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

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ABSTRACT

Radoslaw Grabowski 2014. Identification and delineation of settlement space functions in the South Scandinavian Iron Age: Theoretical perspectives and practical approaches

This article presents an overview of methods used in south Scandinavian archaeology for identification and delineation of settlement space functions. The overview includes commonly utilised archaeological approaches, such as artefact distribution studies and inferences based on assessment of house and settlement morphologies, as well as archaeobotanical, geochemical and geophysical approaches to functional analysis. The theoretical potential and limitations of each presented functional parameter are outlined and thereafter applied and compared using material from five case study sites in east-central Jutland, Halland and Bohuslän. The presentation of the site of Gedved Vest in east-central Jutland also incorporates a comparison of two common approaches to geochemical sampling: 1) sampling and analysis of soil retrieved from feature fills, and 2) horizontal sampling of soil from the interface between the topsoil (A/Ap) and the subsoil (C) - horizons along a pre-determined grid.

KEYWORDS: settlement archaeology, Iron Age, longhouses, functionality of space, multiproxy analysis, phosphate analysis, plant macrofossil analysis, magnetic susceptibility, soil organic matter, artefact distribution, house architecture, settlement structure.

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

Background

The first prehistoric longhouses were excavated in Scandinavia over a hundred years ago (Hvass 1988:53). The archaeological record assessed to date shows that the concept of building elongated dwellings with functions beyond mere habitation existed for almost five thousand years; from the Neolithic until the end of the Viking Age (Ethelberg *et al.* 2000, Ethelberg *et al.* 2003, Welinder *et al.* (eds) 2004). Understanding the functional aspects of the structures and their surrounding space and how these functions changed over time is therefore important if one seeks to grasp the dynamics of prehistoric settlements.

Over the last two decades, the Environmental Archaeology Laboratory in Umeå (MAL, Miljöarkeologiska Laboratoriet) has participated in attempts to elucidate functional aspects of settlement spaces by the use of a selection of archaeobotanical, geochemical and geophysical methods. Utilised separately at first, these strands of evidence have over time been integrated into a comprehensive multiproxy strategy, where space functions are identified and delineated by comparison of the spatial distribution of plant macrofossils, distribution of inorganic and organic phosphates, variations in soil organic matter and variations in magnetic susceptibility (Grabowski and Linderholm 2013).

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Although this set of methods has been applied on numerous archaeological cases - for example during the E6 motorway and the West Coast Rail Link projects in Halland (see articles in Carlie *et al.* (eds.) 2004) and the E4 motorway project at Pryssgården in Östergötland (Borna-Ahlqvist 2002) - its possibilities and limitations are still insufficiently presented in easily accessible publications; most work having been published in “grey literature” reports and local archaeological monographs and anthologies. In a recent article (Grabowski and Linderholm 2013) the development history, underlying theory and examples of application have been presented in an attempt to remedy this situation. However, mainly owing to time and space constraints, this publication was limited to an assessment of the multiproxy method independently of other sources of archaeological functional evidence. Lacking in particular was a comparison of the botanical, geochemical and geophysical data to that originating from approaches commonly applied by “mainstream” archaeology, for example interpretations of structural and artefactual evidence recorded during excavations. That article may thus be seen more as a parallel rather than integrated writing about settlement phenomena in prehistory.

Further, the geochemical and geophysical analyses presented in the abovementioned article were exclusively performed on soil retrieved from feature fills. Here, the theoretical supposition being that the sediment within the features should have originated mainly from activities in the immediate surroundings of the features and thus botanical, geochemical and geophysical signatures would be informative of activities taking place near the features. As such, the study represents one common way in which historically sampling for geochemical and geophysical settlement analyses has been performed in Scandinavia; another common method being horizontal grid sampling of soil strata presumed to carry information relevant to prehistoric settlement activities.

On occasion, however, previous publications where feature-fill sampling for chemical and physical analyses has been considered have voiced strong reservations about the reliability of feature fill sampling. Zimmermann (2001: 42), for example, writes the following about sampling for phosphate analysis:

As a rule it is not worth taking samples from postholes. Generally they are full of randomly mixed soil. Such samples will therefore often have a random character. Since the fill material from the pits is mixed with soil from the old surface, their phosphate values will be higher than the values from the surrounding subsoil. When one is taking phosphate samples it is therefore advisable to steer clear of all structural traces.

At Flögeln samples were only taken experimentally from the post-hole fill. The result showed that the highest values emerged from the byre section. Nevertheless the picture provided by the surface-covering mapping is much clearer. When Blidmo recommends that one should take samples from the post-holes, this is not meant to document the demarcation of the various functional areas, but to demonstrate different construction phases (Blidmo 1995).

However, the accumulating corpus of results from phosphate (and other geochemical) analyses does seem to indicate that the above stated reservation may not be completely accurate. The soil eroding into feature fills can instead be seen as carrying relevant information relating to anthropogenic processes, and demarcation of functional spaces may be attempted based on this type of material. The “random” character referred to by Zimmermann can be argued to mirror the intricacies that prehistoric human action, taphonomy and archaeological extraction imposes on settlement soils, making its assessment highly relevant for archaeological research.

A similar argument is presented by Blidmo (1995: 19) in the publication cited by Zimmermann above:

In complicated cases, with numerous postholes, this type of analysis [phosphate analysis of feature fills] may be used to control whether or not they belong to the same construction. One can also functionally identify different parts of houses, i.e. determine where living space and byre were located, and also determine how the latter was organised [author’s translation].

Since the selection of sampling techniques for functional analyses is a very important issue for archaeologists in the field, there is obviously a need to compare and evaluate the applicability of both sampling strategies under the specific conditions of south Scandinavian settlement archaeology.

Article aims and objectives

Based on the research situation outlined above this article sets out to address two explicit aims:

1. To enhance the understanding of activities played out on settlement sites by analysis of house sections and other settlement spaces based on data from multiple sources of evidence.
2. To evaluate the possibilities, limitations and interpretative relevance of methods used for functional analysis of houses and other settlement spaces, with a particular focus on comparing the multiproxy method developed and utilised by MAL and more “traditional” archaeological approaches to functional interpretation.

These aims are pursued by:

1. Reviewing illustrative cases where a multiproxy analysis of botanical, geochemical and geophysical methods as well as other archaeological techniques have been applied for the purpose of identifying and delineating settlement space functions.
2. Investigating whether relevant geochemical information can be obtained by analysis of feature fills as opposed to analysis of samples from extensive area

surveys, achieved by comparison of data from feature fill sampling and an area survey respectively of two longhouses from the Danish site of Gedved Vest.

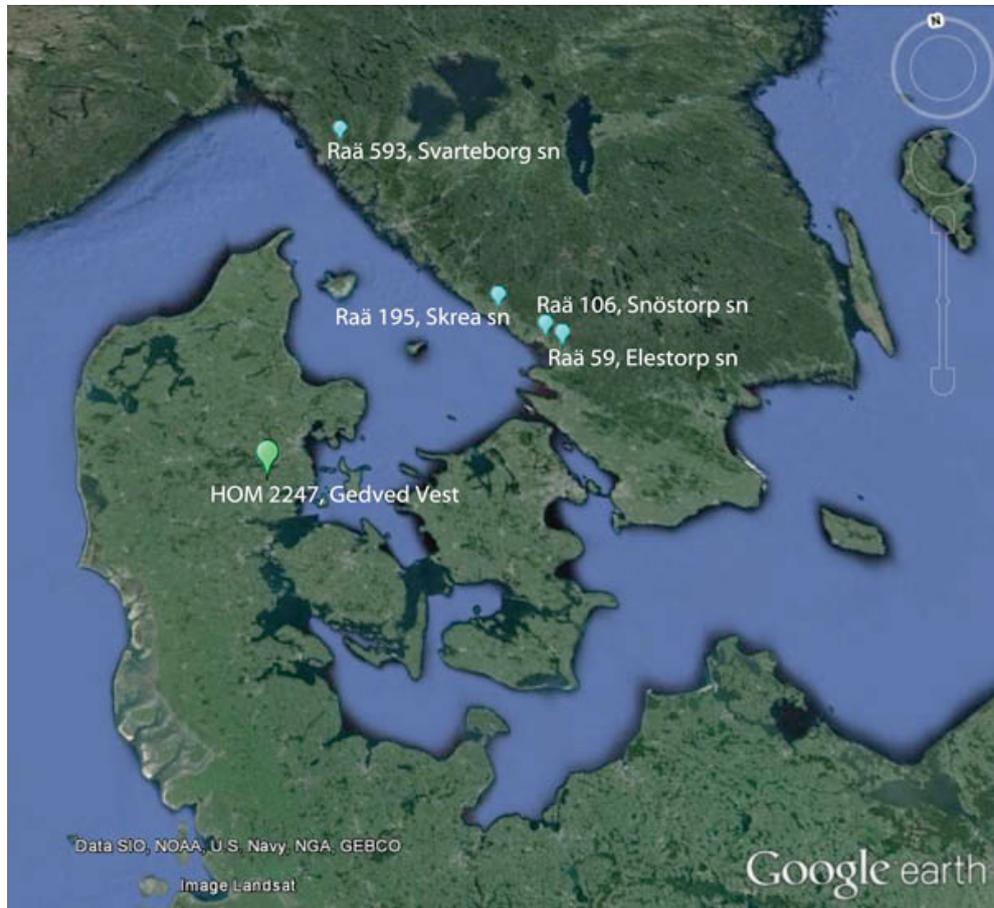


Figure 1. Satellite image of southern Scandinavia showing the locations of case studies presented in the article. Source: Google Earth.

http://clamator.its.uu.se/uploader/92/JAAH_Grabowski_Fig01.pdf

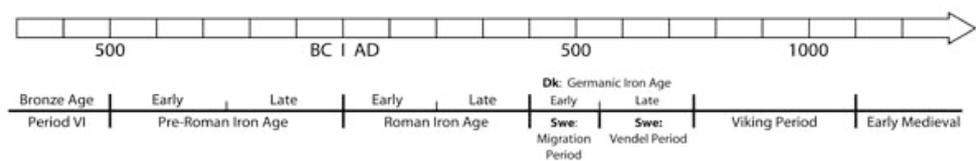


Figure 2. Time-line displaying the local Danish and south Swedish chronological nomenclature. http://clamator.its.uu.se/uploader/92/JAAH_Grabowski_Fig02.pdf

Chronology and geographic context of the analysed case studies

Two groups of material are utilised in order to address the aims of the article.

Material from two late pre-Roman/early Roman Iron Age longhouses, and their surroundings, from the Danish site of Gedved Vest is presented primarily in order to compare the results from the geochemical feature sampling and the horizontal grid surveys. The two houses and their surroundings have been subject to both a high-resolution grid sampling, performed in accordance with the guidelines formulated by Zimmermann (2001), and sampling of all archaeological feature fills within the area covered by the grid. This material thus presents an ideal case for a comparison of the respective sampling strategy. However, the presentation of this case study goes beyond a mere comparison of sampling strategies, as it also illustrates how a combination of functionally indicative methods may be combined in order to reconstruct the internal functional arrangement of a settlement space.

The remaining case studies are presented in order to further illustrate how archaeobotanical, geochemical and geophysical analyses of feature fills can be utilised for functional interpretations of houses and settlement spaces, and how this bundle of methods compares to functional indications made available by other methods traditionally utilised in Scandinavian settlement archaeology. The case studies have been selected from the corpus of analyses performed by MAL during the south-west Swedish road and railroad projects of the late 90s and early 2000s. The material from these projects is particularly well suited to a comparison of the botanical, geochemical and geophysical results to other types of archaeological data, since the methodologically ambitious projects have since been well documented, interpreted and extensively published in report, article and thesis formats.

All the presented case studies derive chronologically from the Scandinavian Iron Age, i.e. 500 BC – AD 1100, but most of the insights presented herein are presumably applicable to other periods with similar traditions of settlement construction.

Methods of functional analysis and their underlying theory

Living and dying houses in dynamic societies and landscapes

All material measured by the botanical/geochemical/geophysical multiproxy analysis utilised at MAL, as well as evaluated with more “traditional” methods of functional analysis, is susceptible to processes that hinder inference of activities. Using Schiffer’s (e.g. 2010) terminology, these can be termed as C

and N-transforms, i.e. anthropogenic or “natural” processes, which modify the original depositions and impose various degrees of complexity.

Anthropogenic modification of the original depositions that are analysed for functional interpretation include redeposition due to waste management, redeposition stemming from symbolically, ritually or ideologically influenced views of “how things should be done” (which may be counterintuitive to an interpreting archaeologist), and mixing of material owing to succeeding habitation and/or activity phases. C-transforms also include more recent processes, such as the cultivation of a settlement space after its abandonment. N-transforms that presumably have a significant impact on functional analysis results are different types of soil erosion and bioturbation.

Functional analyses of houses must also consider their individual biographies, which are closely tied to the life histories of their inhabitants (Brück 1999, Gerritsen 1999, Webley 2008:21, Ångeby 1999 as main references for discussion below).

Regardless of which type of social unit inhabited a house, the structure of the unit would never have been static. People are born, grow up, grow old and eventually die. As an effect of these inevitable changes, the role of a social unit inhabiting a house in the context of the wider community of the settlement area or village would have changed over time. A house could, for example, have been a nexus of agricultural activities during a period of time, with this role shifting to another social unit owing to changes in the demographic composition of the local community. Variations in the functionality of a social unit inhabiting or using a house may also have occurred due to changes in the social or economic standing of the inhabitants within the wider community, irrespective of demographics. Such shifts in the role of a social unit could have had significant influence on the internal workings of its associated houses. They could have necessitated changes in construction details that were not anticipated when the house was first designed and, perhaps more likely, imposed variations in the utilisation of already available space. Furthermore, if the house was used over extended periods of time generation shifts may have resulted in a cyclicity in the functionality and therefore also the physical house. However, each generation may also have imposed idiosyncratic variations unique for its cycle.

Eventually, a house would have been abandoned, but the abandonment process as such could have archaeological implications. The burning of a house would affect the degree of preservation of various types of material. In addition, house fires could have been either planned or accidental, presumably resulting in different archaeological outcomes. A house destroyed by a planned fire could, for example, have either been cleaned prior to the event, or, if burned as part of a ceremony, been enhanced with special types of material culture. However, a house could also have been modified by less dramatic abandonment. Old houses could have shifted in function, while slowly falling to pieces, from habitation spaces to byres or storage barns. They could also, over time, have been cleaned of most material culture, or been enriched with

additional material depositions and soil modifications related to its end-life role.

Functional interpretation based on house structure, internal features and distribution of artefacts and anthropogenically modified soil

Previous functional analyses of longhouses have been based on various types of archaeological data. Overviews of these approaches have been presented in numerous publications. Since a complete review of the discussions concerning longhouse functionality would strain the space limits of this article, the reader is directed to the original sources for in-depth references and details (e.g. Borna-Ahlqvist 2002, Carlie 1999, Ethelberg *et al.* 2000, Ethelberg *et al.* 2003, Hvass 1985, Karlenby 2007, Olausson 1999, Peterson 2006, Ramqvist 1983, Rasmussen 1999, Streiffert 2004, Webley 2008).

One of the more clearly comprehensive presentations of evidence used for functional interpretation is a chapter of Maria Petersson's thesis (2006) which investigates whether or not animals were kept in Late Bronze and Early Iron Age longhouses in Östergötland. The list below presents thirteen of the main pieces of evidence for functional interpretation previously used in southern Scandinavia. Unless otherwise referenced, the list is based on a similar list in Peterson's (2006) thesis.

1. House dimensions. Although not a functional evidence in its own right, the size of a house may give some indications of its function, particularly if compared to other buildings with a spatial and/or chronological association.
2. Post setting. The arrangements of posts, for purposes of creating more or less open spaces, or for creating support for various types of internal features, have often been used in functional interpretations of longhouses. Open spaces, particularly when found containing the remains of a hearth, have been proposed to indicate kitchen/living spaces, while tighter regular settings have occasionally been used to identify and delineate byres. There is, however, some variation in the interpretation of post settings. Unless supported by other data variations in internal post arrangements should perhaps best be seen as indications of possible differences in the functions of spaces, but not of the nature of the function (Ethelberg *et al.* 2003, Olausson 1998, Pedersen and Widgren 2004, Petersson 2006, Tesch 1993).
3. Internal walls. Internal divisions of the interior of a longhouse should presumably indicate some form of functional delineation, although the walls themselves provide little evidence of the nature of the activities they are delineating. It should also be noted that many types of internal divisions, such as light wall constructions or simple railings, may be invisible in the archaeological record but could have been very influential

- in shaping everyday movements and actions inside a house (Carlie 1999 and 2004, Petersson 2006).
4. Entrances. Presumably, the entrances of a house were placed with some functional rationale in mind. For example, houses with byres have been proposed to contain a separate entrance for the animals. Larger, or at least separate, entrances may also have been necessary to facilitate transport of manure out of the house (Carlie 1999, Petersson 2006).
 5. Wall details. Many wall construction techniques have been inferred for prehistoric houses based on the traces left behind in the soil. The wall construction does not provide functional information about a house, but if the walls vary in different parts of the same house one could assume some functional difference between the respective spaces (Ethelberg *et al.* 2003:139pp, Ramqvist 1983).
 6. Topography. If a house was not placed on a level surface, the topographical alignment of the house could indicate functional aspects. Good examples are houses that could have contained a byre and that were built on sloping ground. The byre would presumably have been placed at the lower part of the slope in order to prevent the waste from the animals running toward the habitation space (Olausson 1998, Petersson 2006). The symbolism of placing humans “above” animals has also been suggested as a possible factor (Webley 2008:63).
 7. Physical remains of hearths. A hearth is commonly argued to indicate the kitchen/living space of a house. Although there may have been hearths in other spaces as well, there are some areas where the presence of fires was presumably avoided, for example the fodder and cereal storage areas (Hvass 1985, Olausson 1998, Peterson 2006).
 8. Other internal features. Similarly to hearths, other internal features may be tied to different types of activities. Features of this kind are ovens, cooking pits and storage pits (Webley 2008).
 9. Distribution patterns of artefacts, soil modified by human action and faunal remains. Artefacts such as pottery, material culture from constructions such as daub fragments, faunal remains in the form of bone, and various types of soil modified by human action often show variations in distribution that may be interpreted as patterns stemming from different types of activities (Olausson 1998, Peterson 2006, Webley 2006).
 10. Byre booths. In some longhouses, internal features in the form of elongated narrow troughs or smaller postholes forming short parallel lines perpendicular to the main axis of the house have been interpreted as traces of animal booths. If this interpretation is true, the booth traces should provide convincing evidence of byres. These booths are commonly encountered in Bronze and Iron Age longhouses in Denmark (although far from all houses display these traces), while being very rare in the south Swedish material (Olausson 1998, Ethelberg *et al.* 2000 and 2003, Hedeager and Kristiansen 1988, Petersson 2006).

11. Floor layers inside houses and “cultural” layers outside. Soils that form the floor space for activities over prolonged periods of time may become modified in ways that are identifiable in the archaeological record. Such activities may include animal trampling (possibly combined with input of animal waste), storage and handling of manure (in the form of input of organic matter and repeated removal and cleaning of this material), or waste management (in the form of repeated depositions of organic material and spent artefacts). If found inside or close to a longhouse, a “cultural” layer may provide functional information about the space. In this category may also be included physical traces after consciously constructed floors, for example in the form of paving or packed clay (cf discussion in Peterson 2006:69).
12. Replacement of posts. The wooden posts of a longhouse had a limited lifespan. Eventually, they would rot and would have to be replaced. Replacement of posts is archaeologically identifiable as posthole traces partially overlapping, or closely adjacent, to the original ones. It has been argued that the humid conditions inside byres could necessitate post replacement at shorter intervals than in the rest of the house (Peterson 2006:66p and therein listed references).
13. Evidence of house fires. Evidence of house fires can be manifest in the archaeological material in the form of burnt clay, burnt daub, burnt animal bones, heat affected artefacts and stone, charcoal rich feature fills, and charred structural house details. Although it is not a functional piece of evidence in its own right, the assessment of a house as burnt or not is important for interpretation of many other evidence sources, such as carbonised plants, burnt clay presence and distribution of burnt faunal material (Grabowski and Linderholm 2013, Gustafsson 2000, Moltsen 2011, Ramqvist 1983).

Plant macrofossil analysis: formation and operational background

Macrofossil analysis of carbonised plant remains is a method with a comparatively straightforward analytical procedure but complex interpretative aspects.

Preservation of plants by carbonisation effectively cancels their usefulness to humans and animals. In settlement contexts, charring is therefore commonly either accidental or the result of use as fuel. In both cases, the preserved material has presumably undergone a complex series of modifications stemming from human use prior to preservation (Grabowski and Linderholm 2013 and refs). The pre-preservation use of plants may result in innumerable variations within the encountered carbonised plant assemblages. Further, after preservation, this material is susceptible to modification by C- and N-transforms unrelated to human handling of plant resources (Schiffer 2010).

Preserved assemblages from different activities, or from different stages of a protracted process, will tend to differ in species composition and relative abundance of various plant parts. For example, a newly harvested assemblage that for any reason becomes carbonised will contain a high portion of arable weeds as well as the chaff and straw portions of the harvested cereal, while in contrast, a processed crop storage will contain almost exclusively clean grain. By assessment of these variations, it is possible to gain insights about the activities and possible function of the spaces from which they derived (e.g. Andréasson 2008, Engelmark 1981 and 1985, Grabowski and Linderholm 2013, Grabowski 2013, Gustafsson 2000, Karg *et al.* 2004, Maier and Harwath 2011, Moltzen 2011, Viklund 1998a and b, Viklund *et al.* 2013).

The complex formation and preservation of botanical assemblages makes archaeobotanical interpretation a difficult task. Nevertheless, the variation that results from differences in formation and preservation is also a necessary condition for the use of plant macrofossils in functional analyses of settlement spaces.

In this study, all analysed plant remains are derived from feature fills, primarily postholes. Previous studies have suggested that after the removal or disappearance of the post, postholes would quickly fill up with soil eroding from the surrounding floor and activity layers. If the soil contained carbonised plant remains these would also have been deposited in the features. If the feature were deep enough, the plants would thereafter have been comparatively protected from mechanical damage, bioturbation and later human disturbance such as agriculture and ploughing (Engelmark 1981 and 1985).

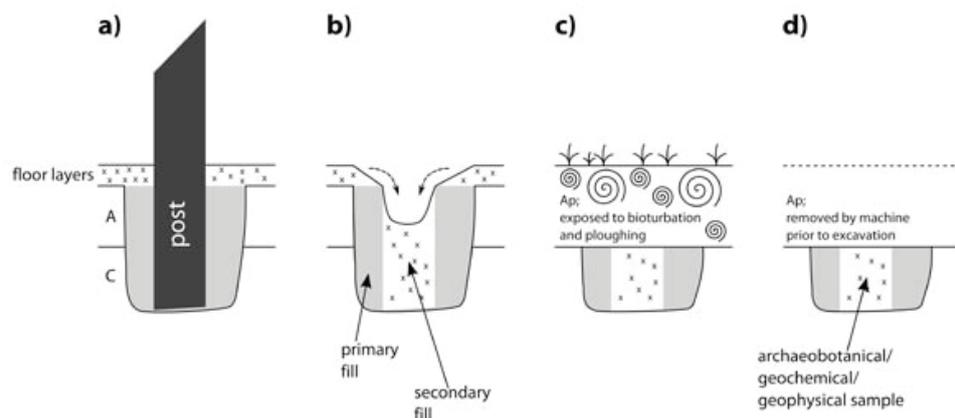


Figure 3. Schematic illustration showing the formation of a sampled posthole (d). Once the post (a) is removed, the surrounding floor/yard layers erode into the posthole, forming a secondary fill, also commonly termed as “the post trace” (b). If the posthole is sufficiently deep, it may survive subsequent disturbances such as bioturbation and ploughing, and be identified and sampled by archaeologists.

http://clamator.its.uu.se/uploader/92/JAAH_Grabowski_Fig03.pdf

Plant macrofossils in burnt and unburnt longhouses

Carbonised plant remains can occasionally provide information about the formation history of the archaeological context from which they were retrieved. Particularly relevant for this study is the fact that plant remains in a longhouse can provide a clue to whether the house has burnt.

In unburnt houses, carbonisation of plants presumably took place primarily during everyday handling in proximity to heat sources such as hearths. Plant remains in unburnt houses will therefore tend to cluster around the hearths or a heat source. A concentration of carbonised plant remains associated e.g. with cooking may therefore on occasion also be used as an indicator for the siting of former hearths, even if other traces are no longer recognisable in the archaeological record. However, it should be noted that hearths would have been regularly cleaned, which could have created more complex patterns of deposition and redeposition inside a house. The timespans represented by plant material in unburnt houses are usually impossible to define, and one must assume that the material could reflect accumulation over many months, years or even longer. To date, the corpus of archaeobotanical analyses in Scandinavia has shown that the amount of carbonised plant remains in unburnt houses tends to be limited, commonly only a few remains per litre of sampled soil. In contrast, burnt houses have been shown to contain high concentrations of macrofossils, often hundreds or thousands of individual remains in single samples (cf. Grabowski & Linderholm 2013, Grabowski 2013, Gustafsson 2000, Henriksen 2007, Viklund 1998a and b, Moltsen 2011). Plant remains in these cases also tend to be more widely distributed, since plant material in spaces that were presumably protected from fire during an active phase of the house also became carbonised. Material from burnt houses is commonly interpreted to represent shorter time spans and as reflecting activities that took place in the house at the time of or just before the fire. Such cases can therefore be perceived as snapshots of the botanical composition of a house at a specific time in its history. An underlying signal from everyday carbonisation that took place prior to the fire is of course also embedded in the material, but owing to the differences in sheer amounts of macrofossils, the effects of preceding activities should have limited effect on the composition of the assemblage (Grabowski and Linderholm 2013, Moltsen 2011, Viklund 1998a and b). However, no doubt there are examples in the archaeological record that deviate from the above generalisation.

In southern Scandinavia, carbonised plant remains from longhouses have been used to identify four main types of activity areas: 1) kitchen/living spaces with hearths, delineated through concentrations of food plants, presumably carbonised during handling around the hearth, 2) byres, through concentrations of fodder plants, 3) cereal processing areas, through concentrations of weeds and/or chaff, and 4) cereal storage spaces, through concentrations of cleaned grain (e.g. Andréasson 2008, Engelmark 1981, Grabowski & Linderholm 2013, Grabowski 2013, Henriksen 2007, Moltsen

2011, Ramqvist 1983, Rowley-Conwy 2000 and therein listed early 20th century Danish examples, Robinson 2000, Viklund 1998a and b, Viklund *et al.* 2013).

Magnetic susceptibility

Magnetic susceptibility (MS) is a soil-physical property largely linked to the content and composition of iron (Fe).

This property may change through human disturbance of soils, water logging, microbial activity, burning or deposition of iron rich material in the soil. An important quality of MS in the context of this study is its strong tendency to increase due to high temperatures, thus acting as an indicator for fires. The effects of fires may be measurable by MS-analysis even if physical traces of fires are no longer detectable by other archaeological methods (Dearing 1994, Linderholm 2010, Thompson and Oldfield 1986, Walden *et al.* 1999).

There are two characteristics of MS-analysis that are important for understanding the herein presented results: 1) MS from heating is not cumulative; it may only be raised or lowered within specific limits determined by the chemical composition of the soil, and 2) MS may be naturally high or low without necessarily indicating human action.

In order to discern between anthropogenic and natural elevated MS the soil is measured twice, with a laboratory-controlled heating performed between the measurements. MS levels that do not increase in the second measurement may be interpreted as representing previous exposure to intensive heating. In this article, all measurements of pre-heating susceptibility are designated as MS and post-heating measurements as MS550. Once both measurements have been performed, a simple mathematical calculation can be applied on the two values in order to obtain an MSQuota, i.e. an expression of the difference between pre- and post-heating values ($MS550/MS=MSQuota$). A low MSQuota indicates a higher similarity between the two measurements, and therefore also a higher probability that the soil was exposed to heating prior to sampling. A quota of 1 indicates that the two measurements were identical, and that the pre-heating sample had already attained its maximum possible susceptibility.

In functional interpretations of houses, MS-measurements are mainly useful for differentiating between burnt and unburnt structures. This in turn allows for more reliable assessment of the background history of carbonised plant macrofossils as well as other types of material culture with formation and/or preservation properties that may be affected by house fires (for example animal bones, daub from house walls and burnt clay).

In unburnt houses, MS may occasionally indicate where the hearths were located (e.g. Engelmark and Olofsson 2000, Gustafsson 2001). However, such indications are not always present, even when the house under study would presumably have contained a hearth. It is possible that the nature of the hearth construction, for example whether it was raised, placed on the ground, or even dug into a pit along with post-use transforms such as bioturbation and

ploughing, have a significant effect of the preservation of hearth related MS-signals.

Ms-analysis, possible archaeological scenarios

In this study, two plausible scenarios of MS-signatures in longhouses have been defined for comparison to other types of archaeological data:

1. Samples showing increased MS550 levels (high MSQuotas); are interpreted as unburnt.
2. Samples showing similar or equal MS and MS550 levels (low MSQuotas) are interpreted as probably burnt. When signatures of this kind are limited to only parts of a house, they may be seen as indications of previous hearth locations or of partial burning.

Analysis of organic and inorganic phosphates by weak acid extraction

"Many elements are left in the soil by humans; but few are as ubiquitous, as sensitive, and as persistent of an indicator of human activity as phosphorous. [...] When people add P to the soil as organic products or inorganic compounds, the P quickly bonds with Fe, Al or Ca-ions to form relatively stable chemical compounds of inorganic phosphate minerals and organic phosphate esters" (Holliday and Gartner 2007:301).

As expressed by Holliday and Gartner, phosphates are compounds of elemental phosphorous (P) and some of the building material of living organisms; which throughout the P-cycle of circulation may be bound in either organic or inorganic forms. Phosphates can be highly informative of human activities that often result in re-distribution and accumulation of naturally occurring phosphorous.

Most organic matter handled by humans contains phosphates, ranging in concentration from 0.01% in fruit to 20-35% in human and animal bone. The ratio between inorganic and organic phosphates also varies, from mostly inorganic in bones to predominantly organic in plants and thereof derived matter, such as manure (Hartmann 1992, Holliday and Gartner 2007, Zimmermann 2001).

A common method of analysing phosphates is through extraction with a weak acid, for example citric acid ($C_6H_8O_7$), which was used in this study (Arrhenius 1934; Linderholm 2010).

Extraction with citric acid allows primarily for analysis of the inorganically bound phosphates present in the sample, here termed as CitP-inorganic. Through exposure of a sample to controlled heating in a laboratory furnace, the organic material in soil can be decomposed and the organically bound elements released. A subsequent measurement also utilising citric acid will therefore result in measurements of both the original inorganic and the organic phosphates, now transformed into inorganic compounds, providing a

measurement of all phosphate present in the sample accessible for measurement by the citric acid method, here termed CitPOI (CitP on ignition). The organic fraction can thereafter be calculated by subtraction (CitPOI – CitP-inorganic = CitP-organic). For interpretative work, the relation between inorganic and organic P can also be expressed as a quota (CitPOI/CitP-inorganic = CitPQuota). A low quota is indicative of a larger content of the inorganic fraction. A quota of 2 represents equal amount of each fraction (Holliday and Gartner 2007, Linderholm 2010).

It should be noted that the chemistry of phosphorous is very complex, and that acid extraction techniques and processing in furnaces provide estimates rather than exact measurements of the phosphate fractions present in the analysed sediments. According to current research, however, these estimates should be sufficient for addressing the questions posed to the material by archaeological research (Holliday and Gartner 2007, Linderholm 2010).

Phosphate analysis of south scandinavian longhouses

The herein presented study is based on an assumption that valuable information may, when utilising a suitable methodological approach and theory, be extracted even from complex source materials by separation of the inorganic and organic fractions of CitPOI, i.e. total phosphate content extractable with citric acid. More specifically, the working hypothesis is that the two fractions should be primarily representative of bone and manure accumulations respectively, since these were presumably the main sources of phosphate-rich material circulating on prehistoric settlements (Engelmark and Linderholm 1996, Grabowski and Linderholm 2013).

On the scale of houses, the phosphate analysis is here hypothesised to provide evidence for identification of byres and/or manure storage (concentrations of organic phosphates, also expressed as high CitPQuota), and house sections containing kitchens or spaces where refuse was handled (concentrations of inorganic phosphates, also expressed as low CitPQuota). Ash from hearths, where the organic matter was combusted and the phosphates rearranged into inorganic forms, is also considered as a contributor to accumulation of CitP-inorganic in kitchen spaces.

A common statement in archaeological literature is that phosphate analysis may be applied to delineate byres through elevated phosphate levels in a specific part of a house (e.g. Aarsleff and Appel 2011:56, Ethelberg *et al.* 2000:193pp, Karg *et al.* 2004:143, Sundkvist 1998:172). Such studies usually refer to estimates of total phosphate content, commonly attained by extraction with a strong acid, as a single parameter. However, this supposition may be argued to have been founded on a problematic generalization (cf. Zimmermann 2001: 23ff). As mentioned above, mammal bone contains approximately 20-35% phosphate, while the amount of phosphates in manure is in contrast only about 0.2-1.1% (Hartmann 1992, Holliday and Gartner 2007, Zimmermann 2001). Bones are therefore more likely to result in high “total” phosphate levels than manure. However, some factors add layers of complexity to any archaeological

interpretation of total levels in soil: 1) Manure is likely to have outweighed bone in sheer volume, although the scales are rarely known, 2) bones and manure were presumably transported along completely different pathways, and 3) the time span and frequency of accumulation of manure is almost never known (Hartmann 1992, Linderholm 1998, Zimmermann 2001). These facts make any statements about the origins of phosphate based solely on P-total estimates highly speculative. A high P-total in a house may indicate a byre or manure storage, a kitchen or a waste handling space, or it may represent an unknown, and non-definable, combination of both.

Well-founded identifications and delineations of byres and kitchens by means of phosphate analysis could therefore be argued to be attainable only through either measurement of the organic and inorganic phosphate fractions respectively, or through comparison of the phosphate data to other archaeological functionally indicative evidence.

Measurement of soil organic matter by loss on ignition

Loss on ignition (LOI) is a straightforward way of measuring the amount of soil organic matter (SOM). By weighing a sample, heating it at 550°C, and weighing it again once the organic matter is oxidised it is possible to calculate the percentage of organic material.

Such measurement can provide information about the nature of a deposit, and be utilised as a correlate to phosphate analysis of byre spaces and/or kitchens, since both intensive input of manure and deposition of kitchen waste may change the stable level of SOM in soils (Engelmark and Linderholm 1996).

Phosphate analysis and measurement of som, possible archaeological scenarios

In this study, four possible scenarios of phosphate and SOM-accumulation in longhouses have been defined for comparison against other types of archaeological evidence:

1. Houses without byres should display relatively stable values of CitP-organic and CitPQuota throughout and concentrations of CitP-inorganic in kitchen spaces or other areas where bones were deposited. The kitchen and refuse handling spaces may also display elevated SOM.
2. Houses with a byre that was either intensively used, or used over an extended period of time, and where the manure was not rigorously cleaned away. These houses should display a high or at least moderate CitPOI in the byre, with a clear CitP-organic signature (high CitPQuota), and high CitPOI in the kitchen and refuse handling spaces, with a signature of CitP-inorganic (low CitPQuota). Elevated SOM-levels should be expected in the kitchen/refuse handling spaces and in the byre if sufficient amounts of manure were retained.

3. Houses with a byre that was only used periodically, used over a short period of time, or was rigorously cleaned when the manure was taken out into the fields. These houses should display a high CitPOI in the space where bone was deposited but not in the byre. The signature of CitP-organic and CitP-inorganic should however still be detectable in the respective areas as high CitPQuotas in the byre and low CitPQuotas in the kitchen/refuse handling spaces. Elevated SOM should be expected mainly in the kitchen/refuse spaces.
4. Houses with internal spaces used interchangeably for different activities, or houses severely affected by functionally unrelated N- and C-transforms, displaying “random” unintelligible patterns, i.e. houses where the resolution of the methods is not sufficient for identification of the sought-after activities.

Methods of functional analysis and their underlying theory: concluding remarks

Based on the discussions above, a final theoretical supposition of this study is that the results of the multiproxy analysis, as well as other evaluated functional evidence, may present hardly intelligible patterns owing to a combination of non-human transforms, quotidian anthropogenic processes, and an unceasing dynamic of house use. In other words, the definition and delineation of functional spaces may on occasion be constrained in outcome, regardless of how stringently archaeological methods of functional evaluation are applied due to a daunting underlying complexity in the histories of the houses and activities played out there.

As a result of this reasoning, all information presented here is weighed with the life-history concept of houses in mind. In practice, this is done by dividing the available sources of evidence into three categories, where each category represents a life-stage of a house that should be archaeologically identifiable for most houses (see table 1).

The first category refers to construction and contains the parameters: house dimensions, post setting, internal walls, entrances, wall details and house topography. It is important to note that all these parameters are primarily perceived not as evidence of the nature of activities performed in a house, but rather as indicators for which activities were planned by the designers of the house. One could therefore argue that parameters such as posthole settings or placement of internal walls as such never provide evidence of actions, but solely evidence of intent.

The second category refers to use and consists of evidence deriving from activities that were presumably performed within a house such as presence of hearths, presence of internal features such as storage and cooking pits, distribution of artefacts, modified soil or faunal remains, presence of booths, presence of floor and “cultural” layers, and replacement of posts. To the “traditional” archaeological data can be added distribution of phosphates,

indications of hearths through MS-analysis and distribution of soil organic matter. All of these sources provide direct evidence for the activities performed in a house, and could arguably be more reliable for functional interpretation. Nevertheless, all of them are also more susceptible to N and C-transforms, than the parameters in the construction category owing to variations in deposition patterns throughout a house's life history, and to interpretative difficulties stemming from irregularities in excavation and analytical technique.

A special note should also be made about byre booths. Similar to posthole settings, these could be seen as questionable as providing direct evidence of or a direct reflection of the stalling of animals and number of animals in a house. Lennart Carlie (1999) has questioned the archaeological practice of equalling the number of byre booths with the animal stock of a household by showing that most booth-carrying houses could not house the fodder necessary to feed a full complement of animals over any extended period of time. A study from Nørre Tranders in Denmark (Nielsen 2002), where nineteen animals were found burnt to death inside a house, showed that the sheep inside the house either had been pregnant or had recently born their lambs. These examples put into question the nature of information about the actual animal stock that can be extracted from the number of stalls. It is possible that a byre designed for a specific number of animals at some times could have carried a much smaller compliment of animals, perhaps the vulnerable or particularly valuable ones, while the rest were stationed and foddered outside. At other times, the byre could have been filled to the brim and beyond, such as during times of birth, when the animals were at risk, or during times when there was other danger in the form of predators, aggressive neighbours or invaders, or particularly harsh climatic conditions. One must therefore conclude that even if a byre is indicated by structurally clear structural traces, its presence and size do not provide actual evidence for its use. One must also consider the possibility of booth-carrying rooms being used for other purposes during times when animals were stationed elsewhere.

The third and final category of evaluated parameters is termed abandonment. In this study, the evidence in this group is limited to indicators of whether a house was burnt or not, including presence/absence of heat-affected artefacts, distribution of burn bone, burnt clay and daub, and observations made during the excavation, such as the presence of charcoal-rich feature fills. To this may be added analysis of magnetic susceptibility.

Table 1. List of parameters that may convey functional evidence on south Scandinavian settlement sites marking the likelihood of their usefulness for identifying and delineating various functional spaces. The parameters are grouped into three main categories: construction, use and abandonment, representing different life stages of prehistoric houses. Parameters included in the botanical, geochemical and geophysical multiproxy analysis developed at MAL in Umeå are marked in bold italics. http://clamator.its.uu.se/uploader/92/JAAH_Grabowski_Table_01.pdf

| | Construction | | | | | | Use | | | | | | | | |
|------------------------------|------------------|--------------|----------------|-----------|--------------|------------------|-----------------------------|-------------------------|--|--|---------------------------|---------------------------|--------------|--|----------------------|
| | House dimensions | Post setting | Internal walls | Entrances | Wall details | House topography | Physical remains of hearths | Internal/other features | Distribution of artefacts, modified soil and faunal material | <i>MS in unburnt houses indicating hearths</i> | <i>Phosphates and SOM</i> | <i>Plant macrofossils</i> | Stall booths | Floor layers inside house or "cultural" layers outside house | Replacement of posts |
| Hearth/kitchen/living space? | ? | X | X | X | ? | | X | X | X | X | X | X | | ? | |
| Byre | ? | X | X | X | ? | X | | X | | X | X | X | | X | X |
| Fodder storage | ? | | ? | | | | | | | | X | | | | |
| Cereal storage | ? | | ? | | | | | | | | X | | | | |
| Cereal processing area | ? | | ? | | | | | | | | X | | | | |

| Abandonment: is the house burnt? | | |
|----------------------------------|---------------------|--|
| <i>MS</i> | <i>Macrofossils</i> | Heat affected artefacts, modified soil, observations during excavation |
| | | |

Grid survey or analysis of feature fills? Functional analysis and comparison of sampling strategies at Locality 1, Gedved Vest

Archaeological background and sampling

The site of Gedved Vest, situated in east-central Jutland, approximately 33 km south-west of Århus and 8 km north of Horsens, was excavated between 2008 and 2010 by Horsens Museum in connection with an industrial development project (Hansen 2012). The site was extensively sampled for analysis at MAL in Umeå by the multiproxy strategy described in the theory and method section of this article. Owing to the scarcity of botanical material from Locality 1 (locality = sub-area), described in further detail below, however, this part of the site was not included in the main archaeobotanical publication of material from the site (Grabowski 2013), and this is the first published mention of Locality 1 from the extensive Iron Age site.

Habitation traces found on the site extended chronologically from the Late Bronze Age (periods V and VI) to the Viking Age; with a strong predominance of settlement remains from the Early Roman Iron Age onward. The case here presented derives from Locality 1 of Gedved Vest, which has been dated, by house and artefact typology as well as ^{14}C -analysis, to the Late pre-Roman and Early Roman Iron Age.

In the western section of Locality 1 two longhouses (A11298 and A11299) were detected, situated comparatively clear of other observed activity traces and displaying only one construction phase each. Nevertheless, replacement of some posts may have taken place, as indicated by the presence of double and elongated postholes (see figure 4 for plan).

The design of the two houses has parallels elsewhere in Denmark, indicating an early Iron Age date (e.g. Ethelberg *et al.* 2003:194, Kaul 1986). This is confirmed by three ^{14}C -samples from each house that provided a cal. 2σ -span of 401 BC-AD 18 for A11298 and 191 BC-AD 70 for A11299. One of the dates from A11298 deviated from the other two. This date was obtained from a charcoal fragment of probable beech (cf *Fagus*) while the other two were obtained from carbonised cereals. Since beech can reach an age of several hundred years, it is probable that the cereals, being annual plants, in this case provide the more relevant chronological evidence. The span of the two cereal-based dates is 341 BC-AD 18. It is therefore possible that A11298 was a precursor of A11299, although the possibility that the houses were contemporaneous should not be excluded.

Owing to the stratigraphically uncomplicated siting of these houses (only one identified activity phase and no overlap of unrelated structures) a grid sampling for geochemical and geophysical analysis was performed, covering both houses as well as the in-between lying space, in the hopes of attaining relevant information about activities performed during the settled phase of the space. The area between the two houses contained six pits with varying horizontal shape, and depths ranging from 21 to 105 cm. A seventh pit (112 cm in depth) also covered by the grid was situated just to the south-west of A11299. The last feature within the grid was a long, narrow, and curved trough, possibly a drainage ditch belonging to A11299, situated just south-east of the roof-supporting postholes of that construction.

The samples for the grid survey were taken in what was interpreted as the uppermost layers exposed by the machine stripping of topsoil and should represent the transition zone between the Ap- and C-horizons. The samples were taken in accordance with the principles proposed by Zimmermann (2001), with feature fills consistently avoided. A total of 345 samples were analysed for phosphates and SOM.

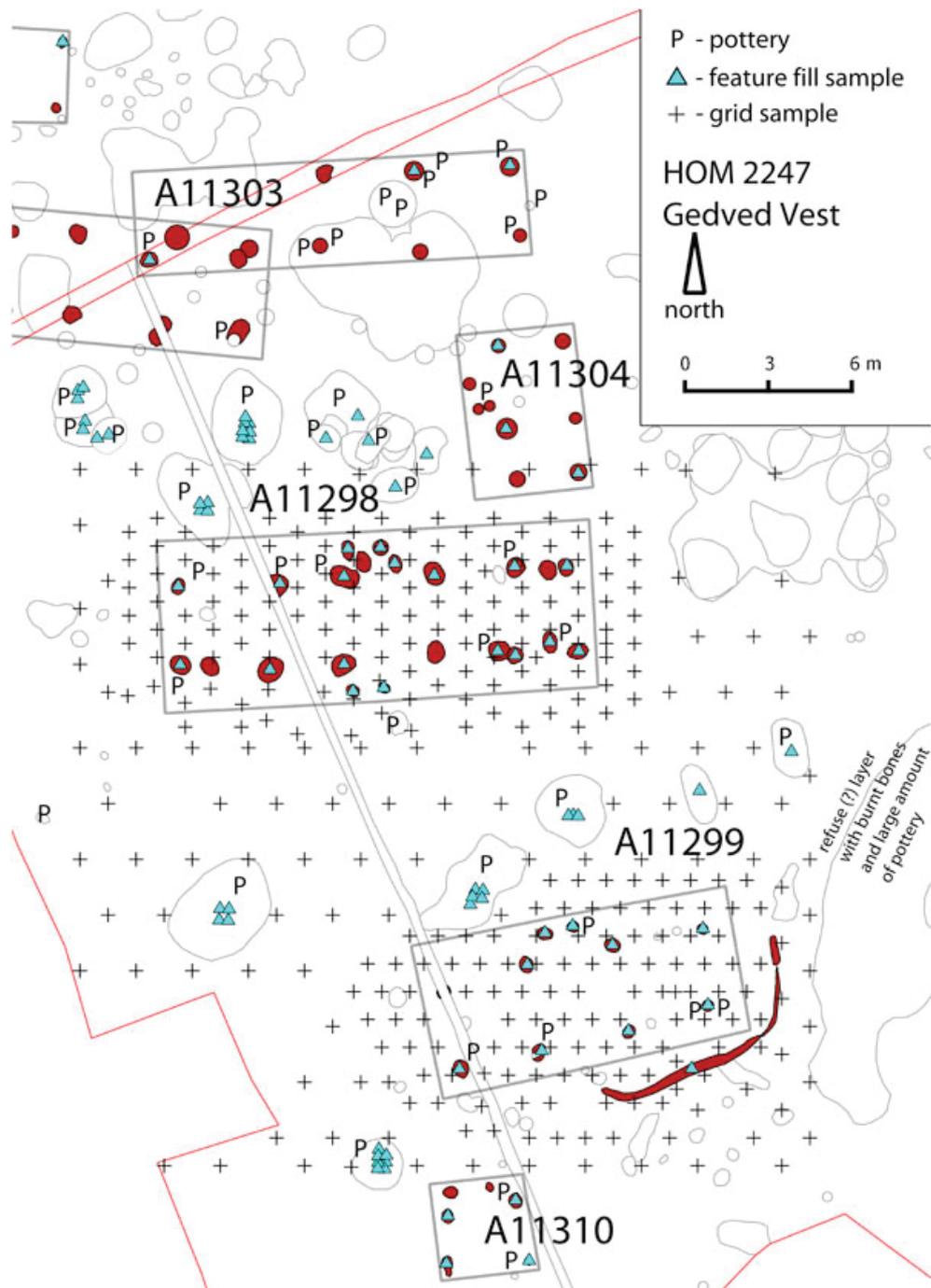


Figure 4. Plan of longhouses A11298 and A11299 with surroundings, showing the locations of samples taken along a horizontal grid (small crosses), samples taken from feature fills (turquoise triangles), and recorded artefact finds, in this case consisting solely of pottery (P). http://clamator.its.uu.se/uploader/92/JAAH_Grabowski_Fig04.pdf

Table 2. ¹⁴C-data for Houses A11298 and A11299.
http://clamator.its.uu.se/uploader/92/JAAH_Grabowski_Table2.pdf

| House | Lab nr | Dated material | Age ¹⁴ C | Cal 1σ | Cal 2σ |
|--------|-----------|-----------------------|---------------------|-------------|---------------|
| A11298 | Poz-44558 | Cerealia indet | 2100±35 BP | 172-57 BC | 341-40 BC |
| | Poz-44559 | Hordeum vulgare | 2065±35 BP | 160-41 BC | 181 BC- AD 18 |
| | Poz-44561 | Charcoal, cf Fagus sp | 2275±30 BP | 395-236 BC | 401-210 BC |
| A11299 | Poz-44562 | Hordeum vulgare | 2075±35 BP | 161-46 BC | 191 BC-AD 1 |
| | Poz-44563 | cf Hordeum vulgare | 2005±30 BP | 42 BC-AD 25 | 90 BC-AD 70 |
| | Poz-44565 | Charcoal, Pomoideae | 2065±30 BP | 156-42 BC | 171 BC-AD 2 |

In addition to the grid-survey, 91 samples from feature fills were also collected. These samples were extracted mainly for archaeobotanical analysis but prior to floatation; sub-samples were retrieved from each bag of soil. In addition to house A11298, A11299 and the previously mentioned pits, this sampling also included nearby structures and features that were situated directly outside the areal grid. Just south of A11299 was a small rectangular structure (A11310) interpreted as an associated outhouse. Two smaller structures were also encountered and sampled in proximity to A11298. A11304 is believed to be a related outhouse and was situated directly north of the eastern half of the longhouse. A11303 was situated somewhat further to the north. This structure was larger than outhouses A11310 and A11304 and it may represent a second and larger outhouse of A11298, although it may also belong to an unrelated activity phase, or even represent poorly preserved remains of a separate longhouse. All presumed associations between the mentioned houses are based on their relative placement. No overlapping stratigraphies exist on which a relative chronology can be formed.

Between A11298 and A11303, and just west of A11304, a cluster of pits was also sampled by bulk collection of soil from feature fills. These pits differ morphologically from the ones situated between A11298 and A11299 by being significantly shallower and having more irregular cuts. The most dug down of these pits was 42 cm in depth, with the remainder ranging from 10-15 cm.

A final observation that may be of relevance to a functional interpretation of this space is the presence of a “cultural” layer just east of A11299. This layer contained large amounts broken pottery and burnt bones; and a portion of the latter was sent for osteological analysis. All bones belonged to mammals, and the ones that could be identified as to genus or species level derived from dog, deer, cow, sheep, goat and horse (Gregersen 2011). The layer has been interpreted as a refuse layer formed by repeated deposition of household waste.

Functional evidence

There are hardly any indications in the material recorded during the excavation of the possible functionality of A11298, A11299 or the surrounding features and structures. Double and elongated postholes that may indicate re-posting are present, but irregularly distributed without any pattern. The post-settings are generally regular and, with the exception of the enigmatic trough south-east of A11299, no other details of the houses have been preserved.

The only artefacts encountered in the investigated area were pottery fragments. These were ubiquitous in almost all recorded contexts. Unfortunately, no metric analysis (for example weighing) or type classification has been performed on this material, making it difficult to ascertain any pattern in the distribution of pottery. In figure 4 the letter P represents each recorded find-coordinate for pottery. It should be noted that each point may contain from a single to any number of fragments. The only clear pattern apparent in the distribution of pottery is that there seems to be comparatively little of it in outhouse A11304, with only one documented find.

The magnetic susceptibility analysis of feature fills in the investigated houses showed no evidence of intensive heating, thus indicating that all houses were unburnt.

This indication is consistent with the sparse amounts of carbonised plant remains recovered from the constructions. The most probable interpretation is that the plant remains represent sporadic accidental carbonisation around heat sources over an unknown period of time. The small amounts of material preclude any high-resolution botanical interpretation of internal house functionality. However, the inter-house distribution may be seen as providing some tenuous functional data. As seen in Table 3, almost all plant remains were recovered from A11298 and A11299, i.e. the two longhouses. It is therefore plausible that these houses contained hearths around which carbonisation could take place, while the other structures did not.

Table 3. Summary of carbonised plant macrofossils recovered from the houses in the case study section of Locality 1 at Gedved Vest. http://clamator.its.uu.se/uploader/92/JAAH_Grabowski_Table3.pdf

| Construction | Cereals | Weeds/ruderals | Other |
|--------------|---------|----------------|--------------------------------------|
| A11298 | 4 | 18 | 2 Poaceae, 1 Persicaria amphibia |
| A11303 | 1 | 0 | 1 Polygonaceae, 1 cf Camelina sativa |
| A11304 | 0 | 0 | 0 |
| A11299 | 2 | 3 | 1 Rumex acetosella |
| A11310 | 0 | 0 | 0 |

The phosphate analysis of CitP-inorganic shows similar results in both the feature fills and the grid survey (figure 5a). Both longhouses display comparatively low levels of CitP-inorganic with little internal variation. However, elevated levels were recorded in the space between A11298 and A11299; both inside the pits occupying that area (feature fills) and in the surrounding subsoil (analysed by grid sampling).

The analysis of CitP-organic showed, similarly to CitP-inorganic, a reasonably consistent pattern in both feature fill results and those from the grid survey (figure 5b). The area between the two longhouses still displays high CitP-levels but a second space with elevated levels is now also identified to the north of A11298.

The visualisation of the CitPQuota (figure 5c), which also shows largely consistent results between the two data sets, allows for an interpretation of the possible sources of the mentioned phosphate concentrations. The concentration of phosphates between A11298 and A11299 displays a low CitPQuota, indicating that CitP-inorganic made up the largest portion of CitPOI in this area. To the north of A11298, the CitPQuota was comparatively high, especially in the posthole fills of A11304. This result indicates that the northern phosphate concentration contained a larger fraction of organically bound phosphates, probably representing accumulation of manure and other plant based matter. This result is furthermore strengthened by the results of the SOM-analysis (figure 5d), which shows high levels of organic matter north of A11298 only. The SOM-analysis results from feature fills and grid survey are, similarly to the phosphate data, largely consistent.

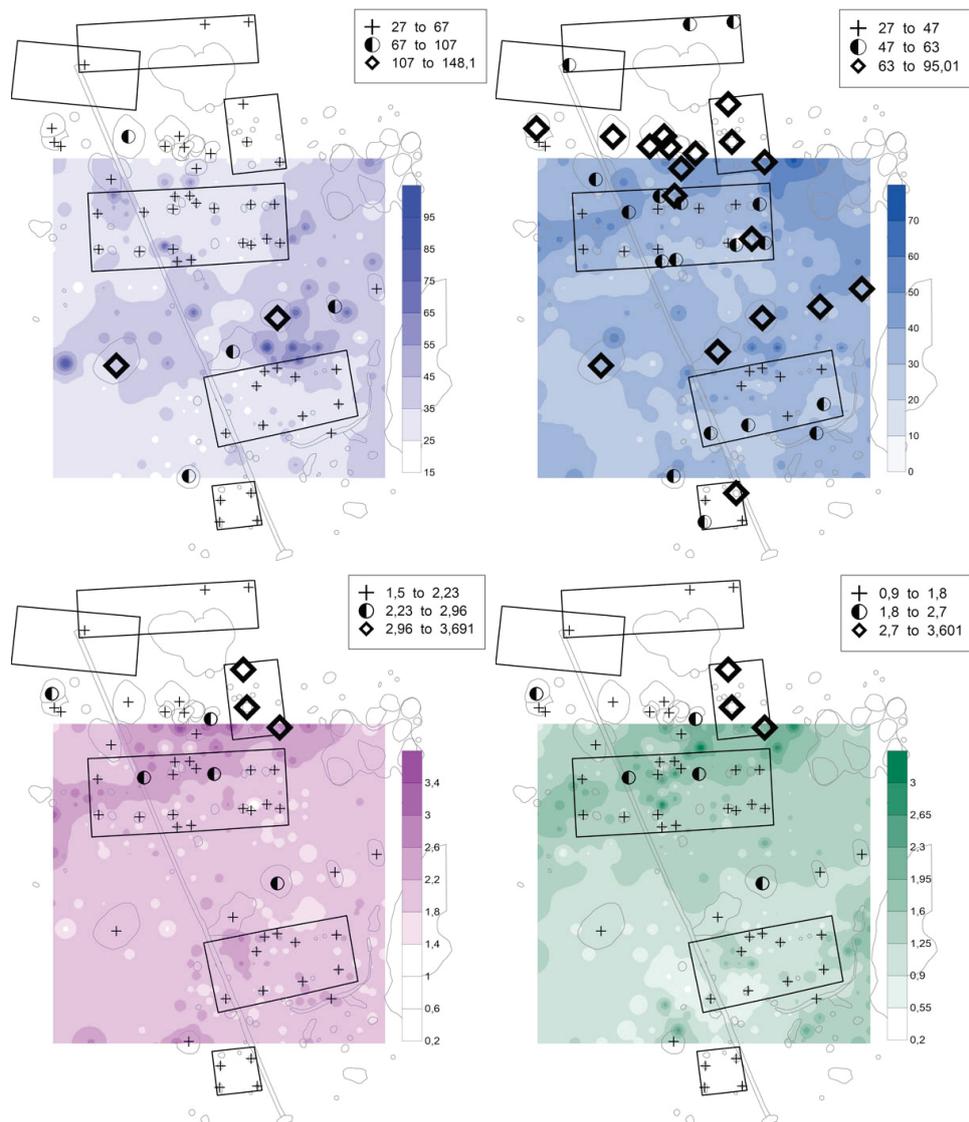


Figure 5. Plan of longhouses A11298 and A11299 with surroundings, displaying an overlaid interpolation of data from the horizontal sampling as well as the results of feature-fill analysis with categorized symbols: a) inorganic phosphates, b) organic phosphates, c) phosphate quota, and d) soil organic matter.

http://clamator.its.uu.se/uploader/92/JAAH_Grabowski_Fig05a.pdf

http://clamator.its.uu.se/uploader/92/JAAH_Grabowski_Fig05b.pdf

http://clamator.its.uu.se/uploader/92/JAAH_Grabowski_Fig05c.pdf

http://clamator.its.uu.se/uploader/92/JAAH_Grabowski_Fig05d.pdf

Functional interpretation

Based on the combined evidence presented above it is possible to formulate a functional interpretation of the analysed area.

Based on the available data, the two longhouses may be interpreted as used primarily for habitation. Both houses probably contained one or more hearths, around which household activities were performed and around which plants were accidentally carbonised. There is no indication in either house of a byre or storage of manure. The low CitP-inorganic levels inside the houses also

indicate that they were kept clean of phosphate rich matter. It is possible that the phosphate concentration between A11298 and A11299 (concentrated in one of the pits) reflects these cleaning activities. It is also possible that the waste management extended to include the “cultural” layer east of A11299, where animal bones and pottery were recovered.

While byres were not identified inside the longhouses, there is a strong indication of manure, based on material rich in CitP-organic (expressed as a high CitPQuota) and SOM, north of A11298. The geochemical byre signature is concentrated inside house A11304, which is also the only building where little pottery was encountered during excavation. Figure 6, displaying CitPOI, CitPQuota and SOM-levels on a three parameter bubble-chart, clearly shows how the chemical signature of A11304 distinctly differs from all the other buildings that otherwise show similar signatures. Put together, the evidence indicates that this house was the byre of the farmstead represented by longhouse A11298. The management of manure probably also affected some parts of the northern yard space, and it is possible that the cluster of irregular shallow pits is a result of removal of soil during cleaning activities associated with the transport of manure to the fields.

The manure-indicating space is enclosed by A11298 to the south, A11304 to the east and A11303 to the north, with the three houses arranged in a rectilinear formation. Although impossible to substantiate based on the available data, it is tempting to interpret this neat cluster of houses as a coherent farmstead. Supporting analogies for such an arrangement being conceivable for the area and period in question are found at the early Roman Iron Age sites of Priorsløkke, approximately 6.5 km from Gedved Vest, where the second phase of the settlement showed clear arrangements of long- and outhouses in rectilinear clusters, and even closer, at HOM 1856 Skovvej, only two kilometres distant. Here the individual houses were not only arranged in a way comparable to Locality 1 of Gedved Vest, but were also bounded by enclosures that clearly confirmed the associations between the identified long- and outhouses (Borup 2004; Kaul 1986). Speculating that the three buildings belong to the same farmstead would mean that animals and manure generating activities were performed in the inner yard, while household/kitchen waste disposal took place behind the house.

Whether A11299 housed similar organisation of external activities is difficult to assess, since the sampling grid did not cover a sufficiently large space south of the building, i.e. the space that would presumably have been the inner yard of the house. Furthermore, the boundary of the Locality 1 excavation was situated merely three metres south of A11310, effectively precluding any further analysis and interpretation of that space.

Grid survey or analysis of feature fills?

Once visualised, the above presented data from the geochemical analyses of feature fills and of the soil extracted from the subsoil along a grid pattern showed distinctly comparable patterns.

The most significant difference between the data sets is in the actual values and not in the resulting patterns. Figure 7 shows that phosphate levels and SOM are higher in samples retrieved from features than those from the grid survey. This is an expected result, which is consistent with the theoretical supposition that material that erodes into a posthole or a pit should remain comparatively sealed and protected from subsequent disturbances that may dilute the signal. This result is also seen as evidence for that the chemical signature of soil eroded into the dug features is not random, as proposed by Zimmermann (2001), but rather consistent with the chemical alterations imposed on the surrounding surface areas; i.e. the soil inside the features is an encased portion of old yard surfaces and house floors.

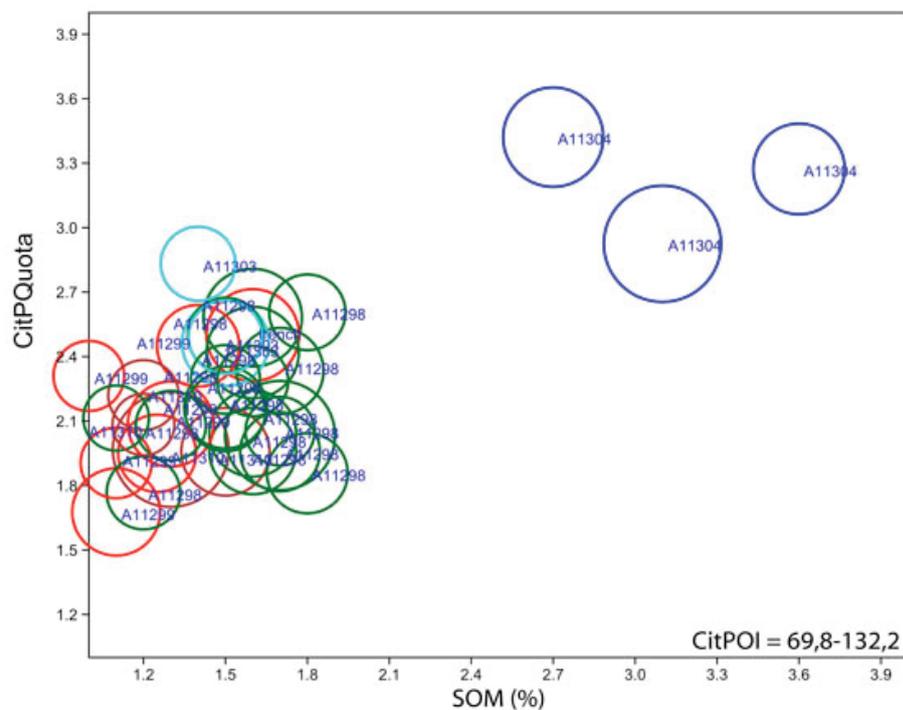


Figure 6. "Bubble" plot showing three geochemical parameters recorded for samples from A11298, A11299, A11303, A11304 and A11310 at Gedved Vest, Locality 1. The circle size represents CitPOI (i.e. the total amount of phosphate accessible by citric acid extraction) in each sample, samples from each house being represented by different colours. The Y-axis shows the CitPQuota, i.e. the relationship between inorganic and organic phosphates, higher quota levels representing a higher proportion of organic phosphate. The X-axis shows the amount of organic matter (SOM) in percentage of the entire sample (after drying). http://clamator.its.uu.se/uploader/92/JAAH_Grabowski_Fig06.pdf

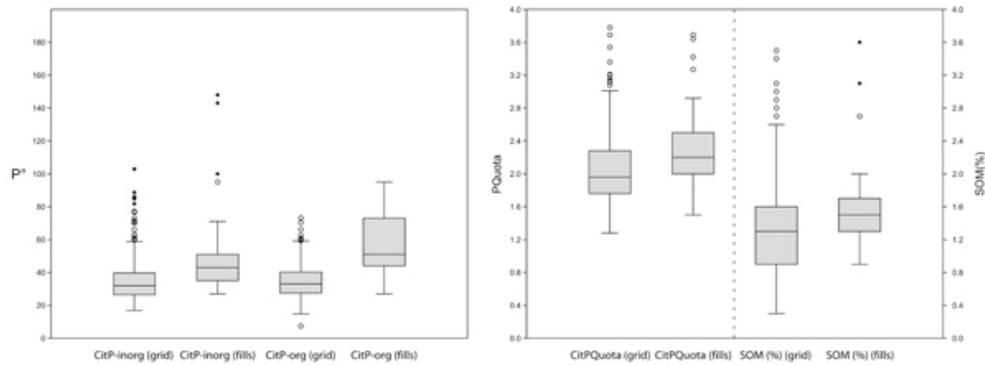


Figure 7. Box-plots showing the measured phosphate and SOM-variation in samples from the horizontal grid-survey and sampling of feature fills respectively.
http://clamator.its.uu.se/uploader/92/JAAH_Grabowski_Fig07.pdf

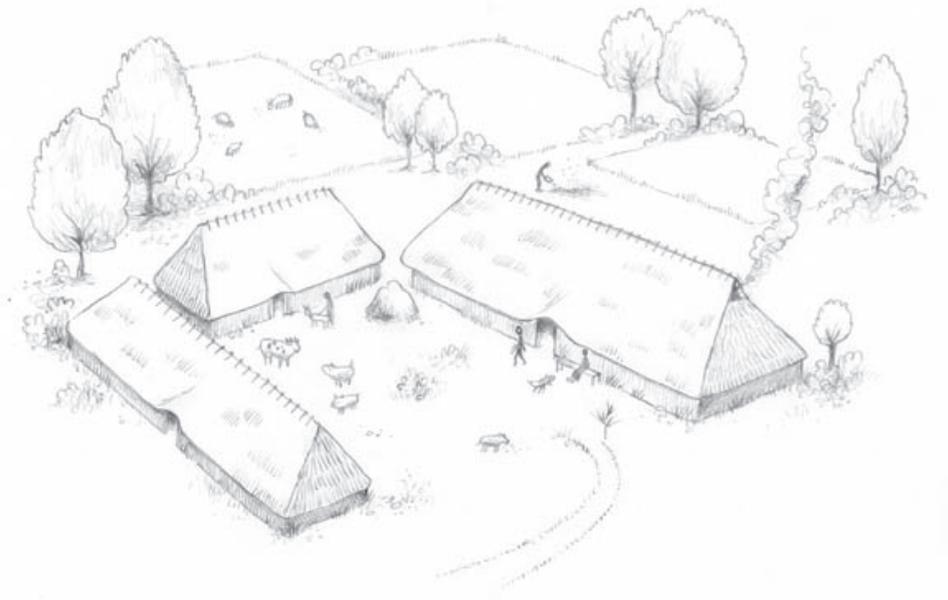


Figure 8. Reconstruction of a farmstead at Gedved Vest around the shift from the Late pre-Roman to the Roman Iron Age, inspired by an analysis of House A11298 and its surroundings. The longhouse is adjoined by outhouses, one of which acts as a byre. Manure is handled in the front yard, while waste disposal takes place behind the main longhouse. Illustration by Sofia Lindholm.
http://clamator.its.uu.se/uploader/92/JAAH_Grabowski_Fig08.pdf

Functional interpretation of longhouses in Halland and Bohuslän based on an analysis of posthole fills

Longhouses from four sites have been selected as illustrative examples of how the botanical, geochemical and geophysical multiproxy analysis of posthole fills may be integrated with other types of archaeological evidence on house functionality.

The locations of the four selected sites of Raä 593 in Svarteborg sn (sn: Swedish abbreviation for parish), Raä 106 (Fyllinge) in Snöstorp sn, Raä 59 in Elestorp sn and Raä 195 in Skrea sn are presented above in figure 1 .

Raä 593, Svarteborg sn, House II

Archaeological background and sampling

Raä 593 in Svarteborg sn was discovered in connection to the construction of the E6 motorway through Bohuslän County. The site turned out to be a settlement area containing several longhouses, small post-built structures, wells, hearths, an oven and various kinds of pits (Flagmeier 2003).

Numerous archaeological features were sampled for macrofossil analysis during the investigation. When these samples were processed at MAL in Umeå they were sub-sampled for additional analysis with geochemical and geophysical methods (Viklund 2003a).

One of the detected longhouses, House II, was sampled for analysis by the multiproxy method described in the method section of the article along its entire length, allowing for comparison of results from different sections of the house. Ten samples were analysed in total.

Charcoal from two hearths found inside the house has been ¹⁴C-dated, providing a combined cal. 2σ-span of 395 BC-AD 20, i.e. Mid to Late pre-Roman Iron Age (Flagmeier 2003).

Functional evidence

House II was a three-aisled construction, approximately 30 metres in length and 7 metres in width. These dimensions place the house among the largest dating to the beginning of the Iron Age excavated in Bohuslän so far (Flagmeier 2003). The wall construction was only preserved along a section of the south-eastern boundary, where it was made up of a narrow trench with adjacent traces of very small posts. A total of ten roof-supporting posthole pairs were found inside the house. These were irregularly spaced, with a slight tendency to more open spaces in the south-western end of the house. Re-posting was not positively observed, although the third and fourth posthole pairs (counting from the south-west) are placed so close to each other that they may in fact represent a post-replacement event. House II was not sited completely isolated on the prehistoric settlement, as it partially overlapped House III (see figure 9). Since the wall-trench of House II clearly cut similar trenches in House III, the former is positively determined as the earlier construction. Besides the wall-trenches no other features belonging to House II cut into those of House III. No samples were taken from house III.

Inside the house were three hearths. One, located at the centre of the house, was cut by the wall-trench of House II and cannot belong to this structure.

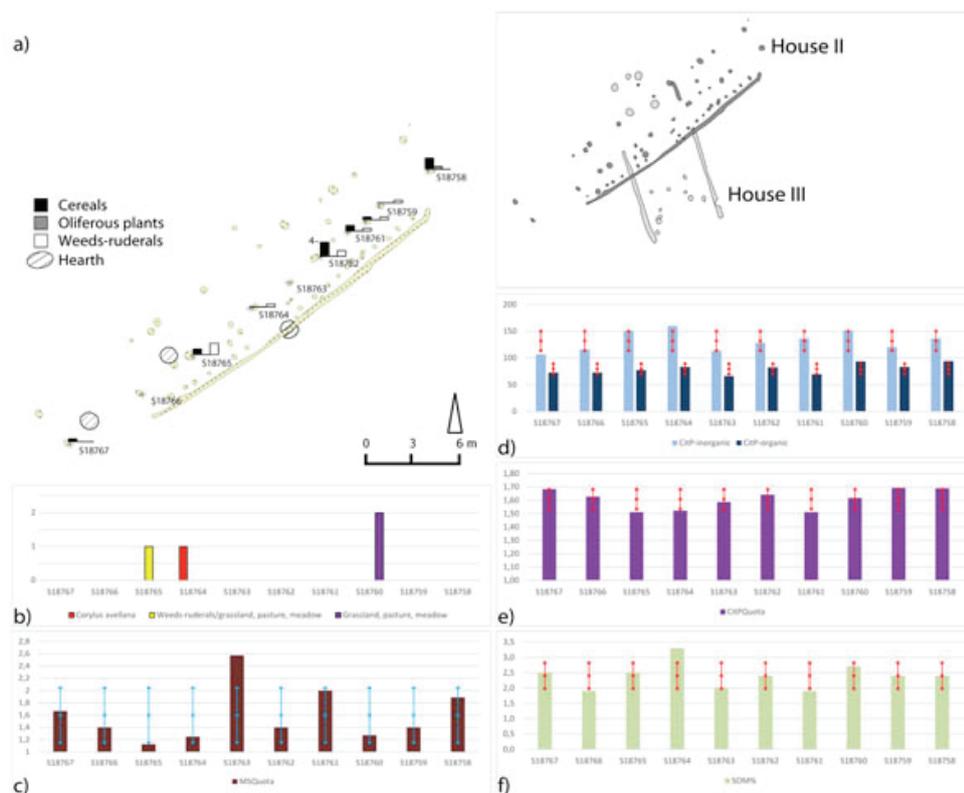


Figure 9. Plan of House II at Raä 593, Svarteborg sn, overlaying the distribution of cereals, weeds-ruderals and oliferous plants (a). Beneath the plan are b) remaining plant categories, c) MSQuota, d) inorganic and organic phosphates, e) phosphate quota and, e) soil organic matter. The overlain lines in graphs c-f show the median for each population (middle dot) and 1 standard deviation (upper and lower dot).

http://clamator.its.uu.se/uploader/92/JAAH_Grabowski_Fig09.pdf

However, it is ideally placed to have belonged to house III. The remaining two hearths were both situated in the south-western half of the house, one at the very end and one closer to the centre next to the third posthole pair counting from the south-west. No other internal features were observed inside the house.

Artefacts in the form of pottery, burnt clay and heat-affected stones were recorded in the house, as were fragments of burnt bone. However, these finds were sparse and did not allow for identification of depositional patterns (Flagmeier 2003).

House II was almost certainly unburnt, since only occasional fragments of charcoal were encountered during the excavation of feature fills. This result corresponds well with the results of the archaeobotanical analysis (figure 9a and b), showing sparse amounts of macrofossils, only 49 in the entire house. Nevertheless, the distribution of these plant remains is interesting despite the low amount, since they cluster in two areas; the majority in the north-easternmost end of the house and a smaller concentration by the fourth posthole pair, next to one of the hearths. The majority of the plants consisted of cereals and arable weeds, although smaller occurrences of oliferous plants (flax,

Linum usitatissimum), hazelnut (*Corylus avellana*) and grassland taxa were also observed. The overall nature of the assemblage clearly indicates household activities in the form of food preparation.

The results of MS-analysis in house II (figure 9c) corresponds well to the pattern seen in the macrofossil record and the observations made during the excavation. In almost all samples, the MSQuota is significantly higher than 1, indicating that the samples were not previously heated. However, there are three exceptions to this result, showing MS-levels indicative of previous heating: 1) Sample S18765 was taken from a posthole directly adjacent to the more centrally located hearth of House II. This sample also contained the smaller concentration of plant remains mentioned above. In this case, the hearth traces, plant remains and MS-levels agree: all indicate the presence of a hearth. 2) Low MSQuota was also recorded in sample S18764, which is the next posthole pair towards the north-east from the S18765. It did not correspond to any identifiable hearth traces in House II, but is adjacent to the hearth cut by the wall trench that most likely belongs to house III. This MSQuota value may thus be a disturbance resulting from the overlap of two habitation phases. 3) Low MSQuota was recorded in S18760, located in the north-eastern end of the house, together with the largest concentration of carbonised plant remains. Since both the plant material and the MS-levels point toward the presence of fires in this part of the house, a possible interpretation could be that this part of the house also housed a hearth, but that for unknown reasons, its physical traces were not preserved in the archaeological record. A final note should be made on the south-westernmost hearth of House II, which does not appear to have left visible traces other than the physical modification of the sediment. It may be possible that this hearth is not related to the house at all, but rather belongs to an unrelated phase of activities. This would explain the lack of hearth-indicating signatures in the surrounding postholes, since they would either not yet have been dug or would already have been sealed when the activities took place. An asynchrony between the two hearths would also explain the somewhat awkward location of the south-western hearth, places right next to one of the walls. Pointing against this hypothesis is the fact the two dates obtained for House II came from each of the hearths showing strikingly similar results; 372 BC-AD 20 (cal. 2σ) for the hearth in the centre and 395-54 BC for the south-western one. With ^{14}C -spans ranging over several centuries, however, the possibility that the south-western hearth was not a part of the house cannot be precluded.

An analysis of CitP-organic (figure 9d and e) in house II shows comparatively stable levels throughout the house. CitP-inorganic, on the other hand, fluctuates with two observed concentrations. Both of these correspond with hearth indications in the already mentioned evidence. The first concentration is situated by the fourth posthole pair, next to the centrally placed hearth. This concentration stretches on to also include posthole S18764, which is situated close to the hearth believed to belong to House III. The second concentration was observed in posthole S18760, which is in the middle

of the area with the largest accumulation of plant remains and the posthole with an MS-signature indicating a hearth. Low CitPQuotas corresponding to these concentrations of CitP-inorganic indicate that the majority of the phosphate derived from sources such as bone.

Lastly, the measurement of SOM (figure 9f) shows a correlation to the areas with hearth-signatures and P-concentrations. This may be seen as an indication that these parts of the house were “dirtier” than average, but since they do not appear along with high CitPQuotas, the organic refuse presumably did not consist of manure.

Functional interpretation

House II can be interpreted as a case where numerous measured parameters show compatible indications of house functionality, but also enhance each other by confirming results that may have been less than convincing on their own, for example the sparse but clustered plant macrofossils.

It appears that House II had two kitchen areas containing a hearth each, one corresponding with the physical hearth remains next to the third and fourth posthole pair, and one somewhere in the north-eastern end of the house. In the latter kitchen area, no physical traces of a hearth were recovered, but its existence is indicated by both plant macrofossil data and MS-analysis. Between these two kitchen (and living?) spaces is a smaller space that provided little in the way of functional evidence. The same is true for the south-westernmost end of the house, which although containing a hearth, provided little evidence about possible function. It is also possible, and tenuously supported by the analysis data, that this hearth may not have belonged to the house. No indication of a byre was obtained from any evidence category, and it is possible that the entire house was used for habitation and presumably a number of settlement activities that did not leave traces measurable by the here utilised methods.

The two postulated kitchen/living spaces of House II may at first be perceived as somewhat unexpected, since longhouses in southern Scandinavia are most commonly assumed to have housed only one household. Nevertheless, the results from House II are not unique. In connection with the E22-motorway project at Bruatorp outside of Kalmar in Småland an unusually large (55 × 8 metres) three-aisled longhouse was encountered. The house was sampled and analysed in the same manner as House II at Svarteborg, showing two almost identical mirrored halves, with areas of increased P, accumulations of carbonised plants and MS-signatures indicating hearths of which no physical traces remained (Engelmark and Olofsson 2000, Gustafsson 2001). The house at Bruatorp was dated to period II/III of the Bronze Age (1500-1100 BC), and is therefore clearly separated from the building tradition of Svarteborg by both space and time. Nevertheless, these two cases may be examples of a previously little known prehistoric phenomenon of large byre-less longhouses housing two separate kitchen/living quarters, possibly indicating shared habitation by two

households, or at least some form of delineated social units. Hopefully, future analyses will shed more light on this intriguing possibility.

Raä 106, Fyllinge, Snöstorps sn, Houses 1 and 3

Archaeological background and sampling

Raä 106 in Snöstorps sn, more commonly known in literature as the Fyllinge site, was excavated in 2001 and 2002 in preparation for the development of an industrial area outside Halmstad. The site turned out to house a settlement with two identified longhouses and traces of smaller buildings, pits, hearths, ovens as well as features associated with iron production. Agricultural activities were also represented in the form of ard marks and a stone clearance cairn (Toreld and Wranning 2005).

House 1, turned out to be one of the largest ever excavated in Halland, with an estimated original size of 58 × 6 metres. The house also displayed a somewhat unusual (although not unknown) trait of being slightly bent, with the main axis of the house changing by 6° roughly halfway along its length (Toreld and Wranning 2003). Three ¹⁴C-dates were obtained for the house, providing a cal. 2σ-span of 810 BC–AD 40. One of the three dates deviated from the other two, interpreted as the result of contamination (Toreld and Wranning 2003). The typology of the house construction, as well as the pottery recovered inside the house points to a probable late pre-Roman Iron Age date. This is supported by the two remaining ¹⁴C-samples, which have a calibrated 2σ-span of 378 BC–AD 40.

House 3 was substantially smaller, with an estimated size of 18 × 5 metres. The chronologically indicative material remains from House 3 point to an early Roman Iron Age date. This is supported by a single ¹⁴C-date, which provided a cal. 2σ-span of AD 23–222. The overall chronological information from the two longhouses seems to indicate that House 3 was the successor to House 1 (Toreld and Wranning 2003).

Both houses were sampled for archaeobotanical analysis during the excavation, and subsequently sub-sampled at MAL for geochemical and geophysical studies. Seven samples were collected from House 1, covering almost its entire length except for the south-westernmost end. Five samples were collected from House 3, representing each of the identified posthole pairs (Viklund 2003b).

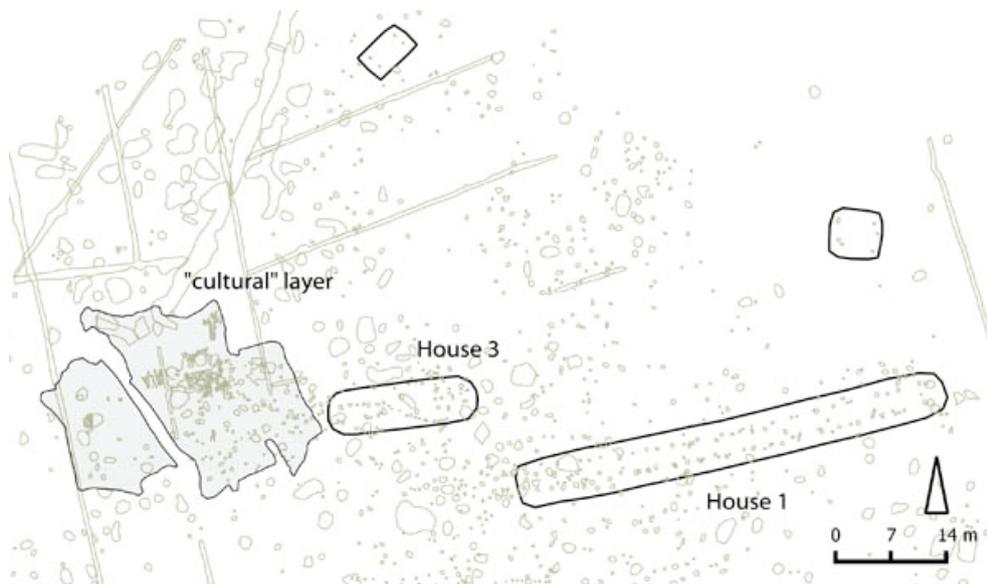


Figure 10. Plan of Raä 106, Snöstorp sn, Fyllinge. http://clamator.its.uu.se/uploader/92/JAAH_Grabowski_Fig10.pdf

Functional evidence

The unusually long House 1 contained a total of 26 roof-supporting posthole pairs (figure 11a). The large amount of pairs could be interpreted as evidence for extensive re-posting, or even of independent but similar construction phases. However, Toreld and Wranning (2003) argue that the postholes are sufficiently homogeneous in design and fill material to assume their contemporaneity.

There were no internal features detected inside the house that could indicate functional areas, neither was a hearth recovered. Neither was there a distinctly open area that could indicate an intentionally larger kitchen/living space with a hearth. However, a slightly more open posthole placement was observed between 22 and 29 metres, counting from the west. This area corresponds to the space around and between samples S181 and S183 on the plan in figure 11a.

House 1 has been interpreted as at least partially burned, based on occurrences of burnt daub and burnt clay throughout its length (Toreld and Wranning 2003). This result is supported by the results of the botanical and physical analyses. All MSQuota levels (figure 11c) are quite close to 1, signifying that the soil had probably been heated before. The botanical material (figures 11a and b) was not overwhelmingly numerous, totalling 300 identified remains in addition to charcoal, but showed a distribution along the entire length of the house. This would not have been the case if carbonisation only occurred around the hearths of the house in connection with everyday activities. It is possible that the fire was not very intensive or long-lived, since sample S173 stands out from the rest with almost identical MS and MS550-levels, indicating the location of more prolonged or intensive heating despite the “overlying” magnetic modification of the fire that appears to have affected

the entire house. This could of course be the result of more intensive heat during the house fire in that particular section, but may also be interpreted as the previous location of a hearth. There are several clues pointing to the second alternative, i.e. the presence of a hearth rather than an uneven house fire, as the more convincing. The first of these is the distribution of artefacts in House 1; consisting of pottery (mostly of kitchen character), glass and flint, which all cluster distinctly in the area represented by samples S170-S181. The second evidence is the occurrence of burnt faunal material, which shows a cluster comparable to the artefacts between postholes S170 and S181. A third indication is the presence of a comparatively intact piece of pottery in posthole S173. This was interpreted by the excavating archaeologists as an intentional house offering inside a posthole fill rather than unconscious penetration of pottery fragments into the fill (Toreld & Wranning 2003). The pot is of a distinct food-preparation character (Toreld 2005), indicating an offering with clear kitchen connotations. Furthermore, the space between postholes S181-S183, as mentioned previously, displayed a somewhat less constricted arrangement of roof-supporting posts, possibly indicating an intention to create a slightly more open space. Lastly, the phosphate analysis (figures 11d and e) shows distinctly higher levels of CitP-inorganic, coupled with the lowest CitPQuotas in postholes S173-S183, values that are consistent with a phosphate signal from the accumulation from bones. Elevated SOM-levels (figure 11f) were also measured in postholes S181 and S183, indicating a generally more “dirty” space.

Other than indicating a possible kitchen space, the phosphate analysis also suggests phosphate accumulation from manure by high CitP-organic levels in posthole S170. The high CitP-organic levels are coupled with the highest SOM-levels in house 1.

Turning back to the results of the botanical analysis (figure 11a) two additional areas stand out with higher than average concentrations of plant remains. Posthole S177 contained an assemblage consisting almost exclusively of weed-ruderal taxa, with a smaller admixture of cereals. In posthole S175, the relations were reversed, with a majority of the material composed of cereals, with smaller inclusions of oliferous plants and weeds-ruderals.

House 3 contained five identified roof-supporting posthole pairs (figure 12a). They were regularly arranged with the exception of significant open space between the second and third pair counting from the west. Toreld and Wranning (2003) speculate whether this area could have housed a sixth pair, which for some reason did not survive in the archaeological record. This hypothesis would result in a construction with roof-supporting posthole pairs at almost even intervals throughout the structure. Supporting their argument is the fact that the northern post of the third pair was also missing, thus opening up for the possibility that more could have vanished owing to the same but unknown reasons. Unable to conclude this issue, the excavators of House 3 present both an alternatives as possible. In addition to the roof-supporting

postholes, no wall traces or internal features were encountered in House 3, neither was a hearth belonging to this house identified during the excavation.

A mere two metres west of House 3, a “cultural” layer, 546 m² in size, was encountered, consisting of several strata that covered or embedded numerous pits, postholes and hearths (see figure 10). The layer was rich in artefacts, including pottery, oven wall fragments, slag and pieces of iron, glass etc. It is quite likely that the layer represents a prolonged period of activities in a yard-space, with a resulting accumulation of material debris and organic matter. The layer has not been ¹⁴C-dated, but the recovered pottery spans types from the Late Bronze Age into the Roman Iron Age (Toreld and Wranning 2003). Since it is clear that the activity area represented by this layer existed prior to the establishment of House 3, it is possible that considerations were made during the construction of the house as to its alignment toward this yard space. Toreld and Wranning (2003) interpret House 3 as burnt, based on finds of burnt daub throughout the house, but also note that these fragments seem less heat-affected than those in House 1, possibly indicating a less intensive fire. Neither the botanical material (figure 12a and b) nor the MS-measurements (figure 12c) immediately support a hypothesis of a house fire. The botanical remains are sparse, totalling a mere 40 individual specimens in the entire house. The MSQuota in most postholes is significantly above 1, indicating a likelihood that the soil was not heated prior to sampling. However, one sample deviates from this result: S161, where the MS-analysis indicates a previous heating of the soil. This could be the result of a partial or uneven house fire, or it could represent the siting of a hearth. There are several clues pointing to the second alternative as more convincing. The botanical material is clearly clustered in S161 and in S145. The macrofossils are also predominantly made up of cereals with a small admixture of weeds-ruderals. Such assemblages could have been created during food preparation and as the last remaining weeds in the grain meant for consumption were hand-sorted out of the material and thrown into the fire. A second clue pointing toward this area housing a hearth, and thus functioning as a kitchen, is the distribution of burnt bone fragments (figure 12a). Although sparse, these were clearly clustered in the three easternmost posthole pairs (Toreld and Wranning 2003). The phosphate analysis (figures 12d and e) is also consistent with this evidence, showing high CitP-inorganic levels with low P-quotas. S144 and S145 also display somewhat elevated SOM (figure 12f), indicating a slightly “dirty” part of the house.

The sparse carbonised macrofossil material in House 3 precludes further functional interpretation based on botanical evidence. However, coupled with measurement of SOM, the phosphate analysis provides one further indication about function, as the two westernmost posthole pairs show increasing CitP-organic levels from east to west, coupled with increasing CitPQuota, i.e. a signature consistent with a signal of an accumulation of manure. Furthermore, this pattern continues outside the house in samples taken from the “cultural” layer.

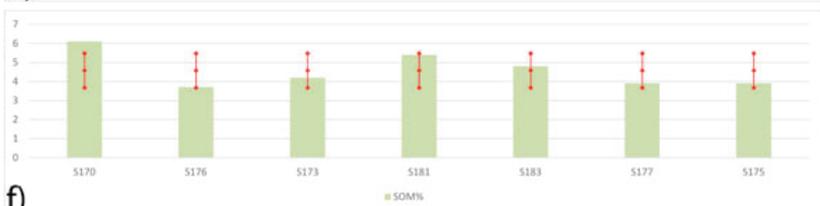
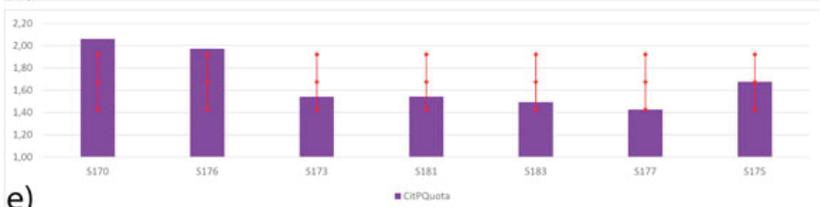
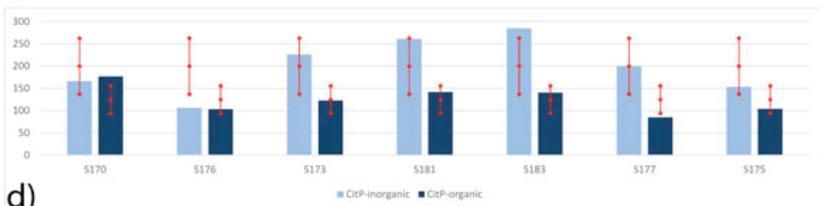
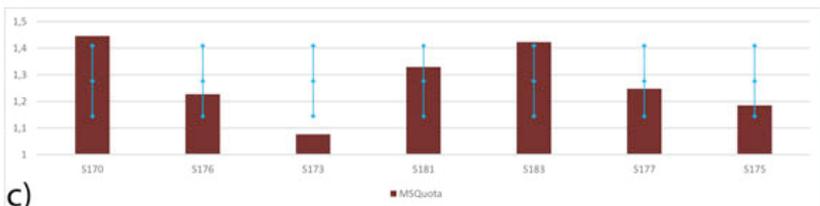


Figure 11. Plan of House 1 at Raå 106, Snöstorp sn, Fyllinge, overlaying the distribution of cereals, weeds-ruderals and oliferous plants (a). Beneath the plan are b) remaining plant categories, c) MSQuota, d) inorganic and organic phosphates, e) phosphate quota, and e) soil organic matter. The overlaid lines in graphs c-f show the median for each population (middle dot) and 1 standard deviation (upper and lower dot). http://clamator.its.uu.se/uploader/92/JAAH_Grabowski_Fig11.pdf

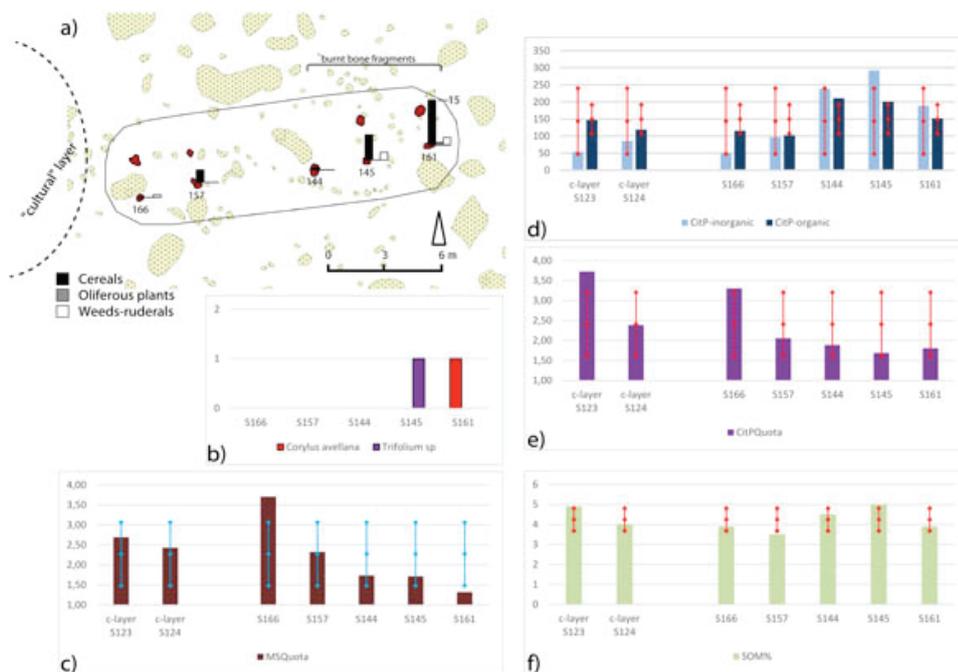


Figure 12. Plan of House 3 at Raä 106, Snöstorp sn, Fyllinge, overlaying the distribution of cereals, weeds-ruderals and oliferous plants (a). Beneath the plan are b) remaining plant categories, c) MSQuota, d) inorganic and organic phosphates, e) phosphate quota, and e) soil organic matter. The overlaid lines in graphs c-f show the median for each population (middle dot) and 1 standard deviation (upper and lower dot). http://clamator.its.uu.se/uploader/92/JAAH_Grabowski_Fig12.pdf

Functional interpretation

House 1 at Fyllinge is one of the best previously published examples of a functional interpretation based on integrated structural, artefactual, botanical and geochemical/geophysical evidence. Based on a thorough review of the material Toreld, Wranning (2003, 2005) and Viklund (2003b) have presented a detailed functional interpretation of this structure. The here presented description of results is therefore mainly a repetition of a previously formulated functional evaluation.

Integrating available strands of evidence, the three researchers suggested that: 1) The easternmost end of the house was a threshing and cereal storage space. This is a plausible interpretation, since the most readily available explanation for the therein encountered assemblages - one dominated by weeds-ruderals, the other by cereals - is that the former represents a cereal cleaning area, where weeds were deposited during cleaning of grain meant for consumption, while the latter was clean grain stored until needed in the kitchen (cf. Grabowski & Linderholm 2013, Grabowski 2013, Moltsen 2011, Viklund 1998). It should be pointed out, however, that neither of these plant assemblages would probably have been preserved, unless the house was exposed to fire. 2) The westernmost part of the house has been proposed as the byre. This interpretation is based on the geochemical evidence pointing to accumulation of material with a high content of organically bound phosphates

and organic matter. 3) The kitchen space is identified to the middle of the house, between postholes S170 and S181, based on high CitP-inorganic levels, high SOM, concentration of kitchen indicating finds and the occurrence of a kitchen resonating house offering. One deviation between the here presented overview of House 1 and the one presented by Toreld, Wranning (2003, 2005) and Viklund (2003b) is that the latter assumed the most probable location of the hearth at posthole S181, which showed the highest recorded MS and MS550-levels. In this overview, focus has been shifted from raw MS-levels to the relationship between pre-heating and post-heating values expressed as MSQuota. Based on the review of the MSQuota in House 1 it seems that the location of the hearth should be shifted further to the east, with a more probable siting around posthole S173.

House 3, although investigated with the same methodology as House 1, resulted in a more cautious interpretation by Toreld and Wranning (2003), who consider the lack of fodder-indicating plants in House 3 an indication that animals were not housed there, despite the high levels of organic phosphates in the western half of the house. This signature was instead explained as a possible contamination from the “cultural” layer. The two archaeologists also use the lack of high MS-levels to argue against the presence of a hearth. However, a contrasting interpretation may be formulated based on the review above.

As discussed in the theory and method section of this article, MS-values have a pre-determined highest level that is bound to the chemical composition of the soil. It is therefore more relevant to assess MS-results by a calculation of the MSQuota, which could be seen as expressing the likelihood of whether soil was previously heated. The MSQuota in house 3 clearly shows that a hearth could have been located in the eastern section of the house, but not in the western. This result is also supported by the presence of the only carbonised plant material in the house. This sparse botanical material, along with the MSQuota result for all areas outside the eastern half also puts into question whether the house had burnt. If the house was not destroyed by fire, the lack of seeds from fodder plants, or indeed any other seeds, is not surprising, since fodder plants would presumably not have been exposed to fire or heat sources. The similarities with the high organic phosphate results in the western end of the house and the “cultural” layer should not automatically be dismissed as contamination. An alternative explanation is that the activities that resulted in the formation of the “cultural” layer and those occurring in the western half of the house were interconnected, perhaps as animals and manure moved between the byre and the yard space, from storage of manure both inside and outside the house, or from drop-off during transport of manure from the house to the fields outside. This alternative would mean that the “contamination” was in fact a reasonable end-effect of the use of the two spaces. This discussion would have been strengthened if an entrance had been identified in the western part of House 3 facing the “cultural” layer. Unfortunately, only the roof-supporting structure survives from this building.

Raä 59, Elestorp sn, House 1

Archaeological background and sampling

House 1 at Raä 59, Elestorp sn, was encountered on a site excavated in connection with railroad reconstructions in the area. The site contained remains dating from the Neolithic to the Roman Iron Age, with a predominance of remains from the Bronze and Iron Ages (Fors 1998).

House 1 represents the latest phase of the Elestorp site and has been ¹⁴C-dated to AD 174-400 (cal. 2σ).

Samples for archaeobotanical analysis were taken from seven postholes, representing all sections of its length. All samples were sub-sampled at MAL for further analysis by geochemical and geophysical methods (Viklund 1997).

Functional evidence

House 1 was 26 metres long and 6 metres wide. Although few remains of the wall construction were preserved, at least two entrances are still recognisable, situated almost opposite each other between posthole pairs S123 and S125/126 (figure 13a). The internal structure contained six roof-supporting posthole pairs. There was a clear difference in spacing between the north-western and south-eastern ends, the posts being placed in a tighter arrangement in the latter space. Furthermore, an open space had been created at the centre of the house between posthole pairs S125/126 and S127. The remains of a hearth were encountered inside the house, surrounded by the twin postholes of pair S127, which were placed more widely apart than the remainder, indicating a conscious design to fit the hearth. No internal wall divisions were detected in House 1 (Fors 1998).

The presence of a hearth, coupled with the diverging post arrangement in that part of the house indicates the kitchen/living space of this house. This indication is consistent with the results of the MS-analysis (figure 13c), which although indicating destruction by fire of the entire building through MSQuota levels close to 1, show increased exposure to heat in posthole pair S127. This indication is further supported by comparatively high CitP-inorganic and low CitPQuotas levels spanning posthole pairs S125/126 to S129 (figure 13d and e). These results are consistent with an area where inorganic matter, such as bones was handled. Additional evidence of a kitchen area in the south-eastern half also appear in the form of pottery finds, which are restricted to the south-easternmost posthole pair, and by the highest concentrations of burnt clay (figure 13a).

The plant remains in House 1 (figures 13 a, b) numbered 156 individual remains excluding charcoal. This is a comparatively sparse amount compared to other burnt houses in south Scandinavia (cf. Grabowski 2013, Grabowski 2013, Henriksen 2007, Moltsen 2011, Viklund 1998), which may perhaps indicate that the fire that presumably affected House 1 was limited in intensity, explaining why the MS-signature around the hearth is still identifiable.

The plant remains in House 1 were quite diverse, consisting of cereals, weeds-ruderals, oliferous plants, wetland and grassland species that probably represent a fodder collection, and stalk fragments of heather (*Calluna vulgaris*). The distribution of edible plants, as well as the weeds, which were presumably brought along from the fields, is clearly delineated to the south-eastern half of the house, supporting the hypothesis that this part of the house was the kitchen. The plant taxa interpreted as fodder show no clear spatial patterns, being spread out across the length of the building (figure 13b). However, it should be noted that none of these groups contain plant remains numerous enough to provide truly convincing patterns.

In addition to indicating a possible kitchen, the phosphate analysis shows two samples with signatures that suggest deposition of manure. The first is centred on postholes S123 and S125/126, which show a high proportion of CitP-organic (high CitPQuota) and comparatively high levels of SOM (figure 13f). The result may indicate the presence of a byre in this part of the house. Such placement would also be consistent with the topographic siting of House 1, which was placed on a slope with a total difference of 1.2 metres from end to end. The possible byre section is located in the lower part of this slope, which would have facilitated moving the animal waste from the house. The second indication of elevated organic phosphates and possibly a byre was obtained in posthole S133, located south-east of the kitchen, in the south-easternmost end of the house. Although one cannot exclude the possibility of a secondary smaller byre in this part of the house, its placement would have positioned it right above the space containing the kitchen and probable sleeping area. An alternative and perhaps more plausible explanation could be that the data from posthole S133 partially derives from some unrelated event that distorts the interpretation of results in this part of the house.

Functional interpretation

The functional evidence from House 1 at Elestorp, with the notable exception of sample S133, all seem to provide a largely coherent picture of its internal organisation. The clear differences in posthole arrangements, the underlying topography, the location of the hearth and the distribution of finds are all in agreement with the results of the multiproxy analysis: all show that the house contained at least two rooms. A kitchen/living space was probably housed in the south-east, while a byre occupied the north-western half. An interesting result is that posthole pair S125/S126 showed a signature consistent with both kitchen activities (plant remains, low CitPQuota) and manuring (high CitP-organic and SOM). It is perhaps possible that whichever type of boundary, if any, separated the two functional areas was located in its immediate proximity. Such internal division of space would place the hearth of House 1 more or less at the centre of the proposed kitchen/living space.

Raä 195, Skrea sn, Houses 5/6 and 1; an illustrative case of the limitations of functional analysis

Archaeological background and sampling

Similarly to all other case localities presented in this paper, the settlement site of Raä 195 in Skrea sn was excavated in connection with a modern development project, in this case the modernisation of the west-coast railroad outside of Halmstad. The site consisted of thirteen identified buildings of different sizes and shapes, as well as numerous ancillary features such as pits, hearths and cooking-related features. The ^{14}C -data along with house and artefact typologies indicate a main continuous activity phase from the pre-Roman Iron Age to the Vendel Period, with traces of Mesolithic and Neolithic stone artefacts as well as a single building, argued to belong to the Early Middle Ages, possibly indicating additional settlement phases (Wranning 2004).

The presentation of material from Skrea 195 in this paper is limited to a segment of the site's history represented by longhouses 5/6 and 1 and four adjacent and chronologically interconnected outhouses: houses 7, 8, 9 and 10 (see figure 14). This time segment has been interpreted as containing three construction/reconstruction phases (Wranning 2004). The earliest is represented by House 5 and outhouses 7, 8 and 9. Houses 7 and 8 have both been ^{14}C -dated, providing very similar dates with a joint cal. 2σ -span of AD 231-542. On typological and artefactual grounds, House 5 has been dated to the same period. On the grounds of the comparable alignment of their main axes, it is argued that the outhouses and the longhouse are part of a single farmstead. The second construction phase is represented by House 6. This structure was initially discussed as a separate building, but the its lack of entrances as well as its constructional correspondence with House 5 have resulted in a final interpretation of House 6 as an extension of House 5. Wranning (2004) also argues for the possibility that this extension was a replacement and enlargement of the roofed-over space represented by outhouses 7, 8 and 9. The third phase of construction is represented by House 1 and outhouse 10. A hearth cut by House 1 has been ^{14}C -dated to AD 424-606 (cal. 2σ), providing a terminus ante quem which fits well with the typological dating of Houses 5/6 and 1 as well with the ^{14}C -data from outhouses 7 and 8. Several features belonging to House 1 clearly cut those of House 5/6, confirming the interpretation of the relative chronology of this place. Outhouse 10 is argued to belong to House 1 on the grounds of its axial alignment to the larger building, which is also inconsistent with the other three outhouses.

Samples were taken along the entire length of the longhouses, but more sporadically from the outhouses. All samples were sub-sampled for geochemical and geophysical analysis (Linderholm, 2001, Viklund 2001).

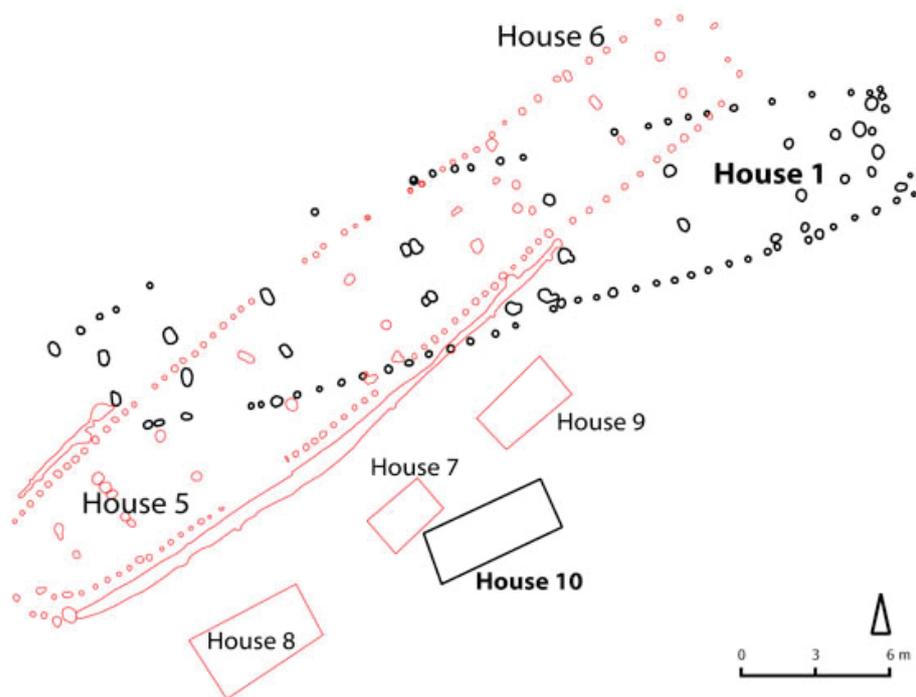


Figure 14. Plan of Raä 195, Skrea sn, showing the construction phases represented by House 5/6 and outhouses 7, 8 and 9 (thin red lines) and House 1 and outhouse 10 (thicker black lines). http://clamator.its.uu.se/uploader/92/JAAH_Grabowski_Fig14.pdf

Functional evidence

The constructional details of Houses 5 and 6 provide little indication of their functionality. Artefacts were present but in such small quantities, that few functional patterns could be obtained from their distribution (Wranning 2004). House 1 also displayed unclear artefact patterns. For all three phases, one must further question the reliability of artefact distributions owing to the significant overlap between these buildings. In contrast to House 5/6, the plan of House 1 displays a distinct variation in posthole placement, indicating open spaces at the centre and more constricted ones at each end. The easternmost end is proposed by Wranning (2004) as having possibly housed a byre.

Wranning (2004) argues that the second phase of construction, represented by House 5/6 and their adjoining outhouses, possibly concluded with a fire destroying the entire farmstead. This interpretation is made on grounds of charcoal rich fills in features belonging to this phase. The MS-levels (not shown in this paper, but see Linderholm 2001 and Viklund 2001) show neither convincingly low nor high MSQuota; thus it cannot be concluded whether or not there had been a farmstead fire. The recovered plant macrofossils were sparse in the longhouses, especially considering their size, with only 22 remains in House 5, 13 in House 6 and 64 in House 1. Similarly, the phosphate and SOM-measurements from plant macrofossils and artefacts showed no clear pattern within the houses (Linderholm 2001, Viklund 2001).

Although no clear pattern was observed within the individual houses, some functional evidence may be elucidated from an inter-house comparison.

With the exception of outhouse 9, from which little material was retrieved, all houses contained a mixed material of cereals, weeds-ruderals and possible fodder plants from both wetland and dryland biotopes (fig 15a). With the exception of 9 and 10, all houses also contained heather, which could have been used as fodder, fuel or perhaps floor covering material. In the analysis of house functionality at Skrea 195, Wranning (2001, 2004) goes into great detail describing the variation in the recovered botanical material in order to find functionally indicative tendencies. However, a comparison of these results to previously investigated comparable houses with clearer patterns (Grabowski and Linderholm 2013, Grabowski 2013, Karg *et al.* 2004, Moltsen 2011, Ramqvist 1983, Viklund 1998a and b), one may argue that the material at Skrea 195 is too small and the variation too insubstantial to be used for in-depth functional interpretation, particularly when the unknown formation history and overall archaeological complexity is taken into consideration. The plant macrofossil analysis also shows that the majority of the fodder plants were recovered from outhouses 7 and 8 and not from the longhouses. This could possibly strengthen the interpretation of a farmyard-enveloping fire, since this material is otherwise unlikely to have been carbonised (unless these small structures also contained hearths, of which there is no evidence). Another possibility is that the plant remains represent waste management pathways on the site. Scrapings from the hearths inside the longhouses could possibly have been temporarily deposited by the outhouses before being taken out to the fields along with manure or to some other final disposal space. 3) The plant macrofossil analysis furthermore revealed organic material in the form of coprolites from goats in outhouses 7 and 8 and from cows in outhouse 8. The coprolites could indicate the presence of animals in these structures, or be the result of movement of material on the site, for example in connection with the collecting and transport of manure.

A comparison of the phosphate and SOM results between the houses provides little additional information to the one presented above (figure 15b). The signatures in most investigated buildings are similar and overlapping, with only two exceptions. House 9 shows higher CitPOI and CitPQuota than any other building, a result consistent with manure deposition. However, there is no other evidence in the form of plants, coprolites or structural details that could indicate a byre. However, House 7, which did contain coprolites and shows SOM-levels somewhat deviating from the rest of the buildings displays phosphate levels and CitPQuotas that are mostly in line with all other samples.

Functional interpretation

Based on the data presented above one can argue for the likelihood of several activities taking place at Skrea 195. Cereal storage and processing is represented in the botanical material by carbonised grains and weeds. Preparation of processed cereal products is also likely to have taken place inside the longhouses. Animal husbandry of at least cows and goats is indisputably indicated by preserved faeces. Finds of fodder plants from both wetland and

dryland meadows indicate that these animals were, at least to some extent, foddered in proximity to the houses.

However, Skrea 195 is also a site where the indicated activities are difficult or impossible to delineate in space. Each of the presented houses shows a mixture of activities with few intelligible patterns visible in the material. This is no doubt a partial result of the prolonged and overlapping settlement history of the analysed space in comparison to previously investigated and comparable houses/farmsteads displaying clearer patterns (Grabowski and Linderholm 2013, Grabowski 2013, Karg *et al.* 2004, Moltsen 2011, Ramqvist 1983, Viklund 1998a and b). Thus, the previous analysis of house functionality at Skrea 195 (Wranning 2001, 2004) needs to be reviewed with some criticism, as it can be argued that the variation is too insubstantial to be used for in-depth spatial interpretation. Roofed-over spaces probably changed function over time, as indicated by the addition of House 6 to House 5, while construction and reconstruction events, coupled with everyday activities may have facilitated a non-reconstructable mixing of soil and the therein embedded material culture.

Although the results of the Skrea 195 investigation could be interpreted as disappointing, one may also argue that the site not only demonstrates the limitations of functional analysis, but allows for an evaluation of the probable factors behind these limitations. In this sense, much can be learnt from this case study; the insights can be carried into future research on house and site functionality.

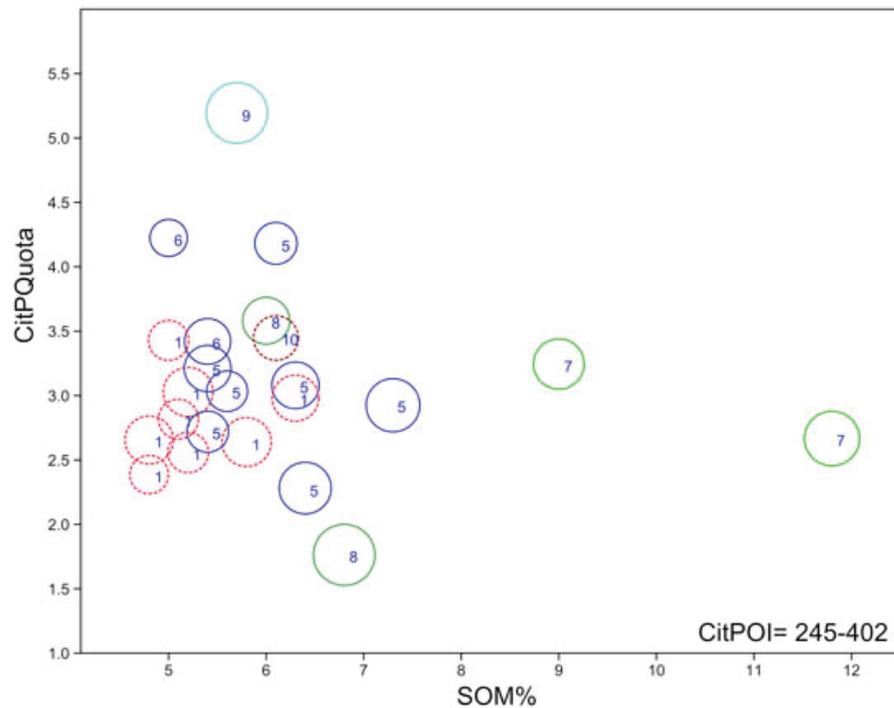
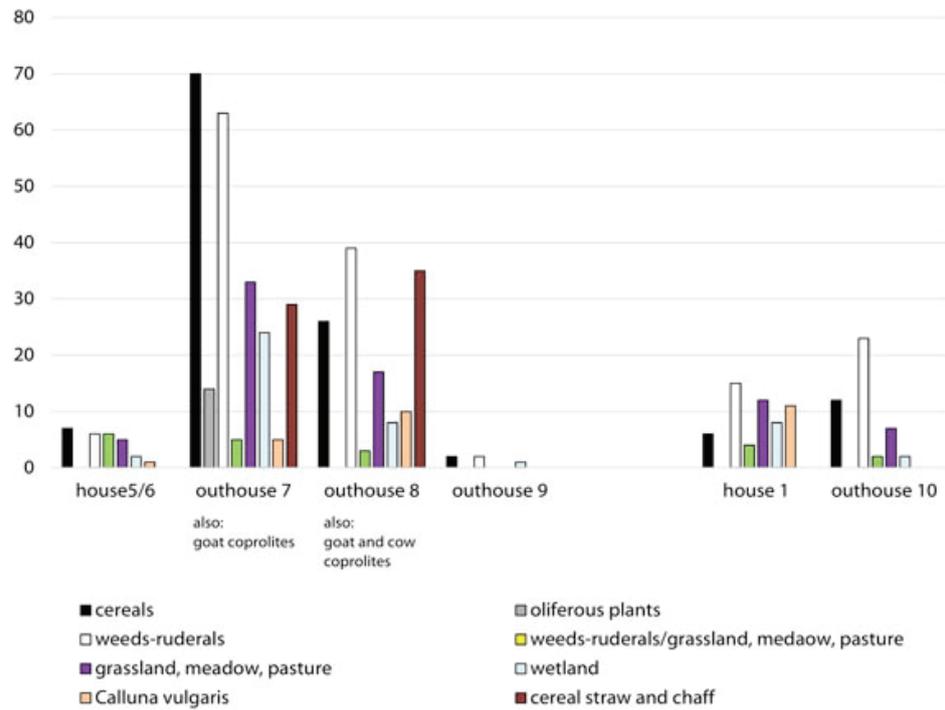


Figure 15. Archaeobotanical and geochemical results from Raä 195, Skrea sn: a) composition of carbonised botanical assemblages, and b) “bubble” plot showing three geochemical parameters recorded for samples from houses 5/6 and 1 as well as outhouses 7, 8, 9 and 10. The circle size represents CitPOI (i.e. the total amount of phosphate accessible by citric acid extraction) in each sample, samples from each house being represented by different colours. The Y-axis shows the CitPQuota, i.e. the relationship between inorganic and organic phosphates, higher quota levels representing a higher proportion of organic phosphate. The X-axis shows the amount of organic matter (SOM) in percentage of the entire sample (after drying).
http://clamator.its.uu.se/uploader/92/JAAH_Grabowski_Fig_15a.pdf
http://clamator.its.uu.se/uploader/92/JAAH_Grabowski_Fig_15b.pdf

Discussion and conclusions

Grid survey or analysis of feature fills?

The results of the phosphate and SOM-analysis of Locality 1 of Gedved Vest, performed on both soil from a horizontal grid survey and on material extracted from feature fills, show largely comparable patterns in both data sets. One may therefore conclude that both approaches are valid in attempts to identify and delineate functional spaces. The choice of strategy should perhaps best be governed by the questions posed to the material and the desired resolution of geochemical results.

Providing the sample points are laid out tightly, grid sampling may provide a higher resolution than analysis of feature fills, since the latter is restricted in resolution by the distribution of the features. However, a high-resolution grid sampling is highly time consuming, as hundreds of samples need to be collected and analysed to cover even relatively small spaces.

Feature sampling is less time consuming, especially since the geochemical samples can be extracted from bulk soil collected for archaeobotanical analysis and has the advantage of directly targeting archaeological features, which tend to be at the centre of all other archaeological analysis of a site. This approach is also preferable if the questions under study necessitate an assessment of the internal stratigraphy of an individual feature.

When used in combination, the two approaches have the capacity to provide highly resolved information with much potential for functional interpretation of houses, features and surrounding spaces, in the way illustrated for Locality 1 at Gedved Vest.

Functional interpretation of houses based on analysis of feature fills

Six longhouses from south-western Sweden as well as the two abovementioned longhouses from Jutland were analysed with an archaeobotanical, geophysical and geochemical multiproxy method, as well as assessed on grounds of house design, site morphology and distribution patterns of various types of material culture.

In all cases, interpretations could be formulated taking into account functional indications from both of the main evidence categories. Nevertheless, it should be noted that no single strand of evidence presented in this article, regardless of whether it belongs to the multiproxy approach or to a more commonly known archaeological technique, would on its own have provided a sufficiently convincing functional model. The compatibility between the various evidence parameters is therefore not only interpreted as mutual confirmation of their applicability in research on settlement functionality, but also as motivation for deeper integration of functional parameters in future research.

At Raä 195 in Skrea sn, the botanical, geochemical and geophysical multiproxy analysis was shown to be severely constricted owing to a spatial intersection of at least three habitation/activity phases, as well as an observed multifunctionality of investigated spaces within each chronological phase - the complex life and death histories of houses. However, it is important to highlight that the limitations of the multiproxy approach on this site also affected all other evidence parameters except the analysis of the building structures as expressed by posthole placements. Although this is an expected result, it should nonetheless be emphasised since it demonstrates how the archaeological record ultimately is one coherent entity. When specific archaeological situations constrict the usefulness of a method, this should perhaps not immediately be perceived as a methodological failure, but rather as a reality of the archaeological profession stemming from the nature of our source material. It is a source of motivation for further methodological development, preferably by integration of singular approaches into broader, integrated strategies, which in time may allow for an extraction of valuable information even in more complex archaeological cases.

Phosphate analysis of byres and kitchens

In the theory and methods section of this article an argument was put forward that identification and separation of functional spaces may be difficult by only assessing estimates of P-total levels in soil. A particular scepticism was proposed about a commonly occurring equalling of high P-total levels with the location of byres. This supposition is largely confirmed by the examples in this paper. With the exception of A11304 at Gedved Vest, none of the here proposed byres showed the highest CitPOI values (total phosphates extractable by citric acid). Identification of byres was only possible by a separation of the measured CitPOI into its organic and inorganic fractions, or through comparison with other byre-indicating evidence, providing the qualitative component necessary for making sense of an otherwise ambiguous phosphate signature. The indication of this result is therefore that some previously published interpretations of byres based on P-total-estimates alone may have to be re-evaluated.

Plant macrofossils in unburnt houses

Based on previous presentations of plant macrofossils from houses analysed in ways similar to those in this paper (Grabowski and Linderholm 2013, Grabowski 2013, Karg *et al.* 2004, Moltsen 2011, Robinson 2000, Viklund 1998a and b), one could argue that an archaeobotanical analysis should primarily be performed on houses defined as burnt, since these tend to present more numerous and less fragmented assemblages on which interpretations are more easily formulated. On occasion, this has also been expressed explicitly (Henriksen 2007, Karg *et al.* 2004).

Nevertheless, this study, presenting numerous unburnt cases, shows that even small botanical assemblages from unburnt houses/farmsteads may

provide valuable insights about their internal organisation. At Locality 1 of Gedved Vest, for example, the material was very sparse, but nonetheless distinctly clustered in areas indicated by other evidence as the living/kitchen quarters where hearths should have been present. At Raä 593 in Svarteborg sn there was a good correspondence between the physical remains of a hearth and a comparatively small concentration of plant remains, while a second concentration clustered neatly with kitchen-indicating geochemical evidence. Similar correspondence was observed at Raä 59 in Elestorp sn, where the recovered plant remains corresponded spatially with geochemistry, house topography, physical traces of a hearth and artefact distribution.

Based on the cases presented here, one could therefore argue that houses for functional macrofossil analysis should not be selected on the grounds of being burnt or unburnt, but rather on the overall questions defined for the material and the complexity of the site in question, making it a task for archaeologists and archaeobotanists to evaluate suitable objects for study.

Stepping out of the house ...

The analysis of Locality 1 at Gedved Vest and of Raä 195 in Skrea sn shows that everyday activities on both sites were in no sense constricted to the longhouses. At Gedved Vest, there is a strong indication that the byre of the farmstead was situated in outhouse A11304 and not in the adjacent longhouse. Results from the outhouses at Skrea 195 showed that settlement functions were as extensively performed there as in the longhouses. Another example of how activities are observed leading out from the longhouses into the surrounding spaces is House 3 at Fyllinge, which indicated a functional connection between the house and an adjoining “cultural” layer.

All these indications lead up to a conclusion that an understanding of a settlement’s functionality must be sought as much outside the longhouses as inside them. Although this could be attempted in some of the here presented case studies, such as Locality 1 at Gedved Vest, Skrea 195, and to a lesser degree Fyllinge (the analysis of the “cultural” layer), owing to the location of the extracted samples, most of the presented cases focused solely on the longhouses. In practice, future extensions of analyses beyond the confines of houses will necessitate sampling not only of postholes in the primary buildings, but of smaller and less secure constructions, of postholes belonging to enclosures and of the myriad of other feature types dotting prehistoric settlement sites, such as pits, wells and various types of anthropogenic deposits commonly known as cultural layers. The strategies for this analytical work will have to be carefully developed, and an in-depth integration and cooperation between different archaeological specialisms will no doubt be required.

Final remarks

table 4 summarizes which functional parameters outlined in the theory and methods section of this paper ended up contributing to the final interpretation of the analysed case study examples. An obvious observation is that none of the

investigated sites displayed the full spectrum of function-indicating parameters. In fact, some parameters, such as byre booths, were not encountered in any of the presented cases.

It may therefore be prudent to emphasise one final conclusion of this study, namely that functional analysis of settlement spaces is difficult. There is not, at this time, a universal method or approach to functional evaluation of settlements. If south Scandinavian archaeology is to take functional analysis seriously it needs to consider a future filled with complex, expensive and tedious (?) work, requiring long-term cooperation of numerous specialist and institutions. Integrating strands of evidence into coherent functional analyses requires clearly question-oriented approaches. Methods must be applied strategically within a theoretical framework, with a degree of planning and inter-specialism communication, and with ongoing evaluation of both successful and dead-end cases (which may be more numerous than desired) if we are to proceed beyond the insights available to us today.

Although this last statement at first may appear as somewhat dismaying, those of us enjoying the challenge of archaeological practice should also expect a great deal of fun.

| | Construction | | | | | | Use | | | | | | | House burnt? | | | | |
|--|------------------|--------------|----------------|-----------|--------------|------------------|-----------------------------|-------------------------|--|---|--------------------|--------------------|-------------|--|----------------------|-----|--------------|--|
| | House dimensions | Post setting | Internal walls | Entrances | Wall details | House topography | Physical remains of hearths | Internal/other features | Distribution of artefacts, modified soil and faunal material | MS in unburnt houses indicating hearths | Phosphates and SOM | Plant microfossils | Byre booths | Floor layers inside house or "cultural" layers outside house | Replacement of posts | MS | Macrofossils | Heat affected artefacts, modified soil, observations during excavation |
| HOM 2247 Gedved Vest, Locality 1 | * | * | | * | | | yes | yes | | yes | yes | | | yes | * | no | no | no |
| Raa 593, Svarteberg sn, House II | * | * | | * | | | * | * | * | yes | yes | | | | * | no | no | no |
| Raa 116, Snøstorp sn (Fyllinge), House 1 | * | * | | | | | | yes | * | yes | yes | | | | | yes | yes | yes |
| Raa 116, Snøstorp sn (Fyllinge), House 3 | * | * | | | | | | yes | * | yes | yes | | yes | | | no | no | partial |
| Raa 59, Elestorp sn, House 1 | * | yes | | * | * | * | * | yes | * | yes | yes | | | | | yes | no | ? |
| Raa 195, Skrea sn, Houses 5/6, 1 and outhouses | * | yes | | | | * | | * | * | * | * | | | | | ? | ? | ? |

Table 4. An overview of which function-indicating parameters were used on each of the here presented cases in order to attain an interpretation about past use of spaces. The asterisk denotes parameters that were observed, but did not contribute toward the final interpretation. To the far right is also an overview of indications of whether the house was burnt or not. http://clamator.its.uu.se/uploader/92/JAAH_Grabowski_Table04.pdf

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