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Demography and the intensity of cultural activities: an evaluation of Funnel Beaker Societies (4200–2800 cal BC)

Martin Hinz [a,*], Ingo Feeser [a], Karl-Göran Sjögren [b], Johannes Müller [a]

[a] *Institut für Ur- und Frühgeschichte, Christian-Albrechts-Universität, Johanna-Mestorf-Strasse 2-6, 24098 Kiel, Germany*
[b] *Institutionen för historiska studier, Göteborgs Universitet, Box 200, 405 30 Göteborg, E 218, Sweden*

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ABSTRACT

The Early and Middle Neolithic in Northern Central Europe and Southern Scandinavia is characterised by substantial changes in economic technology as well as in material culture in different periods. One of the main drivers for social development, but also for anthropogenic changes in the environment, is surely shifts in population density. To evaluate group sizes and population density we need archaeological proxies. Similar to other studies, we use ^{14}C dates to reconstruct the intensity of prehistoric activities. A comparison of the human impact from pollen data with a quantification based on ^{14}C dates proves a correlation which supports our appreciation of the value of sum-calibrated probabilities of radiometric measurements as a proxy for demographic developments. The large amount of usable dates in this study not only enables us to draw general conclusions on a supraregional level, but also makes it possible for us to compare the character of different areas on a regional scale. As a result, we reconstruct a significant rise in population between 4100 and 3500 cal BC and a degression around 3350–3100 cal BC, followed by a reiterated increase for the Funnel Beaker West and North Groups. On the Danish Isles, as well as in the Funnel Beaker North Eastern Group, different tendencies are observable.

1. Introduction

Our aim is to present quantitative evidence for the social activities of Funnel Beaker Societies in Northern Central Europe and Southern Scandinavia. One of our premises is that besides paleoecological dates, a quantification of archaeological remains also bears important information for the presented topic. Although depositional practices and post-depositional processes, different from natural deposition of sediments, have a major influence on which remains of human activities actually have the possibility to become part of the archaeological record, this approach offers a new potential for analysis of past activities and for the reconstruction of demography if profound source criticism is applied. Besides a still desirable quantification of material remains, the quantification of radiometric measurements offers a proxy for at least a relative estimation of the extent of human activities on a temporal scale, as has already been demonstrated by different authors (e.g. Shennan and Edinborough, 2007; Riede, 2009).

In the following, we intend to test the potential of 3178 radiometric dates from different archaeologically definable Funnel Beaker areas to answer three primary questions at a regional as well as general scale for the time between 4500 and 2500 cal BC: Is an increase in population linked with the first hints for a cultural transformation around 4100 cal BC or first with the introduction of new agrarian technologies around 3600 cal BC? Is a degression of social activities and population observable analogue to indications that arise from pollen analysis dating to 3200 cal BC? What impact do cultural differences between the individual Funnel Beaker regions have on possible scenarios?

2. Material and methods

At the time of writing, the radiocarbon database RADON (http://radon.ufg.uni-kiel.de) included 5355 radiometric measurements, mainly from Central and Northern Europe, from the Neolithic era and adjacent periods. From a spatial selection, according to the regional distribution of Funnel Beaker Ceramics divided into the regional stylistic groups, 3178 dates were chosen for analysis (Fig. 1). After source-critical reflections of sample material and context, sum-calibrated probabilities were calculated with Oxcal. Within this procedure e.g. the link between Neolithic architecture and a ^{14}C date was critically examined. In many cases radiometric dates were used for dating megaliths but do really represent only

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* Corresponding author. Tel.: +49 (0)431 880 2067; fax: +49 (0)431 880 7300.
E-mail addresses: mhinz@gshdl.uni-kiel.de, mail@martinhinz.info (M. Hinz).

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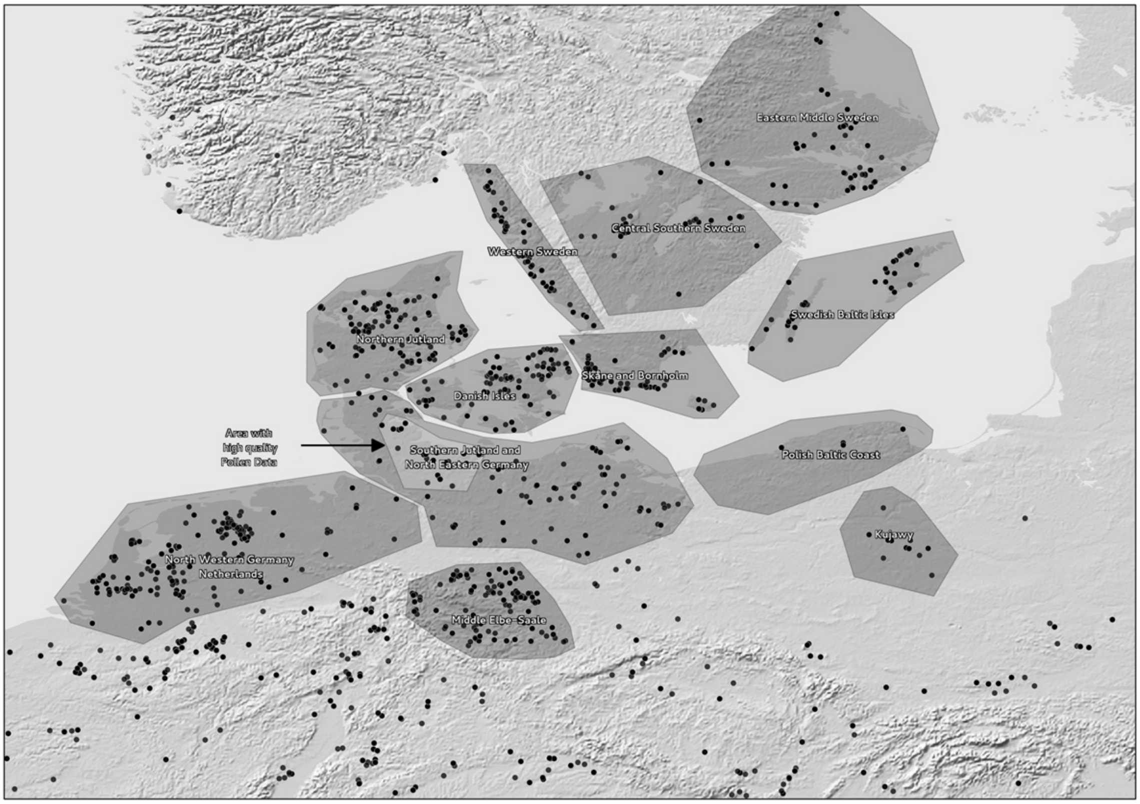

Fig. 1. Distribution of the ^{14}C dated sites and the extent of the areas used.

termini post quem for the monument. In other cases the stratigraphical evaluation revealed dates as *termini ante quem* while they were originally used as *termini ad quem*.

This calculation took place for the whole area under investigation and for the individual regions differentiated by feature type (settlements, enclosures, single graves, megalithic graves, depots) and sample material (grain, charcoal, bones). These groups were combined again after source criticism (as described below) for sum-calibration on a broader scale, but with a higher number of dates in the individual calculations. Furthermore, different chronological foci of research traditions and dating philosophies might influence the composition of the data sets (see also below). In this respect research histories were checked and evaluated.

3. Theory and calculations

If we decide to use ^{14}C dates as a proxy for the reconstruction of the quantity of prehistoric activities, the intensity and depositional processes of dateable material are of major importance for the diagnostic value of the proxy. Changes in settlement behaviour (construction techniques, waste management) or ritual practices (burial customs, ritual depositions) can lead to different probabilities for the archaeological traceability of prehistoric activities. At a finer temporal scale different sample materials result in chronological deviations. Considering this, a source-critical interpretation is necessary. Two main lines of investigation were followed in this study: Firstly sum-calibrated probabilities of collective and individual burials, ritual depositions and enclosures were used to estimate the intensity of ritual activities. As a second line of investigation, dates from settlements were used to gain initial indications of the quantity of profane activities. In a third step, a comparison of both sources was undertaken to discuss, on the basis of both a ritual and profane level of activity, the question: Is it possible to use the sum of all dates as a proxy for social activity in its broad sense? This was done for the individual regions as well as for the whole area under investigation.

The method is not new and has been used with variation during the last decade by different research groups (Gamble et al., 2005; Shennan and Edinborough, 2007; Riede, 2009; Williams, 2012 with a list of further references). The approach has been constantly under review by the international scientific community, and some problems and pitfalls were variously and repeatedly pointed out. These problems include:

1. the dependence of the sum-calibration on the structure of the calibration curve itself (e.g. Williams, 2012, 579);
2. the dependence on the archaeological budget and dating philosophy in different areas (Straus, 2005, 212);
3. the differing number of ^{14}C dates from different sites that could bias the distribution (Bocquet-Appel, 2005 213);
4. the issue that intrasite-sampling is usually concentrated on specific stratigraphic situations to date certain transitions in the deposition process and do not reflect an equal distribution from the occupation of a site (Williams, 2012, 579);
5. the issue that a minimum sample size is needed to produce robust estimations (Williams, 2012, 579);
6. the observation that taphonomic loss results in an over-estimation of younger periods (Williams, 2012, 579);
7. the requirement that a comparison with other proxies is needed to evaluate the results of the ^{14}C-curves (Williams, 2012, 579).

Williams (2012) recently summarised the latest developments of the method, pointed out different problems and proposed strategies to handle them. In our study we tried to deal with them in different ways according to his suggestions.

Regarding the notion that the calibration curve and its inherent structure introduced a bias in the sum calibration, he describes (2012, 581–584) based on other authors that this may actually be a result of a slight misunderstanding of the calibration procedure and the underlying processes. He convincingly shows that dates that fall in steep parts of the calibration curve result in sharper peaks in the sum probability distribution than dates that point to times where we have a plateau in that curve. But this is only one side of the coin, as plateaus have a much higher probability that individual dates will be part of the plateau than steep curve segments have. If we do not discuss single or a small number of dates this effect counters the tendency to produce artificial peaks. This can be demonstrated by a simulation of ^{14}C dates equally distributed over a certain time frame (Müller/Hinz, forthcoming). Moreover, the figure given by Williams (Williams, 2012, fig. 5, 582) implies that an equal distribution of dates in time means that different dates are equally distributed along the uncalibrated BP axes. It is quite clear that this is not the case, as real world processes take place on the calibrated time scale. If a series of events takes place in real time at a site or region, and these events were dated with ^{14}C dates, more events would fall into plateau ranges of the calibration curve than into steep ranges, countering the effects of the artificial overestimation of the steep areas in the sum. The effects are negligible in the case of reasonably large numbers of dates, and can, if desired, be countered by a simulation of an equal amount of dates with an equal BC distance (Müller/Hinz, forthcoming). In this study we abstained from such a correction, because it appeared unnecessary. We followed Williams' proposal (2012, 584) of smoothing the resulting curve, but according to the mean standard deviation in the sample (~80), the shorter time frame in focus, and the situation described above, we reduced the proposed smoothing window from 500 to 50 years.

The second remark, that the number of extant dates depend on a different budget or dating philosophy, seems to be more serious. We tried to counter the problem by dividing the working area into different parts of presumably equal research tradition, and compared the trends within these areas individually. To avoid or reduce the impact of specific projects with a large number of radiometric measurements, we sum-calibrated the dates for each site and used the result as a date for the individual site. In this way all sites, no matter how many dates were taken, impact the resulting total sum distribution with the same weight.

Regarding the question of intrasite dating, strategies affect situations where a small number of sites are the basis for a sum calibration rather than those presented here where a large number of sites are taken into account. Only incidents like major catastrophic events of continental scale would result in contemporary stratigraphically visible markers that would lead to an artificial peak when this event is dated in several excavations. This may be true, for example, for the Thera eruption whose traces may result in the rise of a quantity of ^{14}C dates around the time of the event, but no such events are known for the time frame of this study.

Williams (2012, 581) suggests that for a mean standard deviation (ΔT) of 115 years, a minimum of 200 dates is necessary. He also states that the actual relationship between ΔT and the number of dates still needs to be evaluated. In any case, we would presume – since our ΔT is considerably smaller – that it is also quite reasonable to assume that the necessary number of dates could also be lower to achieve credible results. We would therefore propose that sum distributions from more than 150 dates (before combining them for the individual sites) could be taken as a good proxy for the temporal development of the underlying processes, while those with fewer dates should be taken as indicators for trends, but the resulting interpretations should be seen with respect to the sample size. Such trends cannot be taken as significant result by themselves but may give a good starting point for further investigations and do represent rather hypotheses that should be tested in additional studies.

Because we concentrate on a rather short period, taphonomic loss is not thought to be a major issue in our case. Williams (2012, 584) presents a modified formula for the calculation of the taphomomic loss originally proposed by Surovell et al. (2009).

Using this formula, the difference between Mesolithic and Late Neolithic times would result in an additional taphonomic loss of ~10%. On the basis of this, the ongoing research in that field, and the premise not to add too many parameters into the calculations, we decided against a taphonomic correction for our study.

As an additional proxy for an evaluation and interpretation of the result of the sum-calibrated probability distribution, we used initial results of ongoing investigations of human impact as reflected in pollen diagrams from Schleswig-Holstein. In this context, a case study on the correlation between human impact as reflected in regional pollen analyses and the ^{14}C sum curve will be presented below.

With these strategies we assume that we can be successful in dealing with the problems of methodology as far as the current state of research is concerned. Although there are still some visible or hidden non-demographic parameters influencing the sum-calibrated probability distribution, the results presented here give as good an estimation as possible of the processes shaping and changing human societies during the Neolithic in the Central and Northern European region.

4. Results

4.1. Human impact correlations: pollen analyses and ^{14}C dates in Holstein

To investigate the specifics of the method used, we compared a sum-calibrated probability of a regional subset of ^{14}C dates with the results from a pollen based proxy for human impact. This proxy is based on the results of an ordination using Multidimensional Scaling (2nd dimension) of pollen data from 4 lakes of central Schleswig-Holstein relating to the period between 4700 and 2000 cal BC. The resulting ordination was rotated to align the representation of the pollen taxon ribwort plantain (*Plantago lanceolata*) with the axis used as a proxy for human activity. *P. lanceolata* only occurs regularly in pollen diagrams from ca. 3750 cal BC onwards in the investigated area. This is interpreted to reflect a change in land use strategies which created permanently open habitats related with pastoral and agricultural activities, favouring the distribution of this classical anthropogenic indicator (cf. Behre, 1981). Another taxa showing a high positive correlation with axis 1 is the light-demanding hazel (*Corylus*), whereas arboreal taxa are generally negatively correlated (e.g. *Ulmus*, *Betula*, *Fraxinus*, *Tilia* in descending order). This data set was compared with ^{14}C dates from the surrounding of the lakes to get an idea about the regional signal that could probably reflect human activities in the sum-calibrated probabilities. Both curves were smoothed using a moving average with a window of 50 years.

The pollen proxy is biased somehow by a change of the land use regime, as indicated above. While from the second half of the Early Neolithic onward (since ~3500 cal BC) plantain represents a good indicator for economic activities, we observe in the first half of the Early Neolithic (4100-3500 cal BC) a lower signal for this plant. Some profiles exhibit a strong influx of charcoal, may be the result of fire events triggered by human activities, likely representing some kind of woodland management or slash-and-burn based agriculture. The charcoal influx itself is difficult to quantify because of divergent source qualities, and cannot be used in the same way as the *P. lanceolata* values. On the basis of visual estimation, the charcoal peaks roughly fit the peaks in the ^{14}C curve.

For the later parts of the curve the fit is astonishingly good, despite a general trend in both curves. While the pollen data shows a trend to increased human activities, the ^{14}C dates become sparse during the period of the Single Grave Complex (after 2800 cal BC). This can be due to different scientific activities and different settlement customs resulting in different probabilities for the detection of settlements. Due to this, we detrended both curves for further comparisons.

We calculated a cross correlation of the two curves; the immediate correlation is 0.589 (smoothed curves 0.6197), while the best fit is observed with a lag of 12 years, correlation here 0.599. This lag could be the result of an old wood effect and a hard water effect. For the small sample used for the sum-calibrated probabilities we could not exclude charcoal or food remain data which represents the vast majority of the settlement data in that region.

As a result, the ^{14}C curve and the pollen curve give a very good fit at a regional level, which on the one hand shows the usability of the method itself, but on the other hand also hints to the fact that in a tessellated landscape human activities do take place at different intensities and result in different amplitudes in the proxy data. Pollen data can only be taken as local signals for human activities, and an investigation of ^{14}C dates on a larger spatial scale only reflects major trends, while the resulting curve is affected by a smoothing resulting from the different intensity of activities in that landscape. In the future we will investigate this by using a moving window of specific size to estimate the differences in different regional scales and areas, as well as for an estimation of the spatio-temporal distribution of events observed in the proxies for human activities (Müller/Hinz, forthcoming).

For the area in the vicinity of the origin of our pollen samples we see a fluctuation in the ^{14}C signal that is not visible in the pollen data during the first part of the Early Neolithic for the described reasons, but the peaks (~4100 and ~3800 cal BC) correspond to peaks in the charcoal signal from those lakes. After 3700 cal BC the curves fit well, both indicating a peak of activities around 3500 cal BC and a decline of these activities after 3400 cal BC, resulting in a depression in the curves in or shortly after 3100 cal BC. A second phase of intense activities starts in or shortly after 2900 cal BC, and a second phase of low activity indication takes place between 2600 and 2400 BC. Because the Early Bronze Age is not very well represented in our ^{14}C data source, further developments cannot be discussed on this basis. However, a third peak of activities can be observed in both curves in or around 2300 cal BC.

Consequently, the quantification of human impact proxies of pollen analyses clearly displays a synchronous relation to the ^{14}C-sum curve. Taking other issues into account (research history, changes in the subsistence strategy), the ^{14}C-sum curve can carefully be used as a proxy of human activities.

4.2. *Results on regional scales: comparable developments*

The inspection of ^{14}C dates within the individual regions enables on the one hand a specific regional interpretation of the processes. On the other hand an identification of those regions that showed comparable trends is possible. We differentiate regions where major activities took place between ca. 4000–3350 cal BC, where a second phase of activities can be dated to ca. 3000 cal BC divided by a phase of degression, from those which showed a continuous increase of the ^{14}C signal until 3000 cal BC, and where a descent of the curve is visible thereafter, beside areas that are hard to classify. Additionally, we can also observe a shift within the regions in the temporal focus of certain activities, e.g. the ritual construction of collective monuments. Finally a comparison with the Middle Elbe – Saale region and Kujawy enables us to contrast areas in which Neolithization took place before the advent of Funnel Beaker Ceramics with those in which both innovations happened simultaneously.

4.2.1. *Patterns: regions with high activity phases from 4000 to 3350 and after 3000/2900 cal BC*

In six of the investigated regions we can detect a rise and a peak in the ^{14}C signal in the first half of the fourth millennium BC in the whole set of dates as well as in the dates from settlements, a regression of activities from ca. 3350 cal BC onward and a second phase of major activities from ca. 3000 cal BC onward.

In this sense the 200 dates (61 sites; Fig. 3 top, solid line) from *Western Sweden* indicate a phase of general high activity between ca. 3700–3350 ca. BC, followed by a phase of lower activities thereafter and again a major activity phase starting around 3000 cal BC. The pattern is similar if we only take the dates from settlements ($n = 163$ from 41 sites; Fig. 4 top, solid line) into account. The only few dates from enclosures ($n = 6$), collective burials ($n = 11$) and single graves ($n = 4$) nevertheless indicate continuous activities in the ritual sphere during the whole span of the second half of the fourth millennium BC.

Also in *Skåne and Bornholm* the sum-calibrated probabilities of all dates ($n = 252$ from 92 sites; Fig. 3 top, short dashed line) show high activity during 4000–3350 cal BC and a second peak in the probability curve after 2900 cal BC with a lower indication for human activities during ca. 3350–2900 cal BC. While the same pattern is visible in the settlement dates (138 dates from 54 sites; Fig. 4 top, short dashed line), in the ritual sphere the few dates from collective burials ($n = 22$) and single burials ($n = 18$) hint to ongoing activities, but with foci after 3350 cal BC and after 3000 cal BC respectively. Enclosures ($n = 6$) are unlikely to occur until after 3000 cal BC.

A sudden rise in activity indication is visible in the 342 ^{14}C dates (from 134 sites; Fig. 3 top, dashed line with shorter gaps)

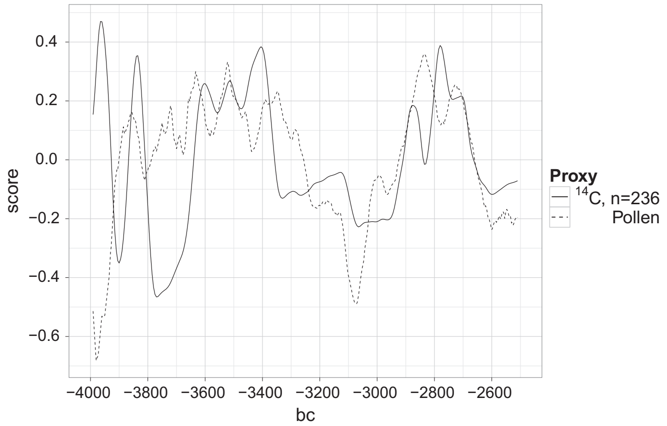

Fig. 2. Human impact curve from pollen analysis in Schleswig-Holstein and the sum-calibration of ^{14}C dates with settlement context from the area with high quality pollen data (see Fig. 1, $n = 236$ from 26 sites). While before 3700 cal BC a comparability is not given because of biases in data amounts and different economic activities, after 3700 cal BC a highly significant correlation ($p < 2.2e\text{-}16$, Pearson's product-moment correlation 0.6197) supports the usefulness of ^{14}C data for evaluating quantities in human activities.

Fig. 3. In six regions (top) from the Netherlands to Central Southern Sweden sum-calibration curves display similar tendencies. Besides an increase especially at 3800/3700 cal BC, a decrease around 3400/3350 cal BC and a second increase around and after 3000 cal BC are visible. Despite these patterns, a lack of data after 2700 cal BC and before 4200 cal BC should be taken in consideration. In three regions (bottom) the pattern is different, explanations given in the text.

from *Northern Jutland* dating to 4000–3900 cal BC, with a further slightly gentler increase from 3800 to 3600 cal BC, a rather sudden decrease around 3350-3300 cal BC and a renewed increase in the signal between 2900 and 2850 cal BC with the highest values between 2850 and 2500 cal BC. The 165 settlement dates (from 44 sites; Fig. 4 top, dashed line with shorter gaps) mirror the rise between 4000 and 3900 cal BC, followed by a stepwise reduction during 3600-3350 cal BC. A second peak in the signal is not observable until around 3000 cal BC, leading to a steady plateau until 2500 cal BC. The signal from the 32 dates originating from collective burials starts at ca. 3900 cal BC with an increase until 3700 cal BC and a decrease in indicated burial activity after 3400–3350 cal BC. A successive reduction is visible until 2900 cal BC, followed by a second maximum dating to 2500 cal BC. Individual burials ($n = 91$) are continuously present with a low intensity from 4000 cal BC onward. A sudden rise is visible after 2900 cal BC and a steady high level until 2500 cal BC. The curve from the 11 dates of enclosures starts around 3650 with a continuous rise until 3400 and a stepwise reduction until 2900 cal BC.

In the area of today's North Germany we combine the dates from *South Jutland and North Eastern Germany*. The overall curve ($n = 515$ from 103 sites; Fig. 3 top, dashed line with longer gaps) indicates major activities between 4500 and 4000 cal BC. While in this area it could be argued that this is an artefact resulting from specific scientific strategies (SINCOS), the validity of the signal

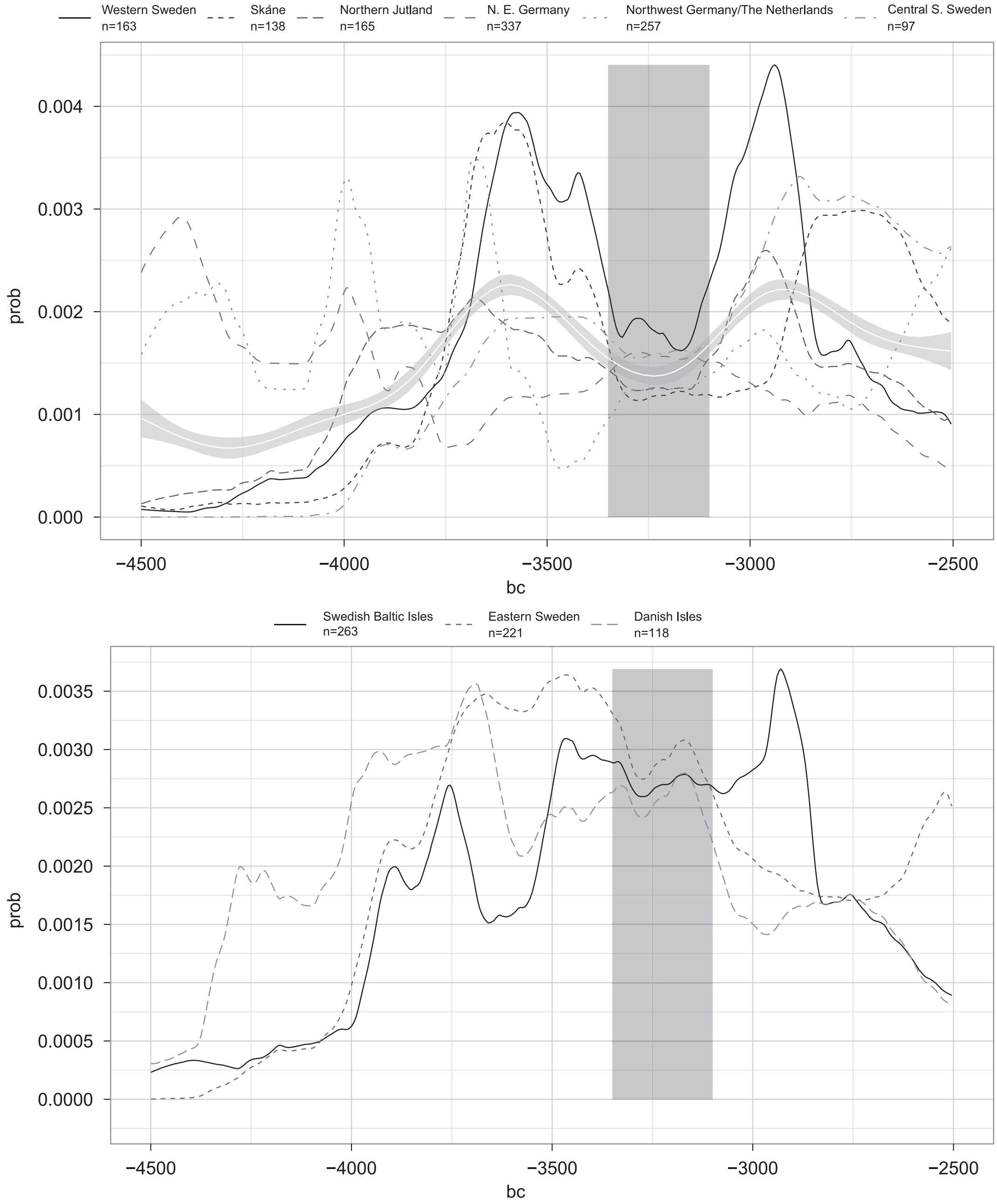

Fig. 4. Sum-calibrations for ^{14}C dates from domestic sites. Data indicates comparable patterns for the 6 regions from the Netherlands to Western Sweden (top) and the different development in the Northeast and on the Danish Isles (bottom).

may be confirmed by its counterpart in the westernmost parts of our study area. Leaving this problematic range aside, a high activity level is visible from 3600 to 3350 cal BC, again a lower level from 3350 to 3100 cal BC and followed by centuries of higher activity indication thereafter. Also the dates from settlement contexts (337 dates from 46 sites; Fig. 4 top, dashed line with longer gaps) partly reflect the same pattern. While individual burials ($n = 74$) are present with changing levels during the whole temporal range of this study with the main foci 3700 to 3350 cal BC, and 3100 to 2900 cal BC, collective burials ($n = 79$) are substantially visible from 3700 to 3350 cal BC with later phases of secondary use present in the data set. Also the few dates from enclosures ($n = 6$) show activity phases from 3650 to 3400 cal BC and 3100-2600 cal BC.

As mentioned the overall dates from *North Western Germany* and the *Netherlands* ($n = 576$ from 185 sites; Fig. 3 top, dotted line) also show a high level in the timespan from 4300 to 3900 cal BC, may be as an artefact of specific scientific projects. A second peak dates to 3700–3500 cal BC, followed by an earlier decrease in the curve compared to the other regions mentioned around 3500 cal BC and a third maximum around 2900 cal BC. From the settlement dates ($n = 257$ from 36 sites; Fig. 4 top, dotted line) a rather congruent situation is indicated. Single graves ($n = 170$) are present with a low level from ca. 4000 cal BC, but show a steep increase from 2900 cal BC onward. The collective burials ($n = 6$) with their small number nevertheless reveal the known pattern of a focus between 3400 and 3000 cal BC and a second signal from secondary use from 2600 to 2300 cal BC.

The pattern that is visible in the preceding examples cannot be observed in the case of *Central Southern Sweden*. The overall dates (243 from 54 sites; Fig. 3 top, dashed/dotted line) convey the idea of a steady yet non-continuous rise of anthropogenic activity from 4000 to 3600 cal BC, a peak around 3350 cal BC and a third steep part of the curve from 3150 cal BC onward. A second peak dates to approx. 2900 cal BC, followed by a sudden decrease again. The settlement dates (97 dates from 20 sites; Fig. 4 top, dashed/dotted line) confirm the picture, although here a slight decrease between 3350 and 3100 cal BC is also visible in the curve. The collective burials (109 dates from 16 sites) start at 3400–3350 cal BC with a steep rise in activity signal, with a step approx. 3100 cal BC and a marked decrease from 2900 cal BC onward. Also here a phase of secondary use is visible after 2500 cal BC.

From the regions of the different stylistic groups of Funnel Beaker ceramics with more than 200 ^{14}C dates a comparable developmental pattern is recognizable. After a substantial rise in social activities and indications of human activities either from 4000 cal BC or from 3800/3700 cal BC onward, a ‘drop’ is apparent from ca. 3350 cal BC onward. This pattern also is observable to a certain degree for the Central Swedish region in the settlement dates. The first increase in activity indicators is either a result of scientific strategies (e.g. specific projects with a focus on Late Mesolithic sites or on Neolithization itself) or might actually represent a demographic expansion resulting from the cultural innovation connected with the Funnel Beaker ceramics. The latter decrease hints to a real decrease in the underlying processes, probably a decrease of population at this time. Differences between an early (population increase), middle (population increase or steady state on high level) and younger (population decrease) Funnel Beaker time is observable. With the transition to the Single Grave/Corded Ware complex in most cases a sudden and substantial increase in population can be deduced. Regardless of this, continuous, in part even intensified ritual activity is likely during the times when the settlement dates hint to a lower population level.

Nevertheless, the scenario could have been much more complicated. During the Funnel Beaker period a concentration of domestic activities towards fewer but larger settlements was observed in some areas (compiling Jensen, 2006, 285p; Jensen, 1994). This could of course influence the pattern that is observable in the ^{14}C sum-calibration curve. Even as this took place later, after the decline of the ^{14}C curve (e.g. Andersen, 2008, 36), the agglomeration still could indicate a higher population rate. The change from a disperse to an agglomerated settlement pattern (as proposed by some mentioned authors) would coincide with the recovery of the settlement activities from 3100 cal BC onward.

4.2.2. Different tendencies: general increase in activities and decrease after 3000 cal BC

Three regions of the northern Funnel Beaker Group differ from the described pattern. In these regions we can observe a rise in activities over several centuries, followed by a degression of intensity after 3000 cal BC.

In this direction the *Swedish Baltic Isles* with 236 dates (from 35 sites; Fig. 3 bottom, solid line) give the impression of relatively continuous activities (with fluctuations) from 4500 cal BC onward until 3600 cal BC, followed by a marked increase between 3600 and 3400 cal BC to a plateau lasting until 3100 cal BC. A second increase (3100–2900 cal BC) to the maximum of the curve and a decrease until 2500 cal BC complete the sequence. The pattern is essentially the same in the case of the dates from settlement contexts (74 dates from 16 sites; Fig. 4 bottom, solid line), while here in the earlier phase a peak around 3750 cal BC and a following decrease until 3500 cal BC is more pronounced. Dates for collective burials ($n = 44$) start from 3600 cal BC onward, stay on a high level until 3200 cal BC with a marked decrease thereafter and a second slight peak between 2700 and 2500 cal BC. The latter dates actually originate from only two graves, so that it is not possible to draw wider conclusions from those results, but at least it fits with the general picture. The second peak is mirrored by an increased level in single graves accordingly ($n = 99$ from 17 sites).

In *Eastern Middle Sweden* 243 ^{14}C dates from 60 sites (Fig. 3 bottom, short dashed line) show a steep intensification in activities from 4000 to 3750 cal BC, resulting in a plateau until 3350 cal BC and then a continuous decrease until 2600 cal BC when again a slight increase is observable. This pattern fits with the result from the dates from settlement contexts ($n = 221$ from 53 sites; Fig. 4 bottom, short dashed line) which represented the majority of this series. Only one collective burial and 4 single graves are represented in our data set with 4 dates, so we abstain from interpretation.

On the *Danish Isles* between 4000 and 3900 cal BC a substantial increase in activities is identifiable in the overall data set ($n = 288$ from 143 sites; Fig. 3 bottom, long dashed line), a peak takes shape around 3700 cal BC and from then onward a continuous reduction until 2500 cal BC is observed. The settlement samples ($n = 118$ from 47 sites; Fig. 4 bottom, long dashed line) also produce the highest probabilities between 4000 and 3600 cal BC. The few dates from single graves ($n = 15$ from 12 sites) represent a continuous background of rather low intensity during the whole timespan since 4000 cal BC. The curve for collective burials ($n = 38$ from 15 sites) reveals a high intensity from 3350 cal BC onward with a decrease to a minimal, but constantly visible, signal of use until late Neolithic times. Enclosures ($n = 22$ from 6 sites) do start around 3650 cal BC, resulting in a rather plateau situation until 2900 and decrease thereafter. A following plateau until 2600 may be connected with the difference between ditch and palisade enclosures.

Obviously we deal in these three regions with developments that do not follow the trends described before. Especially the postulated decrease in population around 3350 cal BC and the intense increase in population after 2900 cal BC cannot be observed. In the case of the Danish Isles this can be explained with the apparent late arrival of the Single Grave traditions and an autonomous, intense Funnel Beaker dynamic (cf. Feeser/Furholt, this volume). Whether, in the case of Eastern Middle Sweden and the Swedish Baltic Isles, the specific distribution across the different feature categories or may be also autonomous tendencies (late and rather scant building activities of megalithic burials hints in this direction) are responsible for the different picture cannot be solved here. Because the South Scandinavian – Northwest Central European pattern is only rudimentarily traceable in Central Southern Sweden, it is plausible that in the Central and Eastern Swedish areas as well as on the Swedish Baltic Isles a different developmental rhythm is present that is more characterised by continuities.

4.2.3. Comparison to the south: Central Germany and Kujawy

From the *Polish Baltic Coast* as well as from *Kujawy* the quantity of dates in the RADON database is still too small to get a detailed picture. Nevertheless, the 22 dates from the Kujawy region can be used to show some interesting tendencies (Fig. 5 bottom). Although here, in contrast to the regions hitherto described, the societies using Funnel Beaker ceramics do not represent the first Neolithic occupation, on the slim data basis a pattern arises that is similar to the general tendency. After the drop that is certifiable

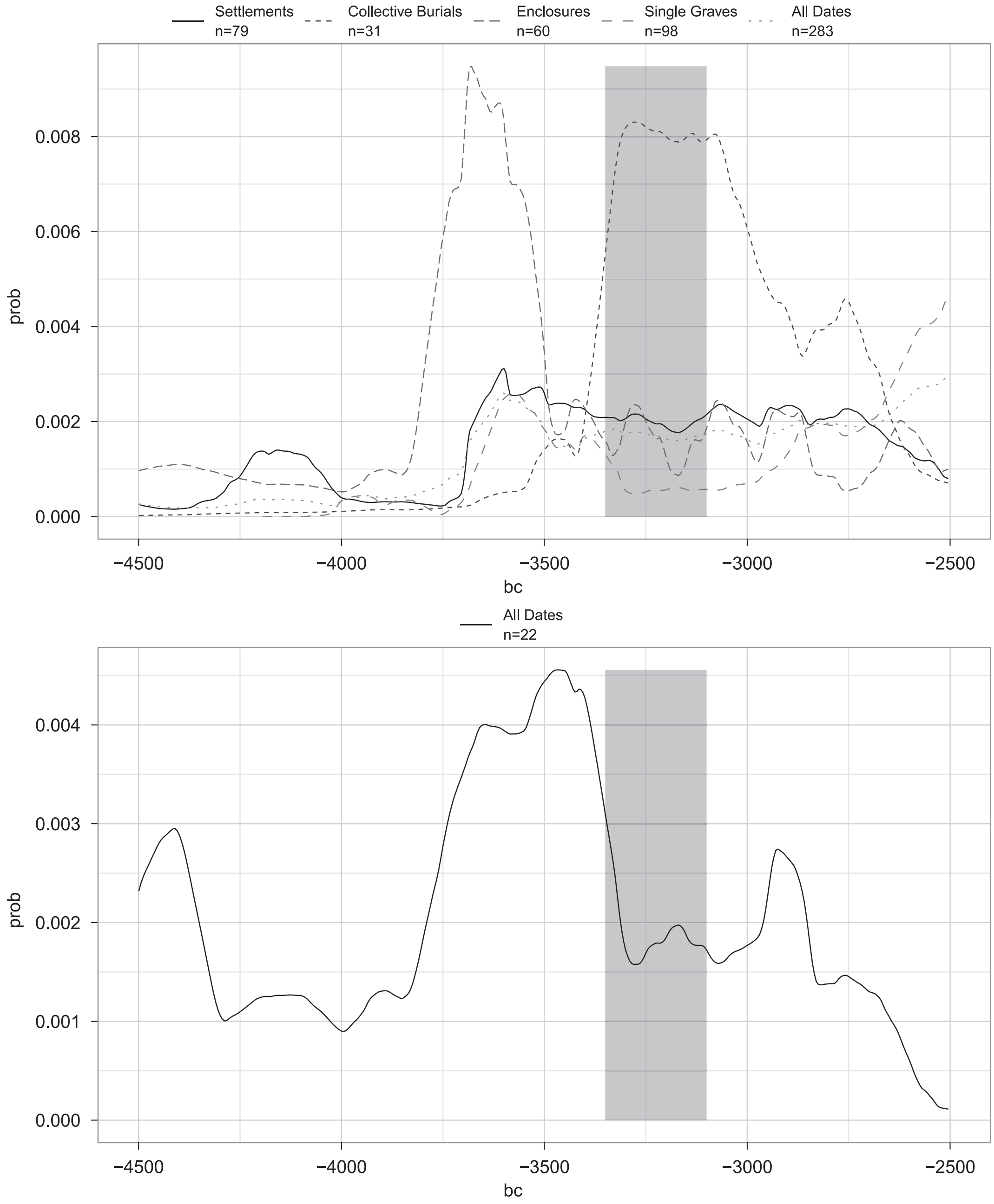

Fig. 5. Both in Central Germany (top) as well as in Kujawy (bottom) data display comparable patterns as in the main TRB-regions despite the fact that in the loess areas Neolithization started much earlier than in the north.

after Brejc Kujawsk, a considerable increase in activities is determinable around 3800/3700 cal BC, followed by a degression around 3400 cal BC. Also around 3000 cal BC we can observe an increase that cannot be traced further in time due to a lack of dates.

In the *Middle-Elbe-Saale* region on the basis of all dates ($n = 283$ from 118 sites; Fig. 5 top, dotted line) an intense rise in the activity signal from the ^{14}C dates can be seen also between 3800 and 3700 cal BC, followed by a slight reduction until 3450 cal BC. Here a high level of the sum-calibrated probabilities lasts until 2650 cal BC, when again the indications rise even more. Collective burials ($n = 31$ from 12 sites; Fig. 5 top, short dashed line) mainly date to the timespan between 3400 and 2900 cal BC, single graves ($n = 98$ from 61 sites; Fig. 5 top, long dashed line with longer gaps) rather before or after this period (ca. 3700–3350 resp. 2900– cal BC). Enclosures ($n = 60$ from 10 sites; Fig. 5 top, long dashed line with shorter gaps) have a main phase from 3800 to 3500 with consecutive usage later on.

In the frame of our investigation it is of specific interest that also in the regions that had a Neolithic occupation before, a strong impulse around 3800/3700 cal BC can be observed as well as a certain reduction in activities in the second half of the fourth millennium BC. The transition from enclosures and collective burials is a phenomenon that is also apparent in other regions of the Central German Upland zone (comp. Northern Hessian/Eastern Westphalia: Raetzel-Fabian, 2000; in general see Fig. 6).

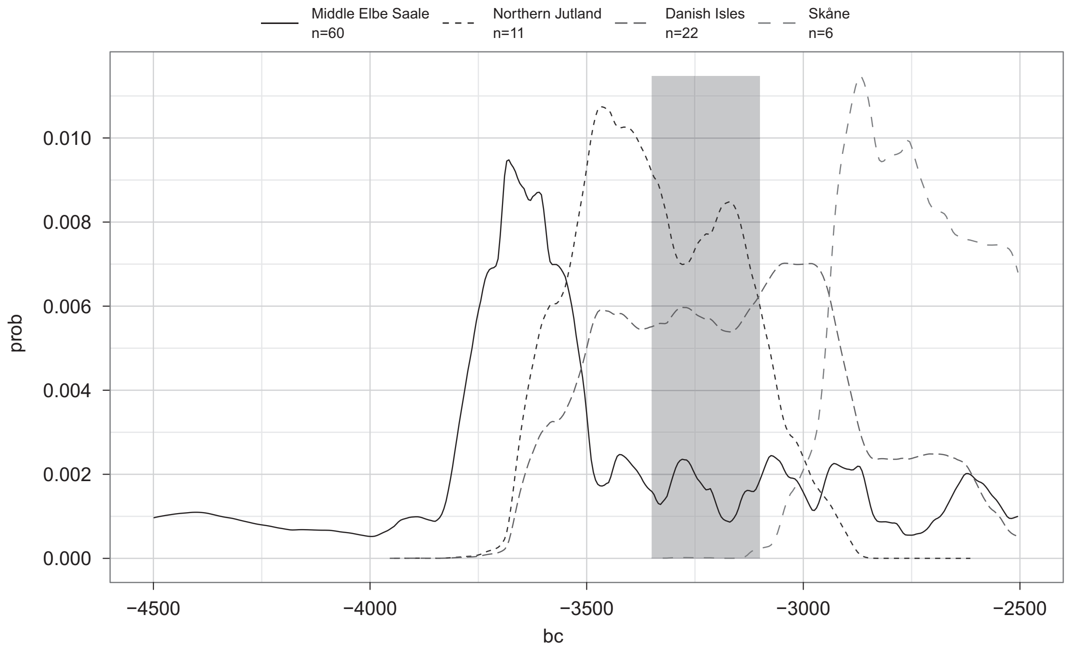

Fig. 6. The ^{14}C dates from enclosures display the introduction of these ritual patterns from the south to the north. A south-north gradient is visible, although differences between ditch and palisade enclosures have to be considered.

4.3. *Interpretation*

The aim of this study was to detect similar patterns in the quantification of ^{14}C dates of societies with Funnel Beaker ceramics and use them, on the basis of sum-calibrated probabilities, as a proxy for the relative quantification of social activities and, connected with that, also for relative demographic estimations. Indeed, it was possible to detect common tendencies in the area between the Netherlands and Skåne as well as the Altmark and Western Sweden. In focus was the time frame between 4500 and 2500 cal BC. While in the comparison of the ^{14}C dates from ca. 3800 cal BC onward a corresponding pattern emerged, this is not the case in the preceding centuries. If this is due to differing states of research resulting from intensive dating programs on the Mesolithic occupation in some areas or if real differences are the basis (e.g. different Mesolithic population sizes) remains open. Differences with the study of Shennan and Edinborough (2007, Figs. 2 and 3), especially in respect to their results concerning Denmark, are likely due to our differentiation between the peninsula of Jutland and the Danish Isles.

The case study comparing the pollen data with the sum-calibrated probabilities of ^{14}C dates from the immediate surroundings of the sample sites showed a correlation between the values for human impact and the curve resulting from the radiometric measurements. In consequence we postulate:

1. After a substantial population growth in the Late Mesolithic as well as with the advent of the Funnel Beaker ceramics for the Funnel Beaker West and North Groups a population decrease around 3350 cal BC can be assumed. Especially this time frame also sees an increase in intensity or at least the continuation of investment in the ritual sphere of society. A second growth phase can generally be assumed connected with the transition to Single Grave/Corded Ware customs.
2. The Danish Isles constitute an exception, where neither the population decrease nor the increase after 2900 cal BC is visible. This fits with the observation of a delayed appearance of Single Grave customs as well as an intensive development of the Funnel Beaker customs.
3. In the northeastern stylistic group of Funnel Beaker ceramics an intense population growth and continuous development became evident. Also here neither the population decrease after 3350 nor the increase in the beginning of the third millennium BC is detectable.
4. Additionally in the more southern areas of the distribution of Funnel Beaker ceramics, where they do not represent the first Neolithic style, an inland colonization with population growth began after 3800/3700 cal BC. The social developments are comparable to those regions in focus of this study only in a limited sense.

Shennan and Endinborough (2007) already summed probability distributions of German, Polish and Danish ^{14}C dates and discovered a steep rise in population with Neolithization in each country and some degree of fluctuation during the Neolithic. With our study we have added detailed regional studies on TRB areas in Northern Central Europa and Southern Scandinavia. As a result, a clear pattern of shifting population growth during the transition from the Mesolithic to the Neolithic could be verified. The decrease in population during the Northern Middle Neolithic and an increase with the Younger Neolithic clearly describes a pattern which must be the result of societal developments. In other areas, different regional patterns are visible which indicate different processes for the Danish Isles or the TRB Northeast Group.

5. Conclusions

We maintain that with an increasing number of ^{14}C dates an estimation of the relative, regional development of population in the distribution area of Funnel Beaker ceramics is possible. We believe that sum-calibrated probabilities, taking the different biases into consideration, can lead to a quantification of social activities and with that relative population sizes. Having this tool at hand we can contribute to the investigation of economic and societal changes and tendencies. The differences in patterns between the areas of the stylistic Funnel Beaker West and North Groups on the one hand and the Northeastern Group on the other hand, accompanied by an island situation, hint to variations that are also expressed in the different economic bases of those societies. While the phases of population growth observed can be linked to developments already known and do not represent a surprise, the population decrease described here around 3350 cal BC cannot be explained as easily and its explanation can probably be found in the social realm.

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