Radiocarbon-based models of earliest Iron Age village community (Køge Bay region, East Zealand)

Mathias Søndergaard[1,2] and Sune Villumsen[1]

[1] Museum Southeast Denmark, Castle ruins 1, 4760 Vordingborg, Denmark.
[2] Corresponding Author (ms@museerne.dk) ORCID 0000-0001-8354-1555.

ABSTRACT

This paper explores the dynamics of village community formation and change during the earliest Iron Age (*c.*500-1 BC) using radiocarbon-based models. A dataset of more than 5000 radiocarbon dates from a study area within the Køge Bay region (East Zealand, Denmark) is compiled to approach multiple scales of analysis. First, overall spatiotemporal trends in the settlement record across the study area are examined to contextualise formational and transformative processes. These models show abrupt, significant growth in frequency and spatial densities of radiocarbon dated settlement from *c.*400/350 BC, consistent with high-tempo processes of expansion and formation into aggregated community configurations. Modelled densities peak *c.*300-200 BC and then decrease rapidly, constraining this dynamic of growth, plateau and reduction to short-duration sequences. Second, site-scale models focusing on a specific village community within a corresponding timeframe are used to assess temporal frameworks and changepoints in detail. These models test diverse spatiotemporal frequencies and distinctive properties of several individual farm clusters constituting the village and consistently suggest significant intra-community variability. The results propose new ways to look at timings and change-rates in the dynamics of interaction, cooperation and division shaping earliest Iron Age village communities.

ARTICLE HISTORY
Received
05 May 2026;
Accepted
08 September 2026

KEYWORDS
Iron Age; Village community; Radiocarbon dating and modelling.

Introduction

The processes of village emergence and development are central to interpretive models of social organisation during the earliest Danish Iron Age period (*c.*500-1 BC, Pre-Roman Iron Age) (*e.g.* Becker 1982; Hvass 1983; Rindel 1999; Holst 2010; Runge 2019; Møller and Dollar 2022). Research has focused on chronologies and structures of individual village sites (Becker 1965, 1969, 1971; Hvass 1985; Rindel 1997; Ejstrud and Jensen 2000; Runge 2009; Meistrup-Larsen and Moltsen 2008; Haue 2012; Nielsen 2020); and on reconstructing timings and patterns of village formation at broader scales (Rindel 1997, 160-170; Lund 2009; Martens 2010). From this basis, a general model has been proposed in which settlement gradually shifted from dispersed to aggregated formats, with extensive village formation beginning from the 3rd century BC. This development is understood as reflecting expanding significance of communal dependencies, obligations and regulations, defining a framework for long-term modes of social interaction (Holst 2004b). Consequently, the village is a key concept in current Iron Age social models (*cf.* Holst 2004b; Herschend 2009; Ødegaard and Ystgaard 2023, 12-16), including those addressing kinship and inheritance systems (Holst 2010), land organisation and cooperative practices (Løvschal and Holst 2015; Nielsen et al. 2018; Fallgren 1993), and social diversity and hierarchy (Haue 2011; Holst 2014; Søvsø 2021).

Previous studies have demonstrated substantial variation in Iron Age settlement at both regional and local scales (*e.g.* Rindel 1999; Ethelberg 2003; Webley 2008; Boye 2008; Møller 2011; Runge 2019), suggesting multilinear trajectories (Holst 2014, 179; Møller and Dollar 2022). However, most interpretations continue to converge on a model presuming gradual changes and long continuities (Holst 2010, 2014; Hansen 2015, 63; Boye 2019, 273-279; Søvsø 2021; Møller and Dol-

Creative Commons License Attribution-NonCommercial-ShareAlike (CC BY-NC-SA 4.0).

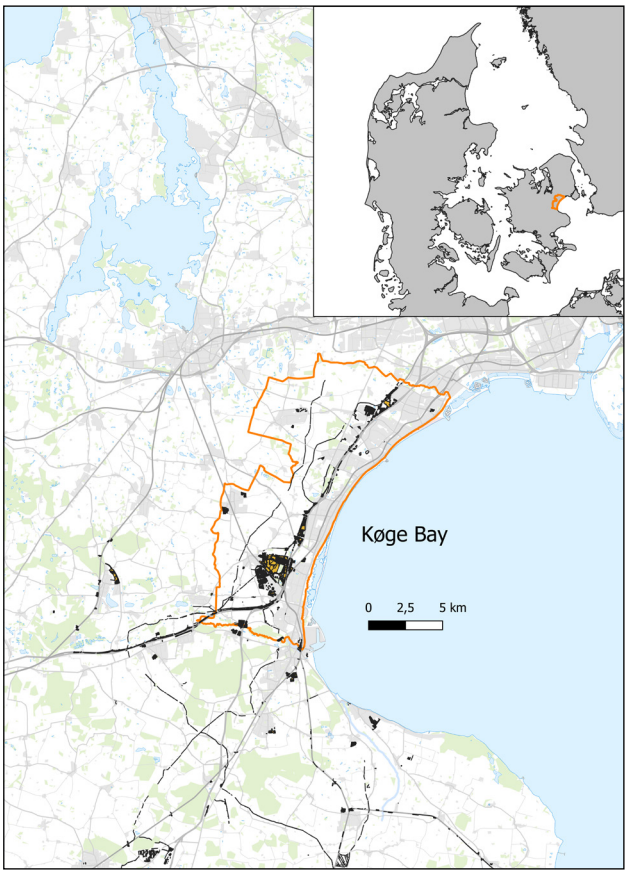


Figure 1. The Køge Bay study area in eastern Zealand, Denmark, and extent of archaeological excavations conducted primarily 2012-2025 (Data by the authors; base map contains data from The Agency for Climate Data and the European Environment Agency).

lar 2022). While some studies have indicated more temporal dynamics (Haue 2023; Egholm Nielsen 2023), the lack of radiocarbon-based analyses has limited precise and independent qualification.

This paper contributes to addressing these limitations, using statistical modelling of a large radiocarbon dataset (n=5401) from the Køge Bay area, Zealand, as a case study (Figure 1). We focus on the *c.*500-1 BC period, for which the regional settlement developments remain poorly understood and interpretations have been strongly shaped by generalised models (Christensen and Tornbjerg 2009; Martens 2010). Our modelling approaches explore contexts, timings, rates and durations of earliest Iron Age village communities at variable scales across the study area with two interrelated aims: to identify and constrain spatiotemporal dynamics in overall settlement densities, assessing whether these reflect extended continuities or shorter-term, nonlinear shifts; and to examine interactions between such overall trends and intra-community processes observed at an individual village scale.

Conceptualising earliest Iron Age village operational principles

Use of the Iron Age village as interpretive framework has long recognised the composite character of the concept, incorporating generalised elements drawn from an extended time span and also including later historical and judicial contexts (Rindel 1999; Holst 2004b, 7-9). Early definitions of what constitutes a village focused primarily on morphological criteria, such as minimum numbers of farms, material indicators of their coexistence and spatial delineations (*e.g.* Becker 1987; Kaldal Mikkelsen 1999). Later work has broadened this by conceptualising the village not just as an aggregate of specific farm quantities, but as a space and process through which to study formation of community (Holst 2004b, 8). This shifts the analytical focus towards relational dynamics, operationalised through formal relative-chronological analyses of changes in the physical structures of individual farms and in relational interplay between farms, using observed patterns to infer organisational principles of general significance to social models (Holst 1997, 2000, 2004a). The operation of these principles is suggested to have been conditioned by kinship relations and hereditary devolution of land within a developed system of partible inheritance (Holst 2004b, 2010). This represents a significant shift from the previously dominant model of the 'wandering village', which assumed that villages developed as cohesive units in linear, regulated processes (Hvass 1983; Rindel 1999; *cf.* Ødegaard and Ystgaard 2023, 15). Instead, this is a bottom-up model that conceptualises developments as emerging from persistent, multilinear modulations and dispersals of individual farms in the village (Holst 2004b, 181-184). This emphasises autonomous processes at farm scale, adopting a biographical approach that identifies generational life cycles of household units as the primary generative mechanism in a continuous, nonsynchronous founding of new farms in the village (Holst 2004b, 127; *cf.* Gerritsen 1999, 2003). As a model, this has the potential to capture both

constitutive and transformative processes of community (Gerritsen 2006, 2008; Bukkemoen 2015, 2025; Büster 2021). However, applicability of the methodological framework supporting the specific use of this model is constrained by the requirements of high relative-chronological resolution; this depends on dense contextual relationships at site scale, which are rarely available for the early phases of village formation (*c.*500-1 BC) (Holst 2004b, 206). Temporal relations are therefore more often estimated based on typo-chronological data and limited radiocarbon dating, effectively reducing the refinement of the analytical results (Nielsen 2015, 101-102; Møller and Dollar 2022, 147). Equally, the existing frameworks cannot provide fixed dates to precisely constrain processes or allow estimates of their tempo and distribution.

Conditioned by both the physical properties of the archaeological record and by current conceptualisation of village community formation and development, temporal frameworks are affected in two main ways: First, while the importance of distribution and redistribution of land to these processes is not in question, the interpretive emphasis on a sustained impact from a consistent system of inheritance foregrounds generative and durable dimensions of community, biased towards slow change and long continuities (Holst 2004b, 184-190, 2010, 161). Second, although fluctuations in frequency and density of settlement – affected by factors such as conflict, climate and epidemics – are recognised as important to conditioning trajectories of settled community configurations, their integration into interpretive models remains assumptions-based (*cf.* Ejstrud and Jensen 2000, 84-91; Hansen 2015, 247; Søvsø 2020, 89-96). Some studies have linked village formation to population growth and intensifications in organisational distribution of land from the 5th-4th century BC (Lund 2009, 193; Haue 2023, 38), but detailed reconstruction of such trends is lacking.

In Eastern Denmark, settlement organisation during this period is generally thought to have been low-density and extensive. Village layouts are described as semi-nucleated, comprising clusters of mostly few and labile farms interspersed with adjoining fields and pastures (Martens 2010; Nielsen 2010, 214-220; Hansen 2015, 118-120, 249-250; Runge 2019). Villages could extend over one or two kilometers, with distances of 100-200 meters or more between farms (Fallgren 1993, 2006, 80-85; Martens 2010, 238). Consequently, interpretations emphasise processes at farm scale, in line with current models. However, combined with coarse resolution of the regional house typo-chronology (Boye 2019; *cf.* Artursson 2005), this involves schematically linear reconstructions (Boye 2019, 265-270), assuming extended village continuities constituted by consecutive farm reproductions over multiple generational phases and several centuries.

Temporality and community

Within current archaeological and anthropological research, community is often conceptualised as essentially a perpetual process shaped by changeable properties and products of social interaction at multiple scales (Yaeger and Canuto 2000; Birch 2012, 2013; Barrier and Horsley 2014; Reese *et al.* 2019; Feinman and Neitzel 2023). This provides a useful framework for exploring social dynamics at high temporal resolution. The explicit emphasis on multi-scalar approaches encourages analyses to range across locally specific and general patterns and to examine their interconnectedness (Yaeger 2000; Knapp 2003). From this perspective, community can be approached as constituted through assemblages of individuals, groups, places and objects operating at multiple nested and overlapping scales and comprising complex, intersecting and potentially contradictory interests. Community may therefore entail both social constraints and benefits, may generate tensions and remain fragile to separative processes (Harris 2014; Knapp 2003; Reese *et al.* 2019). Studies have demonstrated that the degree of social and economic investment in community by individuals and groups is time-dependent, placing communities in constant flux (*e.g.* Birch 2013). Communities are therefore not closed systems: Their constitutive processes are instead shaped by both conscious affiliative choices and by complex contextual factors, including social kinetics generated by changes in population and settlement density (Bandy 2004; Feinman and Neitzel 2023, 3-4). The substantial social and spatial mobility relating to these processes should

therefore not be understood as exclusively intra-communal or sustained, but as involving substantial movement into, across and out of communal relations at non-constant rates (*e.g.* Barrier and Horsley 2014). Comparative syntheses also indicate that a large proportion of settled community durations were actually short, often spanning only a few centuries (Bandy and Fox 2010; Bandy 2010; Crawford *et al.* 2022; Scholtus and Müller 2023). Instead, key temporal dimensions of community may include fluctuations and impermanence, involving sudden formations, abrupt endings, and gaps.

These conceptualisations of community have proven specifically useful when combined with high-resolution temporal and spatial analyses based on radiocarbon data (*e.g.* Bánffy *et al.* 2016; Manning *et al.* 2021; Hart and Means 2022; Birch *et al.* 2021, 2024; Kim *et al.* 2025). Such analyses have included refined identification of intra-community temporal and social dynamics at individual village scales (*e.g.* Nión-Álvarez 2023a, 2023b). They have equally addressed questions of community formation and development across more comprehensive scales, assessing interrelations between individual community temporalities and overall spatiotemporal density trends (Lee and Hwang 2025; *cf.* Contreras 2024). Such interrelations may involve complex variation over time (*e.g.* Bevan and Crema 2021). This makes cross-scale definition challenging. While the record on settled community configurations spans a continuous range between general categories of 'dispersed' and 'aggregated', variation within this continuum may reflect time-sensitive balancing of interacting social, economic, technological and environmental factors (Ortman and Coffey 2017; Gracia-Lázaro *et al.* 2024; Vernon and Ortman 2024).

To address such interplay, studies have explored community fluctuations relating to scalar associations between social interaction and demographic growth, where increasing population densities may generate intra-community social stresses and tensions. This can lead to social fissioning and potentially community dissolution in the absence of developed prosocial and integrative structures, such as stratification, ritual practices and cooperative subsistence modes (Johnson 1982; Bandy 2004; Alberti 2014; Ellyson 2022). Importantly, synthesising studies suggest that the consequence of these process dynamics appear to have cross-cultural and -temporal scope (Bandy 2008; Feinman and Neitzel 2023; Scholtus and Müller 2024). Recent studies using large-scale radiocarbon datasets indicate fluctuating, short-duration growth rate modes each spanning few centuries of alternating positive and negative growth affecting settlement demographics, including across South Scandinavian contexts (Lima *et al.* 2023; Kondor *et al.* 2023, 2024; Friman and Lagerås 2022; Loftsgarden and Solheim 2023). While such fluctuating modes would likely be influenced by diverse context-specific factors, they may therefore also reflect broader conditioning trends with profound implications for social dynamics of cooperation and competition across local and regional scales. Overall, the empirically observed cross-scale patterns of cyclical fluctuations in settlement demography and densities would fit with recurring impacts by endogenous factors such as social stresses and conflicts within and between communities, likely linked to underlying effects from shifts in subsistence intensification and carrying capacity and occurring in interplay with impacts from exogenous factors such as climate (Lima *et al.* 2023; *cf.* Kondor *et al.* 2024).

Addressing questions about the relationship between local and broader-scale modes of community formation and operation requires high spatial coverage combined with precise temporal correlation across flexible analytical scales (Yaeger and Canuto 2000, 9-11; Kowalewski 2008; *cf.* Bevan and Crema 2021; Manning *et al.* 2021; Lee and Hwang 2025). The intense settlement sampling and radiocarbon dating within the Køge Bay area, together with the previously indetermined temporal framework for earliest Iron Age village community formation and change processes in the region, makes it well suited for detailed case study. A precise understanding of the temporal frameworks of earliest Danish Iron Age village communities – incorporating general spatiotemporal aggregation and density trends – is crucial for evaluating settlement and social models. This paper explores these frameworks within the study area *c.*500-1 BC using radiocarbon-based models. The approach integrates middle-range and local scales through two stages: 1) modelling of overall

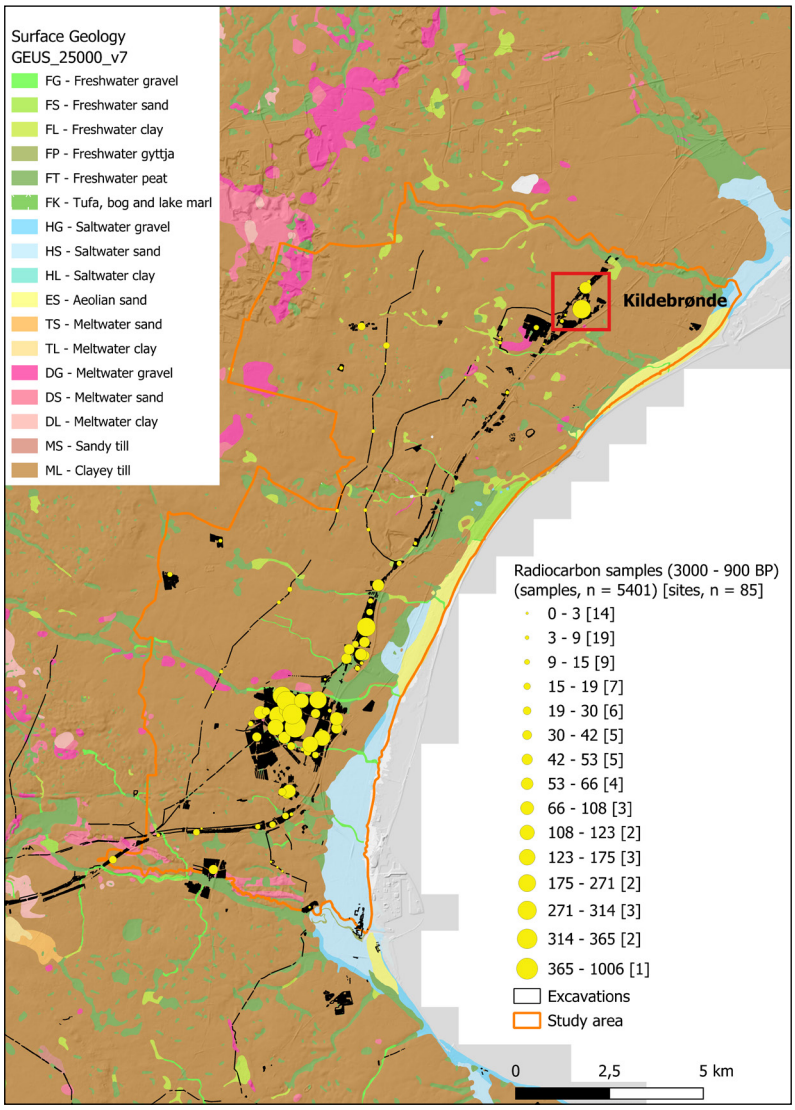


Figure 2. Distribution of radiocarbon dated samples by sites and the extent and geological character of the study area. The location of the Kildebrønde site to the north in the study area is marked by red square (Data by the authors; base map contains data from The Agency for Climate Data and from the Geological Survey of Denmark and Greenland (GEUS)).

radiocarbon densities to examine spatiotemporal modes and changepoints in sampled settlement across the study area; and 2) Bayesian modelling of the Kildebrønde site to test corresponding dynamics and make inferences about their social implications at intra-community scales.

Materials and methods

The analysis uses 5401 georeferenced radiocarbon dates comprising all dated samples from settlement contexts within the study area with measured ages ranging from 3000 to 900 BP (Figure 2). The temporal range extends beyond the period of focus both to mitigate edge effects on initial data evaluation and to contextualise short-term density changes within longer-term Iron Age dynamics in the first analytical stage (*cf.* Crema and Bevan 2021, 30). The second analytical stage uses a local subset of the data.

The dataset is almost exclusively sourced from development-led excavations conducted between 2012 and 2025, reflecting a recent program of consistent, large-scale and quasi-random settlement sampling and radiocarbon dating. The case-study area covers Greve, Solrød and parts of Køge municipalities. The natural terrain is dominated by ground moraine, alternating with stretches of coastal marshland and bogs. The inland delimitation follows natural landscape boundaries, marking a transition to higher ground undulating moraine terrain, while the northern and southern limits are defined by prominent lateral erosion boundaries. Although compact in size, the study area encompasses substantial diversity in geological morphology, ecology and resource potentials, supporting a range of prehistoric settlement and subsistence strategies (Nielsen 2009; Kristensen and Tornbjerg 2009, 30-34). This

Sample type	Radiocarbon dates (n)
Charcoal	1282
Grain	4075
Grain/charcoal (bulk sample)	1
Grains (bulk sample)	2
Other charred	11
Other uncharred	2
Plant charred	10
Plant uncharred	1
Seed charred	10
Wood uncharred	7
Total	5401

Table 1. Number of radiocarbon dates by sample type.

diversity is usefully represented in the archaeological sample of excavated sites.

Only macrofossil samples are included in the radiocarbon dataset. The primary sample types are single-entity carbonised grain or seed and wood charcoal, with other sample types contributing only marginally (Table 1). Sampled contexts primarily comprise postholes associated with remains of houses and other post-built structures, but also include pits, firepits and ditches. Several source-critical, methodological and interpretive issues may affect the radiocarbon data and modelling applications employed in this paper, both those targeting spatiotemporal density trends across the study area and those addressing the site scale. Two fundamental archaeological concerns are 1) sampling error, resulting from random or systematic biases affecting the formation, preservation and investigation of samples suitable for dating from certain contexts and periods of time (*e.g.* Brown 2015; Crema and Bevan 2021, 23-27), and 2) the association between dated samples and the activities targeted by the dating (Waterbolk 1971; *cf.* Bayliss 2009). The latter comprises a specific set of issues in the case of radiocarbon-dated macrofossils from predominantly post-built and largely unstratified Danish Iron Age settlement contexts. These settings impose relatively weak contextual checks on the calibrated dates of individual samples, meaning that residual or intrusive samples, as well as intrinsic sample age, may introduce additional uncertainty (*e.g.* Hansen 2015, 54-59; Torfing 2019). The present dataset, however, derives from an extensive, iterative and deliberately non-discriminatory sampling and dating strategy across the study area, generally involving systematic repeat sampling. In all recorded house contexts, for example, this generally involved sampling all roof-supporting postholes as a minimum, with a minimum of three radiocarbon dates routinely sought per house, subject to sample suitability. The unified sampling strategy and density of radiocarbon data may help establish a baseline for accounting for some inherent issues. We apply current research standards, specified in the sections below, to help mitigate remaining sources of potential bias.

Calibration and analysis of the radiocarbon data use the *rcarbon* (1.5.2) package (Crema and Bevan 2021) in *R* (R Core Team 2026), OxCal (4.4.4) software (Bronk Ramsey 2009a) and IntCal20 calibration data (Reimer et al. 2020). All data and model codes are provided as supplementary material.

Radiocarbon modelling of study area settlement dynamics

Overall study area dynamics are analysed using summed probability distributions (SPDs), composite Kernel Density Estimation (cKDE), simulation-based model testing of SPD results and spatiotemporal Kernel Density Estimation (stkde), all implemented in *rcarbon* (Supplementary material SM1). The analyses follow recent advances in methodologies relating to analysis and inference using large radiocarbon datasets (Crema 2022; Palmisano 2023), including spatiotemporal approaches (*e.g.* Chaput et al. 2015). The specific data-sourcing and proportion of short-lived samples ensure robust contextual and temporal links between dated samples and target events in overall settlement activity (Brown and Crema 2019; Lipo *et al.* 2022). The spatial distribution of dated samples is biased by variable excavation intensities. However, the numbers of samples at individual site level are in principle uniformly scaled relative to extent of excavation and quantity of archaeological contexts, functionally reducing bias by heterogeneity in sample sizes. To nevertheless

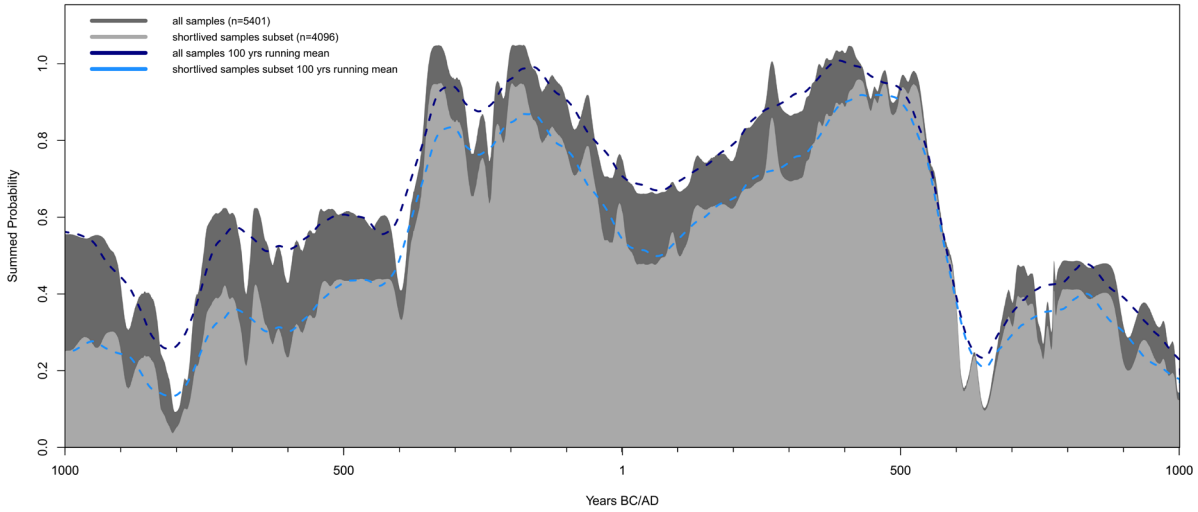


Figure 3. Summed probability distributions (SPDs) of all radiocarbon dates. Comparison of SPD results including all samples and exclusively short-lived samples.

formally control bias from inter-site heterogeneity in date intensity, dates from individual sites were assigned to synthetic site-phase bins (h=25 years; cf. supplementary Figure S3.1) (Timpson *et al.* 2014). To mitigate calibration effects dates were not normalised (Wenninger *et al.* 2015), and SPDs were smoothed using a 100-year running mean. To control potential offsets from inbuilt age of charcoal and (few) other potentially affected sample groups, separate SPDs were constructed for 1) the full dataset and 2) only short-lived grain and seed samples (Figure 3). Pearson correlation coefficient testing shows very high correlation, indicating negligible impact of age offsets (Table 2). The complete dataset is therefore used in subsequent analyses.

First, a cKDE was produced to assess robustness of SPD patterns. A kernel bandwidth of 50 years was used and the cKDE was generated using bootstrapping (n=1000 simulations) for a 95% confidence envelope (McLaughlin 2019). The method addresses potential biases introduced by sampling error (through random draws and replacement of sample subsets from the input data), chronological uncertainty (through sampling one calendar date from each calibrated probability distribution and estimating the Gaussian kernel density of these sampled ages) and calibration effects (through KDE smoothing), all of which can affect SPDs (McLaughlin 2019, 483-484; *cf.* Brown 2015, 2017; Bronk Ramsey 2017; Carleton and Groucutt 2021; Heaton *et al.* 2025). Second, the statistical significance of frequency fluctuations in the empirical SPD was evaluated using the *rcarbon* modelTest() function. This involved testing against a logistic growth-and-plateau model fitted to the observed SPD, with a 95% model envelope generated by Monte Carlo simulation (n=1000) (Shennan *et al.*

Pearson Correlation Coefficient	
3000-900 BP	
	Short-lived samples (n = 4096)
All samples (n = 5401)	0.96*
2800-2000 BP	
	Short-lived samples (n = 1570)
All samples (n = 2121)	0.98**

*r(df) = 2099, p = < 2.2e-16; **r(df) = 799, p = < 2.2e-16

Table 2. Correlation tests of radiocarbon dated samples SPDs: All samples against subsets of short-lived samples exclusively, both for the extended time range of the dataset and covering the time range of analytical focus.

2013; Timpson et al. 2014). Here, this model was used to represent current theoretical expectations for Danish Iron Age settlement levels, including initial Early Iron Age (500 BC-AD 150) growth to a potential Late Iron Age (AD 150-750) inflection point (Hansen 2015, 246-255; Søvsø 2022). Third, to examine potential local-scale heterogeneity in density fluctuations and changepoints within the formative phase of early village operation (*c.*500-1 BC), the *rcarbon* stkde() function was used to compute spatiotemporal kernel density estimates (Collard *et al.* 2010) for the subset of radiocarbon data covering this timeframe. Spatial and temporal bandwidths of 500 m and 30 years, respectively, were used. The spatial object for density mapping was produced with the *spatstat* package (Baddeley *et al.* 2015), and focal intensities and density change rates were visualised as 50-year time slices.

Bayesian chronological modelling of village-scale dynamics

To detail temporal frameworks of village formation and development at the scale of an individual community, several Bayesian models were produced in OxCal using radiocarbon dates from the Kildebrønde site (Supplementary material SM2). The modelling utilises all radiocarbon dates (n=374) relating to the earliest Iron Age contexts at the site, predominantly sampled from postholes associated with house remains. The earliest Iron Age phase comprises the remains of 127 recorded houses, along with ditches and several hundred pits. Of these 127 houses, 88 are assigned to the phase based on one or more radiocarbon dates (with individual house contexts mainly represented by three to six dates), comprising all houses within the phase assemblage for which suitable sample material was available for radiocarbon dating. The remaining 39 houses were sampled in accordance with general sampling routines, but yielded no suitable samples and are therefore assigned to the phase based on typology and spatial location. Within the site boundaries, very few contexts predate the earliest Iron Age phase, comprising scattered pits dating to the Neolithic (*c.*3900-1700 BC) and Bronze Age (*c.*1700-500 BC), while a limited number postdate it, comprising the remains of a few houses all associated with a solitary, spatially isolated farm dated to the Late Iron Age. The risk of potential biases in the radiocarbon dataset arising from residual or intrusive sample material associated with earlier or later activities at the site is therefore reduced.

The archaeological information for the modelling framework includes spatial definition and interrelation of sampled contexts. In the period in focus, each longhouse represents the nexus of an individual farm-unit, combining habitation and stable/storage functions; farm units may additionally include one or more smaller utility buildings (Hvass 1985, 130; Runge 2009, 65). Based on comparative reference the analysis defines longhouses by a roof-bearing construction of ≥7 m in length, and utility buildings by <7 m (Hvass 1985, 99; Rindel 1997, 95-102; Ejstrud and Jensen 2000, 51-56; Runge 2009, 60-69; Haue 2012, 143; Donat 2018, 99-107; Boye 2019, 119-127). Farm unit clusters were delimited by spatial analyses of all radiocarbon dated houses (n=88) relating to the phase, implementing Kernel Density Estimation (KDE) heatmapping (Baxter and Wright 1997) and the Density-based spatial clustering applications with noise algorithm DBSCAN (Ester *et al.* 1996). The KDE algorithm estimates the kernel density of vector layer points in space based on a specified spatial bandwidth parameter and visualises variations as a smoothed surface. DBSCAN is a clustering algorithm that can assign discrete points to clusters based on specified minimum cluster size and maximum distance between points; the analysis adds new columns to the vector layer that identifies resulting cluster field name (CLUSTER_ID) and cluster size (CLUSTER_SI). Here, we used 50 m kernel bandwidth for the KDE and minimum cluster size 3 with maximum distance 50 m for the DBSCAN analysis. The resulting cluster identifications were used as analytical units, here termed Farm clusters. Ten Farm clusters were identified, each comprising a combination of longhouses and utility buildings, and collectively including all 88 radiocarbon dated houses, as well as encompassing all 39 houses with no radiocarbon dates (Figure 4). Within the cluster delimitations, accumulated house phases often overlap, but very rarely provide relative sequence information (Figure 5). A ditch (A1103) lies between Farm

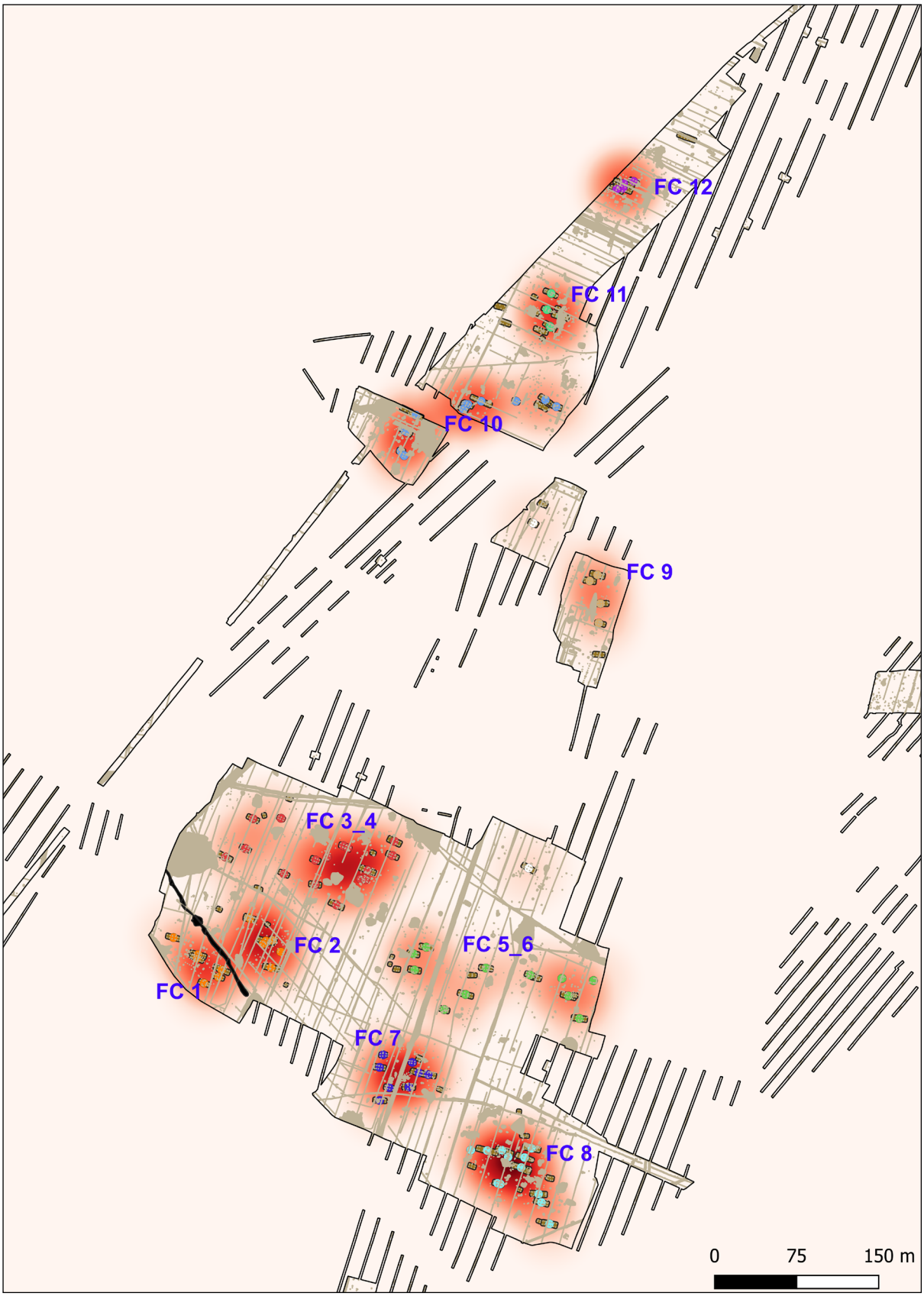


Figure 4. Kildebrønde Farm clusters identified by point cluster analyses in QGIS using KDE heatmapping and the DBSCAN algorithm applied to all radiocarbon dated houses. DBSCAN results are categorised by point colours according to the generated CLUSTER_ID. Farm clusters are designated 1 to 12, since two clusters (3_4 and 5_6) have relatively dispersed densities and ambiguous delimitations in the KDE analysis; both are defined by the DBSCAN analysis. DBSCAN does not identify Farm clusters 1 and 2 as separate; here, the KDE identification is confirmed by ditch A1103 located between them.

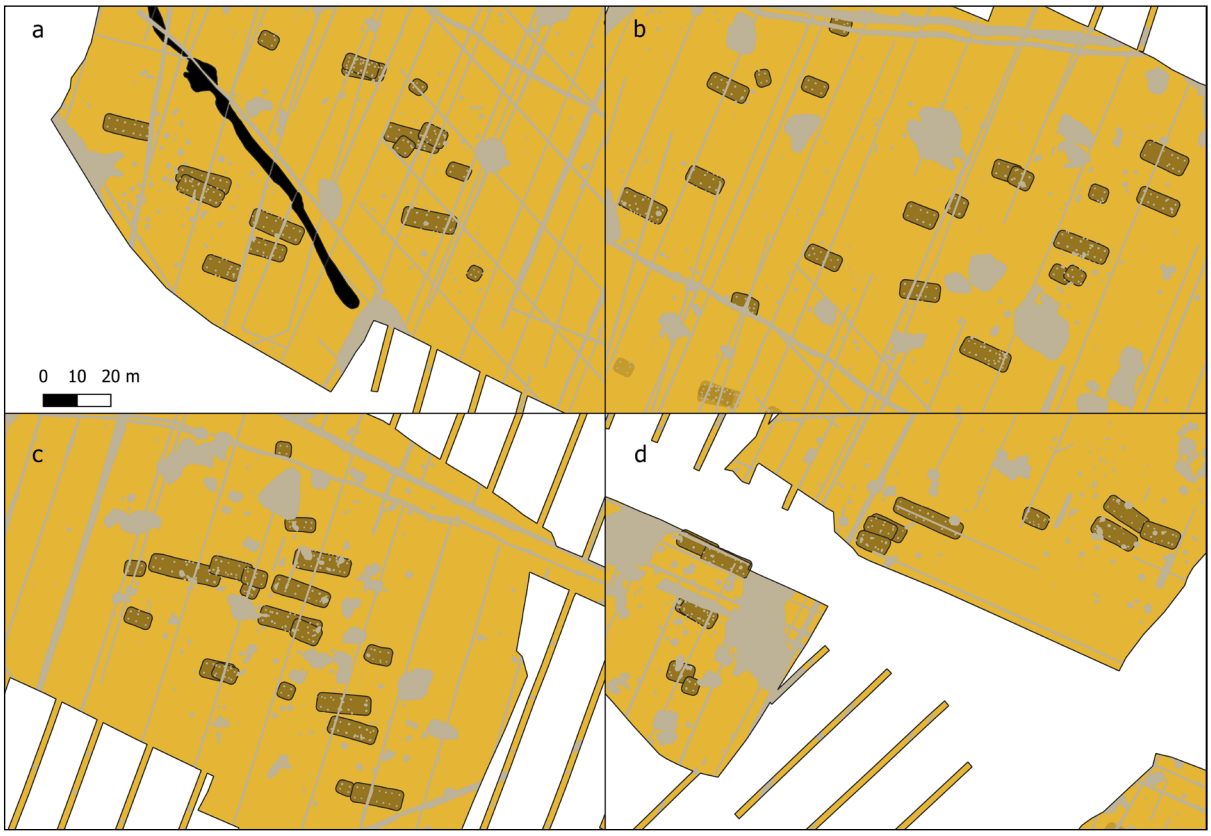


Figure 5. Examples of Farm clusters: (a) Farm clusters 1 (bottom) and 2 (top) divided by Ditch A1103; (b) Farm cluster 3_4; (c) Farm cluster 8; (d) Farm cluster 10. Houses located in the vicinity of defined Farm clusters, but not forming part of them according to the spatial analyses, are shown to visualise the wider contexts, but dimmed.

clusters 1 and 2 and is related to both by radiocarbon dating. Numerous pits of various types show structured accumulation in unbuilt spaces between Farm clusters and similarly relate to the general timeframe of the earliest Iron Age phase. Finally, this phase comprises assemblages of ceramics and animal bone, deposited mainly in the pits, as well as structures and finds of iron and clay slags representing localised iron production.

The Farm clusters form the primary relational contexts for grouping of radiocarbon-dated samples. A bounded-Phase uniform Bayesian model was constructed for each Farm cluster. Dated houses were nested as unbounded Phases in their respective Farm cluster models. Where at least two dates were available for a house (n=72), the OxCal First and Last functions estimated construction and abandonment. A separate model was built for ditch A1103.

To formally assess the consistency of all short-lived samples with model parameters outlier analysis was used in all component models, applying the OxCal General Outlier model with a 5% prior probability (Bronk Ramsey 2009b). To address the intrinsic age of wood charcoal samples, the Charcoal Plus Outlier model was applied with a 100% prior probability, allowing for a small proportion of samples to be slightly more recent than model parameters to account for statistical uncertainty and uncontrollable taphonomic processes (Dee and Bronk Ramsey 2014). For samples with a measured age of ≥2700 BP the After() command was used as a conservative *post quem* cut-off, in practice only applying to a proportion of charcoal samples. Significant posterior outliers (≥10%) calculated by the General Outlier model were specified Outlier() in revised Model 2 versions. In all Model 2 runs, only minor posterior outliers (<10%) were identified and were retained.

The radiocarbon measurements included in the component models fall across a part of the IntCal20 calibration curve affected by a reversal *c.*350-200 cal BC, which could potentially bias the modelled probability distributions. We therefore ran a series of simulations across all component models to test the sensitivity of our results to such bias. The

posterior distributions from these simulations indicate that the final model outputs reported below are reproducible and accurate within their quoted uncertainties (*cf.* Supplementary material SM2, Supplementary Figures S2.1, S2.2 and Table T2.1).

Results

Spatiotemporal density patterns in the Køge Bay region

Figure 6 shows results of the cKDE modelling and SPD with model testing spanning 800 BC-AD 1000. Essentially, the cKDE (Figure 6a) and SPD (Figure 6b) results identify corresponding overall trends across the timeframe, while the cKDE incorporates calibration and sample size uncertainties and reduces calibration-curve artefacts. The evidenced trends represent distinct growth-and-decrease cycles, including gradual growth after *c.*800 BC; steep, short-duration growth from *c.*400 BC, peaking *c.*350/300-200 BC and followed by a decrease; a trough around the BC/AD transition; a peak *c.*AD 200-500; and a significant, sudden drop *c.*AD 550.

In the test of the empirical SPD against the fitted logistic growth model, the growth episode starting *c.*400 BC remains within the 95% envelope of the model expectation until *c.*350 BC, after which it involves significant positive deviation to a plateau between *c.*300 and 200 BC. While substantial, the decrease from *c.*200/150 BC remains within the model envelope and appears gradual compared to the immediately preceding growth as well as to the abrupt decrease and negative deviation from the model after *c.*AD 550. In the wider context of Iron Age settlement dates, the increase for the *c.*400-350/300 BC period stands out as a singular episode of abrupt, significant growth relative to the short duration of this period. This growth in radiocarbon date density indicates a significant expansion in the sampled settlement activity. The derived density change rate (Figure 6c) supports, that this expansion phase does in fact represent a very short-duration impulse, with the interval of statistically significant, positive deviation constrained to *c.*375-300 BC, approximating a maximum of three to four generations. Furthermore, the rate of change appears negative just prior to this during the 5th century BC and again for much of the 1st century BC.

The spatiotemporal KDE (stkde()) modelling (Figure 7, *cf.* supplementary Figure S3.2 in SM3) supports evaluation of any local-scale heterogeneity in the collective radiocarbon density trends across the study area for the focal period 550-1 BC. This produces three significant observations. First, the dynamic of significant and rapid radiocarbon-date density increase in sampled settlement *c.*400-350/300 BC is broadly distributed, with several near-synchronous density kernels across the area for the time-slices covering this short temporal range. Accordingly, the inferred density growth in the settlement sample has substantial spatial extent and relative homogeneity across the area, with the onset of this growth consistently estimated to *c.*400-350 BC. Second, focal intensities within these primary density kernels remain relatively high after the initial growth phase, but are then substantially affected by negative rates of growth from *c.*350/300-250 BC; again, local onsets of negative rates are constrained to a consistent, narrow timeframe, indicating near-synchronous dynamics across these local scales. Third, while the temporally primary density kernels consistently show negative growth rates after *c.*300/250 BC, some smaller density kernels of positive growth emerge in their periphery after *c.*200/150 BC. These episodes of temporally secondary growth are spatially limited, but show fine-grained local variability within the general patterns.

Overall, the rapid growth in radiocarbon-dated settlement density across several local kernels *c.*400-300 BC is consistent with a high-tempo and spatially broad-scale process of settlement aggregation into nucleated configurations of community. The observed trends suggests that this was significantly generated by a short-duration impulse of effective growth and expansion, not only or primarily by organisational reconfigurations impacting the degree of spatial clustering in settlement. While the general trend of stagnant and negative growth rates after *c.*300/250 BC contains some underlying local-scale variation, the patterns of decrease in the spatiotemporal densities of sampled settlement appear robust overall.

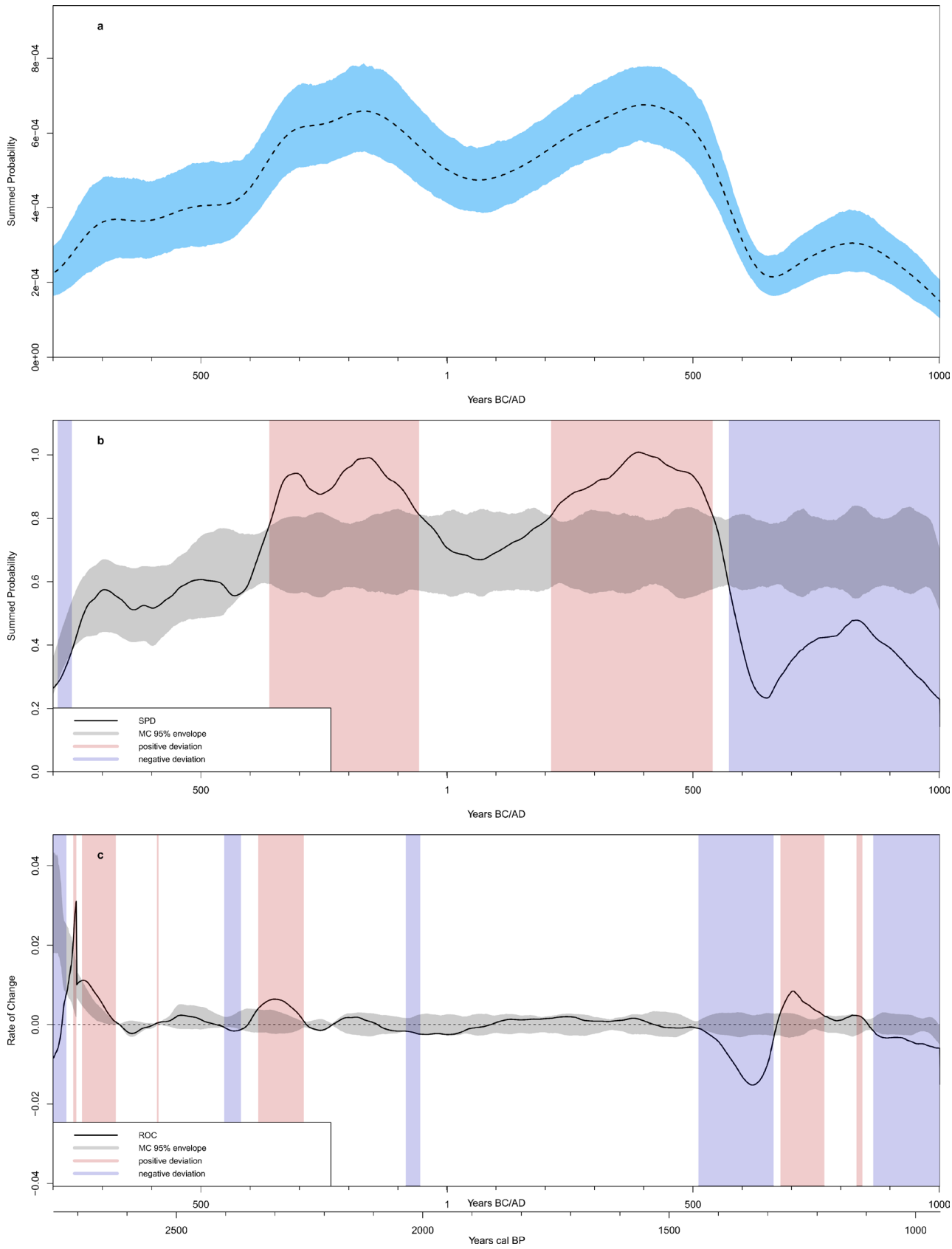


Figure 6. Results of (a) cKDE modelling, (b) SPD against logistic model test, and (c) rate of change (ROC); modelTest() function summary: *n* radiocarbon dates = 5401, *n* bins = 1143, *p*-value = 0.001.

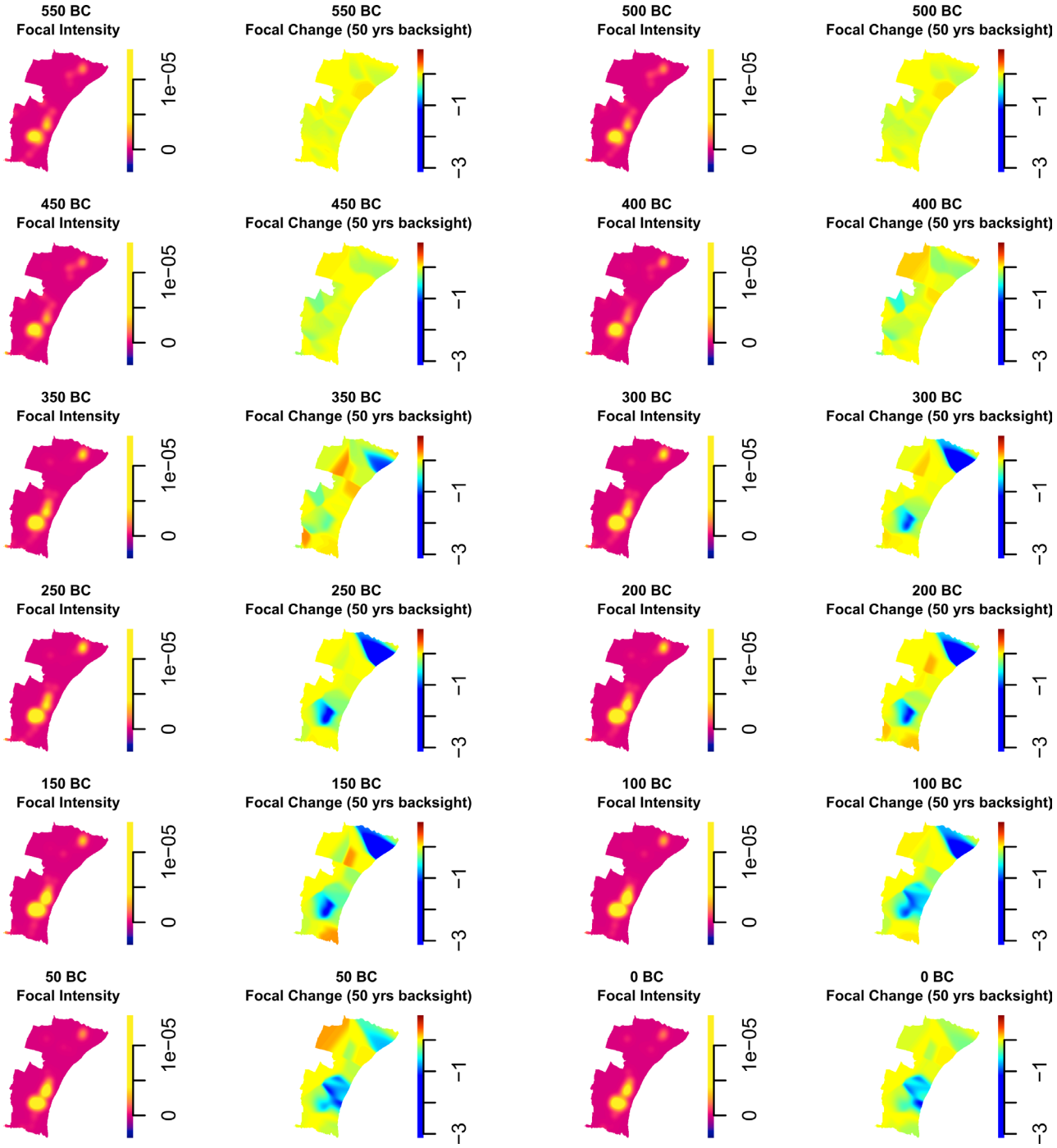


Figure 7. Spatiotemporal KDE modelling of the settlement radiocarbon data across the earliest Iron Age timeframe in 50-year time slices. Focal Intensity panels show spatiotemporal intensities for each focal year. Focal Change panels show spatial patterns of density change for each focal year relative to 50 years before.

Village-scale dynamics

Key results of final Bayesian models of the Kildebrønde data are summarised in Table 3 (*cf.* supplementary Figures S3.3-S3.13). All models result in acceptable diagnostic values (Agreement ≥60%, Convergence ≥95%), indicating consistency between the data and model parameters as well as robust results (*cf.* Bronk Ramsey 1995, 2009a).

Temporal interrelations of model Boundary estimates for the start and end of each Farm cluster are calculated with the OxCal Order function and ordered probability distributions are shown in Figure 8. The formation and abandonment of individual Farm clusters were generally asynchronous events, although with overlapping probability ranges in several cases. The formations likely begin with Farm cluster 7 in *395-234 cal BC (95.4% probability, start: Farm cluster 7)*, and probably in *391-314 cal BC (68.3% probability)*; abandonments likely end with Farm cluster 8 in *183-117 cal BC (95.4% probability, end: Farm cluster 8)*, and probably in *171-144 cal BC (68.3% probability)*. The estimates for Farm cluster formations suggest that three or possibly four clusters coexisted from the mid-late 4th century BC, indicating village community formation from this timeframe. The use of several more clusters overlapped through much of the 3rd century BC, in some cases continuing into the early 2nd century BC (*cf.* Date estimates in Table 3). Estimates for the abandonments of Farm clusters closely overlap toward the end of the community duration (Farm clusters 11, 10, 9, 8, possibly 12). However, abandonments of some Farm clusters (2, 1 and 5_6) are significantly earlier than formations of most recent clusters (9, 11, probably 12). While this suggests complex interplay of independent Farm cluster formation and abandonment, KDE_Plot summary (Bronk Ramsey 2017) of modelled dates from the clusters (Figure 9) confirms partial or near-complete coexistence of several of them, including a collective peaking constrained to the timeframe *c.*300-200 BC. The model distributions for ditch A1103 correspond with those for Farm clusters 1 and 2 on either side of it. Farm clusters 9, 11 and probably 12 belong to a slightly later phase in the first half of the 2nd century BC. Farm clusters 9, 11 and 12 are located at the northern edge of the surveyed context, indicating spatial reorganisation across the final community phase, including partial abandonment of initially central areas. However, there are no indications of changes simultaneously and universally affecting overall organisational developments or the structuring of coexisting Farm clusters. Instead, changes

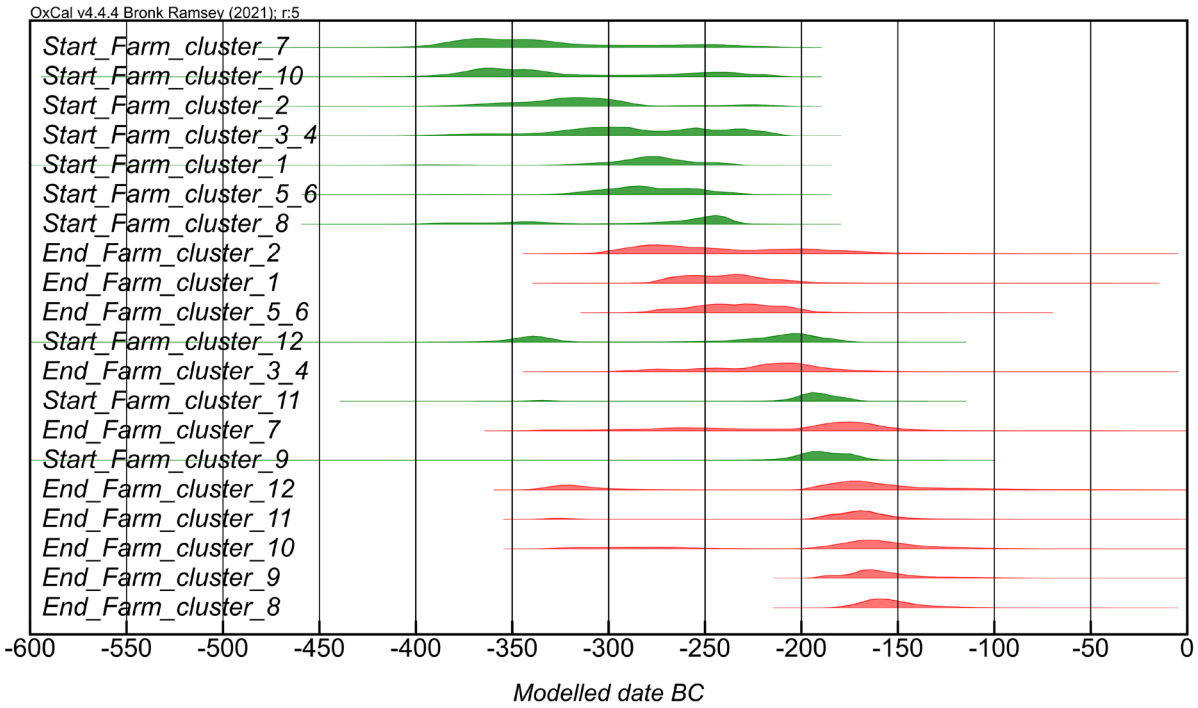


Figure 8. Boundary estimates for the start and end of each Farm cluster from individual Farm cluster models. All start Boundary estimates are colour coded green, while all end Boundary estimates are coded red. The temporal interrelations of the parameters are calculated using the OxCal Order query command.

Component	Model*	68.3% hpd				95.4% hpd				Indices
		start Boundary (BC)	Date estimate (BC)	end Boundary (BC)	Span estimate (years)	start Boundary (BC)	Date estimate (BC)	end Boundary (BC)	Span estimate (years)	
Farm cluster 1	1	301-255	280-238	267-224	0-47	404-380 (2.7%) 329-230 (92.7%)	309-209	278-198	0-117 (94.4%) 143-157 (1%)	A_{model}=80.2 $A_{overall}$=80.8
Farm cluster 2	2	350-290	322-275 (58.4%) 220-202 (9.9%)	296-237 (54.5%) 214-192 (13.8%)	0-71	383-282 (87.8%) 256-213 (7.6%)	338-187	305-163	0-168	A_{model}=81.1 $A_{overall}$=76.4
Farm cluster 3_4	2	324-280 (34.5%) 268-224 (33.8%)	292-274 (14.7%) 260-208 (53.5%)	253-185	0-81	371-212	325-191	289-169	0-156	A_{model}=90.9 $A_{overall}$=82.8
Farm cluster 5_6	2	304-251	283-233	255-209	0-55	331-226	303-209	279-195	0-105	A_{model}=100.5 $A_{overall}$=100.3
Farm cluster 7	1	391-314	330-259 (40.5%) 247-197 (27.8%)	272-242 (13.7) 202-150 (54.5)	58-163	395-234	366-175	311-135	23-213	A_{model}=94.8 $A_{overall}$=87.8
Farm cluster 8	2	354-332 (12.2%) 278-231 (56.1%)	325-322 (1%) 271-162 (67.3%)	171-144	60-123 (55.3%) 172-202 (13%)	397-316 (30.6%) 304-326 (64.8%)	370-155	183-117	53-253	A_{model}=76.7 $A_{overall}$=61.5
Farm cluster 9	2	200-175	191-162	185-145	0-34	218-161	205-130	194-102	0-83	A_{model}=156.9 $A_{overall}$=156.9
Farm cluster 10	1	381-326 (51.3%) 260-231 (17%)	343-294 (22%) 250-172 (46.3%)	193-125	37-102 (43.2%) 153-204 (25.1%)	390-215	364-156	330-245 (20.3%) 199-101 (75.1%)	22-234	A_{model}=94.2 $A_{overall}$=87.5
Farm cluster 11	2	204-179	194-169	186-157	0-26	340-330 (3.3%) 214-169 (92.2%)	337-325 (4%) 204-152 (91.5%)	333-319 (4.1%) 199-135 (91.3%)	0-53	$A_{model=}$141.8 $A_{overall}$=144.6
Farm cluster 12	2	350-329 (19.5%) 226-185 (48.8%)	340-320 (16.5%) 208-167 (51.8%)	330-312 (13.3%) 193-145 (55%)	0-49	375-316 (30.1%) 269-172 (65.3%)	353-293 (25.8%) 249-129 (69.6%)	340-289 (23.1%) 200-90 (72.3%)	0-128 (90.5%) 158-218 (5%)	$A_{model=}$97.1 $A_{overall}$=99.8
Ditch A1103	1	338-287 (39.8%) 256-212 (28.4%)	321-276 (33.7%) 241-197 (34.6%)	307-268 (27.1%) 225-172 (41.2%)	0-57	367-204	349-176	319-129	0-146	A_{model}=105.8 $A_{overall}$=106.2

* Indicates whether the parameters are derived from the Model 1 run or from a revised Model 2 run incorporating the results of formal outlier analysis.

Table 3. Key results from Bayesian component models: Start and end Boundaries, Date estimates and Span estimates for each Farm cluster and for Ditch A1103.

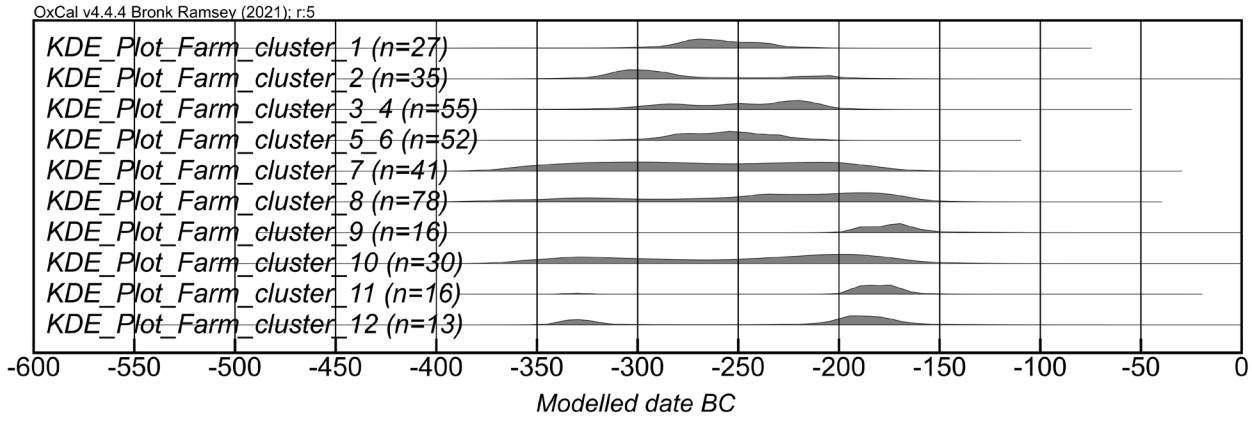


Figure 9. KDE_Plot summaries of modelled radiocarbon dates from individual Farm cluster models. The *n* values in brackets show numbers of modelled radiocarbon dates in each component model.

appear generated by dynamics at Farm cluster scale. Importantly, Farm clusters show sustained internal use within their respective spans.

The overall duration of the village community is estimated to *61-261 years (95.4% probability, difference: Farm cluster 9, Farm cluster 7)*, and probably *141-237 years (68.3% probability)*, corresponding roughly to a maximum of ten generations (based on a 25-year generation) (Figure 10). Span estimates for individual Farm clusters vary, but indicate mostly short durations, in several cases corresponding to only two to three generations (at 68.3%, *cf.* Table 3). Although some early clusters (7, 8 and 10) have long durations, none were in use for the full duration of the overall village context. Span estimates for individual houses are typically short and generally consistent with short use-durations probably not above one to two generations (*cf.* supplementary Figure S3.14).

The models demonstrate marked synchronic differences in the intensity of nucleation between Farm clusters. The highly nucleated Farm clusters (especially 1, 2, 7, 8 and 11) are constituted through maintained use of delimited spatial plots within the village community. The structuring of space into defined habitational clusters, adjoining pit-areas and dynamically maintained buffer-zones is consistent with communal negotiation, while construction of a ditch between two Farm clusters shows constrained instances of specific cooperative efforts. However, plot frameworks were apparently not supported beyond the durations of uninterrupted renewal of the farms constituting them; as shown, durations were typically short-term. Importantly, the durations of the highly nucleated clusters suggest that they would likely in some cases comprise two or more contemporaneous longhouses (*i.e.*: Farms).

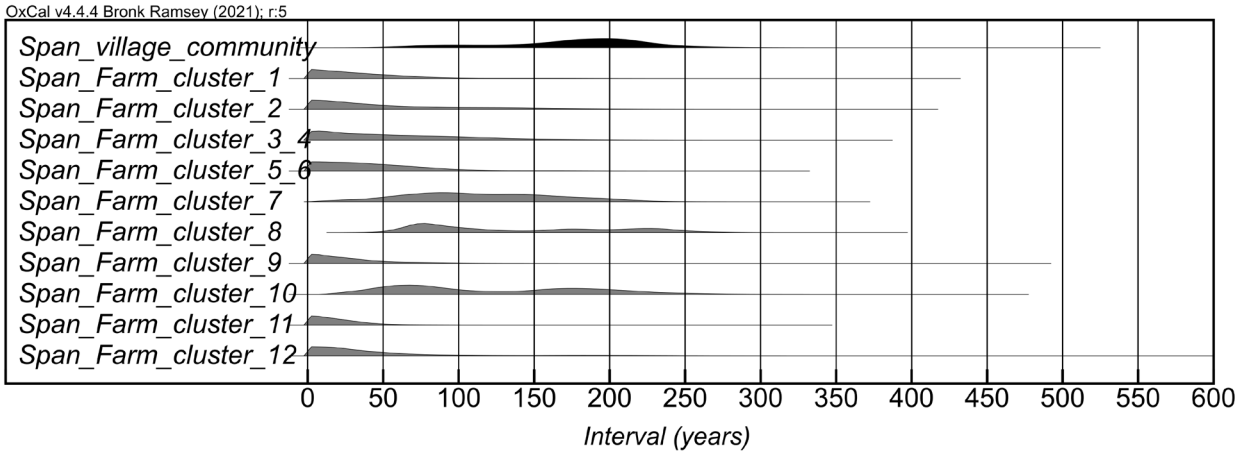


Figure 10. Estimated temporal Span of Kildebrønde village community and individual Farm clusters. The total village community span is calculated as the difference between the estimated end of Farm cluster 9 and start of Farm cluster 7.

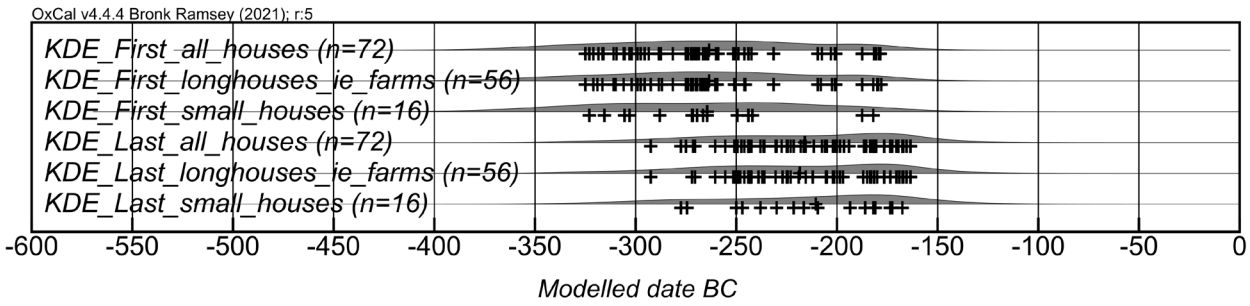


Figure 11. KDE_Plot summaries of First and Last estimates for houses from individual Farm cluster models. The *n* values in brackets show the total numbers of modelled houses as well as the numbers of longhouses and small houses by category. Crosses show median values of date estimates.

The dispersed clusters (especially 3_4 and 5_6) display shifting farm building locations and layouts, implying independent relocations of farmsteads at likely generational scales or occasional reproductive discontinuities.

KDE_Plots of First and Last estimates for 72 dated houses (56 longhouses and 16 small utility buildings for which at least two radiocarbon dates are available in final models) clarify house and farm building and abandonment frequencies (Figure 11). Building frequencies rise rapidly, peaking before *c.*250 BC, followed by decline. Abandonments increase shortly after 200 BC, reflecting the intrinsic delay relative to the building distributions. Temporal distributions of utility buildings show they were present in some farms from the earliest phases, indicating complex farm-unit economies from the outset of community formation. When densities of First and Last estimates are examined by Farm cluster (Figure 12), greater variability emerges. In some clusters, building and abandonment events are tightly grouped; in others, they extend across longer intervals. This pattern does not appear to simply reflect Farm cluster durations or the varying numbers of (dated) buildings they contain, as there is no straightforward correlation between the cluster durations and the numbers of buildings contained within the clusters. Figure 12 shows, instead, how the aggregate patterns of farm building and abandonment mask underlying differences in the timing and tempo of these events between individual Farm clusters. Rather than following a common developmental trajectory, it appears that Farm clusters experienced episodes of building and abandonment at different rates, indicating considerable autonomy in the organisation and reproduction of these units within the village community.

The diversity evident in the timing, tempo and intensity of building and abandonment is also reflected by patterns in the distribution of productive activities across Farm clusters. Figure 13a maps house sizes, density of grain finds volumes in samples, distribution of ceramics and animal bone finds, and records of specialised iron production. Farm cluster 8 stands out: It combines a high proportion of large longhouses, high densities of ceramics and animal bone finds, high density of grain finds and exclusive evidence of iron production. Although Farm cluster 8 may likely have had marginally longer duration than any other cluster, only the densities of ceramics and bone finds should be directly time-dependent by accumulation; iron production activities are evidenced in cluster 8 from around the mid-3rd century BC (Figure 13b). Other clusters show lower relative values in comparison, although some northern Farm clusters (especially 10 and 12) include relatively high densities of ceramics and bone finds and some above-average longhouse sizes. As shown, these northern clusters belong to the late phase of the overall site duration. The collective patterns therefore suggest relatively high and diversified productivity and consumption within Farm cluster 8 and could indicate variable socioeconomic capabilities across Farm clusters overall.

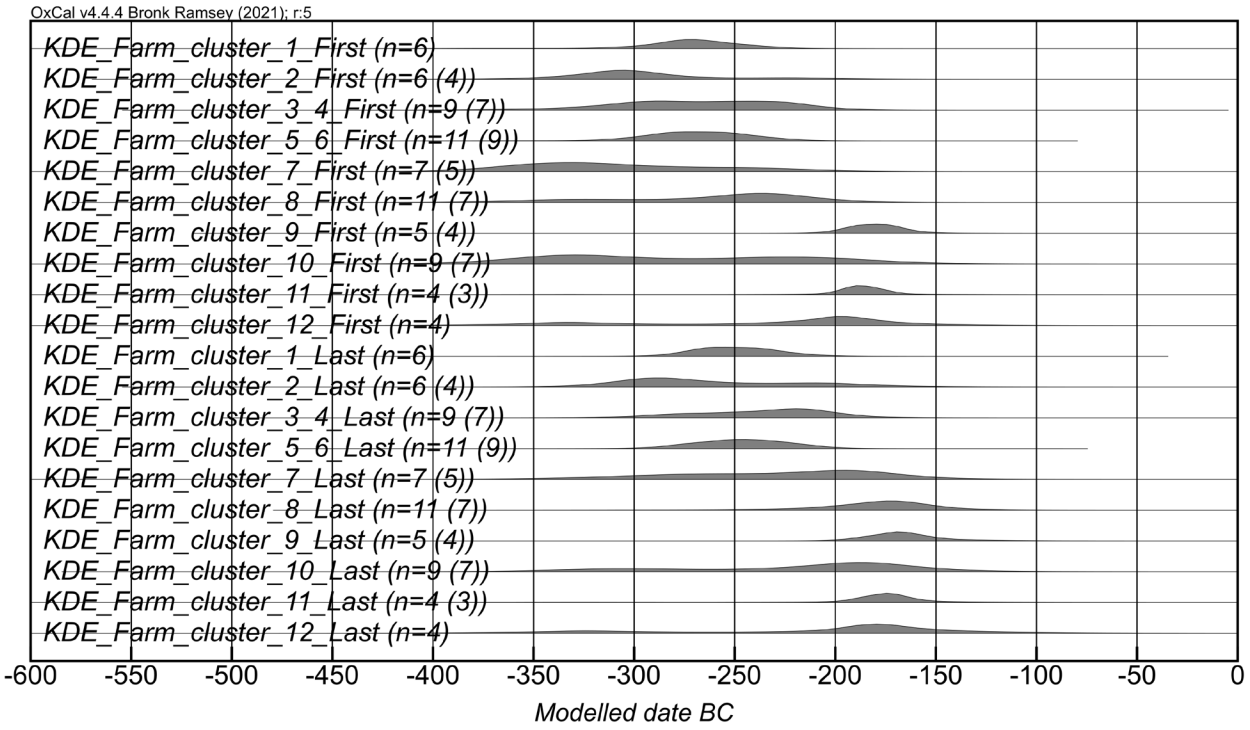


Figure 12. KDE_Plot summaries of First and Last estimates for houses by Farm cluster. The *n* values in brackets show the total numbers of modelled houses and (longhouses) in each Farm cluster; Farm clusters that have a single value comprise longhouses exclusively.

Discussion

The radiocarbon modelling determined significant spatiotemporal density fluctuations in sampled settlement across the Køge Bay case study area and provided resolved date estimates of formation, use and abandonment at the scale of several individual Farm clusters constituting village community at Kildebrønde. The combined results supply a basis for exploring the interplay between broader trajectories and processes within the individual community. It is a key strength that the analyses are formalised and reproducible, and quantify uncertainties. Potentially, the approaches could be replicated including comparable datasets from other regions, enabling precise correlation and qualification from absolute date estimates. The volume and spatial density of the radiocarbon dataset used here is robust even in comparison with wider supra-regional studies (*e.g.* Bunbury *et al.* 2023; Winther Johannsen *et al.* 2024). While inference of population levels from densities of radiocarbon dates entails complex problems (*e.g.* Crema 2022; Freeman *et al.* 2018; Tallavaara and Jørgensen 2021), tests show that such densities may come close to a proxy of settlement counts (Crema *et al.* 2024; *cf.* Crema and Kobayashi 2020; Codding et al. 2024; Bilotti 2025).

The density models produced here suggest rapid growth in the frequency and spatial density of radiocarbon-dated settlement, beginning *c.*400-350 BC and consistent with a short-term episode of expansion and aggregation. After *c.*300 BC this growth episode was replaced by generally stagnating rates, and from *c.*200-150 BC negative growth trends emerged, although including complex local diversity with a horizon of secondary density kernels occurring from around this same time-interval. The high rate and short duration of the growth episode constrained to *c.*400/350-300 BC is a central finding. The identified dynamics appear clearly nonlinear and raise new questions concerning the contexts, factors and processes shaping village community trajectories within the period.

Bayesian models of the Kildebrønde context evidence rapid formation from the early-middle 4th century BC into several clustered, variably coexisting farm units to constitute a village community. From around the mid-3rd century BC, sequential spatial shifts are evidenced: Central Farm

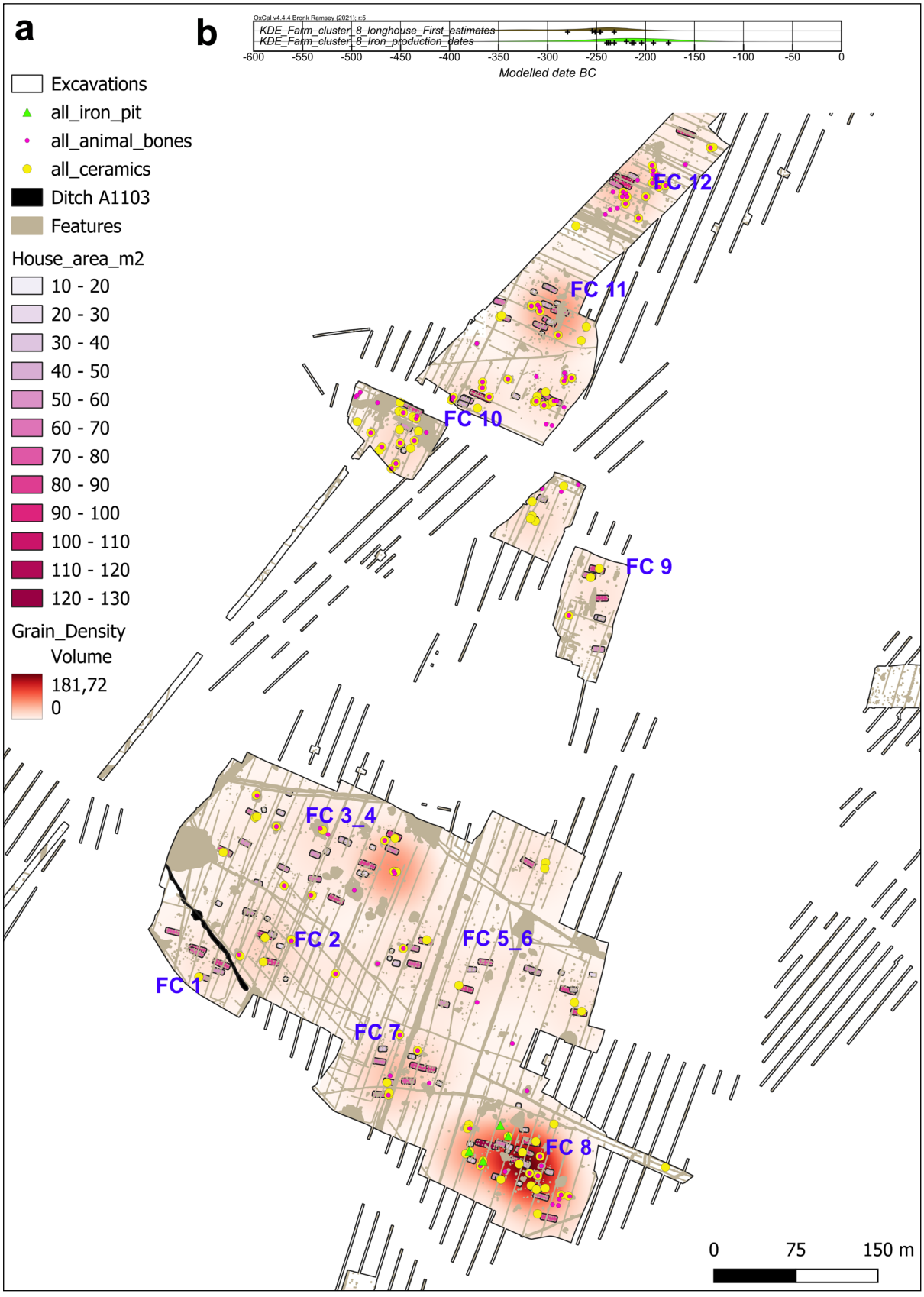


Figure 13. Map of Farm clusters showing house sizes, distribution of ceramics and animal bone finds, and densities of grain finds (a). House sizes are estimated based on a fixed buffer of value 1.3 meters from roof supporting posts. KDE_ Plot summary of iron production dates and First estimates of all longhouses in Farm cluster 8 (b); crosses show median values of date estimates and modelled dates.

clusters were abandoned and new clusters established further north; the community finally dissolved through rapid sequential abandonments during the mid-2nd century BC. As some Farm clusters were abandoned and others established, contexts and contents of social interaction would have continuously shifted over the relatively brief overall community duration. The timings and rates of formation, operation and abandonment processes correspond with broader study area trends, suggesting that they reasonably represent a robust sample of village-scale dynamics within this area.

Contextualising earliest Iron Age village community formation and change in the Køge Bay region

The dynamics in radiocarbon-dated settlement across the study area show nonlinear trends consistent with broader southern Scandinavian patterns. Recent analyses similarly point to oscillating densities in settlement-derived radiocarbon data at regional scales (*e.g.* Friman and Lagerås 2022; Loftsgarden and Iversen 2023) alongside labile, locally diverse community configurations (Iversen 2020; Møller and Dollar 2022; *cf.* Gjerpe 2024b). The proposed onset of dense settlement aggregation from *c.*400-350 BC appears earlier and more rapid than suggested in most previous studies, which generally place these processes from *c.*250-200 BC (Webley 2008, 26; Møller and Dollar 2022, 153). For Zealand, even later and protracted chronologies have been proposed (Martens 2010, 245; Boye 2019, 273-274). By contrast, the results produced here align with recent findings from north Jutland indicating abrupt growth and aggregation in the 5th-4th century BC (Haue 2023), and broadly match the primary phase of village formation at Grøntoft in southwest Jutland (Rindel 1997, 1999, 2010; Haue 2023, 36). Although many Danish and Scanian sites contain numbers of 5th-3rd century BC farms or small farm clusters, chronological resolution has generally been insufficient to resolve frequencies of narrowly coexisting farm units or processes at the community level (Ethelberg 2003, 133; Webley 2008, 24; Friman 2008; Martens 2010; Møller 2011; Boye 2019, 277-278). Webley (2008, 31-33) suggested that settlement aggregation into dense communities during the period primarily resulted from contraction and nucleation processes affecting spatial patterns under conditions of generally linear frequency growth. The present results rather suggest, that the modelled increase in spatial densities of sampled settlement from *c.*400-350 BC was linked to overall significant, high-tempo frequency growth in settlement activity, and that the overall decrease in spatial densities from *c.*200-150 BC was similarly associated with general frequency decrease. This could suggest that patterns of social connectivity and interaction underpinning community formation and dissolution oscillations likely responded rapidly to shifting modes of positive or negative growth in settlement demography (*e.g.* Kim *et al.* 2015; Lee and Hwang 2025).

In the existing interpretive models, these growth variables are often understood within a wider long-term evolutionary framework, assuming overall continuous expansion in settlement and density of land use based on indications of agricultural extensification and intensification after *c.*700 BC in pollen data (Bradshaw *et al.* 2005; Odgaard and Nielsen 2009; Mortensen 2018; Rasmussen 2010, 229-230) and data on soil amendment practices (Kanstrup *et al.* 2014; Nielsen *et al.* 2019; Gron *et al.* 2021; Hald *et al.* 2024). The high spatial coverage of sampling and large number of radiocarbon dates used here, however, revealed substantial shorter-term oscillations in settlement sample densities across the long-term trajectory represented by the study area data.

At the same time, interpretation of the factors underlying these observed dynamics remains limited by the geographical scope of the study area and lack of comparative datasets. Haue (2023, 38) has argued the impact of expanding land-use organisation on rapid village community formations during this period, while emphasising the potential of socioeconomic strategies at local scales to variably shape individual communities within micro-regional contexts. Recent syntheses suggest that growth-rates of early aggregated communities would be impacted by density thresholds on settlement demography, including constraints on organisational and communicative capacities (Müller and Diachenko 2019; Lima *et al.* 2023; Feinman and Neitzel 2023; Scholtus and Müller 2024). While

such dynamics likely represent important factors affecting often short settled community durations, integrating analyses of them with broader trends remains challenging. Methodological advances in radiocarbon modelling and inferential frameworks (*e.g.* Palmisano *et al.* 2021; Parkinson *et al.* 2021; Riris and de Souza 2021) and build-up of local and regional radiocarbon data currently outpace development and correlation of environmental proxy data relevant to the contexts in focus here. Notably however, the density decrease shown in our radiocarbon data after *c.*200/150 BC appears gradual and moderate compared to the abrupt and profound rupture evidenced around AD 550 and associated across southern Scandinavia with volcanically forced climatic downturn following AD 536/540 (Arthur *et al.* 2024; Larsen *et al.* 2024; Gundersen 2025). No comparable environmental impulses are currently identified for the 4th-2nd century BC interval (Sigl *et al.* 2015; van Dijk *et al.* 2024; Edvardsson *et al.* 2024; *cf.* Jensen 2005, 172-178; Gjerpe 2023, 2024a). This supports the likelihood that the marked density fluctuations in settlement samples across the study area during this interval would substantially reflect socioeconomic dynamics within and between communities, rather than primarily exogenous drivers.

Integrative and separative dynamics of social interaction

The abrupt increase in combined farm establishing and reproduction constrained to the formational generations of village community at Kildebrønde from the mid-4th century BC is consistent with substantial initial movement into the community from surrounding areas. Since the Farm clusters comprise varying numbers of longhouses (*i.e.*: Farms) and individually differentiated durations, determining numbers of coexisting farms depends on dynamic variables. However, the rates of farm establishment dates (*cf.* Figure 11) clearly have a non-uniform distribution: new longhouse construction peaked within two to three generations around 300-250 BC before declining. Approaches to these questions relying on linear estimates from typological variables with low chronological sensitivity (*e.g.* Boye 2019, 239-279) may significantly underestimate the numbers of farms within constrained peaks and overestimate overall community durations. Resolving the timings of individual Farm clusters and assessing the temporal dimensions of diversities in spatial layouts and social properties is therefore crucial for understanding intra-community interaction. Some Farm clusters reflect gradual, single-phased modulation across broader spaces, while others show sustained accumulation of consecutive farm phases within delimited layouts. The reconstructed temporal order of Farm cluster formations and abandonments suggest that sustained farm plots became dominant from the outset. However, no clear subsequent chronological patterning in organisational modes is evident. Although the fragmentary records of the final-phase Farm clusters limit interpretive certainty, both nucleated and more extensive patterns appear represented.

Contextualising these spatiotemporal patterns within current conceptualisations of village community (Bandy 2010; Birch 2013; Feinman and Neitzel 2023; Kim 2025; Kim et al. 2025), the distinctly structured layouts sustained by some initial Farm clusters, indications of cooperative infrastructure layout and overall cohesion of maintained spatial zones suggest negotiation involving mutual accommodation. This is likely to imply integrative communal practices including some extent of social emulation across the farm groups constituting the formational community generations. The investments of labour in farm building, particularly for the constrained duration of initial peaking in community expansion, would similarly have required cooperation of broader groups (Draiby 1991; *cf.* Hamilton 2010, 262). At the same time, the several independent Farm cluster dynamics suggested by small scale variations in their reproductive modes, activity distributions and material assemblages indicate substantial and persistent diversity. This diversity could suggest that distinct sub-group identities and practices were maintained throughout community expansion, potentially constraining development of more integrative communal structures (*e.g.* Birch 2013; Kim 2025).

The differences between Farm clusters might be understood to include indications of emerging social stratification and increases in

structural formalisation over time, as proposed for some villages during this period (Rindel 1999; Runge 2009, 166-172; Haue 2011, 2012, 276-277). In particular, the exclusive placing of iron extraction in Farm cluster 8 could indicate control over localised production, and could alongside the high relative proportion of large houses and density of finds suggest development of increased and more diverse socioeconomic capability within this cluster. However, considered against the persistent variability in Farm cluster trajectories and socioeconomic modes throughout the duration of the community, these differences appear to have remained embedded within essentially segmentary social frameworks, limiting the expansion of hierarchical structures (Ejstrud and Jensen 2000, 117-122; Currás and Sastre 2020). Rather, the observed complexities of temporal and organisational modes primarily imply a community co-created through interaction between subgroups that however retained substantial independence. These patterns align with models emphasising how communities could operate at multiple overlapping and nested scales (Feinman and Neitzel 2023; *cf.* Birch 2013; Harris 2014). This would include that social production, reproduction and self-identification processes extended beyond the village community to wider social networks, some of them predating formation of the community itself (*cf.* Kolb and Snead 1997). Such wider affiliative links would have had particular significance in communities formed through rapid aggregation and growth – like in the present study – where they could generate separative dynamics, splitting them along internal divisions (*e.g.* Bandy 2004; Ellyson 2022). Early-generation village communities may have been especially susceptible to such processes due to limited social experience with aggregated co-residence (*e.g.* Bandy and Fox 2010, 7).

Established models concerning the operational principles of Danish Iron Age village communities have long understood them to reflect complex balances between interests of autonomous farms and communal benefits and constraints. Yet while these models have clarified complex intra-community modulations and developed explanations for them, they tend to treat the dominant factors and processes of change as relative constants, reinforcing preconceptions of cohesiveness and long-term continuity. Building from these frameworks, the use in this paper of radiocarbon-based models along with current conceptualisations of community suggest a shift in emphasis, given the rapid oscillations evidenced for the contexts examined in both overall spatiotemporal density patterns and in specific configurations of village community. The results suggest that, in this case, earliest Danish Iron Age village communities should not be understood as gradually evolving, cohesive entities, but as distinctly situated and shaped by nonlinear social dynamics.

Conclusion

This paper applies radiocarbon-based modelling to test theoretical concepts of earliest Iron Age village community dynamics, using the Køge Bay region dataset for case studies. The modelling shows a significant and high-rate increase in overall spatiotemporal density of radiocarbon dated settlement beginning from the early 4th century BC. Several concurrent, local density kernels within this general trend suggest rapid convergence into densely nucleated settlement configurations. The date-range of this trend predates the established temporal frameworks for substantial Danish Iron Age nucleation and village formation processes by around a century. The duration of significant increases in radiocarbon date densities is estimated to end before *c.*300 BC, after which densities stagnate and then decrease rapidly. Shifting spatiotemporal densities observed in localised patterns from this same timeframe suggest that some nucleated communities may have undergone rapid transformation or dispersal. The time ranges of these overall trends correspond with the timing of village community formation, operation and dissolution at the Kildebrønde site. The relatively short duration of these shifts – with expansion processes likely peaking within three to four generations at most – implies that collective experiences associated with processes and challenges of earliest village community formation and operation would have had little time to develop into shared social knowledge. This is consistent with a view of these initial-generation Iron Age villages as substantially subject to maintained group-based identities, while the

extent of consolidating social structuring through communal interaction would have remained limited. Together, the observed temporal dynamics and inferred social implications therefore challenge assumptions of gradual evolution and long continuities that underpin existing interpretive models of Danish Iron Age village communities. Our results instead suggest that highly resolved radiocarbon-based approaches in combination with theoretical conceptualisations of community as a contingent and contested product of interplay between intersecting interests and changeable contexts operating at multiple cross-cutting scales may contribute new dimensions to social models inferred from settlement data. The compact size of the case study area remains a limiting factor for evaluating these perspectives against existing frameworks. Integrated scenarios explaining the spatio-temporal density fluctuations observed across the case study area as well as at localised scales therefore remain ambiguous. Future research could explore how the resolved trends within this area compare to broader trajectories. Such approaches could enable cross-validation of patterns and variations, ranging over micro- and macro-scales of the Danish Iron Age settlement landscape.

Acknowledgements

The work for this paper was funded by Velux Fonden as part of the project "Tidslinjen. Anvendt arkæologi i Køge Nord" ("The Timeline. Applied Archaeology in Køge North"). The authors are very grateful for comments on draft versions from the project Principal Investigator, ph.d. Anna S. Beck, Museum South East Denmark, and from ph.d. Jens M. Ulriksen, then Head of Centre for Viking Studies and Head of Research, Museum South East Denmark. In addition, we would like to thank two anonymous reviewers as well as the editor at the *Danish Journal of Archaeology* for their very valuable and thorough comments. Naturally, only the authors are responsible for any remaining errors.

References

Alberti, G., 2014. Modeling Group Size and Scalar Stress by Logistic Regression from an Archaeological Perspective. *PLoS ONE* 9(3), e91510. https://doi.org/10.1371/journal.pone.0091510

Arthur, F., Hatlestad, K., Lindholm, K.-J., Loftsgarden, K., Löwenborg, D., Solheim, S., Roche, D. M., Renssen, H., 2024. The impact of volcanism on Scandinavian climate and human societies during the Holocene: Insights into the Fimbulwinter eruptions (536/540 AD). *The Holocene* 34(5), 619-633. https://doi.org/10.1177/09596836231225718

Artursson, M., 2005. Böndernas hus. *In*: A. Carlie, ed. *Järnålder vid Öresund, bd 1. Specialstudier och syntes*. (Skånska spår – arkeologi längs Vätkustbanan). Lund: Riksantikvarieämbetet, 76-161.

Baddeley, A., Rubak, E., Turner, R., 2015. *Spatial Point Patterns: Methodology and Applications with R*. London: Chapman & Hall/CRC Press.

Bandy, M.S., 2004. Fissioning, Scalar Stress, and Social Evolution in Early Village Societies. *American Anthropologist* 106, 322-333. https://doi.org/10.1525/aa.2004.106.2.322

Bandy, M.S., 2008. Global Patterns of Early Village Development. *In*: J.-P. Bocquet-Appel, O. Bar-Yosef, eds. *The Neolithic Demographic Transition and Its Consequences*. New York: Springer, 333-357.

Bandy, M.S., 2010. Population Growth, Village Fissioning, and Alternative Village Trajectories. *In*: M.S. Bandy, J.R. Fox, eds. *Becoming Villagers: Comparing Early Village Societies*. Tucson: University of Arizona Press, 19-36.

Bandy, M.S., Fox, J.R., 2010. Becoming Villagers: The Evolution of Early Village Societies. *In*: M.S. Bandy, J.R. Fox, eds. *Becoming Villagers: Comparing Early Village Societies*. Tucson: University of Arizona Press, 1-16.

Bánffy, E., Osztás, A., Oross, K., Zalai-Gaál, I., Marton, T., Nyerges, É.Á., Köhler, K., Bayliss, A., Hamilton, D. and Whittle, A., 2016. The Alsónyék story: towards the history of a persistent place. *Bericht der Römisch-Germanischen Kommission* 94. Frankfurt am Main: Henrich, 283-318. https://doi.org/10.11588/berrgk.1938.0.37156

Barrier, C.R. and Horsley, T.J., 2014. Shifting Communities: Demographic Profiles of Early Village Population Growth and Decline in the Central American Bottom. *American Antiquity* 79(2), 295-313. https://doi.org/10.7183/0002-7316.79.2.295

Baxter, M.J., Beardah, C.C. and Wright, R.V.S., 1997. Some Archaeological Applications of Kernel Density Estimates. *Journal of Archaeological Science* 24(4), 347-354, https://doi.org/10.1006/jasc.1996.0119

Bayliss, A., 2009. Rolling Out Revolution: Using Radiocarbon Dating in Archaeology. *Radiocarbon* 51(1), 123-147. https://doi.org/10.1017/S0033822200033750

Becker, C.J., 1965. Ein Früheisenzeitliches Dorf bei Grøntoft, Westjütland. Vorbericht über die Ausgrabungen 1961-63. *Acta Archaeologica* 36, 209-222.

Becker, C.J., 1969. Das zweite früheisenzeitliche Dorf bei Grøntoft, Westjütland. 2. Vorbericht: Die Ausgrabungen 1964-66. *Acta Archaeologica* 39, 235-55.

Becker, C.J., 1971. Früheisenzeitliche Dörfer bei Grøntoft, Westjütland. 3. Vorbericht: Die Ausgrabungen 1967-68. *Acta Archaeologica* 42, 79-110.

Becker, C.J., 1982. Siedlungen der Bronzezeit und der vorrömischen Eisenzeit in Dänemark. *Offa* 39, 53-71.

Becker, C.J., 1987. Farms and Villages in Denmark from the Late Bronze Age to the Viking Period. *Proceedings of the British Academy* 73, 69-96.

Bevan, A. and Crema, E.R., 2021. Modifiable reporting unit problems and time series of long-term human activity. *Philosophical Transactions of the Royal Society B, Biological Sciences* 376 (1816), 20190726. https://doi.org/10.1098/rstb.2019.0726

Bilotti, G., 2025. Estimating temporal likelihood of archaeological sites in prehistoric Denmark combining typochronological and radiocarbon data (PREPRINT Version 1, 9th january 2025). *Research Square*. https://doi.org/10.21203/rs.3.rs-5656593/v1

Birch, J., 2012. Coalescent Communities: Settlement Aggregation and Social Integration in Iroquoian Ontario. *American Antiquity* 77(4), 646-670. https://doi.org/10.7183/0002-7316.77.4.646

Birch, J., 2013. Between Villages and Cities: Settlement Aggregation in Cross-Cultural Perspective. *In*: J. Birch, ed. *From Prehistoric Villages to Cities: Settlement Aggregation and Community Transformation*. New York: Routledge, 1-22.

Birch, J., Manning, S.W., Sanft, S. and Conger, M.A., 2021. Refined Radiocarbon Chronologies for Northern Iroquoian Site Sequences: Implications for Coalescence, Conflict, and the Reception of European Goods. *American Antiquity* 86(1), 61-89. https://doi.org/10.1017/aaq.2020.73

Birch, J., Manning, S.W., Hart, J.P., Lorentzen, B., 2024. Evaluating the Timing of Early Village Development in New York: More Dates from Classic New York Sites. *Radiocarbon* 66(1), 18-45. https://doi.org/10.1017/RDC.2024.10

Boye, L., 2008. Bosættelsesmønstre på Østsjælland. *In*: A. Carlie, ed. *Öresund – barrier eller bro? Kulturelle kontakter og samhällsutveckling i Skåne och på Själland under järnålderen*. Centrum för Danmarksstudier 18. Lund, 15-32.

Boye, L., 2011. Lots of postholes – but how do we progress? A discussion paper. *In*: L. Boye, ed. *The Iron Age on Zealand – status and perspectives*. Nordiske Fortidsminder, serie C, vol. 8. København, 9-16.

Boye, L., 2019. *Den typologiske udvikling af østsjællandske huse fra førromersk til germansk jernalder – et værktøj til udredning af bosættelses-mønstre, bebyggelsesudvikling og ressource-områder*. Unpublished Ph.d. Dissertation, Københavns Universitet.

Bradshaw, E.G., Rasmussen, P., Odgaard, B.V., 2005. Mid-to late-Holocene land-use change and lake development at Dallund Sø, Denmark: synthesis of multiproxy data, linking land and lake. *The Holocene* 15(8), 1152-1162. https://doi.org/10.1191/0959683605hl887rp

Bronk Ramsey, C., 1995. Radiocarbon calibration and analysis of stratigraphy: the OxCal program. *Radiocarbon* 37(2), 425-30. https://doi.org/10.1017/S0033822200030903

Bronk Ramsey, C., 2009a. Bayesian analysis of radiocarbon dates. *Radiocarbon* 51(1), 337-360. https://doi.org/10.1017/S0033822200033865

Bronk Ramsey, C., 2009b. Dealing with Outliers and Offsets in Radiocarbon Dating. *Radiocarbon* 51(3), 1023-1045. https://doi.org/10.1017/S0033822200034093

Bronk Ramsey, C., 2017. Methods for summarizing radiocarbon datasets. *Radiocarbon* 59(6), 1809-1833. https://doi.org/10.1017/RDC.2017.108

Brown, A.A., Crema, E.R., 2021. Māori Population Growth in Pre-contact New Zealand: Regional Population Dynamics Inferred from Summed Probability Distributions of Radiocarbon Dates. *Journal of Island and Coastal Archaeology* 16(2-4), 572-590. https://doi.org/10.1080/15564894.2019.1605429

Brown, W. A., 2015. Through a filter, darkly: Population size estimation, systematic error, and random error in radiocarbon-supported demographic temporal frequency analysis. *Journal of Archaeological Science* 53, 133-147. https://doi.org/10.1016/j.jas.2014.10.013

Brown, W. A., 2017. The past and future of growth rate estimation in demographic temporal frequency analysis: Biodemographic interpretability and the ascendance of dynamic growth models. *Journal of Archaeological Science* 80, 96-108. https://doi.org/10.1016/j.jas.2017.02.003

Bukkemoen, G.B., 2015: Ett hus – mange livsløp. Boligens biografi i førromersk jernalder belyst gjennom et gårdsanlegg i Askim. *Viking. Norsk Arkeologisk årbok* 78, 95-118.

Bukkemoen, G.B., 2025. Beyond the Longhouse: On the Heterogeneity, Spatiality and Temporality of Scandinavian Iron Age Households. *Cambridge Archaeological Journal* 35(2), 241-252. https://doi.org/10.1017/S0959774324000313

Bunbury, M.M.E., Austvoll, K.I, Jørgensen, E.K., Nielsen, S.V., Kneisel, J., Weinelt, M., 2023. Understanding climate resilience in Scandinavia during the Neolithic and Early Bronze Age. *Quaternary Science Reviews* 322, 108391. https://doi.org/10.1016/j.quascirev.2023.108391

Büster, L., 2021. Iron Age Mnemonics: A Biographical Approach to Dwelling in Later Prehistoric Britain. *Cambridge Archaeological Journal* 31(4), 661-674. https://doi.org/10.1017/S0959774321000263

Carleton, W.C., Groucutt, H.S., 2021. Sum things are not what they seem: Problems with point-wise interpretations and quantitative analyses of proxies based on aggregated radiocarbon dates. *The Holocene* 31, 630–643. https://doi.org/10.1177/0959683620981700

Chaput, M.A., Kriesche, B., Betts, M., Martindale, A., Kulik, R., Schmidt, V., Gajewski, K., 2015. Spatiotemporal distribution of Holocene populations in North America. *Proceedings of the National Academy of Sciences* 112 (39), 12127-12132. https://doi.org/10.1073/pnas.1505657112

Christensen, T., Tornbjerg, S.Å., 2009. Jernalderbosættelsen i det gamle Roskilde Amt. In: H.-C. Eisen, ed. *Mellem fjord og bugt*. Roskilde: Historisk Samfund for Roskilde Amt, 25-86.

Codding, B.F., Meyer, J., Brewer, S.C., Kelly, R.L., Jones, T.L., 2024. Do counts of radiocarbon-dated archaeological sites reflect human population density? A preliminary empirical validation examining spatial variation across late Holocene California. *Radiocarbon* 66(4), 610-623. https://doi.org/10.1017/RDC.2024.81

Collard, M., Edinborough, K., Shennan, S., Thomas, M.G., 2010. Radiocarbon evidence indicates that migrants introduced farming to Britain. *Journal of Archaeological Science* 37 (4), 866-870. https://doi.org/10.1016/j.jas.2009.11.016

Contreras, D.A., 2024. Archaeological 14C assemblages and the Chavín Phenomenon in the Central Andes. *Quaternary International* 703, 67-81. https://doi.org/10.1016/j.quaint.2024.05.001

Crawford, K.A., Huster, A.C., Peeples, M.A., Gauthier, N., Smith, M.E., Lobo, J., York, A.M., Lawrence, D., 2023. A systematic approach for studying the persistence of settlements in the past. *Antiquity* 97(391), 213-230. https://doi.org/10.15184/aqy.2022.175

Crema, E.R., 2022. Statistical Inference of Prehistoric Demography from Frequency Distributions of Radiocarbon Dates: A Review and a Guide for the Perplexed. *Journal of Archaeological Method and Theory* 29, 1387-1418. https://doi.org/10.1007/s10816-022-09559-5

Crema, E.R., Bevan, A., 2021. Inference from large sets of radiocarbon dates: Software and methods. *Radiocarbon* 63(1), 23-39. https://doi.org/10.1017/RDC.2020.95

Crema, E.R., Kobayashi, K., 2020. A multi-proxy inference of Jōmon population dynamics using bayesian phase models, residential data, and summed probability distribution of ^{14}C dates. *Journal of Archaeological Science* 117, 105136. https://doi.org/10.1016/j.jas.2020.105136

Crema, E.R., Carrignon, S., Shoda, S., Stevens, C.J., 2024. Regional variations in the demographic response to the arrival of rice farming in prehistoric Japan. *Antiquity* 98(401), 1290-1305. https://doi.org/10.15184/aqy.2024.146

Curras, B.X., Sastre, I., 2020. Segmentary societies: A theoretical approach from European Iron Age archaeology. *In*: B.X. Curras, I. Sastre, eds. *Alternative Iron Ages: Social Theory from Archaeological Analysis*. London, 127-148.

Dee, M.W., Bronk Ramsey, C., 2014. High-Precision Bayesian Modeling of Samples Susceptible to Inbuilt Age. *Radiocarbon* 56(1), 83-94. https://doi.org/10.2458/56.16685

Donat, P., 2018. *Häuser der Bronze- und Eisenzeit im mittleren Europa. Eine vergleichende Untersuchung*. Weimarer Monographien zur Ur- und Frügeschichte Bd. 43. Weimar: Thüringisches Landesamt für Denkmalpflege und Archäologie.

Draiby, B., 1991. Studier i jernalderens husbygning. Rekonstruktion af et langhus fra ældre romersk jernalder. *In*: B. Madsen, ed. *Eksperimentel arkæologi*. Lejre: Historisk-Arkæologisk Forsøgscenter Lejre, 103-134.

Edvardsson, J., Christensen, K., Jensen, J.O., Linderson, H., Baittinger, C., 2024. Exploring the potential for a 9000-year tree-ring chronology consisting of subfossil oak material from southern Scandinavia. *Dendrochronologia* 88, 126268. https://doi.org/10.1016/j.dendro.2024.126268

Egholm Nielsen, L., 2023. Sdr. Tranders: Bebyggelse gennem 1.300 år fra yngre bronzealder til ældre germansk jernalder. *ALABU. Tidsskrift for Nordjysk Kulturhistorie* 1, 96-144. https://doi.org/10.7146/alabu.vi1.140426

Ejstrud, B., Jensen, C.K., 2000. *Vendehøj – landsby og gravplads. Kronologi, organisation, struktur og udvikling i en østjysk landsby fra 2. årh. f.Kr. til 2. årh. e.Kr.* Højbjerg: Jutland Archaeological Society.

Ellyson, L.J., 2022. Applying Gregory Johnson's Concepts of Scalar Stress to Scale and Information Thresholds in Holocene Social Evolution. *Journal of Social Computing* 3(1), 38-56. https://doi.org/10.23919/JSC.2021.0017

Ester, M., Kriegel, H.-P., Sander, J., Xu, X., 1996. A Density-Based Algorithm for Discovering Clusters in Large Spatial Databases with Noise. *In*: *Proceedings of the Second International Conference on Knowledge Discovery and Data Mining (KDD- 96). Presented at the International Conference on Knowledge Discovery and Data Mining*. Portland, Oregon: AAAI Press, 226-231. https://dl.acm.org/doi/10.5555/3001460.3001507

Ethelberg, P., 2003. Gården og landsbyen i jernalder og vikingetid (500 f.Kr. -1000 e.Kr.). *In*: L.S. Madsen, O. Madsen, eds. *Det Sønderjyske Landbrugs Historie. Jernalder, Vikingetid og Middelalder*. Haderslev: Haderslev Museum & Historisk Samfund for Sønderjylland, 123-373.

Fallgren, J.-H., 1993. The Concept of the Village in Swedish Archaeology. *Current Swedish Archaeology* 1, 59-86.

Fallgren, J.-H., 2006. *Kontinuitet och förändring. Bebyggelse och samhälle på Öland 200-1300 e.Kr*. Uppsala.

Feinman, G.M., Neitzel, J.E., 2023. The social dynamics of settling down. *Journal of Anthropological Archaeology* 69, 101468. https://doi.org/10.1016/j.jaa.2022.101468

Freeman, J., Byers, D.A., Robinson, E., Kelly, R.L., 2018. Culture Process and the Interpretation of Radiocarbon Data. *Radiocarbon* 60(2), 453-467. https://doi.org/10.1017/RDC.2017.124

Friman, B. 2008. *At stå på egna ben. Centrala funktioner och lokal utveckling under yngre bronsålder och aldre järnålder i Mellanbyn, Skåne*. Malmö: Malmö Kulturmiljö.

Friman, B., Lagerås, P., 2023. From Neolithic Boom-and-Bust to Iron Age Peak and Decline: Population and Settlement Dynamics in Southern Sweden Inferred from Summed Radiocarbon Dates. *European Journal of Archaeology* 26(2), 168-188. https://doi.org/10.1017/eaa.2022.43

Gerritsen, F., 1999. To Build and to Abandon. The Cultural Biography of Late Prehistoric Houses and Farmsteads in the Southern Netherlands. *Archaeological Dialogues* 6, 78-114. https://doi.org/10.1017/S1380203800001410

Gerritsen, F., 2003. *Local Identities. Landscape and Community in the Late Prehistoric Meuse-Demer-Scheldt Region*. Amsterdam Archaeological Studies 9. Amsterdam: Amsterdam University Press.

Gerritsen, F., 2006. Archaeological Perspectives on Local Communities. *In*: J. Bintliff, ed. *A Companion to Archaeology*, 141-154. https://doi.org/10.1002/9780470998618.ch8

Gerritsen, F., 2008. Domestic Times: Houses and Temporalities in Late Prehistoric Europe. *In*: A. Jones, ed. *Prehistoric Europe. Theory and Practice*, Oxford, 143-161.

Gjerpe, L.E., 2023. "The 207 BC Dust Veil Event" and the advent of iron reaping tools in Scandinavia. *In*: M. Ødegaard, I. Ystgaard, eds. *Complexity and Dynamics. Settlement and landscape from the Bronze Age to the Renaissance in the Nordic Countries (1700 BC-AD 1600)*. Leiden: Sidestone Press, 85–97.

Gjerpe, L.E., 2024a. Hvorfor en landsby 200 f.Kr.? Klima, redskaper og møkk. *In*: L.E. Gjerpe, ed. *Den komplekse jernalderbosetningen på Dilling: hus – gård – grend – landsby?* Oslo: Cappelen Damm Akademisk, 327-339. https://doi.org/10.23865/cdf.220.ch14

Gjerpe, L.E., 2024b. Gårder, landsby eller grend? Jernalderens bebyggelse på Dilling – en kort biografi. *In*: L.E. Gjerpe, ed. *Den komplekse jernalderbosetningen på Dilling: hus – gård – grend – landsby?* Oslo: Cappelen Damm Akademisk, 341-358. https://doi.org/10.23865/cdf.220.ch15

Gracia-Lázaro, C., Hernández, A.R., Maciel-Cardoso, F., Moreno, Y., 2024. Exploring the interplay of technology, pro-family and prosocial behavior in settlement formation. *Journal of Physics: Complexity* 5, 025027. https://doi.org/10.1088/2632-072X/ad577f

Gron, K.J., Larsson, M., Gröcke, D.R., Andersen, N.H., Andreasen, M.H., Bech, J.-H., Henriksen, P.S., Hilton, R.G., Jessen, M.D., Møller, N.A., Nielsen, F.O., Nielsen, P.O., Pihl, A., Sørensen, L., Westphal,

J., Rowley-Conwy, P., Church, M.J., 2021. Archaeological cereals as an isotope record of long-term soil health and anthropogenic amendment in southern Scandinavia. *Quaternary Science Reviews* 253, 106762. https://doi.org/10.1016/j.quascirev.2020.106762

Gundersen, I.M., 2025. Global challenges, local impacts. Contextualising the 6th-century climate extreme and Iron Age farming societies. *Viking Special Volume 3: Telling different stories: Combining perspectives on the Viking Age*, 163-190. https://doi.org/10.5617/vikingsv.12203

Hald, M.M., Styring, A., Mortensen, M.F., Maltas, T., Vidas, D., Henriksen, P.S., Pihl, A., Jensen, P.M., Christensen, L.B., Hansen, J., Dollar, S., Egeberg, T., Lundø, M.B., Haue, N., Hertz, E., Iversen, R.B., Jørgensen, T., Kristensen, I.K., Klassen, L., Møller, N.A., Pedersen, V.J., Ravn, M., Vestergaard, K., Jessen, M.D., 2024. Farming during turbulent times: Agriculture, food crops, and manuring practices in Bronze Age to Viking Age Denmark. *Journal of Archaeological Science: Reports* 58, 104736. https://doi.org/10.1016/j.jasrep.2024.104736

Hamilton, W.D., 2010. *The Use of Radiocarbon and Bayesian Modelling to (Re)Write Later Iron Age Settlement Histories in East-Central Britain*. Thesis submitted for the degree of Doctor of Philosophy at the University of Leicester. School of Archaeology and Ancient History University of Leicester.

Hansen, J., 2015. *Landsbydannelse og bebyggelsesstruktur i det 1. årtusinde – et bebyggelseshistorisk regionalstudie*. Unpublished Ph.d. Dissertation, Institut for historie, Syddansk Universitet, Odense.

Harris, O.J.T., 2014. (Re)assembling Communities. *Journal of Archaeological Method and Theory* 21, 76-97. https://doi.org/10.1007/s10816-012-9138-3

Hart, J.P., Means, B.K., 2022. The Monongahela tradition in "real time": Bayesian analysis of radiocarbon dates. *PLoS ONE* 17(10), e0276014. https://doi.org/10.1371/journal.pone.0276014

Haue, N., 2011. Social stratifikation og den 'sociale arv' i ældre jernalder – med udgangspunkt i bopladsstudier fra Nordjylland. *In*: N.A. Møller, S.S. Qvistgaard, S.F. Jensen, eds. *Nyt fra Vestfronten – Nord- og Vestjyske bebyggelser fra ældre jernalder*. (Arkæologiske Skrifter 10). København, 87-98.

Haue, N., 2012. *Jernalderens samfund i Nordjylland – belyst med udgangspunkt i byhøjen Nr. Tranders, Aalborg*. Unpublished Ph.d. Dissertation, Aarhus Universitet.

Haue, N., 2023. Early Iron Age village formation in Jutland, Denmark. *In*: M. Ødegaard, I. Ystgaard, eds. *Complexity and Dynamics. Settlement and landscape from the Bronze Age to the Renaissance in the Nordic Countries (1700 BC-AD 1600)*. Leiden: Sidestone Press, 29-39.

Heaton, T.J., Al-assam, S., Bard, E., 2025. A new approach to radiocarbon summarisation: Rigorous identification of variations/changepoints in the occurrence rate of radiocarbon samples using a Poisson process. *Journal of Archaeological Science* 182, 106237. https://doi.org/10.1016/j.jas.2025.106237

Herschend, F., 2009. *The Early Iron Age in South Scandinavia. Social Order in Settlement and Landscape*. Occasional Papers in Archaeology 46. Uppsala.

Holst, M.K., 1997. The dynamic of the Iron-age village. A technique for the relative-chronological analysis of area excavated Iron-age settlements. *Journal of Danish Archaeology* 13, 95-119. https://doi.org/10.1080/0108464X.1997.10590099

Holst, M.K., 2000. Tid og forandring i jernalderens bebyggelse. *Arkæologiske Udgravninger i Danmark 1999*, 21-35.

Holst, M.K., 2004a. Complicated Relations and Blind Dating. Formal Analysis of Relative Chronological Structures. *In*: C. Buck, A. Millard, eds. *Tools for Constructing Chronologies: Crossing Disciplinary Boundaries*. London: Springer Verlag, 129-147.

Holst, M.K., 2004b. *The syntax of the Iron Age Village. Transformation in an orderly community*. Unpublished Ph.d. Dissertation, Aarhus University.

Holst, M.K., 2010. Inconstancy and stability – large and small farmsteads in the village of Nørre Snede (Central Jutland) in the first millennium AD. *Siedlungs-und Küstenforschung im südlichen Nordseegebiet* 33. Rahden: Verlag Marie Leidorf, 155-179.

Holst, M.K., 2014. Warrior aristocracy and village community. *In*: E. Stidsing, K. Høilund Nielsen, R. Fidel, eds. *Wealth and complexity. Economic specialized sites in Late Iron Age Denmark. East Jutland Museum Publications vol. 1*. Aarhus, 179-197.

Hvass, S., 1983. Vorbasse. The Development of a Settlement through the First Millenium A.D. *Journal of Danish Archaeology* 2, 127-136. https://doi.org/10.1080/0108464X.1983.10589898

Hvass, S., 1985. *Hodde. Et vestjysk landsbysamfund fra ældre jernalder*. Arkæologiske Studier vol. VII. København: Akademisk Forlag. Universitetsforlaget i København.

Iversen, R.B., 2020. En kort introduktion til jernalderen i Østjylland. *In*: S.V. Laursen, R.B. Iversen. *Hummelure. Landsby, langhus og landbrug i Østjyllands yngre jernalder*, 11-19. Højbjerg: Jutland Archaeological Society.

Jensen, C.K., 2005. *Kontekstuel kronologi: en revision af det kronologiske grundlag for førromersk jernalder i Sydskandinavien*. Højbjerg: Kulturlaget.

Johnson, G.A., 1982. Organizational structure and scalar stress. *In*: C. Renfrew, M.J. Rowlands, B.A. Seagraves, eds. *Theory and Explanation in Archaeology*. New York: Academic Press, 389-421.

Kaldal Mikkelsen, D., 1999. Single farm or village? Reflections on the settlement structure of the Iron Age and the Viking Period. *In*: C. Fabech, J. Ringtved, eds. *Settlement and landscape. Proceedings of a conference in Århus, Denmark, May 4-7 1998*. Højbjerg: Jutland Archaeological Society, 177-193.

Kanstrup. M., Holst, M.K., Jensen, P.M., Thomsen, I.K., Christensen, BT., 2014. Searching for long-term trends in prehistoric manuring practice. $\delta^{15}N$ analyses of charred cereal grains from the 4th to the 1st millennium BC. *Journal of Archaeological Science* 51, 115-125. https://doi.org/10.1016/j.jas.2013.04.018

Kim, J., Conte, M., Oh, Y., 2025. Community Formation in the Chulmun (Neolithic) and Mumun (Bronze Age) Periods of Korea. *Journal of Archaeological Research* 33, 497-550. https://doi.org/10.1007/s10814-024-09204-7

Kim, M., 2025. Intragroup social differentiation and household inequality in prehistoric Mumun

settlements of Korea. *Journal of Anthropological Archaeology* 78, 101679. https://doi.org/10.1016/j.jaa.2025.101679

Kim, M., Shin, H-N., Kim, S., Lim, D.j., Jo, K., Ryu, A., Won, H., Oh, S., Noh, H., 2015. Population and social aggregation in the Neolithic Chulmun villages of Korea. *Journal of Anthropological Archaeology* 40, 160-182. https://doi.org/10.1016/j.jaa.2015.08.002

Knapp, A.B., 2003. The Archaeology of Community on Bronze Age Cyprus: Politiko "Phorades" in Context. *American Journal of Archaeology* 107(4), 559-580. https://doi.org/10.3764/aja.107.4.559

Kolb, M.J., Snead, J.E., 1997. It's a Small World after All: Comparative Analyses of Community Organization in Archaeology. *American Antiquity* 62(4), 609-628. https://doi.org/10.2307/281881

Kondor, D., Bennett, J.S., Gronenborn, D., Antunes, N., Hoyer, D., Turchin, P., 2023. Explaining population booms and busts in Mid-Holocene Europe. *Scientific Reports* 13, 9310. https://doi.org/10.1038/s41598-023-35920-z

Kondor, D., Bennett, J.S., Gronenborn, D., Turchin, P., 2024. Landscape of fear: indirect effects of conflict can account for large-scale population declines in non-state societies. *Journal of the Royal Society Interface* 21(217), 20240210. https://doi.org/10.1098/rsif.2024.0210

Kowalewski, S.A., 2008. Regional Settlement Pattern Studies. *Journal of Archaeological Research* 16(3), 225-285. https://doi.org/10.1007/s10814-008-9020-8

Larsen, H.M.E., Baittinger, C., Bonde, N., Jensen, J.O., Søvsø, M., Ulriksen, J., Mortensen, M.F., 2024. The impact of the volcanic double event in AD 536 and AD 539/540 on tree-ring growth and felling activity in Danish oak trees. *Journal of Archaeological Science: Reports* 59, 104689. https://doi.org/10.1016/j.jasrep.2024.104689

Lee, J. and Hwang, J., 2025. Abandonment and population fluctuations of prehistoric villages: Focusing on the Geum River Basin during Korea's Bronze Age. *Quaternary International* 747, 109967. https://doi.org/10.1016/j.quaint.2025.109967

Lima, M., Gayo, E.M., Estay, S.A., Gurruchaga, A., Robinson, E., Freeman, J., Latorre, C., Bird, D., 2023 Positive feedbacks in deep-time transitions of human populations. *Philosophical Transactions of the Royal Society B, Biological Sciences* 379 (1893), 20220256. https://doi.org/10.1098/rstb.2022.0256

Lipo, C.P., DiNapoli, R.J., Hunt, T.L., 2022. Claims and Evidence in the Population History of Rapa Nui (Easter Island). *In*: V. Rull, C. Stevenson, eds. *The Prehistory of Rapa Nui (Easter Island). Towards an Integrative Interdisciplinary Framework*, 565-585. https://doi.org/10.1007/978-3-030-91127-0_22

Loftsgarden, K., Solheim, S., 2023. Uncovering population dynamics in Southeast Norway from 1300 BC to AD 800 using summed radiocarbon probability distributions. *In*: M. Ødegaard, I. Ystgaard, eds. *Complexity and Dynamics. Settlement and landscape from the Bronze Age to the Renaissance in the Nordic Countries (1700 BC-AD 1600)*. Leiden: Sidestone Press, 99-112.

Lund, J., 2009. Byhøje og andre stedbundne bebyggelser. *In*: M. Runge. *Nørre Hedegård. En nordjysk byhøj fra ældre jernalder*. Højbjerg: Jutland Archaeological Society. Nordjyllands Historiske Museum, 183-196.

Løvschal, M., Holst, M.K., 2015. Repeating boundaries – repertoires of landscape regulations in southern Scandinavia in the Late Bronze Age and Pre-Roman Iron Age. *Danish Journal of Archaeology* 3, 95-118. https://doi.org/10.1080/21662282.2014.990311

Manning, S.W., Lorentzen, B., Hart, J.P., 2021. Resolving Indigenous village occupations and social history across the long century of European permanent settlement in Northeastern North America: The Mohawk River Valley ~1450-1635 CE. *PLoS ONE* 16(10), e0258555. https://doi.org/10.1371/journal.pone.0258555

Martens, J., 2010. Pre-Roman Iron Age Settlements in Southern Scandinavia. *In*: M. Meyer, ed. *Haus, Gehöft, Weiler, Dorf: Siedlungen der Vorrömischen Eisenzeit im nördlichen Mitteleuropa. Internationale Tagung an der Freien Universität Berlin vom 20.-22. März 2009*. Rahden/Westfalen, 262-280.

McLaughlin, T.R., 2019. On applications of space–time modelling with open-source 14C age calibration. *Journal of Archaeological Method and Theory* 26, 479-501. https://doi.org/10.1007/s10816-018-9381-3

Meistrup-Larsen, L. and Moltsen, A., 2008. Lysehøj ved Korsør. Funktion, produktion og boligindretning i ældre jernalder på Sydvestsjælland. *Aarbøger for Nordisk Oldkyndighed og Historie*, 89-122.

Mortensen, M.F., 2018. *Vikingetidens landskab – pollenanalytisk undersøgelse af Dalby Sø*. Miljøarkæologi og Materialeforskning. Nationalmuseet: M & M-rapport nr. 93/2018.

Müller, J., Diachenko, A., 2019. Tracing long-term demographic changes: The issue of spatial scales. *PLoS ONE* 14(1), e0208739. https://doi.org/10.1371/journal.pone.0208739

Møller, N.A., 2011. Dynamiske bebyggelsesmønstre? Ældre jernalders bebyggelser i landskabet. *In*: N.A. Møller, S.S. Qvistgaard, S.F. Jensen, eds. *Nyt fra Vestfronten – Nord- og Vestjyske bebyggelser fra ældre jernalder* (Arkæologiske Skrifter 10). København, 155-171.

Møller, N.A., Dollar, S.R., 2022. Multilinear Settlement Development and Nucleation during the Early Iron Age in Southwestern Jutland, Denmark. *In*: A. Gyucha, R. B. Salisbury, eds. *The Archaeology of Nucleation in the Old World: Spatiality, Community, and Identity*. Archaeopress, 142-156. https://doi.org/10.2307/j.ctv2nrz7fw.15

Nielsen, B.H., 2020. *Smedegård. A village mound from the Early Iron Age near Nors in Thy, north-west Denmark*. Nordiske Fortidsminder bd. 30. Odense: University Press of Southern Denmark.

Nielsen, H., 2009. Landskabsrelieffet, bosættelsesmønsteret og arealudnyttelsen i jernalder, vikingetid og middelalder. *In*: H.-C. Eisen, ed. *Mellem fjord og bugt*. Roskilde: Historisk Samfund for Roskilde Amt, 9-24.

Nielsen, N.H., Holst, M.K., Gadd, A.C., Holst, K.K., 2018. The Layout and Internal Development of Celtic Fields: Structural and Relative Chronological Analyses of Three Danish Field Systems. *European Journal of Archaeology* 21(3), 385-410. https://doi.org/10.1017/eaa.2017.56

Nielsen, N.H., Kristiansen, S.M., Ljungberg, T., Enevold, R., Løvschal, M., 2019. Low and variable: Manuring intensity in Danish Celtic fields. *Journal of Archaeological Science: Reports* 27, 101955. https://doi.org/10.1016/j.jasrep.2019.101955

Nielsen, S.N., 2015. Brud eller kontinuitet. Bebyggelsesstrukturer på overgangen mellem ældre og yngre førromersk jernalder i Nordjylland. *Kuml* 64, 99-130. https://doi.org/10.7146/kuml.v64i64.24217

Nielsen, V., 2010. *Oldtidsagre i Danmark. Sjælland, Møn og Lolland-Falster*. Højbjerg: Jutland Archaeological Society.

Nión-Álvarez, S., 2023a. Modelling social change: A microspatial analysis of Punta de Muros (NW Iberia) through Bayesian analysis and household archaeology. *Journal of Archaeological Science: Reports* 48, 103912. https://doi.org/10.1016/j.jasrep.2023.103912

Nión-Álvarez, S., 2023b. A preliminary approach to Early Iron Age demography. Testing paleodemographic methodologies on a microspatial scale: The case of Punta de Muros (NW Iberia). *Journal of Archaeological Science: Report*s 48, 103832. https://doi.org/10.1016/j.jasrep.2023.103832

Odgaard, B., Nielsen, A.B., 2009. Udvikling i arealdækning i perioden 0-1850. Pollen og landskabshistorie. *In*: B. Odgaard, J.R. Rømer, eds. *Danske landbrugslandskaber gennem 2000 år. Fra digevoldinger til støtteordninger*. Aarhus: Aarhus Universitetsforlag, 41-58.

Ortman, S.G., Coffey, G.D., 2017. Settlement Scaling in Middle-Range Societies. *American Antiquity* 82(4), 662-682. https://doi.org/10.1017/aaq.2017.42

Palmisano, A., 2023. Inferring Population Dynamics from Multiple Archaeological Proxies: An Overview of Methods and Challenges. *In*: O. Belvedere, J. Bergemann, eds. *Archaeology and Historical Demography. Methods and Case Studies between Mediterranean and Central Europe*. Göttinger Studien zur Mediterranen Archäologie 14, Rahden/Westfalen, 25-41.

Palmisano, A., Bevan, A., Kabelindde, A., Roberts, N., Shennan, S., 2021. Long-Term Demographic Trends in Prehistoric Italy: Climate Impacts and Regionalised Socio-Ecological Trajectories. *Journal of World Prehistory* 34, 381-432. https://doi.org/10.1007/s10963-021-09159-3

Parkinson, E.W., McLaughlin, T.R., Esposito, C., Malone, C., Stoddart, S., 2021. Radiocarbon Dated Trends and Central Mediterranean Prehistory. *Journal of World Prehistory* 34, 317-379. https://doi.org/10.1007/s10963-021-09158-4

R Core Team. 2026. R: A Language and Environment for Statistical Computing, R Foundation for Statistical Computing. https://www.R-project.org

Rasmussen, P., 2010. Geelskov. Vegetationshistorisk undersøgelse I forbindelse med oldstidsagersystemet. In: V. Nielsen, *Oldtidsagre i Danmark. Sjælland, Møn og Lolland-Falster*. Højbjerg: Jutland Archaeological Society, 223-233.

Reese, K.M., Glowacki, D.M., Kohler, T.A., 2019. Dynamic Communities on the Mesa Verde Cuesta. *American Antiquity* 84(4), 728-747. https://doi.org/10.1017/aaq.2019.74

Reimer, P., Austin, W., Bard, E., Bayliss, A., Blackwell, P., Bronk Ramsey, C., Butzin, M., Cheng, H., Edwards, R., Friedrich, M., Grootes, P., Guilderson, T., Hajdas, I., Heaton, T., Hogg, A., Hughen, K., Kromer, B., Manning, S., Muscheler, R., Palmer, J., Pearson, C., van der Plicht, J., Reimer, R., Richards, D., Scott, E., Southon, J., Turney, C., Wacker, L., Adolphi, F., Büntgen, U., Capano, M., Fahrni, S., Fogtmann-Schulz, A., Friedrich, R., Köhler, P., Kudsk, S., Miyake, F., Olsen, J., Reinig, F., Sakamoto,

M., Sookdeo A., Talamo, S., 2020. The IntCal20 Northern Hemisphere radiocarbon age calibration curve (0-55 cal kBP). *Radiocarbon* 62(4), 725-757. https://doi.org/10.1017/RDC.2020.41

Rindel, P.O., 1997. *Grøntoft – og etableringen af det strukturerede landsbysamfund i Vestjylland i 1. årtusinde f.Kr. Bind 1: Hovedtekst. Projekt under forskningsprogrammet "Bebyggelse og Kulturlandskab"*. Unpublished Ph.d. Dissertation, Institut for Arkæologi og Etnologi, Københavns Universitet, København.

Rindel, P.O., 1999. Development of the village community, 500 BC-100 AD in West Jutland, Denmark. *In*: C. Fabech, J. Ringtved, eds. *Settlement and landscape. Proceedings of a conference in Århus, Denmark, May 4-7 1998*. Højbjerg: Jutland Archaeological Society, 79-99.

Riris, P., de Souza, J.G., 2021. Formal Tests for Resistance-Resilience in Archaeological Time Series. *Frontiers in Ecology and Evolution* 9, 740629. https://doi.org/10.3389/fevo.2021.740629

Runge, M., 2009. *Nørre Hedegård. En nordjysk byhøj fra ældre jernalder*. Højbjerg: Jutland Archaeological Society. Nordjyllands Historiske Museum.

Runge, M., 2019. Regional aspects of landscape exploitation and settlement structure in Denmark in the Late Bronze Age and Early Iron Age. *In*: D.C. Cowley, M. Fernández-Götz, T. Romankiewicz, H. Wendling, eds. *Rural settlement. Relating Buildings, Landscape, and People in the European Iron Age*. Leiden: Sidestone Press, 31-43.

Scholtus, L., Müller, J., 2023. European settlement demography: A boom and bust pattern in prehistory? *Documenta Praehistorica* 50, 22-34. https://doi.org/10.4312/dp.50.22

Shennan, S., Downey, S.S., Timpson, A., Edinborough, K., Colledge, S., Kerig, T., Manning, K., Thomas, M.G., 2013. Regional population collapse followed initial agriculture booms in mid-Holocene Europe. *Nature Communications* 4, 2486. https://doi.org/10.1038/ncomms3486

Sigl, M., Winstrup, M., McConnell, J.R., Welten, K.C., Plunkett, G., Ludlow, F., Büntgen, U., Caffee, M., Chellman, N., Dahl-Jensen, D., Fischer, H., Kipfstuhl, S., Kostick, C., Maselli, O.J., Mekhaldi, F., Mulvaney, R., Muscheler, R., Pasteris, D.R., Pilcher, J.R., Salzer, M., Schupbach, S., Steffensen, J.P., Vinther, B.M., Woodruff, T.E., 2015. Timing and climate forcing of volcanic eruptions for the past 2,500 years. *Nature*, 523, 543-549. https://doi.org/10.1038/nature14565

Søvsø, M., 2020. *Ribe 700-1050. From Emporium to Civitas in Southern Scandinavia*. Højbjerg: Jutland Archaeological Society. Museum of Southwest Jutland.

Søvsø, M., 2021. Frie og ufrie bønder: Landsbyer, gårde og socialstruktur på den jyske vestkyst i la longue durée. *Kuml* 69, 109-169. https://doi.org/10.7146/kuml.v69i69.126091

Søvsø, M., 2022. Middelalderens agrare landskab i *la longue durée*. *In*: M. Svart Kristiansen, M. Søvsø, A. Hartvig, eds. *Landskaber og strategier. Sociale miljøer og identitet. Middelalderens rurale Danmark*. Højbjerg: Jutland Archaeological Society, 31-48.

Tallavaara, M., Jørgensen, E.K., 2021. Why are population growth rate estimates of past and present hunter-gatherers so different? *Philosophical Transactions of the Royal Society B, Biological Sciences* 376 (1816), 20190708. https://doi.org/10.1098/rstb.2019.0708

Timpson, A., Colledge, S., Crema, E., Edinborough, K., Kerig, T., Manning, K., Thomas, M.G., Shennan, S., 2014. Reconstructing regional population fluctuations in the European Neolithic using radiocarbon dates: a new case-study using an improved method. *Journal of Archaeological Science* 52, 549-557. https://doi.org/10.1016/j.jas.2014.08.011

Torfing, T., 2019. Hvorfor er der korn i mit stolpehul? Diskussion af C14-dateringer af huse og et bud på en løsning. *Arkæologisk Forum* 40, 43-50.

van Dijk, E.J.C., Jungclaus, J., Sigl, M., Timmreck, C., Krüger, K., 2024. High-frequency climate forcing causes prolonged cold periods in the Holocene. *Communications Earth and Environment* 5, 242. https://doi.org/10.1038/s43247-024-01380-0

Vernon, K.B., Ortman, S.G., 2024. A method for defining dispersed community territories. *Journal of Archaeological Science* 170, 106048. https://doi.org/10.1016/j.jas.2024.106048

Waterbolk, H.T., 1971. Working with Radiocarbon Dates. *Proceedings of the Prehistoric Society* 37(2), 15-33. https://doi.org/10.1017/S0079497X00012548

Webley, L., 2008. *Iron Age households. Structure and practice in Western Denmark, 500 BC-AD 200*. Højbjerg: Jutland Archaeological Society.

Weninger, B., Clare, L., Jöris, O., Jung, R., Edinborough, K., 2015. Quantum theory of radiocarbon calibration. *World Archaeology* 47(4), 543–566. https://doi.org/10.1080/00438243.2015.1064022

Winther Johannsen, J., Laabs, J., Bunbury, M.M.E., Mortensen, M.F., 2024. Subsistence and population development from the Middle Neolithic B (2800-2350 BCE) to the Late Neolithic (2350-1700 BCE) in Southern Scandinavia. *PLoS ONE* 19(10), e0301938. https://doi.org/10.1371/journal.pone.0301938

Yaeger, J., 2000. The Social Construction of Communities in the Classic Maya Countryside. *In*: M.A. Canuto, J. Yaeger, eds. *The Archaeology of Communities: A New World Perspective*. London: Routledge, 123-142.

Yaeger, J., Canuto, M.A., 2000. Introducing an archaeology of communities. *In*: M.A. Canuto, J. Yaeger, eds. *The Archaeology of Communities: A New World Perspective*. London: Routledge, 1-15.

Ødegaard, M., Ystgaard, I., 2023. Settlement organization in Iron Age Scandinavia and beyond. Traditions, terminologies, regionalities and methodologies. *In*: M. Ødegaard, I. Ystgaard, eds. *Complexity and Dynamics. Settlement and landscape from the Bronze Age to the Renaissance in the Nordic Countries (1700 BC-AD 1600)*. Leiden: Sidestone Press, 11-28.

Supplementary Material

Material see also zip, .docx and .txt-attachments on the website:

zip:
kbaydata (.csv): Radiocarbon data
kbaydata (.docx): Radiocarbon data source identifiers and references
kb (.shp): Study area spatial object

SM1: R codes
SM2: OxCal codes and model simulations
SM3: Supplementary figures