vest covers the 1st to the 7th century AD, while the regional cereal cultivation history of east central Jutland, presented in article 3, shows that most of the significant changes - such as
the phasing out of hulled wheat and the shift from naked to hulled barley - occurred earlier (cf. figure 8.1).

Lastly, few contributions have been attempted during this PhD project to the discussions about complex links between cereal cultivation and other Iron Age phenomena or to the debate about causal factors underlying cereal cultivation change. The discussion about the dynamics of early rye cultivation, presented in article 3, could however, by means of additional studies, be expanded into such a contribution. The absence of a causal discussion in this thesis is, however, by no means an omission, or a result of a reluctance to deal with such questions, but rather a pragmatic choice made on the basis of the perceived state of the current empirical archaeobotanical foundation, its potential for addressing complex questions of contemporary archaeobotany, and the level of integration between archaeobotany and other segments of archaeology.

9.2. A reflection about the current nature of archaeobotanical studies
Archaeological research has previously been described as operating on three general levels, which can be termed low, middle and high-level research. Each level encompasses in its definition a different scope of questions addressed to the prehistoric record, and different degrees and scales of integration of diverse archaeological data. Low-level research is exemplified by in-depth studies of, for example, a single site or a specific type of material culture. Middle-level research entails the combined assessment of numerous low-level studies for the establishment of syntheses of, for example, specific regions, time periods or sets of related questions. High-level studies focus on the “big” questions of archaeology, such as supra-regional or global societal change, studies of the mechanics underlying social transformations, and archaeological epistemology (e.g. Ellen 2010, Raab and Goodyear 1982, Smith 2010, Trigger 1989).

Although one may criticise this model for being overly generalising, dividing a continuum of complexity of archaeological practice into three broad groups, it does provide a frame within which the nature of current archaeological and archaeobotanical research can be discussed.

Early archaeobotanical research was in chapter 3 outlined as primarily descriptive, and may be described as having predominantly operated at the lower levels of archaeological research, and been primarily preoccupied with the assessment of archaeobotanical data more or less independently from other archaeological evidence. It was furthermore addressing almost exclusively questions of technology and subsistence economy.

Over time, archaeobotanical research has expanded in scope, and particularly the exploration of methodological issues and the inference of different modes of plant cultivation and processing in prehistory, performed by comparison of archaeobotanical data to experiments, historical texts and ethnographic accounts, gives much contemporary research qualities of the middle-level.

One may however argue that the majority of archaeobotanical research on prehistoric cereal cultivation in southern Scandinavia is still predominantly performed as low-level research, preoccupied mainly with basic studies of technology, technique and subsistence strategies. The scope of most archaeobotanical investigations rarely extends, or is allowed to extend, beyond the primary site and/or assemblages under study. This situation is clearly demonstrated by the fact that the majority of data and insights generated by archaeobotanists are found in reports, appendices and occasional references or sub-chapters in publications from local archaeological projects.

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15 Note that I am actively avoiding the term middle-range research, which, initially originating from sociology, has been used by Binford (1977), Raab and Goodyear (1984), Schiffer (1988), and others in such diverse ways in archaeological discussions as to render the term virtually useless due to the numerous and diverging definitions (see discussions in Johnson 1999: chapter 4, Schiffer 1988 and Smith 2010).

16 Note that this terminology does not denote a low or high value of the research performed within each domain, nor of the complexity of research or level of required expertise.
At the same time, as described in chapter 4, the most interesting and debated topics in current archaeobotany are questions of causality underlying changing cereal cultivation, and discussions on how the cereal cultivation component of prehistoric societies interacted with the whole.

The situation described above is contradictory, and I would like to argue that the most exciting questions in current archaeobotany are largely discussed on the basis of an investigative procedure which allows little possibility of them being properly and convincingly addressed. Questions such as whether the breakthrough of hulled barley cultivation during the late Bronze Age and early Iron Age is connected to the advent of systematic manuring, or whether the introduction and subsequent adaptation of rye during the second half of the Iron Age was a precondition for, or a result of, a nucleation and consolidation of settlements, are in my opinion currently unanswerable. I would therefore want to argue that the exploration of the complex questions in archaeobotany requires:

1) A combined assessment of not only botanical data, but also other segments of the archaeological record; i.e. dedicated middle-level studies where relevant and most probably diverse data is handled in a thoroughly theorised manner to answer well defined questions.

2) An expansion of the main archaeobotanical perspective, from the current focus on technology, technique and subsistence economy, to active participation in spheres of archaeology dealing with for example social organisation and its effects on settlement structure and overall economy. This expansion can be argued as unavoidable for answering the more complex questions of archaeobotanical research, because the causes underlying changes in the technological and economic domains of past societies may well have strong connections to processes and events in other domains of prehistoric existence. The active participation of archaeobotanists in a broadened integration of archaeobotany in archaeological research is necessary because their expertise can facilitate a constructive use of botanical data while accounting for the interpretative complexity of the plant macrofossil material.

While this thesis did not aim to conduct a middle-level study in which archaeobotany is an integrated component, nor did it come close to achieving this in its results, I would like to suggest that the here presented approach for defining operational stages and other transforms of botanical assemblages by functional analysis of settlement spaces, provides an avenue through which a better integration between archaeobotany and other segments of archaeology, particularly “traditional” settlement archaeology, can be achieved.

9.3. The potential contributions of archaeobotany to settlement archaeology

Plant macrofossils are often cited in archaeological literature under the term *ecofact* or *biofact* (e.g. Branch et al 2005, Dincauze 2000, Welinder 2004), two interchangeable terms defining objects which carry archaeological significance, but are previously unmodified by humans, and which reflect human engagement with nature to a higher degree than artefacts (Jones 2005:63ff, Reitz and Shackley 2005:5).

As seen in chapter 5, however, the plant macrofossil material recovered from archaeological sites is never unmodified or “natural”, but rather reflecting very complex processes of human handling and other transforms occurring largely in anthropogenic settings. One may thus argue that the nature of the plant macrofossil material agrees with a growing consensus that “[the] boundary [between ecofacts and artefacts] is far less clear than what was once thought, as all archaeological materials bear witness to their natural origin and cultural modification” (Jones 2005:64), and that the distinction of material remains along nature-culture lines “gives a false perspective on the human role in forming archaeological sites” (Reitz and Shackley 2012:5).
Carbonised plant remains and other forms of material culture should therefore, instead of being bundled into broad categories, be seen as unique archaeological phenomena, with distinctive and diverse properties resulting from their physical make-up and modes of human use and modification. Plant macrofossils are both indicators for the “natural” environment and bearers of cultural information, with the main role ascribed to them by individual researchers being largely governed by the questions under study.

In the context of southern Scandinavian settlement archaeology one may argue that plant macrofossils, as soon as they are harvested or collected, and begin their spatial movement across sites and their physical modification due to human handling, assume qualities traditionally associated with the *artefact*. Although lacking stylistic details and design, carbonised plant remains share many qualities found in types of artefacts such as pottery, metallurgical remains, and animal bone. Plant remains are ubiquitous because, just as pottery or bone, they were processed on sites on a daily basis. If carbonised, they rank among material culture types with some of the better chances of preservation, particularly when compared to uncarbonised plant-based material, textiles, or certain types of animal matter. An important trait of carbonised plant macrofossils is furthermore that the source material, i.e. all the taxa and different parts of individual plants, is exceptionally diverse, allowing them to carry information about the ecology and natural conditions of a region, human subsistence, technology and the spatial distribution of various activities. Finally, plant macrofossils such as cereal grains are due to the short life expectancy of uncarbonised seeds preferably dateable by $^14$C analysis, providing a secure and direct means of chronological control.

In *article 4*, where the archaeobotanical questions of cereal cultivation were put to the side in order to emphasise the complexity of functional evaluation of spaces at settlement sites, a total of 17 parameters indicative of function (four belonging to the previously described multiproxy analysis and 13 commonly used in “mainstream” archaeology) were assessed besides distributions of plant macrofossils. In five out of six assessed cases an interpretation about the functionality of spaces could be achieved on the basis of all evaluated parameters. A review of which parameters had contributed to each of the interpreted cases (*article 4*, Grabowski in prep: 55) did, however, also show that only two evidence sources were instrumental for the functional interpretation in all of the successful cases: phosphates (coupled with measurement of SOM) and analysis of the distribution of plant macrofossils.

I would therefore like to argue that plant macrofossils on settlement sites, although far from unproblematic and requiring further methodological testing, are a type of material culture which, due to its ubiquity and diversity, provides a highly informative record for the study of settlement site dynamics. Plant macrofossils, in their situational capacity as *artefacts*, should be considered of similar significance as more traditionally acknowledged artefacts, such as pottery, and collected and documented accordingly.

In practice, plant macrofossil analysis performed for the purpose of evaluating the functionality of spaces should also be able to contribute insights about:

1) The general distribution and intensity of habitation; by contributing to the identification of dwelling spaces and kitchens.
2) The general organisation of space on settlements; by identification of storage, activity, and refuse disposal spaces.
3) The animal component of prehistoric economies and its manifestations on settlement sites; by contributing to the identification of byres and providing evidence about foddering strategies.
4) The organisation of production; by for example illustrating whether different stages of plant processing and use were performed on all sites or whether there was a division of activities, for example between producer and consumer sites.
9.4. Archaeobotany and settlement archaeology: Concluding remarks

On the basis of the discussion in this chapter the main conclusion of this thesis is that archaeobotanical research on cereal cultivation and archaeological research about the dynamics of prehistoric settlement sites are inseparably connected, and must be explored jointly in order to obtain the best results in both spheres of research.

The exploration of even the most basic archaeobotanical questions of cereal husbandry, i.e. the questions of which crops were cultivated where and when, requires a degree of understanding about the transforms imposed onto the botanical material (as discussed in articles 2 and 3).

Functional evaluation of site spaces and archaeological features, for the purpose of defining operational and other transformational aspects of the botanical material, is proposed as one valid approach to exploration of archaeobotanical questions. The methods of functional evaluation presented in articles 2, 3 and 4 are argued as suitable for addressing the specific conditions on southern Scandinavian settlement sites.

The resulting multiproxy analysis, in which studies of plant macrofossils play an integral role, is however also argued as a tool with potential to contribute to non-botanical settlement research, illuminating aspects not directly related to cereal cultivation and other plant use.

Some questions discussed in contemporary archaeobotany are, in the above chapter, argued as difficult to address on the basis of the current archaeobotanical research strategies. This applies mainly to the questions of how and why in cereal cultivation. Some questions commonly discussed in archaeobotany cannot be solved by the discipline alone because they require an understanding of domains of past existence beyond that which is accessible by archaeobotanical methods.

Because almost all botanical material relevant to the understanding of cereal cultivation derives from settlement sites, increased understanding of site dynamics - an understanding in which plant-based functional evaluations can play an integral role (as described in article 4) - may be argued as the most readily available avenue for expanding archaeobotany in a direction where it interacts and integrates with other facets of settlement archaeology, allowing for the exploration of more complex questions of cereal agriculture.

In short: the exploration of basic archaeobotanical questions commonly contributes to a better overall understanding of the places where the botanical material was created and preserved. This enhanced understanding may in turn provide the conditions for exploring archaeobotanical questions of greater complexity.

Archaeobotany without archaeology can never be anything but limited and descriptive, while archaeology without archaeobotany, i.e. without in-depth knowledge about the plant-based segment of human material existence, is bound to provide an impoverished depiction of the past.
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