Quantitative Archaeology and Archaeological Modelling

Johannes Müller
Wiebke Kirleis
Nicole Taylor *Editors*

Perspectives on Socio-environmental Transformations in Ancient Europe

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Quantitative Archaeology and Archaeological Modelling

Quantitative approaches and modelling techniques have played an increasingly significant role in archaeology over the last few decades, as can be seen both by their prominence in published research and in university courses. Despite this popularity, there remains only a limited number of book-length treatments in archaeology on these subjects (with the exception perhaps being general-purpose GIS). 'Quantitative Archaeology and Archaeological Modelling' is a book series that therefore responds to this need for (a) basic, methodologically transparent, manuals for teaching at all levels, (b) good practice guides with a series of reproducible case studies, and (c) higher-level extended discussions of bleeding edge problems. This series is also intended to be interdisciplinary in the analytical theory and method it fosters, international in its scope, datasets, contributors and audience, and open to both deliberately novel and well-established approaches.

Johannes Müller • Wiebke Kirleis
Nicole Taylor
Editors

Perspectives on Socio-environmental Transformations in Ancient Europe

Springer

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Preface

Transformation processes play a role in all societies and are particularly observable in recent times of climate change. Such processes are being studied in the Collaborative Research Centre Scales of Transformation: Human-Environmental Interaction in Prehistoric and Archaic Societies as a reciprocal interaction of environment and society. Within this framework, corresponding processes for the time period 15,000 to 1 BCE have been investigated for some time, funded by the German Research Foundation.

After the publication of numerous results of this research in various articles, in monographs of the series Scales of Transformation in Prehistoric and Archaic Societies and especially also in 2019 in a special issue of the journal *The Holocene*, we aim at a further holistic discussion and presentation with this book. The aim is to evaluate the theoretical and methodological implications of empirical studies, to present exemplary results from a few concrete studies, and finally to arrive at an overall assessment of a new "Integrative Archaeology". We believe we can show how the interplay of different structural and post-structural explanatory patterns and the high data density of interdisciplinary research have resulted in a groundbreaking research concept, namely that of "Integrative Archaeology".

In addition to the authors, we would like to thank our scientific coordinator Nicole Taylor in particular for the considerable effort that went into the production of this book. We would also like to thank the graphic designers Carsten Reckweg and Esther Thelen for producing the illustrations. The project is funded by the German Research Foundation (Project-ID 290391021 – SFB 1266), which is also to be thanked for its support.

Kiel, Germany

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Chapter 1
New Perspectives on Socio-environmental Transformations in Past Societies

Wiebke Kirleis and Johannes Müller

1.1 Background

One of the main grand challenges and aims within archaeology has always been the understanding of long-term processes, by studying changes in the interactions between human societies and between them and their environment. Looking at our human history, decisive changes have taken place, covering a wide array of societal formations and environmental settings; processes that transformed societies and landscapes into a completely new state. But what socio-environmental components and forces have caused such fundamental re-arrangements of structures, and why? Are there certain parameters that played a greater role in a specific transformation than others? Were perhaps only certain socio-environmental spheres subjected to transformation process, while others have remained unaffected? Do they have the same dimensions, on a spatial level, or are there discernible differences in their trajectories? And most importantly, do transformation processes follow certain patterns, which may even be repetitive throughout the history of mankind? And if so, are these patterns from the past still valid today? Interdisciplinary research concentrated around archaeology, with its long-term temporal perspective on human societies and landscapes, is in a unique position to compare answers to these different questions surrounding past transformations. In addition, the information provided by this "special transformation research" can also make a significant contribution to today's societies, where mass migration, pandemic diseases, abrupt climate change and socio-political debates continue to transform our everyday lives.

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1.2 Socio-environmental Transformations

Societies and environments are never in a steady state. Rather, they are subject to continuous change on different spatial and temporal scales. Alterations in any parameter of social and cultural practices or in the environment result in changes and re-arrangements of the whole socio-environmental system (cf. e.g. Sutton & Anderson, 2004). From this general perspective, reflecting the spatio-temporal dynamics of the socio-cultural and environmental contexts, we define a transformation as a process of change that can be conceptualised by making the following distinctions:

- A transformation is a directed change leading to a substantial reorganisation of socio-environmental relations, which can take place on different temporal and spatial scales. By "directed change" we mean the occurrence of a number of interconnected changes which reinforce each other, leading to a new sustained state of societies and their socio-environmental relations.
- A transformation is connected to the introduction of new social, cultural and/or material attributes and values, which change the existing socio-environmental interplay. These changes in social practices or environmental compositions might result from societal or environmental processes, or from both.
- A transformation has a point of no return and results in a new state with certain endurance, so that changes are clearly visible in different domains of society and the environment, and leave traces in the archaeological and environmental records.

In consequence, a transformation is a complex process, in which several aspects, elements, meanings and perceptions of social, cultural and environmental developments of a society are involved and influence each other. A transformation is thus not a simple displacement, where a new state of affairs in one social domain replaces the original one without affecting developments in other domains, nor is it the cessation of an old aspect or the introduction of one new aspect that does not affect the others. For example, the introduction of pottery into several hunter-gatherer communities did not necessarily lead to changes in economy, social relations or ritual behaviour, and would thus not classify as a transformation (van Berg, 1997). In the same way, the evidence for domestic pigs in Mesolithic hunter-gatherer groups also probably does not mark a turning point leading to transformation. Rather, the domestic pig was integrated into the existing system, most probably as prestige item (Krause-Kyora et al., 2013).

Clearly there are transformations of lower and higher significance or extent, and the comparison of such different scales is addressed also in this volume. For example, on a supra-regional scale one of the most marked transformations of human-environmental interaction is the transition from a hunting and gathering economy to one relying mainly on horticulture and animal husbandry, which involves a fundamentally-different relationship with the environment (Whitehouse & Kirleis, 2014). These developments in the economic domain were connected to changes in nearly all other domains of the socio-cultural context, and to severe changes in most domains of the environmental context. In contrast, the establishment of tin bronze metallurgy at central European domestic sites and the extension of cattle breeding on a local scale in many cases furthered ecological problems. They resulted in a collapse of different village systems around 1650 BCE. The interplay between technological and social changes and anthropogenic influences on the environment resulted in feedback dynamics that contributed to the establishment of new types of domestic sites – restricted, however, to a local scale (Kneisel & Müller, 2011).

The identification and exploration of transformations on different scales, such as Neolithisation, and also the comparison to transformation processes on a smaller scale, such as changes in resource exploitation or the organisation of space in Bronze Age village communities (Kneisel, 2013), enables us to establish a concrete, practical understanding of transformations. In the aforementioned examples, transformations are enduring: On the broader historical scale at a supra-regional level, and at a local scale for the whole living world of prehistoric communities. Nevertheless, the interweaving of changes, developing from local to global or from global to local, have also been taken into consideration.

An example for such a discourse is the identification of the innovation of the wheel and wagon in Europe (cf. Bakker et al., 1999; Maran, 2017). Both convergent regional inventions, as well as a possible sudden spread from one area of origin, were discussed as contributing to societal changes. For example, a shift from horticulture to agriculture (Northern Europe) triggering urbanisation processes (Near East) or the construction of mega-sites (North Pontic) (Müller & Pollock, 2016).

Transformations can take different forms. We have to differentiate between characteristics of transformations regarding the tempo, intensity, depth, and breadth. They can be continuous and long-lasting, or abrupt and fast, they can be accompanied by phenomena of instability and crisis or they can even lead to catastrophic events or the collapse of whole societies. They can affect a specific part of the society only or the whole group, they can alter specific domains of the socio- environmental contexts, or several of them at once, or transformations in several domains may be interlinked. As an example, the environmental and societal development of Southwest-German Hallstatt and early Latène societies has shown many components of different transformation patterns (Nakoinz, 2013; Steffen, 2012). Beside "slow" changes of material culture and environmental conditions, the rapid destruction of the Heuneburg and the reduced importance of central sites around 530 BCE is one archaeological example of how to detect the depth of social transformations that happen in within the time-span of a generation.

In consequence, to identify transformations of human-environmental interaction in prehistoric and archaic societies, studies on changes and the interplay of developments in settlement systems, subsistence and wealth economies, technologies, mortuary and ritual practices, exchange and networks, as well as studies on contemporaneous climate changes, soil and vegetation developments, demography and diseases, have to be explored and integrated.

1.3 Contextualised Comparative Approach: Integrative Archaeology

In order to disentangle socio-environmental transformation processes, it is necessary to strongly interrelate different aspects and parameters of change. For this purpose, not only different temporal and spatial scales have to be addressed, but also different methods for different archives used. The spectrum ranges from aDNA studies to the source-based reception of written texts. The interaction of different disciplines is defined by certain empirical necessities:

- theoretical explication and development of conceptual resources (anthropological, archaeological, environmental, and philosophical theories)
- creation of precise chronologies based on physical science and mathematical methods integrated with archaeological, historical, and palaeo-environmental approaches (stratigraphic information, analyses of written sources, modelled chronology)
- comprehensive, quantitative, and qualitative reconstructions of environmental processes and conditions (palaeoclimatology, palynology, sedimentology, geomorphology, archaeobotany, archaeozoology, molecular biology)
- stringent reconstruction of palaeo-demography and mobility (physical anthropology, aDNA analyses, isotope analyses, archaeological structures)
- comprehensive reconstruction of economies (archaeological studies on material culture and features, archaeobotany, archaeozoology, archaeometrics, economic history)
- detailed analyses on material culture (physical-chemical analyses of material objects, stylistic analyses and typology, functional analyses)
- detailed spatial analyses on site formation processes, the reconstruction of social space and networks, the analyses of built spaces (settlement archaeology, combination of geophysical and archaeological surveys, target excavations, spatial scaling procedures)
- reconstruction of social processes (social archaeology, social history, classics)

Today the use of these different methodological approaches in a joint and productive way is possible; although they have different theoretical approaches, which originally set themselves in a contradictory manner, within different scales of inquiries they could thus be combined within such a multi-proxy approach. In such a way, the contradictory interpretations of post-processualist, processualism, and cultural-historical studies could be overcome. While the cultural-historical tradition in archaeology mainly describes and orders events and historical circumstances, processual archaeology tries to explain events, processes and structures, while post-processual archaeology reflects on the meaning of events to understand archaeological settings in an emic way. Interestingly, in practice the approaches are mostly linked to different spatial scales. While post-processual approaches mainly deal with local and short-term events, processual archaeology is focused on regional comparisons, while cultural-historical approaches are dealing with supra-regional aspects. Thus, all three approaches play their role in a new integrative archaeology (cf. Brinkmann, n.d.). This kind of anti-contradictory, positive and multi-phased handling of theoretical and methodological aspects preconditions the possibility of evaluating socio-environmental transformations.

1.4 Thematic Organisation and Chapter Summaries

Despite the fact that this volume comprises studies from different viewpoints and different perspectives, the chapters share a common research agenda which focuses on the important role socio-environmental transformations played in the rise of human societies.

In the first part of the book, two chapters deal explicitly with the possibilities of identifying anatomies of social change. In Chap. 2, Nicole Taylor et al. explore the new concept of investigating transformations. Four epistemological steps are presented, leading from the actual archaeological and palaeoenvironmental sources to the comparison of scientific narratives. From the above, a new "ladder" of knowledge emerges, which, due to the new approach, can be placed alongside previous processes of knowledge (Fig. 2.1). Within this concept, the identification of both general parameters and diversity is made possible. In Chap. 3, Artur Ribeiro et al. explore the possibilities of integrating and using different anthropological aspects of human cultures and specificities of cognition in process models originally derived from ecological research. In Chap. 4, Franziska Engelbogen et al. examine indicators of transformation processes related to settlement structures, climatic conditions and environmental data.

In the second part of the book, two chapters deal with expressions of transformations as they become visible in the combination of archaeological and palaeoecological data. In Chap. 5, Jan Piet Brozio et al. present quantified data from both the environmental and the social spheres of Neolithic and Bronze Age societies in northern Germany, which in their granularity allow far-reaching diachronic conclusions to be drawn about the structure and course of transformation processes. In Chap. 6, Julien Schirrmacher et al. succeed in evaluating the role of specific climatic events on transformations in the cereal spectrum of Neolithic and Bronze Age societies from south-east Iberia and north-central Europe. Both chapters serve as examples of the anatomy of transformations from a strictly quantitative research perspective.

In the third part of the book, three chapters focus more on the perspectives of decision-making in transformation processes. In Chap. 7, for example, Walter Dörfler et al. attempt to examine the influence of landscape conditions on transformation processes using four diachronic examples. Here, the concept of cultural landscapes is used, which in itself contains the perspectives of anthropogenically-altered landscapes. In Chap. 8, Robert Hofmann and Mila Shatilo examine changes that become visible in the production of non-utilitarian objects. In this way, it can be made clear that the development of realism accompanied the transformation to larger population agglomerations in the Trypillia phenomenon. This study represents an innovative approach for analysing individual categories of material culture and their use as proxies for population-aggregation related social dynamics. Finally, in Chap. 9, Stefanie Schaefer-Di Maida et al. succeed in illustrating the diversity of social decision-making processes, also in different examples. On the one hand, the role of various political institutions such as village councils or village networks becomes clear, and on the other hand, the great importance of community size for decision-making processes is highlighted. Thus, we achieve new perspectives on such processes as well as a level of concrete decision-making components that can only be read from very fine-grained data.

In the concluding Chap. 10, Johannes Müller et al. relate the results presented here to a European perspective in a modified way. It can be shown how the anatomies of transformations result from a comparative consideration.

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Part I
Identification of Anatomies of Socio-environmental Transformation

Chapter 2
Scales of Abstraction: The Kiel Conceptual Approach from Heterogeneous Data to Interpretations

Nicole Taylor, Christoph Rinne, Jan Piet Brozio, Jutta Kneisel, Magdalena Wieckowska-Lüth, Jos Kleijne, Hermann Gorbahn, Wiebke Kirleis, and Johannes Müller

2.1 Introduction

The topic of transformations in the past requires research across the kind of broad timeframe which only projects with an archaeological, *longue durée* approach can tackle; an advantage which is combined with the interdisciplinary possibilities offered by the various researchers who are involved. Archaeology is an interdisciplinary subject from its very nature and history (Kerr, 2020), straddling the social sciences, humanities and natural sciences, which makes the discipline and its practioners often more amenable to collaboration with other disciplinary colleagues. This willingness to design and participate in interdiscplinary research, and the focus placed on this by many major research funding bodies (Kerr, 2020, p. 1339), make it vital to consider practical approaches to integrating heterogeneous data from multiple case studies across this timespan and also a wide geographic area. In this chapter, we present a structuring "scaffold" for comparability — a way of moving between different levels of abstraction of the raw data in order to bring together our results in a meaningful way as a broader understanding of transformation.

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2.2 Getting to Grips with Diverse Transformational Processes

Researching transformations across a wide geographic span (from the Iberian Peninsula to Siberia, from the Mediterranean to Southern Scandinavia, as well as India), over a timespan from 15,000–1 BCE, but also with data from different socio-economic formations (from complex hunter-gather-fisher societies, to horticulturalists, agriculturalists, and on to early state societies), involves working with incredibly diverse transformations and case studies; not only in terms of available data and the interpretations produced from it, but also theoretical approaches to transformation processes. Given our overarching goal of understanding transformations in prehistoric and archaic societies across spatial, temporal and societal scales — within the given spatio-temporal framework — it has been necessary to develop a common understanding which allows us to integrate case study results in a meaningful way, and enables productive communication across these various scales and different case studies.

We began by developing a model of the various contexts, domains and parameters involved in past transformations (see Fig. 2.1).

This model showed the various indicators (see Chap. 4) and proxies we are using to gain data on the specific transformation processes, and that they were related to various different parameters, domains and then finally the two main contexts of our research. In this first iteration, the model had an unintentional hierarchical and static appearance, based on our culturally-learned habit of reading in one direction. The second iteration of this broad model removed this horizontal directionality and through the use of circles shows that we can move mentally in two directions depending on what we are trying to achieve; either from the proxies inwards when

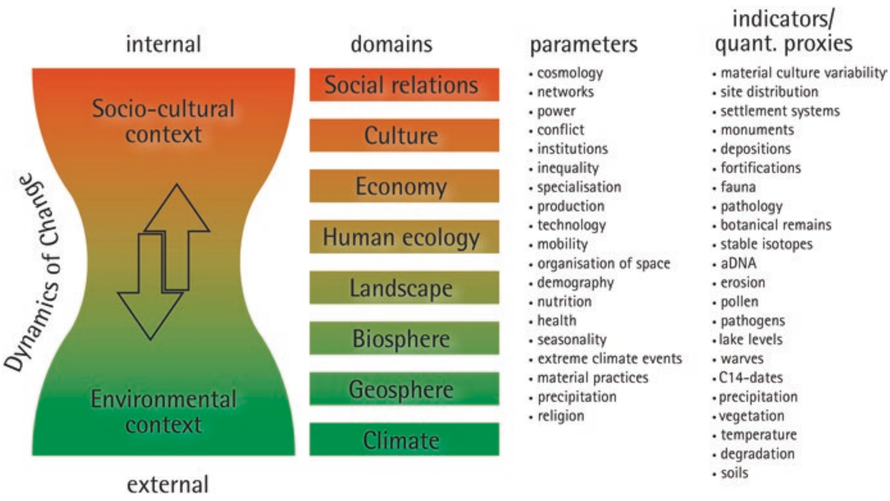

Fig. 2.1 The first iteration of the contexts-domains-parameters model

collecting our data and interpreting it on a case study basis, or from the contexts outwards when we are bringing together our data and interpretations across the project to develop a generalisation of transformational processes as historical phenomena.

What is clear in this model is the necessity of moving through various layers of interpretation and abstraction in order to take our archaeological and palaeoenvironmental data and generate from it a more generalised (and thus comparable) and narrative understanding of the past.

2.3 First Level of Abstraction: From Data to Parameters

These ideas of contexts-domains-parameters-proxies provided in themselves the first level of abstraction necessary for our research: A standardised vocabulary of parameters with which we were able to communicate about our data. The data with which we are dealing is very heterogeneous — from ceramic sherds to pollen grains, from magnetic anomalies to antique texts, from burial mounds to ancient DNA. As such, this first level of abstraction — from individual data sets and quantifiable indicators to a shared vocabulary of parameters — is necessary to facilitate communication during our research. The terms used for the parameters relate to aspects of social and cultural interactions within a community or with the environment (see Fig. 2.2).

The vocabulary of parameters arose from an open discourse within our project on how to understand so-called proxies and their effects on, as well as meaning for, various domains in human action. The various subprojects contributed with their selection of indicators and how they are connected to the parameters, leading to a lively exchange within and across not only the subprojects, but also academic disciplines (see Figs. 2.1, 2.2 and 2.3). Working in collaboration to establish this discourse and interdisciplinary understanding also aids researchers at various stages of their careers in improving their collaboration skills *while* collaborating, which as Freeth and Caniglia (2019, p. 248) highlight, should be actively supported rather than assumed to already occur.

2.4 Second Level of Abstraction: Qualitative-Quantitative Analysis of Parameters

The supplementary questions to be dealt with regarding how to evaluate and measure these indicators and parameters also led to discourse on numbers and scales; this discourse took project members beyond their respective methodological borders. This process of structuring the exchange and communication, using a collaborative basis, can be recognised and traced in the following sections of this text.

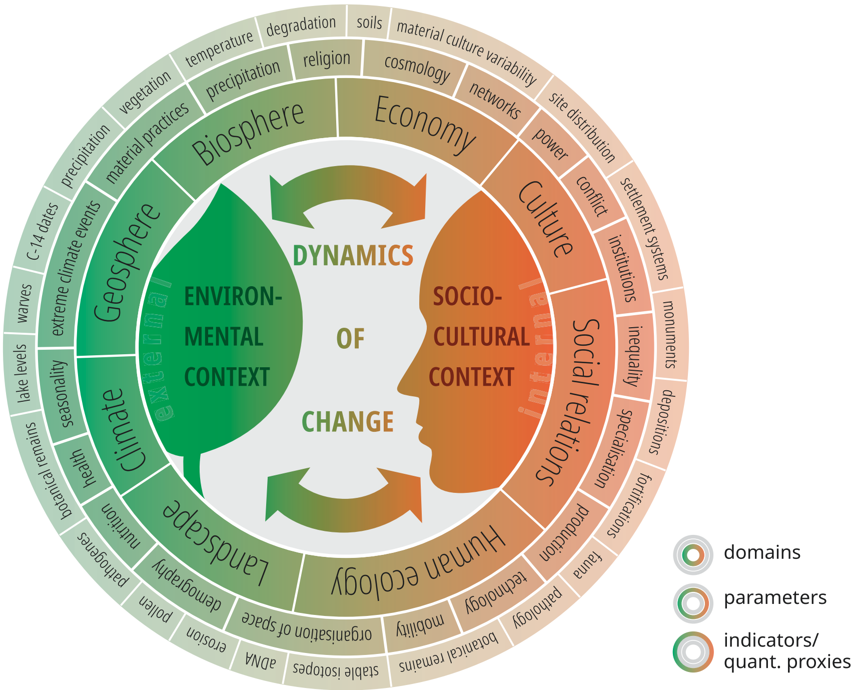

Fig. 2.2 The second iteration of the contexts-domains-parameters model

Rather than follow the path of earlier research into understanding transformations, such as taking a computational perspective using complex systems theory (e.g. McGlade & Van Der Leeuw, 1997), we took a more flexible methodological stance. Our aim is to understand transformations in prehistory, and find patterns and regularities in the various aspects which we identified in our case studies. It should be stressed that these patterns which we see in how transformations came about, evolved and affected prehistoric socio-cultural and environmental domains are not patterns in the classic-archaeological sense, but rather patterns in the transformations of socio-environmental systems.

In order to gather comparable data on the parameters, the individual subprojects evaluated the changes in the parameters relevant to their research on a scale from −1 to +1 (mathematic: derivative), along the timescale of their investigated transformation processes; this scale was used to express the positive or negative development, or the increase or decrease of each parameter. An absence of change between the time intervals was given the value 0. In consequence, the change from one level to another is emphasised, not the duration at a specific level. As there is no change from the high or low level, the “no change” of status equates to zero. The results represent an evaluation by each subproject of the changes in conditions in individual areas of life, the sum of which should enable insights into transformations (in the

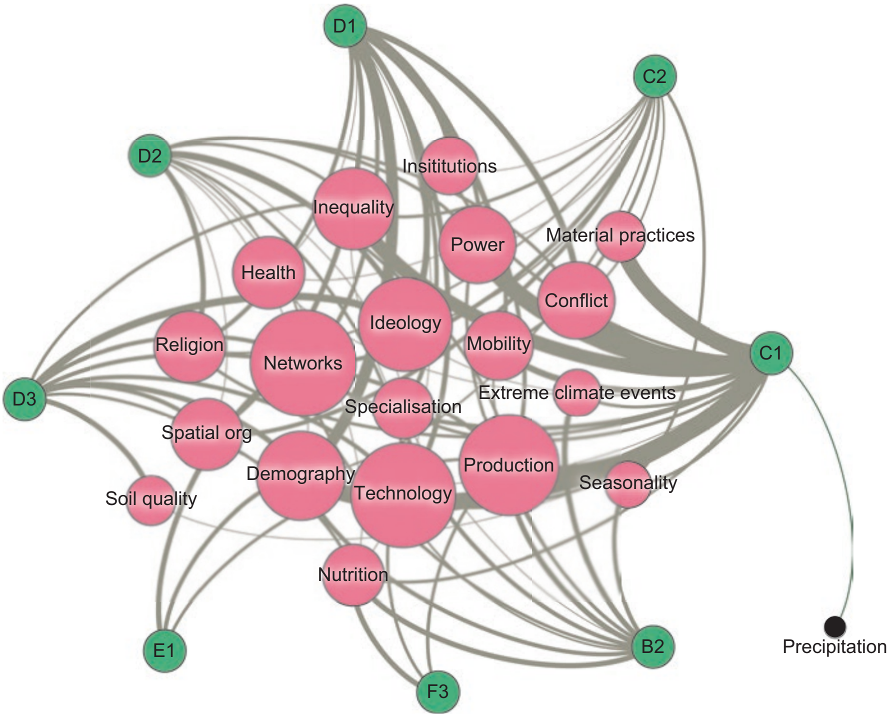

Fig. 2.3 An example of how shared vocabulary aids research communication. This social network shows internal communication on parameters, resulting from analysis of self-reported qualitative-quantitative data. Subprojects shown in green, and parameters in pink. The size of the parameter circles reflects how many subprojects are working with them, and the thickness of the edges reflects the granularity of the changes related to the respective parameter within each subproject. The subprojects themselves are not scaled by any network specific value

sense of the definitions provided in Chap. 1) when synchronous development, identical sequences, or cyclical courses occur. The qualitative element comes from the interpretation of the data within each case study into the various parameters which exist; different data can be used to represent various parameters. For example, in one case study "power" may be represented by the appearance of large, centralised institutional buildings in a certain time and place, and in another case study "power" may be represented by imported prestige goods in the hands of a restricted group within the society. Yet both would be power; hence the abstraction taking place. This qualitative-quantitative data can not only be used to investigate transformative processes in the past, but also provides key insights into how the parameters are used across our entire project. The openness of the definitions used for the individual parameters is both a feature of the abstraction process and a strength which allows us to strive to understand human history on the basis of distinct and varying transformations. The discussions between various case studies and disciplines regarding what the terms mean aided us in sharpening the picture of our parameters without homogenising them completely. It is part of the flexibility of the parameters that they are understood to represent the same concepts but often based on differing types of data. A similar discourse is also taking place in other large, interdisciplinary research projects, as can be seen in the discussion of the definition of "interaction" by Nakoinz et al. (2022).

Table 2.1 shows the data from one subproject as an example. Here can be seen that over the time period 2000–600 BCE across Northern Central Europe, not all parameters from the overall model (Figs. 2.1 and 2.2) are relevant to the transformations taking place (the transition to the Middle Bronze Age and the start of the Urnfield phenomenon). Additionally, certain parameters such as inequality and production only begin to play an important role later in the timespan.

2.4.1 Communication Structure

The current state of research about the impact of interdisciplinarity and its benefits over disciplinary research has so far been unable to draw clear conclusions due to a lack of empirical information about the desired, appropriate and actual levels of communication between disciplines (Jacobs & Frickel, 2009, p. 61). A qualitative-quantitative assessment of the domains-parameters-indicators model using social network analysis and self-reported quantitative weighting of the individual parameters for each subproject is able to shed light on the communicative structure within the CRC 1266 and the various subprojects within it, which are interdisciplinary to different levels. Looking at the example of the quantitative-qualitative data collected by one group, we can observe two different aspects. First, a focus on a set of parameters which play a relevant role for this group. Second, the values provide a scale of granularity within the respective changes, which is linked to the quality of the related data and the effort of evaluation ranging from "on/off" to nearly discrete values of multiple steps of change (see Table 2.1).

The method of social network analysis was chosen for the analysis and visualisation of the aforementioned, underlying communication processes within our project, on the basis of the qualitative-quantitative data previously described. The social network analysis uses 1321 evaluations of change in the relevant time slices from 8 subprojects. The parameters which were assessed in the projects are not equally represented, rather they are based on the various research questions, as well as the collected and generated data, from each subproject. This results in reinforced communication on a specific parameter, e.g. on known networks, and out of this a weighting (indegree) for the individual parameters (nodes) within the CRC 1266. In order to determine the quality or weight of the discourse on a specific parameter within each subproject, the degree of differentiation within the possible values of −1 to +1 are evaluated. This is based on the number of different values. In this way, a rather striking or simple variability leads to a low total value, while high differentiation with numerous increments based on several indicators leads to a high total value for the relevant parameter. The total values reached in this analysis are, as

Table 2.1 Snapshot of the dynamic process of the quantitative-qualitative data collection by one subproject (state 2020). Empty cells show where no relevant parameters were identified in this case study

Domains	Date BCE/ Parameters	2000-1900	1900-1800	1800-1700	1700-1600	1600-1500	1500-1400	1400-1300	1300-1200	1200-1100	1100-1000	1000-900	900-800	800-700	700-600	600-500
Cosmology	Combined burial custom, deposition, cooking pits	0	0.125	0.125	0.1875	0	0.6875	0.0625	−0.1875	0	0	0.125	−0.0625	−0.1875	−0.1875	0
Networks	Gold, iron		0	0	0	0	1	0	0	0	−1	0	1	0	0.5	0
Power																
Conflict																
Institutions																
Inequality	Gold, sword, dagger				0	0	1	0	0	0	−1	0	0	0	0	0
Specialisation																
Production	Tools (axe, sickles)					0	1	0	−1	0	0	0	0.5	0	0	0
Technology	Sickles (flint/ bronze)	0	0	0	−0.5	0	0.5	0	−1	0	0	0	0	0	0	0
Mobility																
Organisation of space	House sizes	0	0	0	−1	0	0.5	1	0	−1	−1	0	0	0	0	0
Demography	Human impact (pollen data)	0	0	0	−1	−1	0.5	0.5	−0.5	−0.5	0	1	0	0.5		
Nutrition	Cereals and oil plants		0.5	0	0	0	0.5	0	1	0	0	0	0	0	1	0

(continued)

Table 2.1 (continued)

Domains	Date BCE/ Parameters	2000-1900	1900-1800	1800-1700	1700-1600	1600-1500	1500-1400	1400-1300	1300-1200	1200-1100	1100-1000	1000-900	900-800	800-700	700-600	600-500
Health																
Seasonality																
Extreme climate events																
Material practices																
Precipitation																
Religion																
Soil quality	Erosion	0	1	−0.5	0.5	−1	0	0.5	0	0.5	0	−0.5	0	1	−0.5	0
Cosmology	Combined burial custom, deposition, cooking pits	0	0.125	0.125	0.1875	0	0.6875	0.0625	−0.1875	0	0	0.125	−0.0625	−0.1875	−0.1875	0
Networks	Gold, iron		0	0	0	0	1	0	0	0	−1	0	1	0	0.5	0
Power																
Conflict																
Institutions																
Inequality	Gold, sword, dagger				0	0	1	0	0	0	−1	0	0	0	0	0
Specialisation																
Production	Tools (axe, sickles)					0	1	0	−1	0	0	0	0.5	0	0	0
Technology	Sickles (flint/ bronze)	0	0	0	−0.5	0	0.5	0	−1	0	0	0	0	0	0	0

Mobility																
Organisation of space	House sizes	0	0	0	−1	0	0.5	1	0	−1	−1	0	0	0	0	0
Demography	Human impact (pollen data)	0	0	0	−1	−1	0.5	0.5	−0.5	−0.5	0	1	0	0.5		
Nutrition	Cereals and oil plants		0.5	0	0	0	0.5	0	1	0	0	0	0	0	1	0
Health																
Seasonality																
Extreme climate events																
Material practices																
Precipitation																
Religion																
Soil quality	Erosion	0	1	−0.5	0.5	−1	0	0.5	0	0.5	0	−0.5	0	1	−0.5	0

weight of the edges in the network, a measure of the diversity and differentiated nature of the indicators upon which the parameters are based, as well as the complexity of the resulting discourses.

The network which results from the variability of the values of change shows the parameters used in the centre, of which the largest were addressed by numerous subprojects by means of the relevant indicators (indegree). Here there are noticeable differences, so that analyses of networks or related topics like exchange and interaction are particularly frequent. Aspects of ideology, in the broader sense of the constitution or definition of groups, and technological changes or shifts in productivity are also particularly in focus.

The weighting of the edges shows a clearly higher variability between the subprojects. This variability consists of not only the number of nodes per subproject, but also the variability of the weighting within the edges per subproject. In Fig. 2.3 the thickness of the edges is inversely proportionate to the level of granularity; the thinner the edge, the more fine-grained the degrees of change.

Granularity is another characteristic of the data we have regarding the parameters, which can be used to inform us of the intensity of communication potential within each case study. It relates to how fine-grained the data are for each parameter; the more differentiated the individual values for a parameter across the time-slices, the more important that parameter for the relevant transformation processes and the more in-depth it is being studied in that case study. This can be quantified and represented by the standard deviation of the values given (derivatives, as stated previously), as in Fig. 2.4.

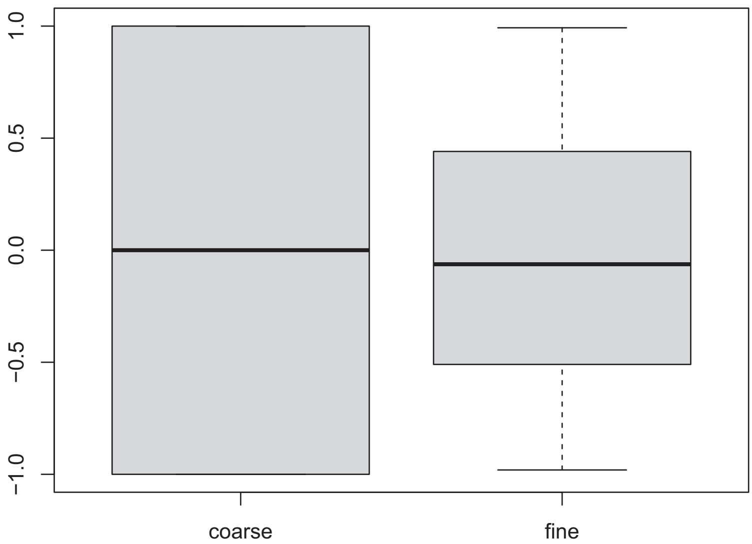

Fig. 2.4 Illustrative comparison of different levels of granularity, each based on 100 random numbers, either −1, 0, +1 exclusively, or from −1 to +1

Overall, the network shows a high density, with a value of 0.225; although it must be considered that the edges are only possible between subprojects and parameters and therefore the value of 1 for the connection of all nodes with each other is not possible. This high level of homogeneity within the entire network and the relatively low variability in the meaning of the individual parameters are the result of the previous discussion on how communication is structured within the CRC 1266. In view of this, the graph shows the degree of success in terms of this goal of structuring communication within the previously heterogeneous research groups brought together within our research project. On the other hand, the variability of the edges shows the emphases and individual configuration of the various subprojects. In addition to this illustration of the previous structural measures and their implementation, the graph also points to the potential of individual parameters and the strengths of the subprojects, which could stimulate further discussions and new co-operations. The graph is, therefore, an expression of further potential which can be explored within our research.

2.4.2 Transformations Across Time

The qualitative-quantitative data could be used to visualise the transformations within the different case studies. Here we continue our example from the Bronze Age of Northern Germany as an illustrative case. Plotting the change in the relevant parameters across the time period under investigation shows several interesting patterns (Fig. 2.5): Firstly, it shows something which our project has emphasised from the start — that change is **always** occurring within socio-environmental parameters. Secondly, there are two transformation phases visible in the chart, where there is change in almost all parameters at once (whether that change be away from or towards stability, here presented as 0); this fits with the

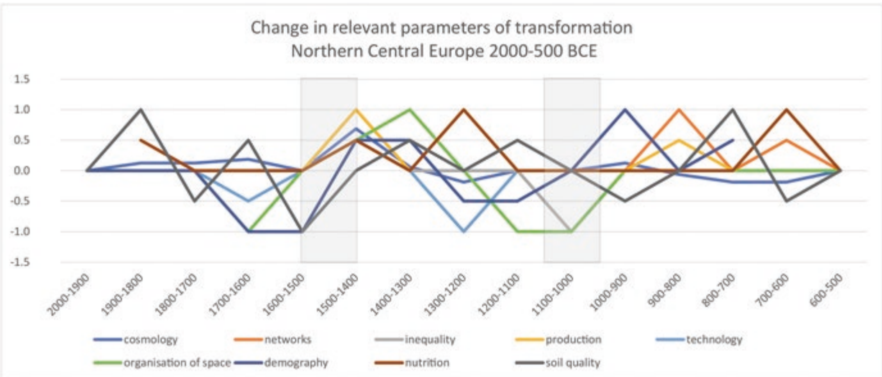

Fig. 2.5 Visualisation of the qualitative-quantitative data from a Bronze Age case study, showing two main transformation periods

definition of transformation we employ in our project (see Chap. 1). In our Bronze Age case study, these transformations occur at around 1500 BCE (when all parameters start to move towards the positive) and 1100–1000 BCE (where many parameters again move towards the positive as soil quality declines). Working with such visualisations from multiple case studies across wider stretches of time could also, in the future, enable us to compare the rates of transformations across human history (see Chap. 10).

2.5 The Third Level of Abstraction: Scientific Narratives

This level of abstraction accompanied the generation of, and is built upon, the qualitative-quantitative data; the writing of narratives of transformation. These were based on the same raw data as the qualitative-quantitative analysis, but this time these data were described and interpreted. As such, they represent a more generalised and accessible understanding of the transformations we are researching. The narratives also use the common vocabulary of the parameters, but are able to bring in more nuance and incorporate some of the levels of inference uncertainty that are inherent in archaeological and palaeoecological interpretation. The clear link back to the data is not, however, completely lost at this scale of abstraction: An advantage of the narrative level is that it can include citations to the original published research from our project. This allows a different form of comparability: Readers can find the original archaeological or palaeoecological data in the publications and thereby use both these and the narratives as a means to compare our results with their own research.

To continue working through our Bronze Age example, here are some examples of the narrative which arose from the original data and the previous levels of abstraction (see Fig. 2.6):

1. Transformation 1500–1400 BCE, beginning of Period II

From 1500–1400 BCE in Schleswig-Holstein changes in the settlement structure can be seen. Despite few finds, there are indications of an increase in house sizes and settlement activities from 1400 BCE. Likewise, from 1500–1400 BCE we can observe a strong increase in import products such as gold and bronze. The number of bronze axes, swords, and daggers increases steeply (there were previously a very small number of finds), while the frequency of sickles (in bronze) once again reaches the levels from during the Late Neolithic (when they were made of flint) after a short decline (1700–1500 BCE). Around 2000 BCE in Schleswig-Holstein burial mounds began to be erected, which increased greatly 1500–1400 BCE and then maintained this level of intensity until approximately 1100–1000 BCE. From 1300 BCE, cremation burials began, eventually ousting inhumations around 1100 BCE. The deposition of hoards also greatly increased once again c. 1500 BCE. From this time onwards, a very uniform increase occurs in all

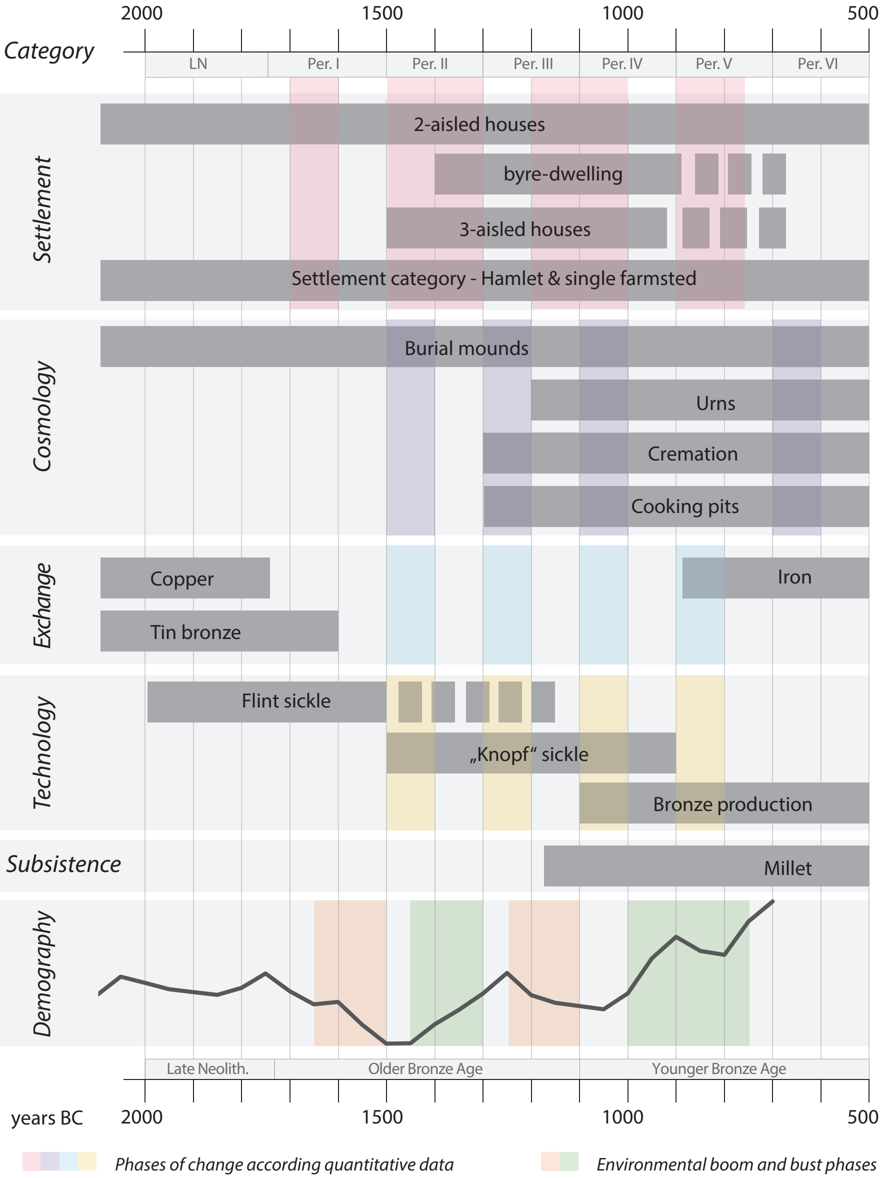

Fig. 2.6 An overview of the qualitative data on the transformations between 2000 BCE and 500 BCE in Northern Germany (Kneisel et al., 2019, Fig. 5)

investigated proxies. A diversification of agricultural strategies can also be recognised from 1500 BCE. The increase of bronze artefacts and monumental structures first begins slowly from Period 1a, and gathers pace in Period II.

1500 BCE is the time in which the more southerly Únětice groups had already collapsed, out of which grew new economic networks. Metal, which was a previously controlled resource, now reaches the Jutland peninsular and leads to an "explosive" increase in metal finds. The contact zones are directed to the south, in the alpine area. A social elite emerges in the north, which is defined by prestige goods (daggers, swords, gold artefacts), monumental structures, and monumental houses. These social structures are maintained until approximately 1100 BCE. The number of burial mounds remained the same, and even when the number of swords and daggers was slightly reduced around 1300–1200 BCE, the number of gold artefacts in the burials increased. Likewise, there is an increase in secondary burials in the mounds; the number of newly erected mounds remains the same, yet more individuals are given a (secondary) burial in a mound. Since the human impact on the environment is slightly reduced from 1300 BCE, this means that more individuals aspired to the social level of the "people buried in mounds", yet did not always have access to the grave goods for such a burial (reduction in daggers, swords). (Example: ambitious citizens in the nineteenth century with monumental burial structures and small mausolea mimic noble burial monuments of the eighteenth century).

Whilst we can detect an increase in burials of the elites, we can, however, already see stark changes from 1300 BCE. These are associated with the ever-increasing number of cremation burials, the start of 'ritual' cooking pits ('Kochsteingruben'), and the reduction in deposits, as well as tools such as axes and sickles. Simultaneously, we can identify a diversification in cultivated plants, with the use of gold of pleasure (*Camelina sativa*) and broomcorn millet (*Panicum miliaceum*). The social system remains intact, yet metal objects and the desire to deposit them are both reduced.

2. Transformation 1100–1000 BCE, beginning of Period IV

At the beginning of the Younger Bronze Age from 1100–1000 BCE various changes appear, which are clearest in the burial rites. The total number of burials rises, as does that of flat graves which were not placed in mounds. Once again there is a rise in the number of hoards, which are constantly deposited until approximately 700 BCE. Bronze sickles are phased out, constantly reducing in number, while instead a new variant of flint sickle appears. Axes continue to increase, while gold finds decrease at first. Houses also become smaller again, and a new form of settlement feature — pit areas — appear. From 800 BCE, during Period V, we see an increase in import finds, axes, and the re-occurrence of gold and hoard finds, which are distributed very differently across Schleswig-Holstein. Dithmarschen emerges as a rich regional centre, with exchange networks extending as far as the Carpathian Basin. The most drastic change is, however, the renouncement of monumental structures (houses, graves), the appearance of urned burials and the connected change in the spectrum of grave goods to smaller and more personal items (razors, tweezers). Only in Dithmarschen are further small burials mounds erected, as well as the occasional monumental mound for specific elite burials (e.g. Albersdorf), with parallels to other centres in Seddin (Brandenburg) and Lusehøj (Fyn), which also date to Period V.

In the Younger Bronze Age, the changes are much less uniform and the spikes in the various curves much slighter. The Period V changes are, however, clearly visible. The transition to the Younger Bronze Age takes place step by step and categorically cannot be viewed as the kind of far-reaching and dramatic change seen in the first transformation around 1500 BCE.

2.6 The Fourth Level of Abstraction: Constellations of Parameters and Classifying Transformations

So far, the integrative, multi-scalar model of human-environmental interactions presented here has led to important and insightful results regarding the driving forces behind both specific transformations in the past and transformation processes more generally. For the specific transformations, we developed constellations of parameters which were involved (see Fig. 2.7), and from these were able to create more abstracted, but even more useful, classifications:

- Interaction: certain parameters influence each other and this interaction causes one parameter to be key to the transformation
- Succession: the decisive parameter for a transformation comes at the end of a chain of successive effects of other parameters
- Disconnection: a transformation can be triggered by the disconnection of one parameter
- Multilateral: individual or grouped parameters affect a main parameter independently of each other

As an example, in the case study on Bronze Age transformations, the transformation process around 1500 BCE has a constellation of parameters which can be characterised as an interacting one. It shows how the interaction of changes in certain parameters (here technology, networks, and production) led to a transformation which was expressed primarily through ideological change, in the form of inequality and monumentality (Fig. 2.8).

These constellations can now be used in further research to describe and interpret data on specific transformations. They also formed the basis of a further evaluation of the parameters of transformation first conceptualised in the original model, which lead to the identification and clarification of the following six main driving forces of transformation in European prehistory:

Climate, Land Use, and Land Cover Changes were shown to have had varying effects on different past societies, based on their technological capabilities, social structure and political strategies. The more options a society had in terms of mobility, technological innovations, and diversification of subsistence strategies, the better they were able to cope with environmental impacts (Brozio, Filipović, et al.,

Fig. 2.7 The various constellations of parameters — the culmination of the scales of abstraction and an important step in reaching general conclusions about transformation processes in past societies

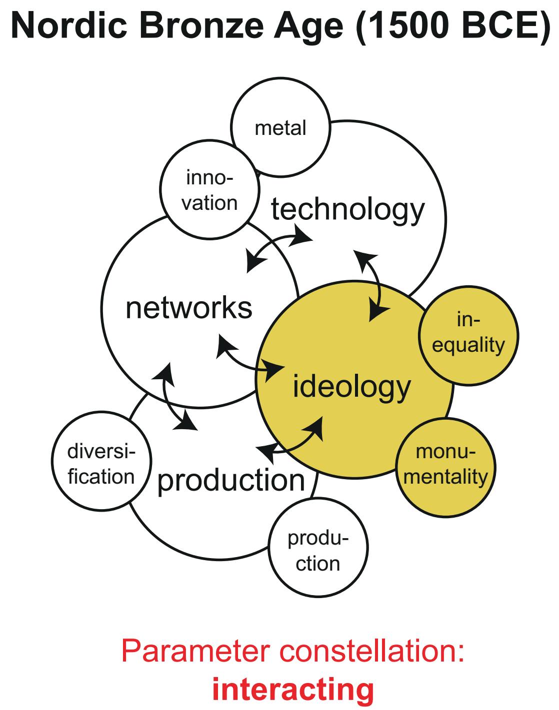

Fig. 2.8 The parameter constellation for the transformation in the Northern German case study around 1500 BCE

2019a; Dal Corso et al., 2019; Feeser et al., 2019; Groß et al., 2018, 2019; Hinz et al., 2019; Kirleis, 2019a, b; Krüger & Damrath, 2020; Mevel & Grimm, 2019; Wieckowska-Lüth et al., 2018; Wild & Weber, 2017; Zanon et al., 2019). The importance of this topic in recent decades outside of our own research has been highlighted by many researchers (cf. the review article by Carleton and Collard (2019), the compilation of papers dealing with the pile dwelling phenomenon and the settling of waterscapes througout Europe (Hafner et al., 2020) or the volume on coastal landscapes of the Mesolithic (Schülke, 2020).

Demography and Mobility arose as important factors enabling population to be reduced when the carrying capacity of its landscape is reached, which is in line with other research on these topics (cf. Bocquet-Appel, 2002; Shennan & Sear, 2021). However, transformations involving population growth or decline in itself was shown to be related more to the status of a society in terms of social stability and economic wealth (Brozio, Müller, et al., 2019b; Feeser et al., 2019; Kneisel et al., 2019; Knitter et al., 2019).

Subsistence Strategies are a vital aspect of what enables social groups to act, especially in the face of climatic change or in dealing with population growth. Evidence of subsistence changes can be seen as expressions of transformational processes (Hartz & Müller, 2018; Kneisel et al., 2015). They can also be a driving factor for establishing networks (Effenberger, 2018, 2017), developing new technologies (Brozio, Müller, et al., 2019b; Feeser & Furholt, 2014; Kirleis, 2019a, 2019b), and even form the basis of new forms of wealth accumulation through surplus production (Brozio, Müller, et al., 2019b; Prats et al., 2020).

Epidemics were previously assumed with the shift to, and intensification of, animal husbandry over the time period under investigation (e.g. Barrett et al., 1998; Cohen & Armelagos, 1984; cf. Lindahl & Grace, 2015 for more recent societies). Our results were able to show that, while sporadic infections with zoonotic and crowd diseases did occur, no true epidemic diseases occurred in our case studies (Fuchs et al., 2019) and are, therefore, perhaps not the unavoidable consequence of keeping livestock. In this way, our research was able to show that epidemics were *not* a main driving force in transformations within prehistoric farming societies; at least not in those which we are researching.

Networks influence not only contact between different societies, but also the internal structure of human societies. Changes in networks can trigger transformations (Groß et al., 2018), introduce new technologies (Brozio, Müller, et al., 2019b; Filatova et al., 2018; Kirleis, 2019a, 2019b) or architectural styles (Haug & Müller, 2020), or provide 'exotic' import goods which temper internal social structure within the societies adopting them (Kneisel et al., 2019). Given the many different forms of networks which can be investigated using archaeological materials and methods (cf. Brughmans & Peeples, 2023, pp. 28–46), there are likely to be many insights that can be gained from further research into their role in prehistoric and archaic transformations.

Ideology could be recognised in two main forms of transformation processes so far; in the political sphere and in relation to burial rites. Ideological solutions were used to maintain group cohesion in the face of social agglomeration and population growth, which affected established socio-political and economic habits (Hofmann et al., 2019; J. Müller et al., 2020). When wider socio-cultural variables are considered, ideological changes can also be seen in shifts in burial rites; whether that be a change from inhumation to cremation, which was part of a wider transformation of social networks and levels of equality (Kneisel et al., 2019), or changes in who was allowed to be buried in the framework of regional social transformations (Drummer, 2022; Rinne et al., 2019).

At this highest level of abstraction, we were additionally able to determine the key factors in socio-environmental transformations since 15,000 BCE, which are now our current research foci; the presence, and specific nature, of mechanisms for resilience in the face of environmental change, and the significant role of demography, networks, and decision-making power for such resilience. These constellations are also flexible, in that they can shift and change based on new data and interpretations which may arise with future research.

2.7 Conclusion

Moving from the multitude of data sources within case study projects to useful conclusions about general patterns of socio-environmental interactions and transformations is a complex and challenging undertaking. Here we have shown our Kiel approach; moving from the hard data to models and general patterns through increasing levels of abstraction.

At the first level of abstraction we moved from our heterogenous data to parameters, developing a shared vocabulary for transformative processes. This process enabled us to communicate and compare more fruitfully across our various disciplines and case studies, while simultaneously widening our understanding of the diversity of the parameters which hold transformative power. The flexibility and openness of the definitions used is a key strength of this level, since it allows for comparison across different data based on a shared understanding that the data represent the same kind of parameter; this is of paramount importance for such a diverse research project. In this way, we were able to mitigate the issue of needing to invest extra time in increasing competences in other disciplines at the cost of time and scope of the research itself (cf. Kerr, 2020, p. 1344).

The second level of abstraction was the qualitative-quantitative analysis of this communication and the parameters which we developed. This analysis is also part of our reflexive approach to (re-)evaluating our parameters and assumptions at each new stage of our research. Here, we were able to determine that certain parameters were more intensively discussed across our research, which became important in the fourth level of abstraction, as we shall see later.

The third level of abstraction is where we developed scientific narratives on the basis of the data from the previous levels of abstraction. This is the level at which interpretation begins to play a greater role in understanding what happened during past transformations, and impact they had on people and their environments. This level is one of increased nuance and is able to incorporate elements of uncertainty which are harder to express at the lower levels of abstraction.

The fourth level of abstraction presented here is the one which moves towards generalisation of our results, further enabling comparison not only within our research project, but also beyond it. It is a level at which we can gather the patterns we have determined at lower levels of abstraction into models which are applicable beyond the temporal and spatial scales which originally informed them. At this level we are able to couple back to insights from early levels, such as identifying the six main drivers of prehistoric transformation in European prehistory which we are continuing to investigate, and evaluating how these relate to those parameters which can be seen to be the crux of communication across the project in the second level of abstraction (see Fig. 2.3).

The Kiel approach should, however, not be seen as a purely linear, directional process, which culminates in results only at the very end. While the levels build upon each other, the process is reflexive as we gain more data and revise our interpretations. The interplay of these different levels of abstraction is what allows us to create a more holistic understanding of past transformations, while still coming to clear and comparable interpretations of our data. The methodology of the Kiel approach we developed was used in other contributions to this volume, for example 'Cereal Agriculture in Prehistoric North-Central Europe and South-East Iberia: Changes and Continuities as Potential Adaptations to Climate' (Chap. 6).

Another result of our application of this approach is the digital exhibition of the CRC 1266 — 'Alles bleibt anders? Transformation processes in time and space' (allesbleibtanders.com). Thanks to having worked through this interpretative framework of scales of abstraction, we were able to distil the essence of ten important prehistoric transformations (so far) into a format which is easily understood and accessible for the wider public. While still being based on the original data of the individual case studies, the parameters step into background somewhat to allow the stories of past experience to shine and inform the public in an engaging and entertaining, yet still scientifically-based, way.

The Kiel approach presented here has not only enabled our research project to uncover great insights into transformation processes in prehistoric Europe from 15,000 BCE–1 BCE, but we also hope that it will inspire other researchers working with equally complex data and questions. It is also a complementary approach to the methodological anatomy of transformation presented in the next chapter by Ribeiro et al.

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Chapter 3
Conceptualising an Anatomy of Transformations: DPSIR, Theorisation, Semiotics and Emergence

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3.1 Introduction

Archaeology and the study of past societies have undergone some of their most radical changes in the last decades. Meanwhile, archaeology advances so fast that it is difficult to capture the state of the art at any key moment. Some of the most radical changes concern how interdisciplinary research on human-environmental interaction has helped us understand and explain past societal transformations. Most of these changes were spurred by new funding schemes and the rise of new scientific, computational, and quantitative methods. These changes occurred in a rapid fashion – in fact, as David Killick (2015) documents, the rise of archaeological

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science was so quick that it led to several issues with regards to funding and training scientists and also assessing the scientific quality of this new type of research.

While archaeological science and the study of human-environmental interactions have improved and become quite successful in the meanwhile, they still carry issues inherited from past archaeological traditions as we shall explore further below. With the advent of postprocessual archaeology, human-environmental interaction was critiqued and accused of being determinist and overlooking human agency (e.g. Hodder, 1982; Shanks & Tilley, 1987) but these did not stop human-environmental studies from further development, remaining a prevalent way of doing archaeology today. Some of the developments that human-environmental studies have undergone include the incorporation of theories and have been more attuned to human agency and symbolism, however, the overall perception of human-environmental studies is one that recognises it as primarily determinist and focusing more on the environment side in detriment to the human side (Arkush, 2011; Stanton, 2004). Archaeological theory, as it has been practiced in the last decades, is partly to blame for this situation. More often than not, theorists have tended to avoid engaging directly with human-environmental studies with the aim of supporting or improving them. In fact, in recent decades, archaeological theory has fragmented into a plurality of mutually independent forms of discourse, most of which just ignore human-environmental interactions altogether (Gardner & Cochrane, 2011; Kristiansen, 2004). On a similar note, the role of semiotics in archaeology was to explore meaning and context in past societies, but this has been done only by a handful, none of whom have been primarily devoted to the study of human-environmental interactions.

In summary, archaeology has developed some new and interesting methods and insights, but it has done so in a splintered way. This chapter aims towards finding common ground by pursuing an integrative framework that combines the study of the transformation of past societies with the study of human-environmental interactions, archaeological theories, and semiotics. More specifically, we aim to outline a flexible model that allows us to understand how transformations occurred in the past, with a particular focus on the environmental sciences, by making a combined use of the DPSIR framework, archaeological theorising, semiotics, and emergence. We believe that this "anatomy of transformations" allows archaeologists to recognise and explain most of the aspects concerning how societies transformed in the past (and present, too).

Nonetheless, this anatomical framework is not meant to provide the only way to recognise or understand how transformation processes occur, nor shall it give a dogmatic perspective on past societies. It is above all a heuristic framework that assembles several powerful tools and integrates them as modules, some of which are already used by archaeologists, while some remain unknown. When we state that this framework is 'flexible', we are deliberately stating that parts of it can be removed or other modules might be added, depending on the circumstances and aims of the research in question. As we described above, archaeology is a very complex and multi-faceted discipline today, so it is unreasonable to expect that there can be a single and unified framework that can be used universally across the board. For instance, given that some regions of the world have more historical data, whereas other regions have richer environmental archives, it is only reasonable to expect that the anatomy of transformations framework has to be adapted accordingly to what is available. Furthermore, it is also unreasonable to expect that the same amount of attention and funding can be devoted to the anatomy of transformation by different people and projects around the world. This means that it should be possible for the anatomy framework to be downscaled or upscaled proportionately to how much is invested.

3.2 The State of the Art

With regards to transformations, there is an ongoing discussion as to how one should describe human agency and action. Travis Stanton (2004) and Elizabeth Arkush (2011) have pointed out that archaeology of today, in most parts of the world, describes human action under two distinct frameworks: as systems-centred or agent-centred. Systems-centred research tends to focus on reconstructing past environmental conditions, with the aim of ascertaining how certain ecologies affected human behaviour, and in the process understanding how humans affected the environment in turn. From a methodological standpoint, this type of research relies primarily on the hypothetico-deductive approach (Kelley & Hanen, 1988) and/or inductive/quantitative methods, which involve the recognition of patterns that can be correlated with each other (Clarke, 1968, p. 20). Agent-centred approaches forgo the environment in favour of the social, political, and ideological contexts, which shape how humans behave. Unlike systems-centred approaches, some agent-centred approaches involve the study of how past social agents fought against the formation of hierarchies (e.g. Angelbeck & Grier, 2012; Crumley, 1995) or how social relations form identities and shape behaviour (e.g. Fowler, 2016). In summary, the difference between these two types of approach concern how much environment or intentionality one is willing to concede as the main driver of transformation in history (Arkush, 2011, p. 200).

However, there is much more to archaeological practice than just these two approaches to the past. Besides the dual way of describing human action, there is also the role of archaeological theory in providing context to those descriptions. Archaeological theory is perhaps where most fragmentation is noticeable because theories are now being generated and discarded following very short use-cycles (Mizoguchi, 2015, p. 16; Ribeiro, 2016). Thus, theories have become an arena of discussion for a select group, with most archaeological practitioners ignoring theory altogether. For example, many of the big theoretical movements in archaeology of the previous century have disappeared to give way to a more pragmatic way of thinking. The hermeneutic approach (e.g. Hodder, 1991, 1992), the phenomenological approach (e.g. Tilley, 1994), and all the critical/epistemological discussions (e.g. Kelley & Hanen, 1988; Kosso, 1991; Wylie, 1989) that characterised archaeology during the 1990s have gradually disappeared. Some theoretical ideas tried to make their mark during the turn of the millennium, such as practice and agency theory. These were based on different thinkers but relied largely on the work of Pierre Bourdieu (1977) and Anthony Giddens (1979, 1984); while these theories still have adherents in archaeology (e.g. Gardner, 2021; Kienlin, 2020) they have largely fallen out of favour among practitioners. Another idea that gained some degree of popularity in archaeology was semiotics: even though many of the key ideas of postprocessual archaeology have lost popularity, the idea of an interpretive archaeology that focuses on symbolism and meaning was considered important to many archaeologists (e.g. Bauer, 2002; Crossland & Bauer, 2017; Preucel, 2006; also cf. Frerichs, 2003; Furholt & Stockhammer, 2008), yet semiotics never reached a mainstream status. In a similar fashion, the New Materialisms, relational ontologies, and posthumanisms (e.g. Harris & Cipolla, 2017; Olsen et al., 2012) have gained considerable attention, but like many previous trends, they have not managed to make a widespread or lasting impact on the practice of archaeology.

As stated by Stephen Shennan (2007, p. 220), it seems that after the hectic theoretical debates of the previous century, archaeology has simply gone back to conducting archaeology. It can even be claimed that outside of the anglophone world there were never that many theoretical debates to start with. As Reinhard Bernbeck (2007, p. 208) points out, the theoretical concerns we might have in Europe are certainly not felt in other parts of the world, such as the Middle East. There have also been calls for a 'death of theory' in archaeology, in the sense that theory should not be the dogmatic position it often appears to be but should rather be an eclectic and flexible exercise of reasoning about past societies (Bintliff & Pearce, 2011). Mizoguchi (2015, p. 16) has also pointed out that theory has generated some negative feelings among some archaeological practitioners because of the perception of archaeology consisting of contract archaeology (i.e. CRM), which is seen as tough, low-income, and practical, whereas academic archaeology is considered fairly easy, high-income, and theoretical. While there is certainly some truth to the differences between contract and academic archaeology, there is much misunderstanding about the role of archaeological theory and what it can contribute.

With this being said, archaeologists have also found some degree of common ground, rallying around certain objectives, such as the study of inequality, demographic growth, the role of conflict, mobility, etc. (Kintigh et al., 2014). At the same time, archaeology has become much more data-centric, with archaeologists focusing primarily on the recovery, analysis, and modelling of archaeological material rather than theory in the search for answers about past societies (Kristiansen, 2014). For instance, there has been widespread adoption of computational methods, akin to a 'Big Data' revolution, which have allowed archaeologists to access and model vast amounts of data (Gattiglia, 2015; Ribeiro, 2019). Isotope and genomic analysis have gone from niche to fairly standard methods that many projects now engage with (Killick, 2015). In addition, given the current prevalent use of C14 dating, Bayesian modelling and sum-probability distributions of C14 dates have become very popular (Otárola-Castillo & Torquato, 2018; Williams, 2012). It must be mentioned that this shift to more practical concerns, the use of new scientific methods, and the aggressive collation of data that characterises the archaeology of today has been thoroughly critiqued from several angles (Cunningham & MacEachern, 2016; Ion, 2017; Ribeiro, 2019; Sørensen, 2017, to name just a few).

Many of these critiques highlight very valid issues, some of which cannot just be hand-waved away. We need to address some of these critiques because the anatomy of transformations is not simply a framework where different approaches are piled onto each other uncritically but rather a framework that aims to unify how we explain the transformation of societies (see Mandelbaum, 1977, for an attempt towards the unification of historical knowledge). But for this to be possible we need to address the difficulties we face and how they can be overcome.

3.3 Human-Environmental Interaction from the DPSIR Perspective

The themes and topics that have caught the attention of many archaeologists in the last decades seem to revitalise and rehabilitate many of the concerns of processual archaeology of the 1960s and 1970s. To refresh the reader's memory, processual archaeology was a large-scale movement in archaeology with particular prominence in the US and the UK, but it has influenced many archaeologists outside of these regions as well. It was, to use David Clarke's (1973) words, a period of 'loss of innocence', when archaeology underwent a series of changes making it focused less on raw data collecting but on developing new methods of explanation of past societal change. The changes to archaeology enacted by processual archaeologists have been discussed authoritatively elsewhere (e.g. Johnson, 1999; Trigger, 1989) so there is no point repeating them here; however, processual archaeologists subscribed to systems theory (Plog, 1975) which we will need to discuss in order to understand some issues concerning human-environmental interaction.

In general, systems theory conceives of society through an organic analogy, that is to say, as a cohesive system of interrelated parts, where changes in one part necessarily entail changes to other parts, very much like in the case of the human body. Systems theory also presupposes that societies have some degree of resilience (Redman, 2005), making it adaptable to changes of the external environment and keeping it in homeostasis, a status of balance between people and the environment. The understanding of systems theory varied to some extent among processual archaeologists (e.g. Clarke, 1968, pp. 42–83; Flannery, 1972), but many archaeologists followed Lewis Binford when it came to systems theory. According to Binford (1962), archaeology had the task of explaining culture change and in order to do this, culture needed to be recognised as a *system that adapts to the environment*. Following Leslie White's cultural evolutionism, Lewis Binford argued that culture is 'man's [sic] extrasomatic means of adaptation' (Binford, 1965, p. 205). *Prima facie*, what Binford argued was that the explanation of how past societies changed was contingent on how these adapted to their environment. This might seem like a form of ecological determinism (Arponen et al., 2019; Stanton, 2004), but as Binford argued, humans live in an ecological system where they can react within certain limits (Binford, 1962, p. 218). But systems theory was never applied with the coherency nor the consistency that the literature seems to denote – in fact, it has been used in archaeology in a rather liberal manner – by referring occasionally to terms such as 'feedback', 'equilibrium', or 'homeostasis' (Salmon, 1978, p. 182).

Nevertheless, processual archaeologists did devote a large part of their attention to the role played by the environment, highlighting environmental changes as the primary factor for how societies transformed in the past.

From the 1980s onwards, postprocessual archaeologists levelled a radical critique against processual archaeology in general, and the idea of culture as a system in particular. As Ian Hodder (1982, p. 3) points out, the idea that society is analogous to an organism is not necessarily a helpful way to think, since societies can undergo several transformations throughout its history, which an organism cannot. Additionally, Hodder points out how archaeologists who subscribe to systems theory automatically presuppose that past societies were primarily homeostatic, which means that the transformation of a society could only occur due to external factors, and measured by independent variables, such as environmental factors, long-distance trade, or demographic increase (Hodder, 1982, p. 3). But perhaps what postprocessual archaeologists were most troubled about was the fact that systems theory was *functionalist*, that is to say, it conceives of a culture in purely utilitarian terms. For postprocessual archaeologists, it was unacceptable that cultural elements, such as rock art, rituals, and idols, were designed with utilitarian principles in mind. But when a society and its culture is defined as the means of adapting to the environment (*sensu* Binford), then one is forced to explain how certain decoration patterns on pottery and rock art designs helped their society adapt to the environment.

With postprocessual archaeology's demise and its critique having lost most of its influence in recent years, there has been a return to processual archaeology. As stated earlier, there has been a rallying call by Kintigh et al. (2014) to pursue 25 grand challenges in archaeology. Most of these challenges mimic the concerns of processual archaeologists, and it has come as a surprise to some that these have been picked up again (e.g. Barrett, 2016). Following a systems-centred archaeology, the 25 grand challenges focus on measurable objectives, such as understanding how certain societies survived in certain environments, how the environment shaped resilience among human communities or led to their downfall, how humans shaped the environment, or what factors constrained and drove population dynamics. In addition to this, there has been a renewed concern with the evolution of societies (e.g. Morris, 2022; Shennan, 2018), as demonstrated by the growing popularity of niche construction theory – a theory that in archaeology involves recognising ecology and human culture as a process of constructing a niche that is inherited by subsequent generations (Laland & O'Brien, 2010). The resurrection of these concerns is due to many reasons, but certainly one of the most important is the increase in the quantity and quality of paleoenvironmental data, which in turn has provided more nuanced and refined reconstructions of past environmental landscapes.

At face value, there is nothing inherently wrong with this type of research, but oftentimes the study of past human-environmental interaction can appear to provide very oversimplified explanations of transformation processes. Just because postprocessual archaeology has fallen out of fashion, this does not mean that it was wrong in its critiques of processual archaeology. For example, Contreras (2017, p. 6) states that while processual archaeologists such as Lewis Binford argued that culture could only change because of the environment, research in human-environmental interaction of more recent times is more nuanced, with studies focusing on changing climatic conditions that focus on contingency, behavioural diversity, and human adaptation. This is true and while some studies are in fact more nuanced, the vast majority still follow rather formulaic models in which some environmental factors act upon a human system and the humans act in response. As Alexandra Ion (2019, p. 11) points out, these types of studies tend to follow remarkably simple hypotheses, such as did the climate lead to the collapse of civilization *X*, yes or no? Naturally, reality is certainly more complex than 'lack of food/climate/epidemics/wars led to the collapse of civilization *X*', so we should consider a way of conceiving of human-environmental interaction that is not reduced to simple explanations such as factor *A* caused result *B*.

One way out of this issue is to employ the DPSIR framework. DPSIR is an acronym of Driver-Pressure-State-Impact-Response and DPSIR aims at describing processes that occur within human-environmental interactions. It was first developed from the Stress-Response model by Rapport and Friend (1979) and has gone through several iterations until it became known as DPSIR. Originally, this framework was not designed as a unified model for scholarly research but as an eminently practical tool that could be used for environmental assessments and policy creation by entities such as the OECD (1993) or the US Environmental Protection Agency (EPA, 1995). As such, the most important function of the DPSIR model has been to provide an analysis not just of cause-effect relations but also of challenge-response relations. Without replacing causal explanations, DPSIR provides the means that are necessary to speak of causations in a way that allows for a more complex and nuanced perspective of how human-environmental interactions operate. At the same time, DPSIR avoids the opposite scenario, namely that of overcomplicating the various causal relations involved in socio-environmental processes, which in turn could burden our understanding of those processes. Overall, DPSIR provides a way to recognise human-environmental interactions that is not reduced to two-way causal feedback loops (i.e. the environment affects a society, and the society affects it back) nor is DPSIR an overly complex model composed of countless causal interactions. The idea of DPSIR is to reduce complexity, as models often do, without falling prey to simplifications and reductionism.

The earliest iterations of the DPSIR model were quite simple and described human-environmental interactions as pressure on a social system, which in turn responds to that pressure (Burkhard & Müller, 2008, p. 968). These earlier iterations, however, are too reminiscent of the systemic and functionalist model of processual archaeology described above and rather too simple for our purposes. The more complete version of DPSIR that involves drivers, pressures, states, impacts, and responses is certainly more adequate. This being said, it is important to consider that DPSIR does not require all these elements in this order; the term 'DPSIR' refers to a conceptual framework that can have multiple elements and different categories, with the natural scientific disciplines focusing more on some elements and categories, and the social sciences more on others (see Patrício et al., 2016, for a survey of DPSIR and its derivatives).

The first element of the DPSIR scheme is 'drivers'. In general terms, drivers can be both natural and human-induced. In modern applications of DPSIR, human demand for goods and services, good health, security, education, and freedom can be considered drivers. This makes perfect sense in our current world, but some attention must be paid when applying the same notion of drivers to the past. Certainly, the past was populated by human groups that demanded certain goods, but probably not the same and not in the same scale as modern societies do. So, for example, the energy demands of today's civilisation puts pressure on ecosystems via the emission of CO_2, but this type of driver and pressure was largely irrelevant in prehistoric times. In the prehistoric past, a more relevant driver would have been something like demographic growth (see Shennan et al., 2013) which could have led to internal societal pressures and pressure upon the environment, such as overuse of land for agriculture. DPSIR, however, does not state that demographic growth leads to overexploitation, since that is something that can only be ascertained by testing this hypothesis against the available data; what DPSIR does instead is allow the identification of demographic growth as a driver, which might have put pressure on a society and/or the ecosystem. War is another example of a driver, namely in the sense that a war can drive a society into a state of pressure by burdening the wealth of the society and/or by leading to migration.

In ecological research, DPSIR is most commonly conceived to pave the way for policy change rather than as a tool for past human-environmental research. In these contexts, DPSIR tends to focus on those drivers that are socially and/or economically motivated, such as an increase in the human demand for goods and services or the human demand for freedom. In the past and in different regions, however, it is safe to say that the environment itself may be understood as a driver (Bidone & Lacerda, 2004; Pinto et al., 2013). Either way, both environmental and human drivers lead to 'pressure', the second element of the DPSIR model. Drivers are the direct cause of pressure, namely in the sense that a process such as the increase in the demand for goods and services will put pressure on the environment through the intensification of agricultural and industrial production and/or energy expenditure. In general, pressures tend to be easier to measure than drivers since pressures often have a variety of proxies and display parameters that can be more easily derived from socio-economic and environmental databases.

The third element of DPSIR is 'states', which often result from pressures on the ecosystem. Unlike pressures, which can be continuous processes upon socio-environmental contexts, states are usually conceived of as the consequence of pressures. Oftentimes, a state is a delayed response resulting from pressure, such as acidification caused by pollution or a pandemic on the economic status of a country.

The previous three elements of the DPSIR scheme sometimes lead to an 'impact' on socio-environmental systems, especially as relates to the effects on human life. In general, an impact as the fourth element of the DPSIR scheme is measured on how human lives are affected by drivers, pressures, and states, such as how the overuse of soil leads to poorer agricultural practices, which in turn leads to poorer nutrition either for the overall community or for specific groups. On a similar note, the natural or human destruction of habitats can lead to demographic pressure and difficulties with managing and distributing goods and services. The advantages of thinking in terms of impact as a result of the compound of drivers, pressures, and states allow us to think of various processes of the past in a more dynamic manner and to conceive hypothetical processes which analytically unfold into various elements rather than to think in simple monocausal terms. For instance, demographic decline among prehistoric societies is commonly still framed in outdated Malthusian concepts, with wars and overexploitation of resources as the main causes: it is certainly true that these could have been the causes of demographic decline, but several key processes must have occurred in between wars or overexploitation, on one hand, and demographic decline, on the other hand.

This leads to the final element of the DPSIR scheme, namely 'responses'. In the overall framework, responses account for those human actions that deal specifically with changes in the socio-environmental contexts that human societies occupy. From a modern perspective, responses might be conceived of as tending to be legislative and educational in character, but for our research purposes, a more adequate way to think of responses is in terms of what has been termed 'resilience' or 'resilient strategies' (Redman, 2005). As socio-environmental contexts change through time, due to drivers that are sometimes natural, oftentimes human, humans have engaged with resilient strategies to maintain the flow of natural, social, and economic capital. Shifts to more sustainable subsistence strategies, increased mobility, and the introduction of new technologies are all examples of the ways humans managed to adapt to changes in their contexts. Thus, we suppose that humans are responsive beings. Here, a cluster of responsive agency concepts come into play, such as 'cope with', 'adapt to', 'react to', 'combat', and 'stimulate'. As responsive reactions suppose some capabilities on the part of agents, it makes sense to apply Sen's capability approach to archaeology (Arponen et al., 2016). Responses may also bring about new and unprecedented societal states; if so, they are transformative.

With the five basic elements of the DPSIR framework described, it bears reminding that this scheme should be understood as a heuristic tool that aims to represent and categorise human-environmental transformations and not as an all-encompassing explanatory framework in the strict sense of the word. That is why DPSIR has been used in a very wide variety of ways, with many new elements included when it is justified, or with a reduced number of elements to facilitate categorisation. When researching the past, breaking down a process of transformation of society into four to five elements can be helpful from a methodological standpoint. This does not entail, however, that deep societal and environmental transformations in the past only involved four or five elements. Rather, DPSIR helps us to perceive transformations that are neither oversimplified (monocausal) nor overly complex and hard to capture. Furthermore, as a framework, DPSIR has some shortcomings, the most important of which is that it does not seem to easily lend itself to capturing complex long-term dynamics (Rapport et al., 1998; Rekolainen et al., 2003). This limitation is why DPSIR often focuses on the effects of less-complex short-term processes, such as how recent industrial practices affect water sources or how modern construction has affected shorelines, rather than multifaceted long-term processes, such as the effect of the industrial revolution on demographic growth and pressure.

Nonetheless, in and of itself, DPSIR can be a powerful tool to understand past transformation processes, but as a tool used primarily for modern cases and designed for environmental policy, one is limited in what it provides. In fact, even in modern use cases, DPSIR is usually combined with other methodologies (Gari et al., 2015). In the study of past human-environmental transformations, on the other hand, there is the danger of replicating systems theory and thus limiting oneself to conceiving past societies through a functionalist viewpoint. This, in turn, might lead to a perception of past human societies as mere causal chains that affect one another. For some scholars, this qualifies as human agency, especially as it relates to the 'response' element in the DPSIR framework; for other scholars, however, agency is much more than humans acting and reacting to their environment, with the notion of agency concerning social institutions, social identity, customs, and choices, which are conceived of as not just responses to changes in the environment. This above all holds true for those methodologies that emphasise the role of the human as an acting subject (Peebles, 1992).

For instance, when discussing issues such as demographic growth or decline in prehistoric periods, the prime methods tend to focus on the carrying capacity of a given society (cf. e.g. Zubrow, 1971), with overexploitation of subsistence resources leading to periods of famine. However, overexploitation of resources is only one explanation for famine, and in most cases, overexploitation requires understanding the complex processes of how past societies claimed ownership of resources and distributed them. Furthermore, the concept of carrying capacity has been adopted from zoology and it remains doubtful whether there are fixed carrying capacities for human-environmental systems. Overall, the relationship of demographic decline and famine is one that requires much more than just recognising a decline in subsistence, but also involves issues of power and restriction in accessing the commodities entailed by social living, such as certain capabilities (Arponen et al., 2016), with subsistence being one of the most important of those commodities (Sen, 1981). Another example is the concern over the emergence of modern human behaviour somewhere in Africa between 150,000 and 40,000 years ago (Kintigh et al., 2014, p. 14): while the emergence of modern human behaviour has been attributed to environmental triggers (Ziegler et al., 2013), other studies have cast doubt on such a perspective (Roberts et al., 2016); in fact, the very idea of the sudden emergence of modern human behaviour is somewhat suspect (McBrearty & Brooks, 2000).

3.4 Contextualising Behaviour Through Theory

It is central that the anatomy of transformations recognises the role of past communities in history without reducing them to robots following prescribed programmes. While certain models of human behaviour require assumptions that simplify human motivations, such as models that view sociality as altruistic behaviour or subsistence strategies as optimising energy expenditure, the anatomy of transformation realises that human behaviour is also meaningful (Hodder & Hutson, 2003).

This does not mean that there are two levels with regard to human behaviour, one that is mechanistic and functionalist, to which we simply add another layer composed of meanings. All action is simultaneously and integratively causal and meaningful in the sense that all action that might appear purely mechanistic also involves a purpose. For instance, a migration requires much more than just the physical movement from one place to another. Most people move on a regular basis, whether it is to commute to work, to plant something in the garden, from the kitchen to the living room, or to the next town to buy groceries, but none of these forms of movement qualify as migration. Sometimes even moving several hundred kilometres might not qualify as a migration, since to migrate requires the (semi-)permanent relocation to a new region. Concomitantly, this requires the recognition of what qualifies as a 'new region' and some sort of process of passage into that new region (van Gennep, 1960). Thus, while the pure DPSIR scheme can allow us to recognise migration as a pressure or a response, it does little to help us understand the intention of migration in the past. This is why, as a first supplementary ingredient, theory is important.

Theory refers to multiple things in the study of the past: it can refer to the scientific epistemology of research, it can be a synonym of 'hypothesis', and it can refer to methodological discussions. But for our current efforts, theory refers to the ideas that help us contextualise and understand human action of the past. As Henrietta Moore (2000) points out, 'agency' need not be a 'real' thing; it can simply be a concept-metaphor and as such, a way of acknowledging that past people were socially competent actors who knew how to behave in a social setting. Following this line of reasoning, theory aims at making the actions of past people explicit in their original social context. Anthropological theory and ethnoarchaeology remain two of the most powerful tools in providing context to the actions of past people. For example, the study of past societies that have relied on long-scale trade along Europe, especially via maritime routes, has been contextualised quite competently through the anthropological theory of Mary Helms (Helms, 1979, 1988; Kristiansen & Larsson, 2005). Similarly, with the advent of next generation sequencing, biological relationships in the past are now possible to reconstruct; however, in order to do this, it is required to understand how the structure of kinship in different societies could have shaped those biological connections (Brück & Frieman, 2021).

Some humility is necessary to apply theories to the past with some degree of success. This is because it is all too easy to fall into the trap of assuming that there can be a single theory by which one can understand all the relevant processes of transformation and human behaviour in its entirety. As a rule, it seems safe to assume that the more general a theory appears, the less applicability it tends to have. For example, practice theories (Bourdieu, 1977; Giddens, 1984) can be very useful at understanding the general process by which all practices are formed in society, but these theories tend to become more limited when trying to contextualise specific practices and a host of other social phenomena, such as slavery or hierarchisation. What is usually the case is that those theories that appear at face value to concern very specific social and/or economic phenomena are those that tend to be most useful but at the same time have less geographical and chronological incidence. The aforementioned work of Mary Helms (Helms, 1979, 1988) on travel and long-distance trade, for instance, is certainly helpful to contextualise those regions and periods where long-distance travel occurred, such as the European Bronze and Iron Ages, but it is certainly less helpful in those places and times when long-distance travel was not a common occurrence. It is up to the researcher to realise when specific theories are useful and to determine which theories in particular are suitable for different periods and times.

Nonetheless, in general it is often beneficial to rely on theory in explaining human action. The past was not a simpler version of the present nor should past human action be conceived of by way of direct and oversimplified correlations: for example, climatic events did not, in all probability, lead directly to collapse, large-scale structures did not *per se* entail hierarchy and top-down power structures, and famine was not always connected with low subsistence resources. It is not so much that claims such as these are necessarily wrong but they do convey a view of past transformations in a very simplified manner and divest the humans of the past of their capacity for acting meaningfully within those transformations.

3.5 A Semiotic Perspective on Transformations

Taking up this last thought, let us turn back to the DPSIR scheme and see how it can be adapted to our purposes in such a way as to more adequately conceptualise the anatomy of transformations. Let us begin by recalling of some of its potential short-comings that have already been addressed above. In particular, it might appear problematic that the scheme allows historical transformations to be conceived from the outside only, i.e. as some natural process that happens to occur within a purely empirical 'reality', in which humans are not only subject to the same natural forces as all physical objects such as rocks and stones, but in which they also display the same automatic patterns of quasi-robotic reaction as they do. In consequence, our adoption of the DPSIR scheme might seem to conceive of transformations involving humans as non-complex deterministic processes for which the description of the basic laws of physical nature are sufficient.

As important as the physical dimensions of transformations are, humans have, nonetheless, by way of their natural constitution as sentient and rational living beings, the capacity for perceiving and reflecting upon the outer world, both as individuals and within the synchronic and diachronic dimensions of the cultures they are part of; and this capacity for perception and reflection forms, as it is being actualised in the course of the historical events and processes, acts as the basis of the human interaction and manipulation of the environment. It follows that how humans interacted with the environment in the past not only depended on the 'objective' state and change of the environment itself and the subsequent influence this exerted *per se* as if this amounted to a fixed action-reaction scheme, but also how the humans as an independent part of the complex and irreducible system consisting of themselves and the environment perceived, and reflected upon, the environment in turn, including their own place within it.

For example, for human action to have occurred in reaction to a change of the local climate it would have been neither a necessary nor a sufficient precondition that the change itself occurred in the natural world, but the change, and/or its impacts as proxies, had also to be perceived, in whichever way, before it could possibly have led to any response. We need not assume that the response in its concrete shape was anything prescribed and predetermined by physical nature, but we may hold that it was, to whatever degree, shaped by the individual and cultural preconceptions the humans involved in these processes held, as particular as those preconceptions which explicitly or implicitly defined those future states which were eventually chosen in order to cope with the perceived changes. For example, one response to a cooling of the overall temperature might have consisted in migrating to another, more suitable place; or in inventing a new technology like fire with the aim of making it warmer inside one's dwellings; or in just doing nothing because you accept that the eventual annihilation of the community resulting from the change of temperature would be fair divine punishment for not having worshipped the god of the sun enough. Obviously, which specific response was taken would have been informed, *inter alia*, by the prevalent belief system and the available knowledge in the given society that was confronted with the perceived change in the environment; and in addition, this was not a question of human action or intentionality *per se,* but first and foremost of perception and reflection that allowed for identifying, understanding, and responding to the relevant aspects of the environment and its change.

To complicate matters further, we not only have to acknowledge that the relation between humans and the environment, in principle, has such a non-deterministic and mediated quality, but there are, in particular, three more points to consider: first, if an objective change of the environment occurred, it might not have led to any cultural or societal transformation at all because the change was not perceived. For example, it may have occurred too slowly to be perceived, or it happened in an area that was not being looked at, or it was even deliberately ignored because it ran counter to the prevalent belief systems or was beyond the realm of available knowledge that guided the assessment of one's perceptions. In short, outward change had to be actually perceived, and at the same time adequately judged, in order to become a driving force etc. that eventually resulted in human action.

Second, an objective change of the environment might have led to a manipulation of the environment in response, which nonetheless in turn recursively changed the perceptions of the humans and, subsequently, recursively reshaped the interaction with the environment itself. In consequence, we have to conceive of a mediated and at the same time complex interrelation between the environment, its perception by humans, and any action resulting from it, and we also have to allow for irreducible (as the case may be, 'emergent') dynamic feedback loops within the human-environment system.

Third, it is apparently also possible, against this backdrop, that transformations of the human-environment relationship could have been initiated without any objective change in the environment itself, but only because, for example, ideological world views had changed the perception, and the subsequent conceptualization, of the relation of the humans to the environment. That is, transformations need not only be conceived of as purely passive reactions by humans to changes of the environment, but they might equally well have had the form of spontaneous actions that were initiated by the humans themselves without any outward prompt. So it might have been the case that people began to change the agricultural environment because they somehow started to believe that the gods disliked trees and subsequently felled all the trees in their surroundings, with the consequence of this having a profound impact on the hydrological situation that might have made it impossible to feed the animals in this specific area, which in turn led to other consequences that initiated further transformative processes.

Notwithstanding further potential complications of the theoretical situation, which need not be addressed and explicated here, it suffices at this point to see that the relation between humans and the environment, and its dynamic transformations within time, does not have a unidirectional, hierarchical, monocausal, and deterministic character, but instead displays, at least potentially, a bidirectional, complex, mediated, and non-linear entwinement of its two constitutive components. Though there is, of course, a significant variation of the resulting situation with regard to each single transformation, whose concrete historical profile has accordingly to be assessed individually for each specific case, these additional dimensions of the notion of transformation have to be accounted for and must be adequately assessed in the theoretical dimension in order to holistically conceptualise the anatomy of transformations.

How then can we represent this state of things within the approach taken here, especially with regard to the adoption of the DPSIR scheme? First of all, we have to conceive of the relation between the environment and humans not merely in the way we conceive of the relation between physical nature and, for example, a stone as one of its parts. Even if this may, and should, form the basis for understanding transformative processes involving humans within an environment, we at the same time have to situate humans within a mediated relation to the environment that is generated by, and based on, the representation of the world in all of its pertinent dimensions within the humans themselves, both individually and culturally. First of all, this encompasses perceptual content, but then in particular also higher-level mental content on an individual and collective, societal, and cultural scale, including not only the basic meanings of words and linguistic content, but also complex phenomena like religious beliefs, cosmologies, ideologies, and imaginary worlds. It seems trivial to state that the world was meaningful to past humans, but this trivial statement opens the door for a series of difficult questions as to how to identify meanings at the emic level (cf. Furholt & Stockhammer, 2008) – which, to be sure, is no easy task even in the case of cultures for which extensive written sources are still extant, such as the ancient Greco-Roman culture.

The presumptive key to account for such phenomena in a unified and coherent way is to bind the notion of 'representation' to the notion of 'sign', namely insofar as 'to represent' can be understood as 'to stand for' and thus 'to relate to' something, and to use the tools semiotics, as the general theory of signs, can provide us (see Gardin, 1988; Frerichs, 2003; Furholt & Stockhammer, 2008; Parmentier, 1997), especially that form of semiotics that was initiated and developed by the American philosopher Charles S. Peirce (for an overview see, for example, Short, 2007; also Jappy, 2019; Keane, 2018; cf. Atkin, 2016; Colapietro & Olshewsky, 1996; for its recent use in archaeology see the overviews in Baron, 2021; Harris & Cipolla, 2017, pp. 109–128; and cf. the instructive applications by Bauer, 2002, 2013; Crossland & Bauer, 2017; Furholt et al., 2019; Kissel & Fuentes, 2017; Knappett, 2005; Lele, 2006; Watts, 2008). Of course, we cannot here delineate a comprehensive and full-fledged semiotic approach to transformations that covers them in all their various manifestations both in the theoretical and historical dimensions, but we can nonetheless give a rough sketch of how semiotics might significantly expand the basic DPSIR scheme – and thus address some of the latter's previously mentioned shortcomings – by adding a semiotic layer that accounts for the pertinent aspects of the inner view of the humans involved in transformations.

Given this aim, the solution to the task at hand is straightforward; namely to not only account for the objective, measurable dimension of transformations – and this includes the human actions themselves, also in part their aspects of agency and intentionality –, but to also add to this physical layer an additional layer consisting of, and theoretically representing, the subjective representations of the pertinent dimensions of physical transformations in the semiotic realm of signs, and this with a view to both their static and their dynamic natures. In this expansion of the DPSIR scheme, the secondary layer directly, but in an independent and non-deterministic manner by way of independent entities that need not show any similarity, mirrors the objective (etic) dimension by a subjective (emic) dimension, with the additional stipulation that any element of any dimension might potentially exert an influence upon any element of any other dimension resulting in a highly complex and non-deterministic system. So it is important to note that the interconnected duality of the real and semiotic layers of the extended DPSIR approach is not only confined to the general levels *per se*, but that we can find this duality at play with every relatum of the scheme: to every 'objective' fact, there is a semiotic correlate expressed via, and in the form of, signs.

While it is clear that the primary layer can be described by way of 'hard' data that can, at least potentially, be measured by scientific or other means, either directly or via proxies, what nature does the secondary layer have? As stated above, a representation of (parts of) the environment is in principle nothing but a sign, which Charles S. Peirce abstractly defined as 'something which stands to somebody for something in some respect or capacity' (Hartshorne et al., 1931, 2.228; cf. 1.564 and 2.303; we need not go into the details with regard to the characteristics of the three relata of any sign relation, i.e. 'sign'/'representamen', 'object', and 'interpretant'; cf. 2.228 and 2.242).

This definition has an abstract and general character, which entails, first, that in principle *anything* can serve as a sign, including all physical objects of, as well as events and processes within the material world, and, second, that signs are not reduced to linguistic signs, i.e. natural language, but are primarily conceived of with regard to their use as signs, i.e. in a functional, 'pragmatic' way (for archaeology, cf.

Bauer, 2002; Preucel & Bauer, 2001, albeit both with a primary focus on things and objects; see also Furholt et al., 2019, for the eminent dimension of 'practice', as well as Bauer, 2013, with a view on meaning as mediated by 'habit' of use). This theoretical framework allows for describing all possible signs there might be and thus in particular provides, in a coherent and overarching framework, all the elements that are necessary and sufficient for setting up the second layer of our approach (on the generality of the Peircean notion of 'representation' especially with a view on archaeology, see Swenson & Cipolla, 2020; also Preucel, 2020). This further allows for conceiving of transformations not as rigid cause-effect relations, but to make room for the impact of what can be called the 'meaning' of things and events (with the notion of 'meaning' construed in the broadest way possible) all the while taking seriously the characteristic of humans as living beings for which the use of signs individually and collectively is constitutive and, in this capacity, plays a pivotal role in the transformative processes affecting societies of the past.

A sign, however, is not simply a sign. But while there are numerous ways to exhaustively classify all signs according to different criteria (for some insights see Jappy, 2017), for the present purpose one classification is relevant in the first place, namely that which exhaustively classifies all signs as 'icons', 'indices', and 'symbols' (for the semiotic basis of this classification, see Hartshorne et al., 1931, 1.369; 2.247–249; and 4.447–448 with 2.243 giving the criterion for distinguishing these sign classes). These three forms of sign together allow us to begin building a complex understanding of what a representation of the natural world within the description of transformations in the sense of the DPSIR scheme might imply and how it can be practically achieved: first, the class of icons comprehends in particular perceptual content (construed most broadly), such as what humans saw when they looked at the Acropolis at Athens in the year 430 BCE or when one group perceived that alien people migrated to their location (for the semiotic definition of an icon, see Hartshorne et al., 1931, 2.276; cf. Kralemann & Lattmann, 2013; Lattmann, 2012). Second, the class of indices comprehends signs that indicate the existence or 'reality' of something, for example, smoke as something that points to a fire existing somewhere or migrating people that indicate the lack of resources at their place of origin (on indices see, e.g., Hartshorne et al., 1931, 2.305). Third, the class of symbols comprehends abstract signs such as words, sentences, or texts, e.g. those relating to how people of the past themselves conceived of notions such as 'migration' or 'overexploitation of land', i.e. signs that in particular (though definitely not exclusively) fall within the scope of language, abstract thinking, and explicit knowledge (on symbols see, e.g., Hartshorne et al., 1931, 2.249).

This general semiotic framework allows the comprehensive description of all the elements that are relevant for putting together the secondary layer of the DPSIR approach to conceptualising the anatomy of transformations, namely by establishing a semiotic correlate to every relatum of the 'objective' human-environment relation that captures the inner perspectives of the involved humans. Semiotically speaking, this correlate acts as the 'sign' or 'representamen' to the 'object' that might be understood as that thing in the 'real' world the sign, as an in principle independent entity, relates to within the sign relation (while, however, this 'historical' use of the sign has to be analytically distinguished from the 'use', i.e. conception of the respective sign, in our modern-day research). As such, signs were used by humans of the past not only to passively represent (the perceptions of) one's world in a direct way – representations which were, if we are lucky, expressed by the humans themselves and are still extant as drawings, figurines, texts etc. – but more importantly with regard to conceptualising transformations, they might have also actively, and potentially to a great degree, contributed to the dynamics of transformations, not least because humans direct their actions toward goals, which are, at least implicitly, expressed by signs in whatever form. For example, the perception of populated villages may have led to migration in response because of an expectation that there might not be enough food for all inhabitants in the years to come and the perceivers found that they must aim for the survival of themselves and their social group; alternatively, this perception could have led instead to innovation in order to avert the overexploitation of the land so that more people could survive in the long run.

While the concrete response would have been, as we have seen, to a greater or lesser degree dependent on more general and abstract parameters like belief systems, ideologies, knowledge, etc. – which themselves would also have been constituted semiotically – we can nonetheless gather from these examples one significant general mechanism that is at work with transformations from a sign perspective, namely how the different forms of sign interact within the semiotic realm in order to contribute, or lead, to real-world transformations. First, people perceive some change in the environment, be it grounded in objective facts or having just an imputed character. These perceptions constitute, in any case, basic iconic content. This forms the basis for the subsequent stages of the transformation processes, for these icons become involved in indexical sign relations wherein the iconic (perceptual) content is interpreted as having a connection to some 'fact' in the outer (natural etc.) world, namely based on the knowledge (or so imputed) of the people involved, in particular including their world views, ideologies and so on. In consequence, the icons are conceived of by the humans as a proxy for something that is, or happens in, 'reality' and as such they form the potential basis for further action insofar as, finally, these indices become embedded in complex symbolic signs such as propositions (i.e. 'dicisigns'; cf. Hartshorne et al., 1931, 2.251 and 2.310; see Stjernfelt, 2015) that allow, for example, truth-apt statements about the state of things in 'reality' or in even more complex signs such as those that, for example, delineate logical conclusions or the setting of goals of action, or develop more complex imaginary worlds that put up a world different from that the people were living in, for example forming an ideal goal of human action as a utopia to be aimed at.

On the other hand, the semiotic description of transformation processes given above sheds light upon another mechanism that might equally have led to, or at least have been involved with, transformations, for it allows for the possibility that transformations did not start with bare iconic content (i.e. perceptions), but instead with a primary change within the realm of symbolic content, for example, as relating to the belief systems or societal ideologies or the knowledge available to the humans of the past. This change within the abstract realm then might have led to actively searching for and identifying indexical or iconic signs within the ‘real’ world (with all the caveats noted above) with the aim of validating the spontaneous change on the symbolic level in turn. For example, having acquired the knowledge that carbon dioxide might contribute to the warming of the atmosphere, one might venture to measure the atmospheric concentration of this gas, from which measurement certain practical responses might follow, such as the attempt to reduce the production of this gas (this actual response itself, by the way, would be also included in the basic sign relation, namely as so-called ‘interpretant’, here with a practical nature). Such a mechanism might be involved with transformations which were not primarily induced by the external world, but were instead first initiated within societies of the past on the basis of semiotic processes and then had a secondary impact on the environment, which to be sure would not have taken place if the semiotic processes on the abstract level had not taken place beforehand.

Of course, these are only two exemplary and rough outlines of the mechanisms pertaining to the additional semiotic layer of the extended DPSIR scheme sketched here; additional case studies could significantly deepen our concrete understanding of the complexities of the entwinements of the objective and subjective dimensions of transformations. But what is clear in any case is that this approach, first, allows for understanding transformations as connected with, and informed by, complex semantic dynamics that evolve in a range from concrete perceptions to the most abstract thinking on both the individual and collective levels, also with a view on their genuinely practical consequences, and that at the same time are embedded within the overarching semiotic systems that were used by the humans of the past as, for example, given by the language they used or the belief systems they held or the knowledge they possessed. Second, this approach accounts for the non-deterministic complexities of human-environment interrelations and takes seriously the character of humans as not only entities with agency and intentionality but as beings for which semiotic processes are constitutive on the individual and societal levels (on this difference between agency and the semiotic dimension, see Harris & Cipolla, 2017, pp. 120–125, for a discussion of instructive case studies; cf. also Bauer, 2013; Preucel, 2016; Watts, 2008, with semiotic takes on material agency, which makes the theoretical situation even more complex). The semiotic relation involving ‘real’ world and sign therefore does not have a deterministic, quasi-naturalistic character, but it has to be conceived of as historically contingent within a range from the individual to the cultural parameters. Assessing transformations, then, involves the historical exploration of both layers of the scheme. Even if this might prove difficult in the particular case at hand, this integrative approach might help in finding and identifying the meaning within transformations and thus holistically combining their etic and emic dimensions.

3.6 Emergence

The final element of the anatomy of transformations outlined here is emergence. Employing an emergentist perspective on broader archaeological and historical contexts, and specifically in the undertaking of conceptualising an anatomy of transformations, has several upsides. The reasons for this are straightforward: first, the contexts analysed by the anatomy of transformations can be described as complex systems, that is, as systems involving humans, animals, and the immediate ecosphere. These systems are self-organising, involving dynamics that are non-linear and occur at different levels of interaction. Thus, complex systems concern a variety of phenomena occurring at various scales, recognising the connection between them, for example in the production of a pot and the diverse ways agriculture emerged (for an overview on complex systems see Bertuglia & Vaio, 2005; Sayama, 2015; for some philosophical takes on complexity see Hooker, 2011; Wimsatt, 2007). Second, in our combined efforts to detect and explain transformations in human history, from the viewpoint of several different perspectives between the sciences and the humanities, it would certainly be beneficial to have some sort of measure that allows us to understand the different levels and scales of organisation, and this holds also true with regard to the interrelations between the objective and semiotic layers of the anatomy of transformations sketched in the previous section. Lastly, we have – by virtue of the contexts we study – a narrow access to knowledge about all the constituent parts of these systems, but by focusing on a wide range of parts, it is possible to obtain a clearer picture. In short, emergence provides a much larger picture than what is provided by DPSIR, theory, and semiotics alone, especially by bridging different gaps in our explanations of a variety of phenomena which occur at varying scales. So, the big question at hand is how to effectively define emergence in this context and how to position it within an anatomy of transformations.

Several principles of emergence require parsing. Emergence needs to accommodate diachronic processes, since the transformation of societies cannot occur outside of the progression of time; emergence needs to account for differences on several scales in an integrative way, which means that it must accommodate some sort of synchronic ‘levels’ of organisation represented by specific sciences and their respective means to describe and explain (e.g. climatology, anthropology, biochemistry, archaeology, etc.); and finally, emergence should avoid striving for a status of being a ‘general theory of everything’ while being flexible enough to work as a guiding principle in the multidisciplinary undertaking that modern archaeology represents.

These principles have been discussed quite extensively in the literature (e.g. Bedau & Humphreys, 2008; Manzocco, 2018; Sartenaer, 2015), but for our purposes, it is central to recognise the difference between an ‘emergence basis’ and ‘emergent’. As the name indicates, the basis brings about emergence – in simpler words, it is the conditions from which emergence is possible. Emergents can then be understood as novel qualities that do not exist in the basis; that is, they denote a situations where something new comes into existence. There is much more to emergence than these ideas, and not all is clear. For this reason, understanding emergence rather as a heuristic guiding principle to approach causal and scalar relations in an anatomy of transformations is the more pragmatic approach.

Taking the definition above, it is possible to translate it into such a principle that enables us to broaden our view of transformative processes such as ‘neolithisation’. The advent of agricultural practice and the overall development of agriculture becoming the dominant mode of subsistence in Europe viewed ‘from above’ on a large geographical and temporal scale seems to be directed, irreversible and, compared to the whole history of humanity, rather quick, even though from the human perspective it took a very long time (cf. Robb, 2013). However, the more we zoom in on smaller and narrower scales, the more it becomes apparent that ‘the European Neolithic’ as we would call it in total is located at a conceptual level of organisation which is not easily explained given the knowledge of lower conceptual levels of times, traditions, groups, families, or individuals. Viewed from ‘below’ possible interactions between, for example, groups of hunter-gatherer-fishers and groups of farmers in all their variability and in all of Europe do not sufficiently explain the directed and irreversible character of the higher level ‘European Neolithic’. This is simply because there are more factors at play than just interactions between people; each system we observe is open to influences outside of our view. In that light, we could say that the transformation we would subsume under the advent of agriculture – on a higher (conceptual) level – is emergent upon the interactions of lower (conceptual) level entities (humans, animals, climate, weather, geography, aesthetics, ideology, etc.), without us being able to trace the complete extent of its constitutional chain and likewise the complete set of causal trajectories that led to it. Synchronically as well as diachronically the dominance of agricultural practices emerged from the set of choices people made, possibilities people had, available resources, and so on. But also each of these (maybe except for resources, depending on how those are defined) could be said to be emergent upon other systemic interactions: possibilities inform choices, yet choices cannot be reduced to fundamental laws in the sense that every choice made has an element of unclear determinative traceability. Still, these choices form the basis for new – emerging – possibilities and the cycle continues, leading to qualitatively novel states of affairs.

To conclude, treating emergence as a guiding principle in this way does not mean we should stop striving for new insights into causes and effects regarding transformations, but it keeps us from falling back on oversimplified explanations by implicitly keeping our minds pliable to the openness and uncertainty of the systemic relations we try to uncover.

3.7 Concluding Remarks

The idea of an anatomy of transformations is much more than a methodological toolkit, containing a variety of methods and concepts; it is a programme that conceives the long journey of human history as something that cannot be understood in isolation nor under oversimplified models. The history of archaeology, the study of long-term changes in ways of life, and the study of human-environmental interactions have undergone considerable amounts of research and study but oftentimes in separate sub-fields with very different epistemologies, assumptions, and methods. This divergence is somewhat unavoidable given that there cannot be a single approach or methodology that can uncover and explain the entirety of human history. The understanding of past and present transformations cannot be subject to the unity of method, but it can be subject to a unity of purpose.

Throughout our common history, there were deep, structural, and long-lasting transformations, and despite their apparent disparity, the concepts and methods employed by the anatomy of transformations are unified when it comes to explaining how and why these transformations happened. As a heuristic tool, DPSIR has the advantage of being an open and flexible model that can explain specific phenomena of change, while avoiding the risk of oversimplification and overcomplexification. Theories go a little deeper by contextualising the behaviour of people within their specific social and historical setting and thus examine their agency. Semiotics provides access to the emic side of life and point to avenues of smoothly integrating it with its etic dimension. Whereas DPSIR uncovers the perspective of hard materiality, semiotics offers a tool to assess how this reality was represented in the human mind and how these mental representations in their turn had an impact on the historical transformation processes. Finally, from an ontological standpoint, emergence recognises how new behaviours, practices, and conditions emerge by establishing the connection between the various levels at which transformations occur and how these levels relate to one another.

Overall, the issue of incommensurability of methods and explanations will continue to exist; that is to say, no matter how much effort is invested into creating an overarching system of methods and theories, such as the one presented above, some contradictions and lapses will nevertheless occur. For instance, DPSIR, semiotics, and certain theories tend to have different definitions as to what “collapse” means; what is important is to recognise that these different definitions and forms of analysis allow for one to choose those definitions that work best for the case in question. Rather than thinking of the anatomy of transformations as a single, monolithic, and unified system, it is best to think of it as a very expansive toolkit, to which one can add and remove items. By perceiving the approach to human-environmental interactions through this large toolset, it becomes easier to recognise where overlaps in methodology and epistemology occur, resulting in a cleaner but nonetheless more holistic approach to research.

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Chapter 4
Indicators of Transformation Processes: Change Profiles as a Method for Identifying Indicators

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4.1 Introduction

Societies are in a constant state of change. Archaeological research has shown how some of the driving factors of change in societies include technological innovation, change in subsistence strategies, climate change (e.g. Chap. 6), environmental change, changes in political organisation (e.g. Chap. 9), and population increase or decrease. The list of factors can be extended and detailed at will. However, at what point and in what combination do these factors lead to profound transformations? Recognising and understanding transformation processes is the central research focus of CRC 1266 "Scales of Transformation". Each of the previously mentioned processes may contribute individually to change, but it is their interplay that describes the picture of a profound transformation. Our knowledge on components

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of individual transformation processes is heavily influenced by region-specific chronologies, cultural materials, data availability and research standards. Due to the data variability, and to avoid deterministic approaches, this chapter does not aim to identify a "universally valid set of indicators" of transformation, but rather define a multi-proxy approach based on archaeological aspects, changes in social relations or subsistence, and environmental factors. Analysing singular factors only does not do justice to the complexity of human-environmental interactions. The identification of indicators and their interconnection will ideally permit a better understanding of transformation patterns on a transregional and diachronic scale. In addition to establishing sets of parameters which can be used as indicators of transformation, learning which parameters do not serve as indicators contributes to a much more efficient work flow.

A particularly useful tool for identifying and comparing transformations is change profiles or change plots. Change plots show the degree of change between two phases. This kind of visualisation makes it possible to address the interaction between different parameters and hence it highlights the most relevant ones. Therefore, change profiles might provide us with information about which factors played a significant role in shaping transformations and how the strategies for their integration varied in different (archaeological) contexts. This method is rather easy to apply to different regions and processes and results in a synthetic plot of changing factors. The interpretation has to carefully consider potential natural correlations of different factors that are not entirely independent.

Accordingly, the aim of this chapter is to provide a method not only to visualise interdisciplinary conducted results on transformations, but also to provide a multi-proxy approach for identifying relevant factors in transformational phases using a minimal set of highly available archaeological information. This will not include a full description, or even detection, of *all* transformations, but rather a decent approach for identifying corresponding transformations within different domains. The parameters used comprise geographical key numbers, such as the topographic position index (TPI) and locational preferences, as well as archaeological information, such as site category and the location of specific artefacts such as weapons, imports, and jewellery. Some parameters will show a rather marginal influence but still contribute to a holistic perspective that provides a balance between too simplistic and too complex models. The data sets of this pilot study cover the early Iron Age in South-West Germany and the Iron Age in Central Italy. Especially, for the

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transformation in South-West Germany the interplay of different social, economic and ritual factors is quantified within change profiles. Furthermore, an estimation of the intensity of each transition can be compared to identify those factors most relevant to the transformation.

An important aspect of this approach is the use of publicly available geographical data and the accessibility of the archaeological data used, which ensures not only a certain degree of reproducibility but also the extendibility of this approach. The latter is particularly important, since the present study is a pilot study which aims to trigger additional ones with targeted sets of parameters. These further analyses are intended to include other CRC 1266 projects, as well as completely independent analyses by different authors.

4.1.1 Domains, Parameters and Indicators for Transformations

Transformations are defined here primarily as processes leading to a substantial and enduring re-organisation of socio-environmental interaction patterns, e.g. changed material culture, social relations, settlement patterns or subsistence strategies. A transformation leads to a transformed society that both adapts to new conditions and shapes new conditions. Transformations cannot be reversed because the society has a completely new configuration. Therefore, the continuous change which characterises all communities and societies cannot be considered to be a transformation. Social organisations can adapt gradually to new conditions; societies can collapse and re-emerge with a different shape or undergo transformations that change the internal mechanism of the society. Gradual adaptation has its limitations, it is not only the current political situation that shows that social and political systems tend to preserve themselves and not to transform, if not forced to.

Transformations are embedded in a dynamic process of change between external environmental contexts and internal socio-cultural contexts (cf. Fig. 2.2). These contexts can be assigned to domains, which can range from economy and culture to climate and landscape. Parameters can be assigned to the domains, but they can also be related to each other and cannot be considered as independent variables. Parameters are described by indicators or quantitative proxies. Inequality, for example, can be represented by indicators such as house size, equipment or distribution patterns. However, indicators that are primarily assigned to the parameter of burial rites can also be used as parameters for inequality. Indicators, parameters, and domains form a complicated network of interrelationships and mutual references. Additionally, due to the mutual interference of the factors, a common synchronous representation makes sense in order to be able to circumvent possible duplications in the evaluation. The following examples serve as an illustration of the interconnectedness of the individual factors, parameters and domains.

The parameter climate influences temperature, precipitation, growing season duration of crops and thus also the possible subsistence strategies. Climate has far-reaching influences on agricultural societies, and thus defining independent variables from the parameters of, for example, subsistence, economy, vegetation or hydrology will be difficult. Humans live in, and with, their environment, which is strongly affected by climate. Even in the industrial age, with manifold technical achievements and comprehensive knowledge, societies have to face new problems and conflicts, which are triggered and intensified by the current climate change. Despite the important influence of climate, other relevant factors should not be ignored when interpreting the curves. It is the innovative nature of humans that reduces their dependence on climate. Climate variability is plotted on the synoptic change profiles as a parameter for orientation, but is not included in the analyses.

Settlement patterns can be driven by climatic changes, for example, when the hydrology of the region changes and settlements move closer to bodies of water, or when regions are too dry for arable provisioning of the community. The factors to be derived from this, such as proximity to water, elevation (TPI, aspect, etc.) can be derived from the location, categorisation, and dating of sites in combination with digital elevation models. A critical analysis of the source situation should precede, especially when considering distance to water and other settlements, as missing settlements or imprecise dating can have a significant impact on the results.

The social domain of settlement systems, on the other hand, such as even distribution within a region versus the clustering of settlements, can be considered as detached from climate. However, caution must still be taken in the interpretation here, and the inherent limitations of the method and alternative explanatory models must be examined.

Other social markers can be extracted from burial rites. The number and size of burial mounds or cemeteries, the number of "status symbols" in graves (weapons, chariots, ornamental vessels, jewellery), or even changes in burial rite (e.g. the change from inhumation to cremation graves) can be interpreted as effects of social change in a change profile. Changes in the ritual sphere of a society can also be seen, for example, from a change in burial rite and the associated change in world-view (*Weltanschauung*). The shift to inhumation, together with the abandonment of the hoard tradition and of sun iconography, at the beginning of the Early Iron Age can be seen as an expression of a fundamentally changed world-view and conception of the afterlife (Rebay-Salisbury, 2017). However, an additional political aspect cannot be excluded, especially at the beginning of the early Iron Age, because the so-called elites first accepted the new ideological world-view, before it became generally accepted by the whole population (Faupel, 2021; Tremblay Cormier, 2017).

4.2 Archaeological Case Studies

With the selection of the case studies, two quite contrasting cases are considered. In one case, little additional data is available besides the categorisation and dating of the site; therefore, the first step is to begin analysing the site parameters and then, if possible, to add further research results at a later stage. The second case study has numerous additional data from a very detailed data collection of an earlier project (http://landman-neu.sfb1266.uni-kiel.de/landman/repository/24/). The comparison of these two case studies is intended to show the feasibility of transformation research with change profiles and location-based indicators. Furthermore, in both cases a phase with well-known transformation has been chosen; these transformations take place almost at the same time, but in very different geographical settings.

The Early Iron Age in Baden-Württemberg represents a well-known transformation of society – which includes the emergence and rise of certain elites, visible in prestige graves and princely seats in the Hallstatt period, followed by a process sometimes called democratisation, in the Latène period – and is a perfect test case for the parameters focusing on settlement location. The second case study of Etruria partly covers the same period but has completely different history, with the emergence of city states, their competition, and the end of a balanced political system by the Roman occupation.

4.2.1 Baden-Württemberg

Ostentatious burial mounds, rich grave goods, and princely seats with exotic Mediterranean imports describe the picture of the early Iron Age in southwestern Germany and the Alsace. With the beginning of the Iron Age, a new epoch seems to have dawned, which led to a change in the form of settlement, brought new materials and thus new markets with it, as well as introduced a new burial custom. At first sight, this new cultural phenomenon has an enormous spread and extends – divided into the western and eastern Hallstatt areas – over almost all of Central Europe. However, if one takes a closer look at the material culture, the settlement pattern and the burial rites, this cultural entity is divided into numerous small regional groups. Studies have clearly shown that the heterogeneity of the cultural groups is predominant (Nakoinz, 2013; Parzinger, 1991). The commonalities are induced by an elite that apparently shared a comparable symbolism of their power (Tremblay Cormier, 2017).

The transition from the Late Bronze Age to the Early Iron Age is not recognisable in the archaeological material as an abrupt change. The introduction of the new material, iron, is also slightly delayed in relation to the social changes already discussed. The fact that the typology of numerous artefacts develops continuously from the Bronze Age into the Iron Age is a clear indication of changes within a domain. The accumulation of these changes, especially the changed settlement patterns and possibly new social structure, combined with climatic changes (Billamboz, 2007; Milcent, 2009) led to a transformation process.

Even though the end of the Early Iron Age is chronologically more precise than the beginning, the possible reasons for the collapse of the Hallstatt culture are not fully understood. Climatic deterioration, migratory movements (Celtic migration), and centres of power shifting northward are possible explanations (Brun, 1995; Fernández-Götz, 2018; Maise, 1996; Tomaschitz, 2002). Recognisable changes include a drastic reduction in population and the collapse of central places, such as the so-called princely seats. The settlement pattern in the following epoch is characterised by a very decentralised settlement pattern (Fernández-Götz, 2018).

Accordingly, by considering the Early Iron Age in Baden-Württemberg, two transformation horizons are considered: on the one hand, the change from the Bronze Age to the Iron Age and, on the other hand, the transition of the Hallstatt Period to the Latène Period. The fact that profound changes in society occurred during these periods is evident in the analysis of material culture, but it remains unclear which factors are relevant in this phase of change and which are possibly "only" clear detectable archaeologically.

4.2.2 Etruria

The region of Etruria is commonly identified as the area between the Arno and Tiber rivers, with its eastern borders defined by the mountainous chain of the Apennines. Here, several urban centres rose to prosperity during the first millennium BCE, each characterised by their own cultural identities and political institutions, (Haynes, 2000), but united by a sense of belonging to the same ethnic identity.

The study of material culture, especially of aristocratic funerary contexts, highlighted these aspects, but were often approached from an antiquarian point of view, and therefore stripped of their social and cultural context (Izzet, 2007, p. 16). Further impediments are the limited data coming from urban contexts, as these ancient cities have either been severely damaged by erosion or by reoccupation. Moreover, the texts and language of the Etruscans are limited in number, as well as in their comprehension: the majority of the information comes from foreign sources (Greek and Roman), who had the habit of reporting the Etruscans as fun-loving but lewd people. Because of such scant and biased information, landscape studies from numerous twentieth-century surveys and excavation projects become vital for the study of a civilisation that has its roots deep in the Bronze Age and that developed over a millennium, going through several 'transformations'.

And 'transformation' is indeed the characterising quality of Etruria. Several stages can be highlighted, from the occupation of open sites in the Middle Bronze Age, to their abandonment by the tenth century BCE, and the choice to relocate large portions of the population on naturally defensible locations (Peroni, 1989). From the tenth to the eighth centuries BCE, the largest plateaus, where available, were preferred for the establishment of large centres, while a good portion of the earlier, smaller sites were abandoned. Clusters of villages formed, initiating a major process of nucleation and a radical change in value system and political development, all of which was particularly visible in the new warrior ideology present in the cremation cemeteries that rose around them. This new cultural manifestation is referred to as the 'Villanovan' period, with sparks of what will be characteristic for the fully urbanised Etruscan period (Stoddart, 2016). These include the emergence of lineages and elites, the acquisition of resources, and the mitigation of conflicts by promoting the stability of centralised polities (Terrenato, 2011, 2020). These pull factors are completed in the following centuries, from the eighth century BCE onwards, when centralisation was accompanied by gradual craft-specialisation and social differentiation, as well as technological development. These transformations are represented by large tumuli that surround the now-urbanised plateaus, as well as the countryside, characterised by rich deposits showing the integration within eastern Mediterranean trade networks (Bartoloni, 2012, p. 103). In this period, Etruscan centres become forces to be reckoned with, some establishing their primacy on the sea, as well as on the Italian peninsula, through the control of resources, trade routes and the foundation of colonies. Conflicts must have characterised relations not only with external players (Greeks and later Romans) but also among the cities themselves, as the destruction of minor frontier minor settlements such as Acquarossa and Murlo and the foundation of a league of Etruscan cities can indicate (Stoddart, 2020). Parallel to this, the previously emptied landscape underwent a massive repopulation, with the development of complex settlement hierarchies sustaining such growth.

These major developments affected Etruria at different rates and at different times: southern centres became prominent in the early phase of Etruscan development, while northern centres emerged unchallenged when southern Etruria declined from the fifth century BCE. After the loss of international supremacy with the battle of Cumae (474 BCE), these southern centres had to deal with the aggressive political agenda of a new and determinant factor of transformation: Rome. One by one the cities fell or joined Rome, Veii being the first, and colonies were founded. Northern centres, on the other hand, opted for a different strategy – one of collaboration –, seeking political advantages, as is evident once again from the rural data and the funerary evidence. Etruria was severely punished during the Marius/Sulla conflict for siding with the loser (Torelli, 1990). It was dismantled in 27 BCE, when a new phase of its history started, one that saw it officially as part of Roman Italy, becoming its seventh region, with the disappearance of the Etruscan language and the adoption of Latin (Haynes, 2000, pp. 385–386).

4.3 Data

Comparable datasets of specific, known transformational phases are rarely available. Regions differ not only in their individual geography and associated vegetation, climate, and possible subsistence strategies, but also in their source material. Additionally, differences refer not only to archaeological source filters, but also to the presence of palaeoenvironmental archives, as well as current research status. Even within the CRC 1266, which investigates various transformations, it is not always possible to obtain a good, directly comparable database. The categorising, dating, and localisation of a site can serve as the smallest common denominator, although there are limits here; for example, the dating accuracy. If one accepts a certain degree of inaccuracy, which usually describes the archaeological reality, these three fundamental aspects about a site can be compared to some extent. However, the inaccuracy must be taken into account when interpreting the results. By evaluating location parameters, a comparative study can be carried out, which can be supported by additional data if necessary. In addition, depending on the epoch, research question, and data availability, additional data might cover other social and political factors, such as a known settlement hierarchy, prestigious graves, the number and distribution of imported goods, central buildings, or signs of social group affiliations.

4.3.1 Geographical Data

Modern digital elevation models are used for evaluating parameters of the location of a given site. Whether modern data can be used to study past changes in parameters depends on the degree of change in landscape and the likelihood of preserved archaeological features. The continuous transformation of landscapes is well known (Gerlach, 2003; Kvamme, 2006). Whether it is erosion induced by climate or changes caused by anthropogenic land use, the speed and extent of change are relevant. Knitter et al. (2019) compared the duration of the existence of landforms with that of monuments from a Neolithic case study to demonstrate the applicability of modern terrain models. Valleys or isolated hills exist for a period of between 1000 and 10,000 years (Ahnert, 1981), while more pronounced landforms endure for even longer periods. The epochs under consideration here are about 3000 years old, so the modern surface can be considered comparable.

Nevertheless, during the past two centuries, there have been notable changes in the landscape. These anthropogenic influences, such as building activities, raw material extraction, channelling of rivers, and reallocation of agricultural lands after World War II, do not change the geomorphological trend of a landscape (Herzog, 2014; Herzog & Posluschny, 2011; Kvamme, 2006; Mischka, 2007; Sauerbier et al., 2006).

The present analysis of the geographical data is designed for a regional comparison, which is why a DEM with a resolution of 90 m (SRTM of 3-arc-second[1]) was chosen. This provides a sufficiently precise representation of the landscape without being overly influenced by modern structures (such as highways). The R-Package *geodata* (Hijmans et al., 2023) was used to download the SRTM 3 digital elevation model, the global administrative boundaries (GADM) and the soil data for the area of the case study in Baden-Württemberg. Afterwards, the package *terra* (Hijmans, 2023) was used for calculating derived data, such as slope and aspect. The soil data (ISRIC, 2021, https://www.isric.org/explore/soilgrids) are from 15–30 cm depth

[1] Generally, accuracy for SRTM-C band data (90% confidence intervals are 8.8 m absolute geolocation error and a 6.2 m absolute elevation error: Rodriguez et al., 2005).

and cover nitrogen (total nitrogen (N) g/kg), pH (pH (H_2O)), sand (>0.05 mm, in fine earth %) and clay (<0.002 mm, in fine earth %).

4.3.2 Climate Data

The climate data originate from transient model simulations of the Earth System Model from the Max Planck Institute for Meteorology (MPI-ESM, version 1.2: Mauritsen et al., 2019; cf. also Mikolajewicz et al., 2018). The model consists of the spectral atmosphere general circulation model ECHAM6.3 (Stevens et al., 2013), the land surface vegetation model JSBACH3.2 (Raddatz et al., 2007), and the primitive equation ocean model MPIOM1.6 (Marsland et al., 2003). In this set-up, the atmospheric component ECHAM6.3 has a T31 horizontal resolution (approx. 3.75°) with 31 vertical hybrid s-levels which resolve the atmosphere up to 0.01 hPa (Stevens et al., 2013). The ocean component, MPIOM1.6, has a nominal resolution of 3° with two poles located over Greenland and Antarctica (Mikolajewicz et al., 2007). The Earth System Model was started from a spun-up glacial steady state and integrated from 26 ka until the year 1950 with prescribed atmospheric greenhouse gases (Köhler et al., 2017) and insolation (Berger & Loutre, 1991). Volcanoes are not included. The ice sheets and surface topographies were prescribed from the GLAC-1D (Briggs et al., 2014; Tarasov et al., 2012) reconstructions (Kageyama et al., 2017, see standardised PMIP4 experiments). The topography varies with time (Meccia & Mikolajewicz, 2018) and river routing (Riddick et al., 2018). We focus our analysis on simulated temperature and precipitation with a time resolution of 100-year averages during the last 10 ka of the simulation.

The reference model refers to the version described in Kapsch et al. (2021, run 212). To assess the model uncertainties, this reference model simulation is compared to additional simulations based on another ice sheet product (ice6-g: Peltier et al., 2012) and a slightly changed cloud parametrisation. By combining these modifications, four model simulations are used in total.

The climate models for both case studies are aligned with an archaeological chronology. Therefore, variation in temperature (average, summer, and winter) and precipitation is depicted in dates BCE (see Figs. 4.1 and 4.2). Although climate variation will be plotted in the change profiles of the given transformational phases, climate is not assumed to be the sole trigger of transformation. Nevertheless, climatic variation is important to highlight changes in specific domains, and serves as orientation in change profiles.

The average temperature rises at the beginning of the Hallstatt period in Baden-Württemberg, with a maximum around 650 BCE. During the Hallstatt period a minimum average temperature occurs around 350 BCE. The variation in temperature becomes more prominent when considering the average temperature curves for summer versus winter seasons.

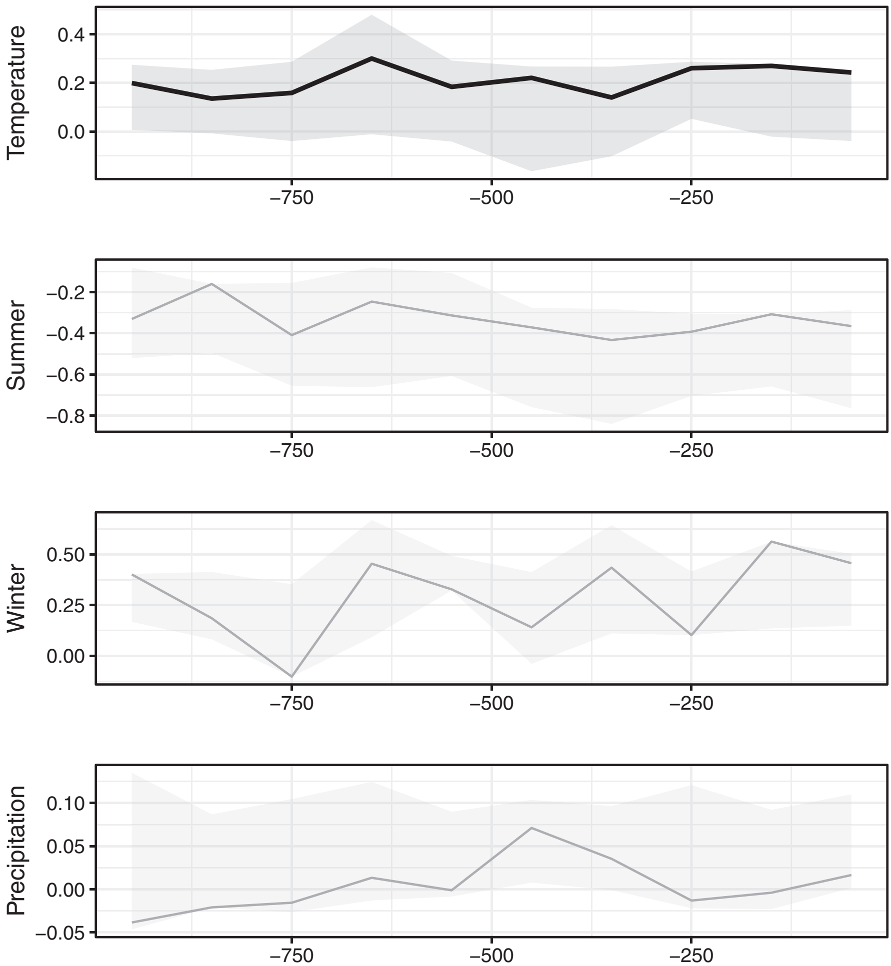

Fig. 4.1 Climate variation during the Early Iron Age in Baden-Württemberg

Similar to climate curves in Baden-Württemberg, a rising average temperature can also be observed at 650 BCE in Etruria; however, the average temperature does not drop as drastically as in Baden-Württemberg (Fig. 4.2).

4.3.3 Archaeological Data

For the present analysis, an existing data collection was used, which lists the locations of the early Iron Age in Baden-Württemberg with coordinates, datings and, if available, archaeological finds. The database (SHKR: Krauße et al., 2013; cf. also Faupel, 2021; Nakoinz, 2013; http://landman-neu.sfb1266.uni-kiel.de/landman/

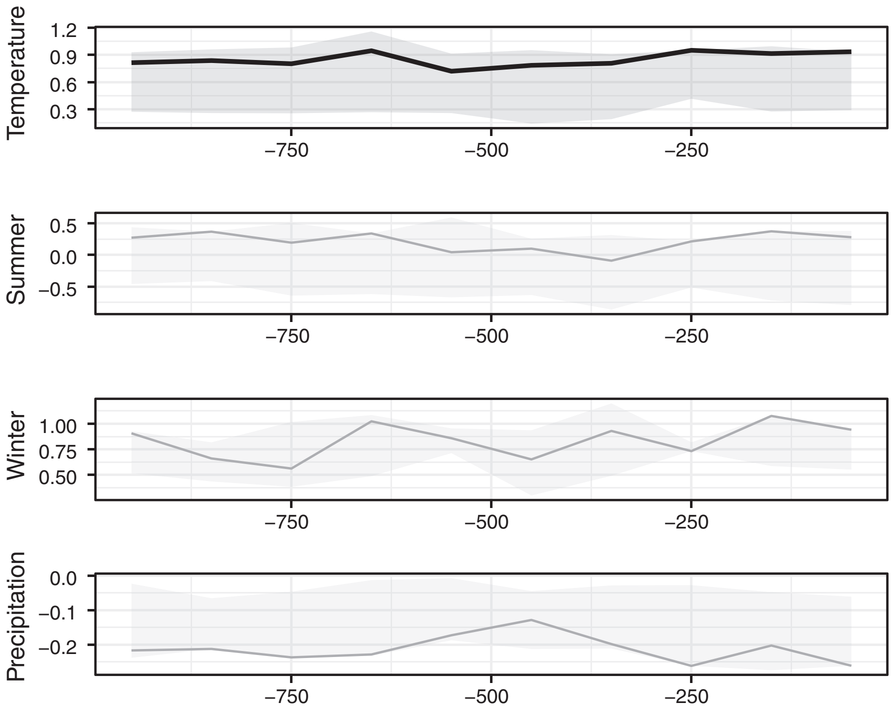

Fig. 4.2 Climate Variability for Etruria during the Iron Age

Table 4.1 Site numbers for case study in Baden-Württemberg

Phase	Counts
Ha C + Ha D	1019
Hallstatt period (Ha)	2137
Early Latène period (FLT)	505
Iron age (EZ)	2901
undated	8170

repository/24/) contains 7954 graves and 2353 settlements. The graves include undated burial mounds that very likely date to the Iron Age (see Table 4.1).

According to the variable precision of dating (Table 4.2), the number of sites decreases with increasing dating precision. This accounts for the fact that the sum of Ha C and Ha D sites does not match the number of Ha sites (Table 4.1), although the Hallstatt period is supposed to comprise Ha C and Ha D only, while Ha A and B are Bronze Age.

Due to the methodological focus of this chapter, we are using the phases Ha C, Ha D and Early Latène (= Lt A and Lt B). Hallstatt (= Ha C and Ha D) is considered for comparison, as mentioned above, and the chronological subphases such as Ha D2 are not taken into consideration for this chapter; though in the future they need to be considered in order to obtain detailed knowledge on all transformations.

Table 4.2 Chronology for Baden-Württemberg

Name_ short	Name_long	Plotname	Start (BCE)	End (BCE)	Centre (BCE)	Duration (in years)
Ha	Hallstatt period	Ha C-D	−800	−450	−625	350
Ha C	Hallstatt C period	Ha C	−800	−620	−710	180
Ha D	Hallstatt D period	Ha D	−620	−450	−535	170
FLT	Early Latène period	Lt A-B	−450	−250	−350	200

Table 4.3 Type of sites for case study in Baden-Württemberg

Phase	Graves	Settlements
Hallstatt C period (Ha C)	161	91
Hallstatt D period (Ha D)	537	250
Hallstatt period (Ha)	909	1147
Early Latène period (FLT)	234	296

Table 4.4 Chronology and sites for Etruria

Phase names	Start (BCE)	End (BCE)	Centre (BCE)	Duration (in years)	Sites
Iron Age	−1000	−730	−865	270	71
Orientalising Phase	−730	−580	−655	150	286
Archaic Phase	−580	−470	−525	110	957
Classical Phase	−470	−330	−400	140	643
Hellenistic Phase	−330	−30	−180	300	2354

The two categories of sources, graves and settlements, are distributed differently (see Table 4.3), so that source filters can be deduced. Hence, both categories are analysed separately. This makes six datasets to analyse in total: graves Ha C, graves Ha D, graves Early Latène, settlements Ha C, settlements Ha D and settlements Early Latène. Accordingly, these datasets cover two transformations: Ha C to Ha D, and Ha D to Early Latène.

The archaeological data for the case study in Etruria are based on the Palmisano et al. (2017) data collection (see Table 4.4 for the used chronology and sites).

4.4 Methodology

Before describing the methods in detail, a rough sketch will be given in order to provide an orientation in the methods section. This chapter aims to explore the use of rather simple and widely applicable transformation indicators. For this purpose, we focus on rather well-known transformations and use only the location-based indicators for these transformations. Although the Iron Age transformations used in this chapter are rather well known, sound quantitative approximations of the intensity of change are not available for these transformations. Hence, a simple validation of the results of our indicators is not possible, and we have to turn to hermeneutic evaluations of the indicators which compare the different Iron Age transformations and this involves additional information.

The first step is to define indicators. For this purpose, we develop simple characteristic numbers for the different phases that aim to use natural units and are normalised; for example, based on point pattern analysis. These numbers are used to calculate the factor of change between the phases. In addition, some indices provide change factors directly, since no single characteristic number for the phases is involved.

The next step is to explore the interrelationship of the provided indicators, for which we assume a certain degree of correlation. A principal component analysis (PCA) serves the purpose of a first exploration and visualisation. In the next step, a certain correlation threshold is used to define clusters of indicators, one of which is selected as representative of each cluster. This approach reduced the number of indicators considerably without reducing the information the indicators cover too much. The visualisation of these remaining indicators with change profiles provides us with a basis for evaluating the predictive power of the indicators. Finally, the location indicators are compared and discussed with other information as hermeneutic evaluation.

4.4.1 Point Pattern Analysis

This study applies different methods that are concerned with the location of sites. The conceptual background is formed by the so-called first-order and second-order point pattern analysis (PPA). While first-order analysis is focused on the environmental parameters that determine a site location, second-order analysis investigates the relationship of sites to other sites. Hence, first-order analysis focuses on economic aspects, while second-order analysis focuses rather on social aspects at a certain level.

Based on the first and second order analysis, transformation indicators are then defined. These indicators are presented with diachronic change profiles. The diachronic change profiles have the purpose of comparing the results of the individual cases. This allows us to estimate the degree of changes. Furthermore, the comparison is much more methodologically robust than the estimation of particular point pattern types.

Finally, correlation analysis and principal component analysis serve the purpose of validating the set of indicators and identifying redundant variables. With these methods we will answer the question of which minimum set of indicators is required to characterise a transformation from the perspective of settlement patterns.

4.4.1.1 Identifying First-Order Effects

First-order effects of PPA are estimates of a point pattern with regard to underlying or explanatory covariates, most likely environmental parameters such as topographic features, geomorphological conditions, or the distance and access to fresh water deriving from hydrologic systems. Inherent in such an approach is the rather deterministic assumption that particular environmental features in the landscape are more attractive than others, and that there are environmental factors that control human behaviour. Depending on the type of archaeological record (e.g. settlement or graveyard), attraction and rejection in the moment of human-environment interaction can be – at least theoretically – traced through the manifestation of the record itself as a function of the explanatory covariates. Eventually, and considering large archaeological site databases, this produces an estimate of preference or avoidance of particular landscape features during specific chronological periods and further allows tracing differences among groups, time-slices, or geographic areas.

Furthermore, the approach presented in this chapter enables us to track site location parameters not only as a spatially static component in human decision-making; it also integrates a catchment composition evaluation in the analysis. Using continuous data, for example from slope gradient generated using the DEM, preferences for particular slope ranges, and thus topographic roughness, can be estimated. In addition, a focal approach can be applied that aims at testing the composition of particular environmental conditions within a predefined complementary region. This has the advantage that, for example, when using a soil database not only the environmental conditions at a specific site (here a point, which can be considered at best two-dimensional) are taken into account, but also the variation of these conditions within the catchment; in this case, different soil types with different suitability for crop cultivation, as pastures, or for settlement purposes.

The terrain characteristic is calculated with the function *terrain* from the terra package (Hijmans, 2023) based on the srtm3 digital elevation model (CIGAR-CSI: Jarvis et al., 2008). Slope, aspect, TPI (Topographic Position Index), TRI (Terrain Ruggedness Index), and roughness are used.

4.4.1.2 Identifying Second-Order Effects

The second order effects (Baddeley et al., 2015; Nakoinz & Knitter, 2016; Ripley, 1981) focus on the interaction between sites: do they reject or attract new ones? Or is there no interaction at all? At a point pattern level, the question is whether existing points determine the location of new ones. At a data level, we are turning from the relationship of the sites to other kinds of data, to the relationship inside the site dataset itself. The reflective nature of the methods discussed here accounts for the name ‘second-order point pattern analysis’.

The traditional approach of second-order point pattern analysis is to test whether a point pattern could be the result of a random point process, specifically a Poisson process. Defining squares and comparing the counted points to the point number estimated by a theoretical process has the disadvantage of arbitrary squares influencing the result. Ripley (1981), hence, suggested distance-based methods he called field methods. The basic idea is to look at the distances between points and calculate the accumulated numbers up to a threshold that serves as an independent variable of the curve. If the curve of the empirical point pattern matches the one of the theoretical random point process, interaction cannot be assumed. Due to the problem of estimating how far apart the two curves can be while still assuming randomness, simulations are used. The upper and lower limits of the simulations of random processes are indicated in the graphs. Randomness is rejected if the empirical curve is outside this area.

Ripley (1981) defined different types of curves according to the consideration of different pairs of points. The nearest neighbour function or G-function considers the nearest neighbours of each point only. If the empirical curve is above the theoretical one for random processes, more shorter connections than expected exist and hence, clustered point pattern is expected. The probability of a next point being nearby is rather high due to the concentration of the points in a certain cluster. Accordingly, an empirical curve below the theoretical one indicates a regular pattern because the points are spaced with rather maximal distances.

The empty space function or G-function uses a simulated set of random points that connect to the nearest data point. The interpretation is inverse because the likelihood of a simulated point of having a data point nearby is rather low for clusters, since the simulated points are not concentrated in the same area as the data points. An empirical curve below the theoretical one shows more large distances from the random points to the data points than expected.

Finally, the K-function has to be mentioned. This function works similarly to the G-function but does not consider only the nearest neighbour. For this reason, the K-function is considered rather robust but not very sensitive to specific patterns. The G- and F-function in particular have a specific sensitivity. The G-function can be said to take a perspective from inside the pattern because each data point provides a starting point for a connection, and hence a perspective on the pattern. Low density areas and the overarching organisation of clusters are blind spots in this approach, while the F-function focuses on exactly these aspects. Accordingly, the different functions complement each other and one function alone is not able to produce a decent description of a point pattern.

The second-order point pattern analysis can be considered to represent the social aspect of landscape archaeological research because it focuses on the relationship of sites. This type of analysis cannot reveal details of the relationship between different communities, but simplifies rather complex relationships to an estimation of intended intensity of interaction between the sites. This approach has two weaknesses. First, either first-order effects are excluded completely or they need to be included into the analysis by making them part of the simulation of the theoretical point patterns. Both alternatives are rather unrealistic in archaeology. Second, the theoretical models usually used in the analysis are meaningless in archaeology. It would require specific archaeological point pattern simulations instead of Poisson processes to gain meaningful knowledge. These points would question the application of second-order point pattern analysis in archaeology if a simple solution were not at hand. This solution is to not interpret the results directly, but to compare the results of different phases and regions. In this way, the influence of the first-order effects and of the theoretical model are minimised.

For this purpose, the curves need to be transformed to single numbers. With this additional simplification we lose further information but the basic characteristics of the point patterns are still preserved. Since we do not need the theoretical model to answer a question concerning the nature of the point pattern, but rather to characterise the point pattern, we can just use the theoretical curve as a base line and subtract it from the empirical one. Subsequently, the mean value of the sample points of the curve can be calculated. This number has a different meaning than just using the mean of the distances used for the curve, because the curves are mapping frequencies not distances. This leads us to a final simplification. Though the meaning of the index developed in the aforementioned process is different from an index based on the mean nearest neighbour distance, this difference is not that relevant for the comparison of different phases. Finally, we reach very simple second-order point pattern indicators that are based on the nearest neighbour distances and that are justified by the reasoning above. With this tool at hand we are able to compare different phases quite easily.

4.4.2 Identification of Indicators

Technically, we can distinguish three cases due to the kind of data used for the characterisation of the transformations and the phases.

1. **num**: Each settlement pattern is characterised by a specific number. Two point patterns can be compared by the difference of the characteristic numbers divided by the characteristic number of the first point pattern. This number represents the relative change.
2. **vec**: Each settlement pattern is characterised by a specific vector or set of numbers such as the number of sites at certain altitude ranges. These spectra allow us to calculate distances between the point patterns. For this purpose, we are using the Manhattan distance because each variable is scaled in the same way, but the variables need not establish a meaningful space in which the Euclidean distance would make sense. The distances can be scales comparable with the other indices.
3. **mat**: Each settlement pattern is characterised by a specific matrix or complex set of numbers, such as density distribution of two settlement patterns. In this case, a specific function (e.g. the displacement score) is used to describe the relationship of the two settlement patterns.

Though the change profiles would be the preferred place to compare two settlement patterns from two phases, for all three cases transformation indices are calculated for the sake of coherence and comparison.

In the case of vectors of characteristic value spectra, the values are normalised to fit the interval between 0 and 1, and twelve categories are defined. The observations of each category are calculated with the histogram function, and hence this indicator type is indicated with "hist" as part of its name. We have to distinguish two perspectives on the transformations. First, the values can change and this transformation aspect is covered by the distance between the two point patterns. In this case the diversity of values might be preserved. As an illustration, in the first phase only low altitudes might be used for settlement purposes, while in the second phase the settlements might only use high altitudes. In both cases the diversity is low. In a third case, all altitudes might be used. In this case the diversity is high. Obviously, the distance based on the vector of values has to be distinguished from the change of diversity. We use different diversity indices (Shannon-Weaver index (cf. Chap. 5), Simpson index, evenness (Oksanen, 2022; Oksanen et al., 2022) and inverse weighted rank sum) that also are indicated in the name of the indicators.

Now follows the description of the different indicators used in this study. In general, 1 and 2 indicate the two settlement patterns, while i indicates grid cells or positions in a vector. Furthermore, dens = kernel density, nn = nearest neighbour distance, cnn = cross pattern nn from one point pattern to another one, k = neighbourhood degree, v = vector of values, data = actual observed settlement pattern, random = simulated settlement pattern (Tables 4.5, 4.6, and 4.7).

Table 4.5 Displacement measures

displacement1	The kernel density estimation values for the two settlement patterns are compared by calculating $mean((abs(dens_{1i} - dens_{2i})) / max(c(dens1, dens2)))$. This is the difference in density patterns.
displacement2	The number of grid cells with a larger value in the second pattern than in the first one is divided by the number of grid cells: $\Sigma(kde_{1i} < kde_{2i})/length((kde_{1i}))$. A value of 0.5 represents an equal distribution, while lower or higher values can indicate an extension of the occupied area rather than an actual displacement.
displacement3	This displacement score is based on the nearest neighbour distances and uses the mean value of the nearest neighbours of all points from the first point pattern to the second point pattern, minus the mean of the nearest neighbour distances of both point patterns and divided by the mean of the nearest neighbour distances of both point patterns: $(me(cnn_i) - mean(c(nn_{1i}, nn_{2i})))/mean(c(nn_{1i}, nn_{2i}))$. For displacement3 only the nearest neighbour (k = 1) is used.
displacement4	This displacement score is similar to displacement3, but instead of the nearest neighbour (k = 1) the fifth neighbourhood degree (k = 5) is used. This provides a less sensitive but more robust result.

Table 4.6 Shannon-Weaver index, Simpson index, evenness and inverse weighted rank sum

even_slope	Evenness of categorised slope values
even_aspect	Evenness of categorised aspect values.
even_TPI	Evenness of categorised Topographic Position Index (TPI) values.
even_TRI	Evenness of categorised Terrain Ruggedness Index (TRI) values.
even_roughness	Evenness of categorised roughness values.
even_soil_nitro	Evenness of categorised soil nitrogen values.
even_soil_phh2o	Evenness of categorised water pH values.
even_soil_sand	Evenness of categorised sand values.
even_soil_clay	Evenness of categorised clay values.
simpson_slope	Simpson index of categorised slope values.
simpson_aspect	Simpson index of categorised aspect values.
simpson_TPI	Simpson index of categorised TPI.
simpson_TRI	Simpson index of categorised TRI.
simpson_roughness	Simpson index of categorised roughness values.
simpson_soil_nitro	Simpson index of categorised soil nitrogen values.
simpson_soil_phh2o	Simpson index of categorised water pH values.
simpson_soil_sand	Simpson index of categorised sand values.
simpson_soil_clay	Simpson index of categorised clay values.
shannon_slope	Shannon-Weaver index of categorised slope values.
shannon_aspect	Shannon-Weaver index of categorised aspect values.
shannon_TPI	Shannon-Weaver index of categorised TPI.
shannon_TRI	Shannon-Weaver index of categorised TRI.
shannon_roughness	Shannon-Weaver index of categorised roughness values.
shannon_soil_nitro	Shannon-Weaver index of categorised soil nitrogen values.
shannon_soil_phh2o	Shannon-Weaver index of categorised water pH values.
shannon_soil_sand	Shannon-Weaver index of categorised sand values.
shannon_soil_clay	Shannon-Weaver index of categorised clay values.

(continued)

Table 4.6 (continued)

rank_slope	Inverse weighted rank sum of categorised slope values: *sum(sort(*v_i*) * length(*v_i*):1) / length(*v_i*)*^{2}. The values are sorted and multiplied with their inverse rank and divided by the square number of values.
rank_aspect	Inverse weighted rank sum of categorised aspect values.
rank_TPI	Inverse weighted rank sum of categorised TPI.
rank_TRI	Inverse weighted rank sum of categorised TRI.
rank_roughness	Inverse weighted rank sum of categorised roughness values.
rank_soil_nitro	Inverse weighted rank sum of categorised soil nitrogen values.
rank_soil_phh2o	Inverse weighted rank sum of categorised water pH values.
rank_soil_sand	Inverse weighted rank sum of categorised sand values.
rank_soil_clay	Inverse weighted rank sum of categorised clay values.
hist_slope	Manhattan distance of the of categorised slope values.
hist_aspect	Manhattan distance of categorised aspect values.
hist_TPI	Manhattan distance of categorised TPI values.
hist_TRI	Manhattan distance of categorised TRI values.
hist_roughness	Manhattan distance of categorised roughness values.
hist_soil_nitro	Manhattan distance of categorised soil nitrogen values.
hist_soil_phh2o	Manhattan distance of categorised water pH values.
hist_soil_clay	Manhattan distance of categorised clay values.
hist_soil_sand	Manhattan distance of categorised sand values.

Table 4.7 Second order indices

ppa_G	G-score: *(mean(nn(*$data_i$*,* $data_i$*)) – mean(nn(*$random_{1i}$*,* $random_{1i}$*))) / mean(nn(*$random_{1i}$*,* $random_{1i}$*))*. The mean of the nearest neighbour distance of observed points to other points of the observed settlement pattern, minus the mean of the nearest neighbour distance of simulated points to other points of the simulated settlement pattern, divided by the mean of the nearest neighbour distance of simulated points to other points of the simulated settlement pattern. The G-score accounts for the internal perspective and is an inverse clustering score.
ppa_F	F-score: *mean(nn(*$data_i$*,* $randomi_j$*) – mean(nn(*$random_{1i}$*,* $random_{2i}$*)) / mean(nn(*$random_{1i}$*,* $random_{2i}$*))*. The mean of the nearest neighbour distance of observed points to points of a simulated pattern, minus the mean of the nearest neighbour distance of simulated points to other points of another simulated settlement pattern, divided by the mean of the nearest neighbour distance of simulated points to other points of another simulated settlement pattern. The F-score accounts for the external perspective and is a direct clustering score.
nSites	Relative change of the number of sites.
siteFreq	Relative change of the site frequency (sites/year).

4.4.3 Exploring the Initial Set of Indicators

The input of the synthesic analysis is a table with the transformation indicators as columns and the transformations of the different regions and period transitions as rows. Bar plots of the different rows allow for a visual comparison of the transformations. A principle component analysis of this table contributes to the question of the relationship between variables and objects. The plots of the first two dimensions are usually hard to judge because a certain degree of the variability is hidden in the remaining dimensions. The cos2 colouring (see package *factoextra*), helps to estimate which points are affected by this phenomenon and to judge whether or not it is necessary to also plot other pairs of dimensions. Keeping this problem in mind, the PCA-plots help estimate groups of similar transformations and groups of redundant transformation indices.

For a sound analysis of groups of redundant indicators, we are using a hierarchical cluster analysis (complete linkage) based on a correlation matrix (Pearson correlation index). The histogram is cut at an acceptable level (e.g. 0.05) to obtain groups of redundant indicators. One indicator might be sufficient to represent an indicator group, but the small number of transitions observed in this study prevents generalisation.

It is worth noting that the cluster analysis on the variables is required because the PCA focuses on re-projecting the data to another set of dimensions. In this study we are not interested in obtaining artificially transformed variables with reduced dimensions, but in deciding on a reduced set of original indicators.

4.4.4 Change Profiles

When looking at change, one inevitably has to deal with three components: time, the before, and the after. Even though it has been known since the introduction of Albert Einstein's (1905) theory of relativity that the Newtonian concept of an absolute time, which passes equally at every place in the universe, is wrong, time still plays a key role in measuring change. Without the measure of time, no change can be detected because the reference point is missing.

Change can be quantified by comparing specific aspects of two time slices. Relative time series, as they result from relative chronology, also lend themselves to such a consideration, since the sequence of events can be determined. In a change profile, time is plotted on the x-axis and individual changing processes are quantified on the y-axis. A variation at a certain point in time, relative to the previous time period, is entered with a normalised value. If there are no further changes in the following period, the value to be entered is zero in a systemic perspective.

If, for example, several new crops are developed synchronously with each other, there will be an increase in the corresponding value. Assuming this condition persists for a few generations, the value drops to the baseline. Once a crop plant establishes itself, another rise appears. This is because the abandonment of previous practices also represents a fundamental change and is not synonymous with a "step backwards" or a "return to the previous state". Phases with a high rate of innovation result in a high rate of change, as does the manifestation of a new standard. Before a transformational phase, the values might differ slightly throughout the parameters. During the transformational phase, there is a clear increase in the change profiles, either staggered or synchronous. After the transformative process, the change values "calm down" again, which can be recognised by low values within the different parameters of the change profile. For the graphical representation of change profiles, the value of a factor is plotted as a bar plot. If the rate of change remains constant, and more or less the same number of individual aspects change, the height of the individual bars remains similar. The value is created by the difference of the quantified change to the previous time span: change = $\text{abs}(n_{after} - n_{before})$.

In order to display factors synchronously, the individual change values are lined up one above the other, aligned according to absolute chronology and grouped according to parameters. The independence of the factors is not guaranteed (see discussion on the latent influence of climate), so they are correctly presented as individual bars. The values of change are plotted on the y-axis and normalised beforehand to avoid over-estimating factors with good data or high counting rates. The absolute numbers do not imply any valuation of the importance of the factor, but result from the nature of the data. The significance of a changing factor does not necessarily depend on the count rates, but on the change within the behaviour that resulted in this particular change. The deposition of hoard finds, for example, ends in Central Europe with the beginning of the Early Iron Age. This factor of the ritual domain, which reflects fundamental changes in the concept of the afterlife, can be represented by presence/absence. The number of certain artefacts in graves, on the other hand, is better represented by quantities. By normalising the rates of change, the influence of count rates and quantity of artefacts is minimised and presented in a comparable way. The quantification of the rate of change is strongly determined by the respective factor.

Change profiles in the present case studies show the absolute chronology[2] on the x axis. Since relative chronologies are accompanied by the assumption of epoch transitions and often also transformations, absolute dating is to be preferred. Furthermore, two difficulties occur when using a relative time scale. First, the definition of chronological stages is determined by the archaeological material. Naturally, it is easier to define epoch boundaries when the material culture changes fundamentally. However, relative time scales are not evenly distributed, so that a phase can cover a significantly different length of time. Hence, for the creation of a change profile, the relative chronology should be mapped onto an absolute chronology. A fuzzy approach can be used to mitigate the dominance of the relative stage allocations, for example by distributing the numbers over the absolute time. If, for

[2] This differs from the graphical representation for the identification of indicators (see Fig. 4.4). Here, the explicit transitions are used to display changes between the two assumed phases.

example, the number of settlements is plotted as a factor, insufficiently precisely dated sites can be divided among the time classes with a fuzzy approach and thus relative phases that are easier to identify can be balanced out. Second, the use of absolute chronologies allows to easily in-cooperate precisely dated material. Using a fuzzy approach allow here again to take in to account method inherit dating imprecisions.

4.4.5 Software

The analyses in this chapter were conducted using R (R Core Team, 2022) and the R packages geodata (Hijmans et al., 2023), terra (Hijmans, 2023), sf (Pebesma, 2018), spatstat.geom and spatstat.explore (Baddeley et al., 2015), FactoMineR (Lê et al., 2008), factoextra (Kassambara & Mundt, 2020), and ape (Paradis & Schliep, 2019).

4.5 Results

4.5.1 Transformation Spectra

For presenting the results, all transformation indicators are compiled in one table with indicators in columns and transformations in rows (Fig. 4.3). The indicators form a kind of transformation profile that can be visualised with bar plots for each transformation. For these bar plots we omit the y-scale since the information of the normalised indicators also can be understood without looking at the actual numbers.

The transformation indicators help to characterise the transformations in detail. We start with the two transformations in Baden-Württemberg, which were recorded from the perspective of the graves and the settlements respectively. For the sake of simplicity, we call the transition from Ha C to Ha D the first transformation and that from Ha D to Lt A/B the second. First, we turn to the topographic indicators. Slope changes strongly in the first transformation and less in the second, with diversity increasing strongly at first and increasing little, or decreasing slightly, in the second transformation. Aspect also changes strongly in the first transformation and less in the second. The diversity of the values, however, is hardly changed in the first transformation and increases slightly in the second. The same pattern of first strong and then weaker change is also observed for the TPI, whereby the change is smaller for the settlements than for the graves. Diversity increases at first and then remains the same or even decreases slightly. The differences in TRI and roughness decrease from the first to the second transformation for the graves and remain more or less the same for the settlements. Diversity first increases and then tends to decrease.

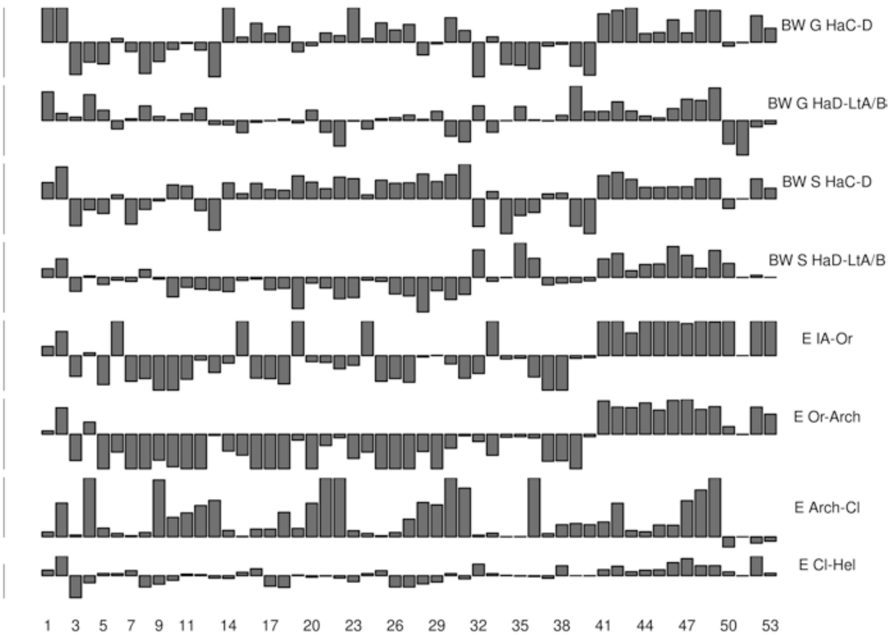

Fig. 4.3 Bar plot of the initial location-based transformation indicators for all considered Iron Age transformations

The chemical soil indicators show a heterogeneous picture of distances. Diversity decreases for the graves in the first transformation and in the second, while this is reversed for the settlements. It should be borne in mind that these indicators certainly do not provide primary evidence, as soil chemistry may have changed more than the other parameters. As indirect indicators, however, they may well show changes. In any case, their interpretation is difficult. The changes in soil types are easier to assess here. The changes in clay decrease from the first to the second transformation, while diversity increases strongly in the first transformation and then slightly in the second. For the sand, we can observe that the distances tend to increase from the first to the second transformation, with diversity first increasing slightly. For the graves, sand decreases in the second transformation, but increases for the settlements. Overall, the increase is stronger for the settlements.

The first displacement score is slightly positive, especially for the graves, indicating a slight shift in settlement space. High values of the second displacement score for the first transformation indicate an increase in the settlement area, while low values for the second transformation show a reduction. The negative values of the third displacement score in the first transformation indicate a slight shift and densification of the settlement areas. This effect is significantly lower in the second transformation. Both are confirmed by the fourth displacement score with somewhat more moderate values.

We turn now to the second order effects, for which we only have two indicators: the G-score and the F-score. The scores we are using can be interpreted as a kind of inverse (G) or direct (F) clustering coefficient since it measures the neighbourhood distances in relation to a certain base line. The G-score decreases slightly in both transformations and only increases slightly for the settlements in the second transformation. The F-score, on the other hand, first increases and then decreases, with the graves being more subject to this change. Overall, the clustering reaches its maximum in Ha D, with the internal structure of the clusters remaining largely the same. The G-score shows obviously smaller effects than the F-function. This suggests that it is mainly the large-scale structures that change, while the local or cluster-internal structures, i.e. the view from within, vary less. The difference in chronological phases indicates an increase in clustering in the external (F) view at the transition from Ha C to Ha D. This may be because settlements are becoming more ephemeral (more settlement sites in the same time and in close proximity) or because isolated settlements are disappearing. The pattern is consistent with the concentration of power discussed by Biel (1987), Sievers (1982) and Pare (1992), but can also be explained by a change in land use or an increase in insecurity. At the transition from Ha D to Early Latène a decrease of the clustering can be observed. The numbers of sites show a clear change and the site frequencies do not differ much because the phases have similar length. In the first transformation, the numbers of graves, in particular, increased significantly. In the second transformation, the numbers of graves decrease while the numbers of settlements continue to increase slightly.

Overall, the picture of a Ha C to Ha D transformation emerges, which is clearly more substantial than, but also somewhat different to, the transformation from Ha D to Lt A/B.

Let us now turn to Etruria. Here we have data on four transformations, but only on one type of site at a time, the settlements. The first two transformations show considerable changes while the later two are characterised by rather low change values. For the first two transformations, the diversity of the slope increases while it decreases slightly with the other transformations.

The same is also true for the aspect; the first two transformations have high change values while the later two transformations show lower change values. The diversity of the aspect shows rather low values throughout. The change values and the diversity of the TPI show the same patterns as for slope. TRI and roughness also have higher values in the first two transformations than in the later two transformations. The diversity of TRI and roughness decreases in the first, second and fourth transformations, and only increases in the third transformation. The change in chemical soil values is quite strong in the first two transformations, moderate to strong in the fourth transformation and rather small in the third transformation. The diversity of the chemical soil values increases according to the already known pattern in the first two transformations, drops somewhat during the third transformation and shows only slight changes in the fourth.

Sand and clay change strongly in the first and third transformations, slightly less in the second and even less in the fourth. The diversity of sand increases slightly in the first transformation, more strongly in the second, drops noticeably in the third transformation and is only slightly influenced by the last transformation. For the clay, an increase can be seen in the first transformation and a decrease in the third transformation. The other two transformations show low change values.

The first displacement score shows rather low values in all transformations, while the second shows predominantly medium values and thus small changes. Only for the fourth transformation is the value somewhat higher and indicates an expansion of the settlement area. Displacement score 3 shows negative values in the first, second and fourth transformations, indicating densification, which only decreases in the third transformation. Displacement score 4 has a negative value only in the fourth transformation and increasingly positive values until then. Thus, while the nearest neighbour moves closer in the first two transformations, the fifth neighbour moves further away in the first three transformations.

This picture is also confirmed by the G-score and F-score. The inner clustering decreases in the first two transformations and then remains the same. Viewed from the outside, the clustering also decreases in the first two transformations, then increases and then decreases again in the fourth transformation. The number of sites increases in the first two transformations, then decreases, and increases again in the third transformation. The first transformation has a strong growth of the site numbers that is even stronger when looking at the site frequencies, as well as an internal and an external de-clustering. In combination with the slight expansion of the settlement area this speaks to a stronger and more systematic spatial organisation. This continues with the second transformation that, in contrast, maintains the internal settlement structure. The third transformation with decreasing site numbers, increasing clustering from the external perspective, and the preservation of the internal structure, seems to reverse the process. This transformation is consistent with a certain centralisation process that abandons isolated areas and focuses on the urban sites. Finally, the fourth transformation resembles the second one, but the increase in site numbers becomes less pronounced when looking at the site frequencies.

Overall, a dichotomy emerges with strong changes in the first two transformations. The later two transformations are less pronounced and partly opposite. The third transformation, in particular, seems to differ from the others and to represent a kind of consolidation.

Though this description of the transformations does not address all aspects available with the transformation indices, a rather rich technical image of the transformations in the different regions emerges. The simple transformation indicators paint a picture of a rather complex settlement development that involves a multitude of decisions. At the same time, the indicators also allow a comparison of regions that offer entirely different source situations. This is made possible by the fact that the indicators are quite abstract and have been partly adjusted by multiple normalisation. The price to be paid for this advantage is that it is more difficult to assess the concrete characteristics of the respective transformation processes. This cannot be done at the level of abstraction necessary for comparison and must be done in the individual regions against the background of the individual developments and parameter characteristics. Since this is not the aim of this chapter, we will not try to reduce the abstraction, but rather to increase it. This is done with the following analyses and visual representations.

4.5.2 Transformation Plot

The transformation plot presents values of all transformation indices at the date of the transformation. In order to better see the values on the x-axis, the square-root of the indices is used. This means that low values (much smaller than 1) are scaled up and that values larger than 1 are scaled down. The mean value of all indicators per transformation is presented as solid black point. In addition to this effect, all indicators become positive and hence, measure the degree of transformation independent of the decrease or increase of the value.

The transformation plot (Fig. 4.4) shows that the mean values of the early transformations (before 500 BC) all have slightly higher mean values than the later ones. This change in the transformation degree is independent of the region, since it affects Baden-Württemberg as well as Etruria. The black horizontal line aims to highlight this effect. This might indicate supra-transformation at the next level of abstraction. Judging the significance of this effect cannot be based on statistical significance tests only, but requires a deeper understanding of the relationship between the indicators. For now, we just can take this assumed supra-transformation as a hypothesis for future research.

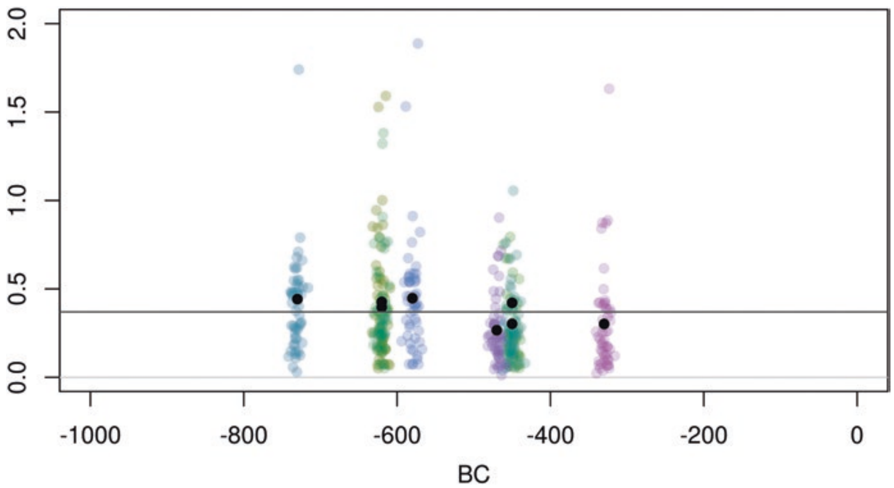

Fig. 4.4 Transformation plot of all considered Iron Age transformations. The colours identify index values from the same transformation in a specific region and the black dots are the mean values of each transformation. The horizontal line is merely for orientation; to better distinguish the mean values of the early and late transformations

4.5.3 Synopsis of Preliminary Location Parameter

The synopsis is dedicated to the question of how the transformation indicators are related. A principal component analysis can help with exploring the data-inherent structures and hence shed light on the relationship of variables as well as of objects.

The scree plot (Fig. 4.5) reveals that 67% of the variance in the data is covered by the first two dimensions. Though a considerable part is hidden in the remaining dimensions, this value suggests that most information is visible in a plot of the first two dimensions. The cos² value shows how much an original indicator contributes to the first two new dimensions. The plot indicates that some indicators are highly correlated and hence, redundant.

The variable and object plots (Figs. 4.6 and 4.7) of the transformations show that the transformations are different, but that some form a kind of cluster. In particular, the clusters of the early and late transformations in Baden-Württemberg, which indicate a similarity of the transformations perceived from the settlements and from the graves, assures us that the indicator approach makes sense.

For the actual detection of the groups of indicators, we use a cluster analysis of the original data because a reduction of the dimensions cannot be covered by theory. Instead of a distance matrix, we use a correlation matrix, since we aim to find clusters of highly correlated indicators. A heatmap (Fig. 4.8) shows this correlation matrix.

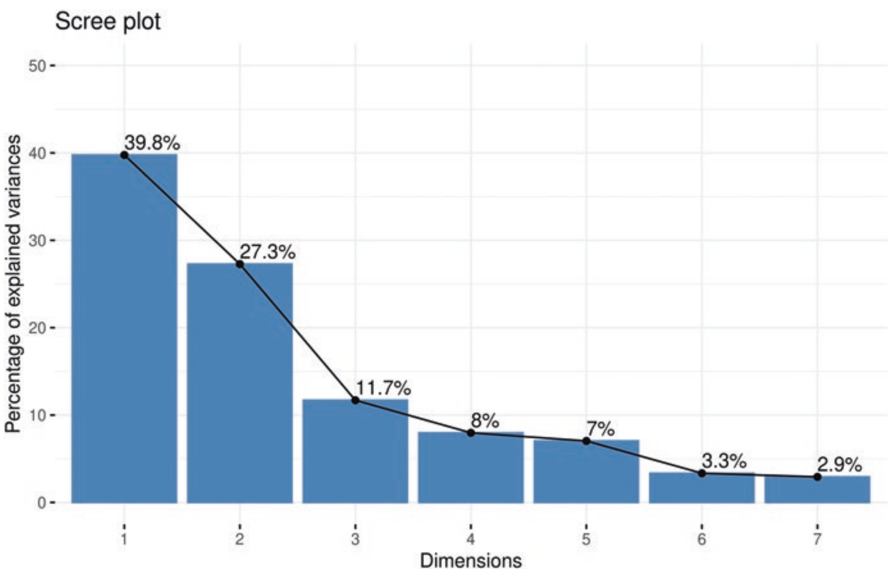

Fig. 4.5 Scree plot of the principle component analysis of the initial transformation indicators

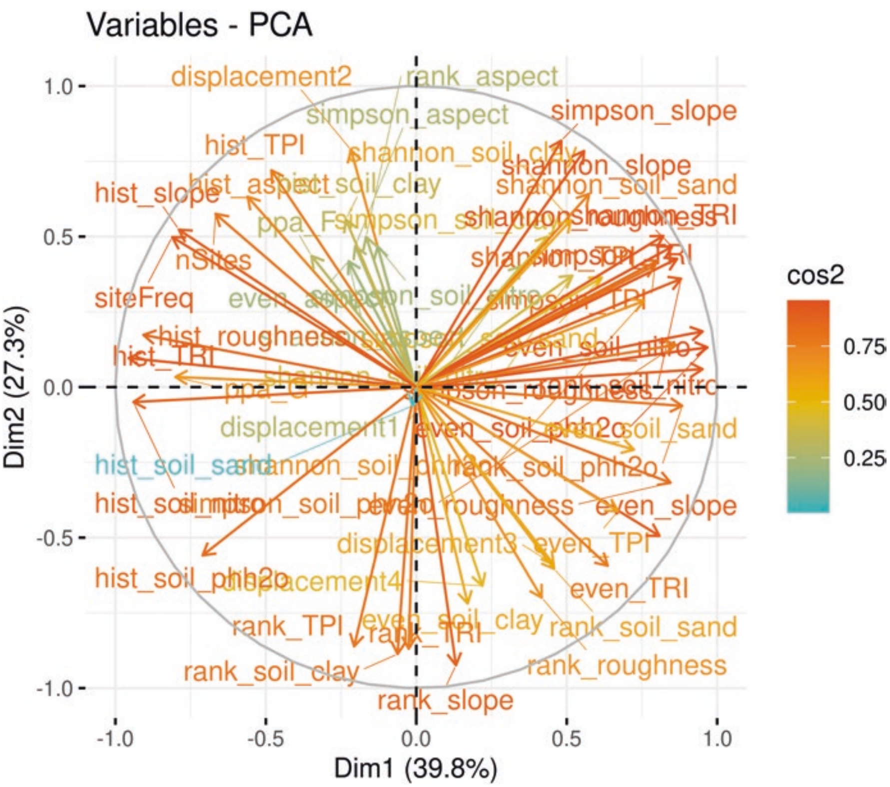

Fig. 4.6 Variable (indicator) plot of the principle component analysis of the initial transformation indicators

A hierarchical complete linkage cluster analysis produces a dendrogram that can be cut at a level of 0.05 to reveal the clusters of highly correlated indicators. Each indicator is assigned to a cluster and for each cluster a representative can be selected.

4.5.4 Indicator Selection

It emerged that most indicators provide specific aspects for the characterisation of sites. Nonetheless, only part of the information is useful for an identification. We hence develop two sets of indicators, one for identification and one for characterisation. The latter includes more correlated indicators than the first one. Each displacement score provides information complementing each other. Because the distances are also covered by the G-scores and F-scores, we keep displacement 1 and 2 for identification and use all indicators for characterisation.

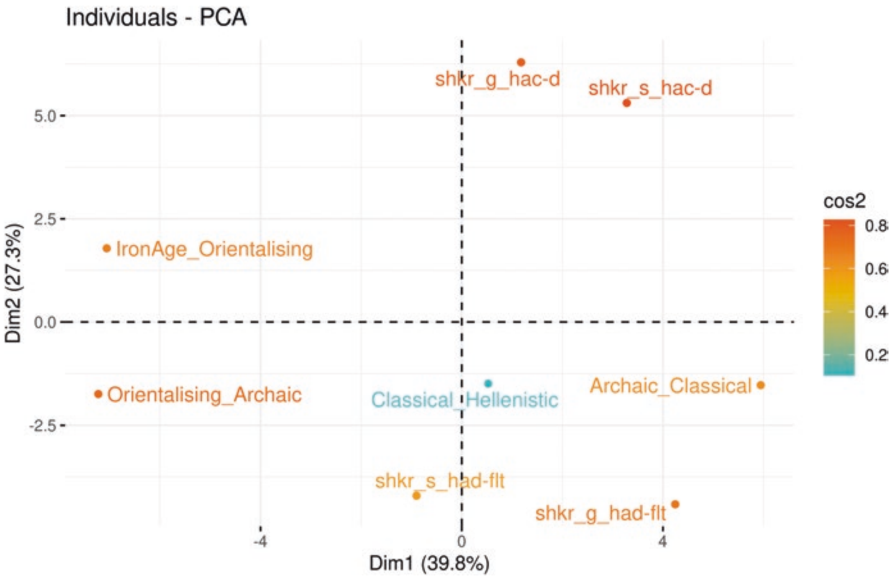

Fig. 4.7 Object (transformation) plot of the principle component analysis of the initial transformation indicators

The analysis reveals that the different diversity scores are highly correlated. The evenness seems to be the most powerful diversity indicator, or rather inverse diversity indicator, in particular because it makes the Shannon-Weaver index comparable. This leads to the decision to keep evenness for the identification indicator set and evenness and ranking for the characterisation data set.

Additionally, as expected, TRI and roughness are highly correlated, so that we keep TRI for both sets. The chemical soil data are hard to judge for our purpose, so that they are not included in our indicator sets.

All histogram-based distance scores, as well as the second order scores and the site frequency, are kept for both indicator sets. The site number offers additional information involving the length of the phases compared to the site frequency, but is much less telling than the site frequency and, hence, is excluded.

4.5.5 Change Profiles for Early Iron Age in Baden-Württemberg (Fig. 4.9)

The case study on Southwest Germany serves as an example to show how additional information is involved. The change profiles visualise parameters from different domains and climate change.

Climate change reaches a maximum in the seventh century BCE and a phase of change starting in the third century BCE. In the period between, climate change is

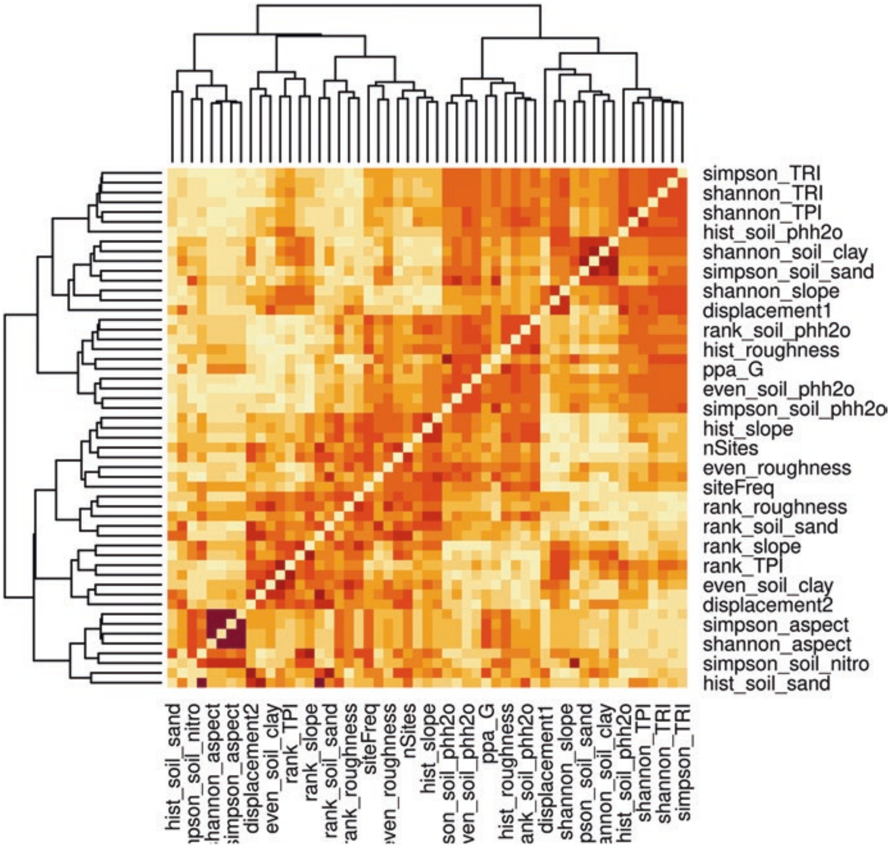

Fig. 4.8 Heatmap of the Pearson correlation of the initial transformation indicators

less pronounced, with a local maximum in the mid-fifth century BCE. This local maximum coincides with maximal change values in most domains. For the settlement and grave numbers, that value is even higher than the change of the previous transformations. However, caution is required with these numbers. The change values map the hierarchy of the chronological system, and the strong change in question corresponds with the Hallstatt and Latène transition. Though this effect is real, to some extent the aoristic dating reinforces the main transitions. The comparison with the transformation plot (see Fig. 4.4), which is less prone to have this aoristic bias because all observations are relative to a specific baseline, shows that the trend is the same: stronger change in the Hallstatt period, including the Latène transition. If we consider the bias, the indicators map the well-known transformations in a convincing way. It is just the correlation with climate change that is rather poor, but a convincing correlation cannot be assumed on a regional level.

The other domains suffer far less from the aoristic bias of the change values, because the poorly dated sites play a much smaller role in this subset of the data.

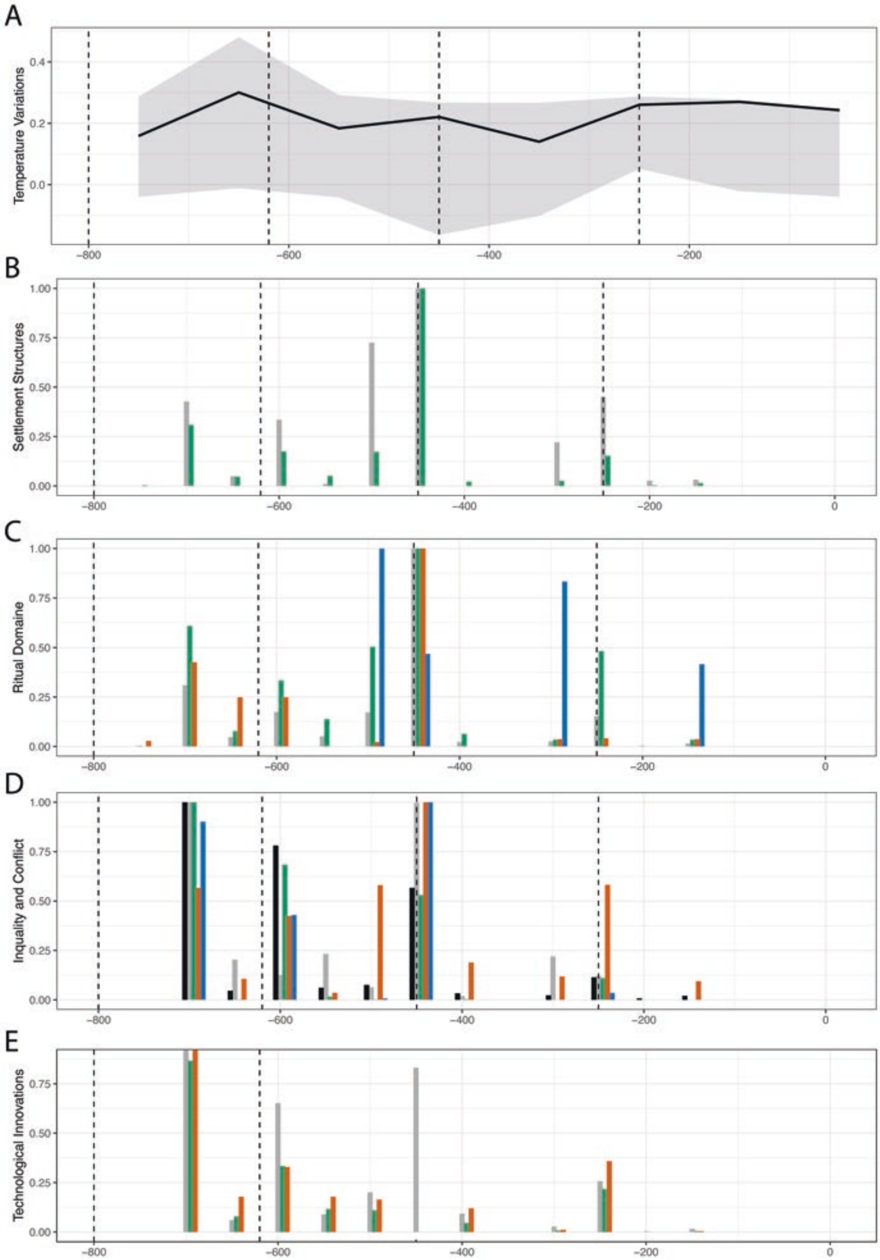

Fig. 4.9 Change profile for the Early Iron Age in Baden-Württemberg (**A**) Temperature variation; (**B**) Change in settlement structures (grey: number of settlements; green: graves); (**C**) Changes in ritual domain (grey: graves; green: inhumation; orange: cremation; blue: hoards); (**D**) Changes in inequality and conflicts (grey: gold objects; green: gagate objects; orange: swords; blue: daggers; black: lance / arrows); (**E**) Technological innovations (grey: iron objects; green: bronze objects; orange: Fibulae); dashed lines indicate the main chronological phases

These other domains, in particular, provide additional information for comparing the different transformations. The ritual domain has a dominant change in burial practices in earlier phases, while the change in hoard numbers becomes relevant from the late fifth century BCE onwards. This is particularly interesting because it does not coincide with the main chronological transition.

The social sphere, involving inequality and conflict, provides a particularly detailed pattern. With a very strong transformation at about 700 BCE, we enter a phase of social visibility that is usually considered to be the emergences of elites and prestige. The next strong transformation at 600 BCE amplifies this process. This phase ends with the main chronological transition in the middle of the fifth century BCE. It is worth mentioning that only the sword numbers change frequently throughout the younger transformations. This might be caused by a change from prestige to status, and the role of the sword as a status indicator with changing relevance.

The technological domain shows a similar pattern. At about 700 BCE, maximal values are reached in nearly all indicators from this domain.

The overall pattern is that of a main transformation at the main chronological transition in the mid-fifth century BCE, with more pronounced sub-transformations in the early part of the period. Comparing the different domains, two patterns can be distinguished. The first pattern, represented by the settlement and ritual domains, shows a noticeable change at 700 BCE and an even stronger one at 500 BCE. The second pattern, represented by the social and technical domains, shows a strong transformation at 700 BCE, a decent one at 600 BCE and a rather minor one at 500 BCE. These patterns indicate that social processes and technical innovations trigger the process characterised as the "emergence of elites", while settlement structures and ritual aspects are mainly involved in a later transformation of the society. A first process focused on the formation of a specific social group, which supports and accelerates technical developments, is followed by a second process that involved the whole society and includes a kind of social consolidation. The less-pronounced transformations in the social and technological domains prepare the way for the second transformation process.

This analysis indicates that different processes took place, which affected the domains differently. Nonetheless, the different transformations are likely to have influenced each other and to be part of one longer transformation process that is not uniform, but has distinct and characteristic phases. Even domains with low change values play an integral role in this process.

4.6 Discussion

The main idea of this chapter is to make transformations comparable by introducing an abstraction layer, with transformation indicators that indicate the degree of change between two phases. This approach can be applied to completely different sets of archaeological data as long as the geographical location and the chronology of the sites are available.

An important question is, which set of indicators is sufficient for characterising the transformations and hence for measuring the degree of change? We were able to reveal that some indicators are correlated.

The clusters can contain two types of indicators: indicators that are actually redundant and indicators that only correlate in the considered transformations (see Table 4.8). Since only a few transformations were considered in this chapter, the second category should be taken into account and indicators should not be excluded prematurely. We therefore only exclude indicators that are both strongly correlated and seem to be related in terms of content. Thus, at least one indicator is obtained from each cluster.

Since many indicators cover very similar things, for example the different displacement scores, it could be assumed that many indicators are redundant. In fact, however, only a few indicators seem to be redundant.

The numerous indicators, many of which are interrelated in terms of content, have an astonishingly low level of redundancy. This gives us a large number of relatively simple indicators that all describe certain aspects of the transformations and can characterise them well and in a differentiated way.

This observation opens the door for developing a transformation classification based on the transformation indicators. Different kinds of transformations can be identified and characterised, and perhaps even supra-transformations can be detected.

The transformation indicators used in our case study show a different dynamic. Some categories show small changes, while others show rather substantial changes. We assume the reason to be partially different degrees of dynamics within the different categories. Though this is probably mapping real behaviour of the different categories, this phenomenon makes a comparison rather difficult because the overall result is dominated by the dynamic categories, no matter how relevant they are. A solution to this problem could be a calibration of the change indicators according to the categories. The result would be transformation indicators that show the same level of change in general. It will not be possible to calibrate the values using "real" values. However, a calibration using some standard case studies might be sufficient for the purpose of gaining better comparability. The development of this kind of

Table 4.8 Indicators for identification or characterisation of transformations

Transformation indicators for identification:	Transformation indicators for characterisation:
displacement1, displacement2, even_slope, even_aspect, even_TPI, even_TRI, even_soil_sand, even_soil_clay, hist_slope, hist_aspect, hist_TPI, hist_TRI, hist_sand, hist_clay, ppa_G, ppa_F, siteFreq	displacement1, displacement2, displacement3, displacement4, even_slope, even_aspect, even_TPI, even_TRI, even_soil_sand, even_soil_clay, rank_slope, rank_aspect, rank_TPI, rank_TRI, rank_soil_sand, rank_soil_clay, hist_slope, hist_aspect, hist_TPI, hist_TRI, hist_sand, hist_clay, ppa_G, ppa_F, siteFreq

calibration certainly has to consider the kind of transformation typology mentioned above.

It should be mentioned, that the set of transformation indicators considered in this chapter is rather limited. In particular some scientific data, such as stable isotopes (e. g. Ventresca Miller et al., 2021) or aDNA data (e. g. Gretzinger & Schiffels, 2020; Schiffels et al., 2016; Schmid & Schiffels, 2023) could prove to be extremely helpful if they become available across the board.

4.7 Conclusion

Summing up the results of the transformations in South-West Germany, and including the additional information besides the simple settlement pattern indicators, we can characterise the transformations. When we consider the first transformation, the transition from Ha C1 to Ha C2 is of high intensity. Changes mainly concern gold objects, gagate, weapons – with the exception of swords, which have half the change intensity – and fibulae, as well as iron and bronze items. Less intense, but still substantial, are the components of the settlement patterns and the burial rituals. The swords are at the same level. Hoards do not play a role in the change. Overall, the focus of this transformation is obviously on the social and economic domain. Though not one of the transitions traditionally considered highly relevant, this transformation shows strong activities in the technological and social sphere, where a reconfiguration of society that concerns all of its parts is underway.

The next transformation, the transition from Ha C to Ha D, is rather of medium intensity. Only the displacement of the sites is strong. Gagate, iron, and lances are at a medium level, while settlement patterns, burial rituals, gold, swords, daggers, bronze, and fibula are factors of low intensity. The type of settlement pattern remains, while the settlement locations change. Besides this observation, this transformation is mainly concerned with the social and technological domains. This transition is traditionally perceived as the emergence of elites. It somehow continues the trend of the previous transformation. The rather large lance change value indicates that it still does not only concerned the elites.

The third transformation is the transition from Ha D1 to Ha D2, and this one is even less intense than the previous one. The strongest factor (gold) with low change intensities is from the social domain. Inhumation graves, settlement patterns, lances, and the technical domain play an even smaller role, while the remaining factors do not contribute to the transformation at all. If we want to name a focus of this transformation, that would be the social domain. The rather short Ha D2 phase is introduced by a transformation that, though not very intense, mainly concerns the elites.

The transition from Ha D2 to Ha D3 is stronger, and the most intense factor is hoards, with a very strong change. The settlement patterns also show a strong change, followed by the swords and the inhumations. Lances, gold, and technological factors play a minor role in small change intensities. The focus of this transformation is on settlement patterns and the ritual domain and hence, it represents a new type of transformation compared with the previous Iron Age transformations. With Ha D3, we are entering a kind of culmination of the social processes of the Hallstatt period, and at the same time a certain consolidation.

The transition from the Hallstatt to the Latène period is also a rather strong transformation that concerns all domains. Hoards, gagate, and lances show medium change intensities and represent the smallest factors of change in this transformation. The settlement pattern is at about the same level. Here, we can perceive a strong change in settlement numbers and moderate changes in the site locations and the type of settlement patterns. It is hardly possible to define a focus for this transformation. The Latène period is not only marked by a new art style, but also by a very strong ritual component. At the same time, a social transformation that affects all parts of society takes place, with the elites particularly affected as they become less visible.

Our final transformation is the transition from Latène B to C, which shows rather low intensities. The strongest factors are the swords, the inhumations and the settlement patterns on a medium level, while all other factors show minor or zero contribution to the transformation. The settlement patterns and the ritual domain seem to dominate the focus slightly. While the later part of the Early Latène period (Lt B) is, in particular, considered a kind of democratisation, the transition to Lt C is marked by the swords and conflict-oriented factors in contrast to the prestige of social status.

The case studies in this chapter suggest that a set of location-based transformation indicators can be used to indicate, characterise, and measure the degree of transformations. The change profiles appear to be a useful tool for comparing and integrating the multitude of location-based transformation indicators and information from other domains. This allows for the development and communication of rather complicated or even complex transformation interpretations.

The correlation between similar transformation indices is much smaller than expected and hence, they offer a better and more detailed characterisation of the transformations. The change profiles allow the easy integration of additional information. This allows a deeper understanding of the individual transformations and even of interrelated transformations. For the case study from South-West Germany, we revealed two interrelated transformation processes. The first process focuses on the formation of the elites, which supports and accelerates technical developments. This prepared the way for the second process, which affects the whole society and involves a kind of social consolidation.

A remaining problem is that different domains and sub-domains, represented by indicator types and single indicators, have different natural degrees of change or different natural variability. Though this is a result in its own right, it makes comparison more difficult. A calibration of the change factors, according to several very different case studies, could be a solution and would at the same time be a sound measure of the natural variability. This suggestion goes beyond the present chapter, however, due to the required number of case studies.

The change profiles suffer from an aoristic dating bias that has to be considered with the interpretation. Because of the simple methods and greatly limited data requirements, the location-based indicators appear to be a rather simple though powerful tool, but obviously they cannot cover all domains. A next step could be to develop similar sets of indicators for other domains.

With the diachronic representation of the changing processes via synchronous quantification, change profiles make it possible to integrate information from different domains for the interpretation of transformations. The benefits of the method provided here are twofold: first, by using a widely available set of parameters (in this case of the location of sites) change profiles can identify indicators for well-known transformations. This needs to be transferred to other assumed indicators and applications. Second, change profiles provide a tool for visualising heterogeneous data and deepening our understanding of intertwined parameters.

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Part II
Expressions of Socio-environmental Transformations: From Climate Preconditions to Decision-making

Chapter 5
Patterns of Socio-economic Cultural Transformations in Neolithic and Bronze Age Societies in the Central Northern European Plain

Human-Environmental Interaction Concerning Bourdieu's Forms of Capital

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5.1 Introduction

There are distinct advantages in writing and researching as an ensemble of scholars in the field of archaeology, especially when they include people of distinct genders, age-groups, and cultural backgrounds, who tend to engage with different chronological phases and different geographical areas. Furthermore, as an ensemble group, our background incorporates different sets of skills developed in archaeology, such as those furnished by the natural scientific disciplines and the humanities, allowing us to address material culture, social theory and the palaeoenvironment. When observing an object, each researcher will have a different train of thought, because each one observes the object according to their unique frames of reference. The observations on the object, its qualities and characteristics, can be quite varied because they depend on the researcher's community of practice. Nevertheless,

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despite the variety of viewpoints, all this knowledge remains complementary and can be brought together meaningfully.

The CRC 1266 is a research group that unites many scholars under a constellation of practices, where contexts such as the one described above are directed towards understanding different transformation processes, which are researched at different scales of interaction, and which reveal meaningful patterns relevant to our understanding of the past. Ultimately, the aim of the CRC 1266 is to compare, test, and analyse transformation processes within a special time frame in Europe and beyond (Müller & Kirleis, 2019). In order to enable a differentiated analysis, an intensive exchange between the involved CRC 1266 subprojects researching Northern Germany and the creation of a comparable data basis was required. However, this uniform recording of the material basis did not exist before and was compiled in course of the framework of the CRC 1266.

In this pilot study we will present an approach that enables a *long durée* diachronic comparison of the sociocultural development in a given geographical area, based on the differing basic data sources of the epochs of the Nordic Neolithic and the Bronze Age between 4100/4000 and 500 BCE. Our working area covers the Southern Cimbrian Peninsula or today's Schleswig-Holstein, Germany, an area of approximately 15,500 km^2, and is part of the major geographical region of the North European Plain (Fig. 5.1). The research involves quantifying material culture and converting it to time-series, which will serve as representations of long-term economic, cultural, and socio-economic developments. This will be presented in conjunction with palaeoenvironmental and archaeodemographic proxies, thus enabling us to identify possible antithetical or co-evolutionary developments. Within this scope we focus on identifying phases of transformation and explain the restructuring process of societal or economic arrangements by means of changes in our proxies and available qualitative data. As we provide an approach in which the comparability of proxies over time is given, we are able to identify patterns driven by possible structurally similar triggers or emerging from similar origins.

The practice of discerning patterns that emerge from the inductive analysis of data is usually restricted to a single period (Allentoft et al., 2022; Bunting et al., 2022), or even just a short sub-phase; it is rare to see cross-cultural comparisons of patterns that extend beyond a single chronological phase (Kohler & Smith, 2018). This is because the material culture, the architecture, the environment, etc. of past societies could have had very different meanings depending on the period and location (Brozio et al., 2019; Kneisel et al., 2019). What might have been a fairly cheap commodity for one social group might have also been a very luxurious and rare commodity for another group. To address the issue, we compare diachronic data by adapting Bourdieu's (1986) forms of capital (economic, symbolic, social, cultural) and applying them to our Neolithic and Bronze Age data. Regardless of the material, the four forms of Bourdieu's capital allow for an attribution of discrete artefact groups to a socio-economic sphere, or in other words, the data we use serve as a proxy to determining what type of capital it could have represented to our past informants. In addition to our material culture, we also include proxies for demographic development for a period of c. 3500 years.

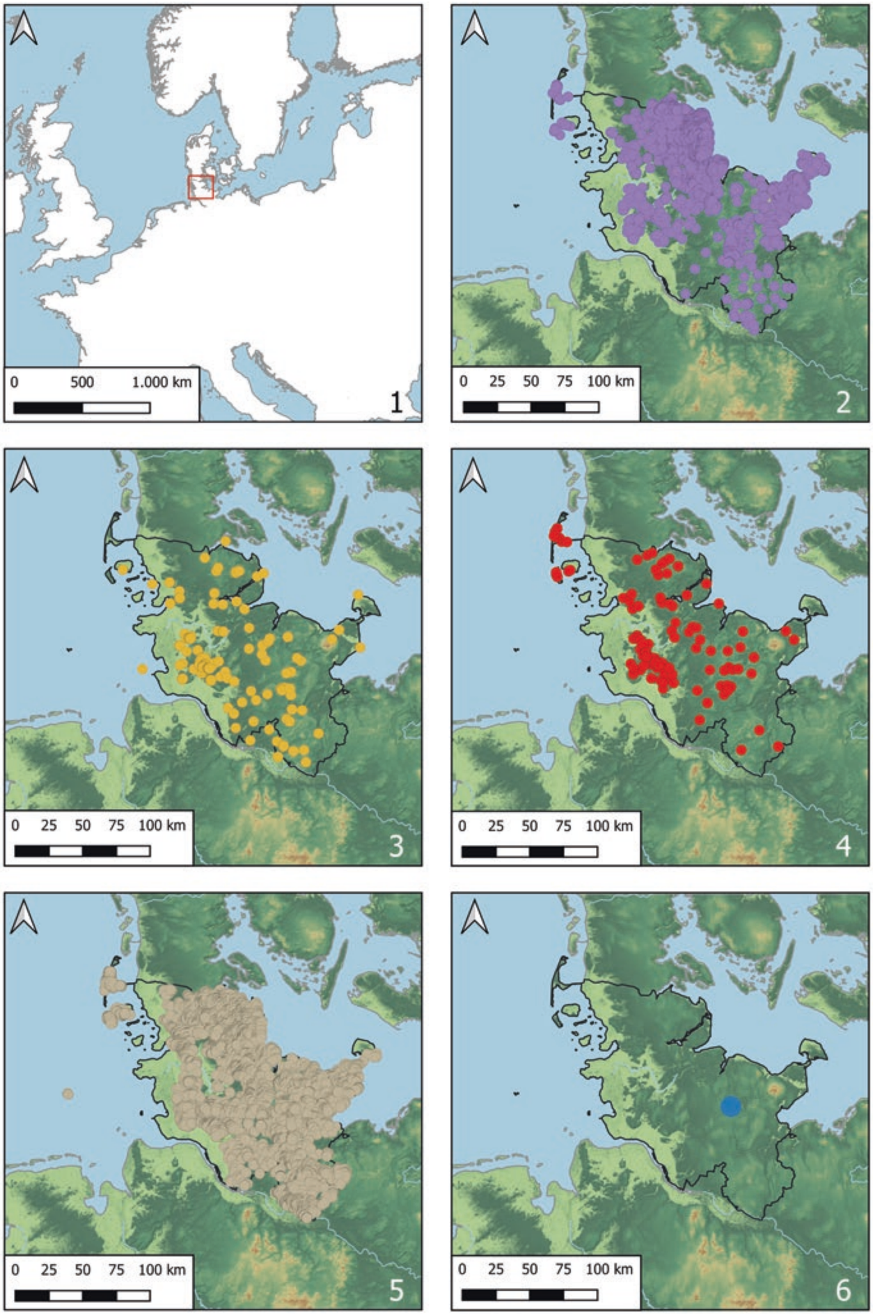

Fig. 5.1 Map of the research area: *1* Location of the Southern Cimbrian Peninsula, Germany, *2* TRB megalithic tombs, *3* SGC tumuli, *4* Dagger groups tumuli, *5* Bronze age tumuli, *6* Location of Lake Belau. (TRB Funnel Beaker – SGC Single Grave groups). (Figure by the authors)

5.2 Theoretical Approach

When comparing proxies derived from material culture, which represent societal and economic characteristics of a society over a time-span of 3500 years and over an area of approximately 15,500 m^2 the question arises: is it possible to compare things that might have had different meanings, significances, and/or different purposes?

This issue was discussed in Igor Kopytoff's (1986) concept of the cultural biography of things. In the social analysis of objects Kopytoff followed the Marxian perspective, which viewed objects as imbued with use-value and exchange-value (Kopytoff, 1986, pp. 70, 83), whereas Arjun Appadurai distinguished things as products and non-products, thus defining things as exchangeable (Appadurai, 1986, pp. 12–17). This perspective helped Kopytoff in understanding the life-story of objects. According to him, every product has a general character, because the product has a certain value and is comparable with other products, as exchange value for other products or money. In contrast, there are things that are not exchangeable with others because of their singular character. As he argued, both categories – products/non-products – are ideal forms that do not exist, because every product has a potential for singularisation and exchange; their evaluation depends entirely on the social context (Kopytoff, 1986, p. 73). A product can be a product or a non-product both diachronically and synchronically. The order of transformation and also the synchronous meaning as product and non-product accumulate to an object biography. For an example, Kopytoff describes the biography of a Suku hut in Zaire, which during its lifespan of circa 10 years underwent a transformation from a house for a couple or a woman with children to a guest house or a house for a widow. After that, the hut was used as a meeting place for teenagers, then as a kitchen and then as stable for goats or chickens. Finally, termites took over the hut and the building collapsed (Kopytoff, 1986, p. 67). An object can thus undergo a unique biographic process that transforms it from general commodity to a singular object.

The concept of object biography has been used to some degree in archaeology (cf. Gerritsen, 2009; Gosden & Marshall, 1999; Joy, 2009; Jung, 2015) although not always according to the framework designed by Kopytoff. The challenge raised by Kopytoff's biography concerns whether it is possible to compare different values of things from vastly different times and places.

According to Polanyi (1944), such a comparison only works if one takes the emic perspective. Due to the lack of contemporary witnesses from the Neolithic and the Bronze Age, we decided to turn to the epistemological process to assess value and relevance of material culture in societal context as established by Bourdieu (1986). A clear and brief summary of this process is provided by Bernbeck (2009), who explains Bourdieu's process in three steps as follows: A first approach, he says, is to engage intensively with the emic view and the basic non-dialogical structures of the research subject, which – as mentioned – is of course problematic for prehistoric studies. A second step, according to his description, was to break away from the paradigm of understanding and to analyse it from the objective etic perspective – "[…] the traditional cold-blooded scientific analysis […]" (our translation: Bernbeck, 2009, p. 2) – thirdly and finally, the subjectivity of this objectivist perspective had to be reflexively related to the "object" of investigation.

Bourdieu's (1986, pp. 241–258) division into economic, social, cultural and symbolic capital, which places people in social space, i.e. describes the relationships between people or their positions. With this division of the concept capital into different representations, he provides a suitable theoretical model which can be used to categorise archaeological material accordingly (Kadrow & Müller, 2019). Economic capital represents all forms of material wealth (e.g. income, movable assets, land ownership; Bourdieu, 1986, pp. 17–21). Archaeologically, we could recognise economic capital in the form of accumulation of finds, grave goods, and/or surplus production. Social capital comprises social networks (Bourdieu, 1986, pp. 21–24). Here, the relationships between people or groups of people can, for example, order the common possession of resources. This requires a willingness to cooperate, which we find reflected in the archaeological evidence, for example, in the form of communal house and grave building activities. Bourdieu divides cultural capital into three forms: incorporated, objectified and institutionalised. Incorporated cultural capital is – as the name already suggests – body-bound and is learned or instilled as people grow up, and modified in the course of their education (Bourdieu, 1986, pp. 17–19). It is, for example, taste, knowledge or personal behaviour. Objectified cultural capital consists of cultural goods (Bourdieu, 1986, pp. 19–20). Transferred to archaeology, these can be artefacts, especially everyday objects, made of pottery or flint. Institutionalised cultural capital comprises the titles one acquires during one's life (Bourdieu, 1986, pp. 20–21). For prehistory, we could speak of social functions that included, for example, decision-making processes or the regulation of resource distribution. Symbolic capital refers to one's rank in a society, which may not necessarily have been hierarchical in prehistory. This can show itself, for example, in the form of prestige goods or given symbology, but also in who received a special grave and who did not.

5.3 Material and Methods

The process of assigning artefact groups to the forms of capital proved to be difficult, as they are interpreted and attributed differently for the Neolithic and Bronze Age because of different traditions of research. The challenge was to find common ground where different artefacts or different materials allow the same statement about the society in question.

5.3.1 Defining Socio-cultural Spheres

According to Bourdieu (1986), all the mentioned forms of capital are interdependent and can therefore allow a series of different scenarios. Thus, no standard scheme exists that could explain processes and reactions according to capital forms and societal behaviour. For the comparison of the Neolithic and Bronze Age material, we determined from our expert perspectives which artefacts and features can be assigned to each form of capital. We have used this classification as a basis for our comparisons. For example, not all periods within our time perspective have axes or swords. Another example is that the materials used for artefacts are different (e.g. stone, bronze). However, in the case of swords and axes we see both of them as an expression of a certain social role and thus conceptualise them as traces of such across the epochs.

5.3.1.1 Material – Monumentality, Artefact Studies and Domestic Sites

The reconstruction of the intensity of monument-building activity through the Neolithic is based on available data from primary burials in single mounds and the oldest assemblages in megaliths or non-megalithic long barrows. An interpolated relative index of the construction of new monuments is derived through the described aoristic evaluation according to the detailed chronology. Values from the relative index obtained in this way can be extrapolated to the number of monuments known from the Archäologische Landesaufnahme Schleswig-Holstein (Archaeological State Survey) that, in contrast to other areas of Germany, covered nearly the whole southern Cimbrian Peninsula with fieldwalking and other types of surveys (Ahrens, 1966; Hingst, 1959; Kersten, 1951, 1981; Kersten & Schwantes, 1939). Known undated burial mounds are differentiated according to the known (through excavations) relative temporal distribution of mounds to the different phases in periods between the Neolithic and the Middle Ages, a procedure that Holst (2013) also successfully used for Denmark. Thus, these monuments with more general dating categories were redistributed to the main periods according to the relative frequency of dated records within the main periods (Brozio et al., 2019; Holst, 2013, pp. 42–44). The distribution of megalithic tombs in their temporal dimension is reported for the southern Cimbrian Peninsula (Hoika, 1999; Lorenz, 2012).

Complementary evidence of economic, as well as social, aspects of the Neolithic societies is provided by the character of artefact types and categories, which are linked to specific purposes. These objects of material culture are associated via their contexts and functions to utilitarian uses within economic production and/or with non-utilitarian meaning within the social and ritual sphere of the societies. Thus, the different quantity and sequences of artefact categories provide information about economic and social aspects of societies. Stone axes (Schultrich, 2018; Zápotocký, 1992), stone adzes (Breske, 2017), metal objects (Klassen, 2004; Schultrich, 2019), flint daggers (Kühn, 1979; Willroth, 2002) and jewellery (Woltermann, 2016) in different find contexts like burials, hoards (Rech, 1979) or single finds (Rassmann,

1993) are available as data sets for such an analysis (Brozio et al., 2019). Information on settlements was compiled from different sources (Brozio, 2016; Hage, 2016; Schultrich, 2019; Steffens, 2009). In the Bronze Age, new categories are added (swords, daggers), in other categories the material changes from stone to copper and bronze (axes). Stone tools become fewer and eventually disappear altogether. The catalogues "Die Funde der älteren Bronzezeit des nordischen Kreises" contain extensive find material for the Older Bronze Age (Aner & Kersten, 1978, 1979, 1991, 1993; Aner et al., 2005, 2011, 2017). For the younger Bronze Age, a complete record of all finds up to 1993 is available (Schmidt, 1993). New excavated settlement sites were also added (Donat, 2018; Meier, 2013).

5.3.1.2 Methods – Aoristic Method/PCR and Diversity Index

'One way to engage more effectively with temporal uncertainty is for us to make the best of all our available temporal information, however fuzzy' (Bevan et al., 2013). The 'aoristic' statistical method is used for a better comparison between quantitative data, for example from pollen diagrams or sum-calibrations, and typochronological classification of archaeological data. The aoristic method creates a relative frequency graph based on different dating accuracies – such as 'Bronze Age', 'Older Bronze Age', 'Period I-II', 'Period Ib' and ^{14}C dates (Mischka, 2004; Ratcliffe, 2000). In order to grant comparability of the data, the different dating ranges are divided and uniformly plotted in 100-year steps on the time scale. A dating such as Late Bronze Age (1100–500 BCE) is divided by n/6, a dating to Period IV early (1100–1000) is divided by n/1 and plotted on the timeline per 100 years. The sum of all artefact frequencies provides the aoristically calculated frequency curve. While this reflects the different timespans and dating accuracies, it allows for a substantial comparison with other data (Brozio et al., 2019; Kneisel et al., 2019). A comparison between Bronze Age and Neolithic pottery makes little sense, as the result would only show the differences between the periods. For this reason, we decided to use the diversity of shapes and decorations for a comparison. Diversity indices are known from biology and can, for example, describe the species diversity of a region or area. The Shannon–Wiener index is a mathematical quantity used in biology to describe diversity or biodiversity (Spellerberg & Fedor, 2003). The index describes the diversity in the data under consideration, taking into account both the number of different data categories (types) and the abundance (number of pots/sherds per type). Since, for example, the decoration of vessels – such as knobs, handles or vessel roughness – is a free decision of the potters that does not contribute to the functionality of the vessels, it can be used as a measure of creativity, individuality or simply diversity in the material. The same applies to the shape. Shape follows style, taste and fashion, but also functionality. A high diversity of forms indicates a specialised function (bowl, dish, plate, jug) or the absence of any norm. However, the latter is not possible within a society, as shapes are adopted unconsciously.

As the aoristic time series summarise different values, mostly counts but also floor area and the Shanon–Wiener Index, they were standardised statistically as z-scores for better comparison.

5.3.1.3 Characterising Social Cultural Spheres – Forms of Capital

The forms of capital describe a community/society in a given social space in prehistory. In particular, the classification of archaeological find groups from different times and spaces into capital types enables comparability. They do not serve to identify inequalities within societies, but to compare social/societal processes over time and space (Table 5.1).

Symbolic Capital

This form of capital encompasses the social rank of an individual in society and is acquired through recognition and is presented to the outside world. The battle axes of the Neolithic and daggers and swords of the Bronze Age represent a social rank and a certain prestige of the buried person. Also, house sizes, here given in m^2, can be understood as a sign of certain social importance of the inhabitants presented to the community and outside group. Although, house sizes could be understood as economic capital, as Bourdieu (1986) states, symbolic capital is indicated by economic capital. To assign house size to the realm of economic capital would neglect the symbolic meaning of houses, and would overemphasise economic capital within the capital structure. Houses as symbolic capital of small groups are known from various ethnographic parallels (Wunderlich, 2019). Here, we have assigned houses to symbolic capital in the sense of projection of internal socio-economic realities within a community.

Table 5.1 Forms of capital and assigned archaeological contexts

Form of capital	Archaeological contexts
Symbolic	Hatchets (‘battle axes’) and swords
	Daggers
	House sizes
Social	Copper (Neolithic) and gold (Bronze Age)
	Amber
	Number of monuments
Cultural	Diversity in pottery shapes
	Diversity in pottery decorations
	Treatment of the dead (single vs. collective burials; inhumation vs. cremation) – qualitative proxy
Economic	Hoards
	Sickles
	Axes
	Monument size

Social Capital
Relationships between people and groups, access to networks and the intensity of these networks make up social capital. Archaeologically, we can identify resources that are not locally available. Bronze was omitted here because there is no comparable equivalent in the Neolithic. Instead, Neolithic copper items and Bronze Age gold finds were combined in one proxy. Both materials have to be imported from afar and hint to the embeddedness of supra-regional networks providing such objects/resources. Amber serves as an indicator of reduced network intensity when it is present. When it is absent – and occurs massively in a distant region at the same time – it is an indicator of supra-regional networks. Likewise, the number of monuments is seen as an indicator of cooperation between local groups and stronger intra-regional networks.

Cultural Capital
Cultural capital is knowledge of practices and action (Handlungswissen) in any form and is the basis of most archaeological remains, as its realisation can lead to production of material culture. However, it is difficult to grasp materially. Burial customs and changes in material culture can generally be seen as cultural capital because they either show knowledge of how to perform normative implementations of practices or the introduction of new knowledge altering/replacing old practices. In our examples, however, we have the issue that the quantification of respective proxies tends to be mutually exclusive. The transitional phases of practices burial costumes (e.g. single vs. collective burials or inhumation vs. cremation) can be used as a qualitative argument to explain transformative processes. Therefore, we relied here on a diversity measure that represents differences in the frequency of pottery forms and decoration seen as cultural phenomena.

Economic Capital
This form of capital circumscribes possessions and material values, which in our modern times are comparable to money. Our assignment of depots refers to the alienable possessions of a society that are deposited in order to be taken out of the value-cycle. The number of sickles is often equated with money (Sommerfeld, 1994), but they can also have an economic value in terms of agriculture. Likewise, hatchets (axes), made from flint or bronze, are expressions of labour in the form of tools. The construction of large monuments is also to be seen as a labour effort, for which further surplus must be available in order to sustain labourers. The larger the monument, the more food and resources must be provided.

5.3.2 Demographic Proxies

Although demography is not defined as a form of capital, it is highly related to all of them. Population size, density and structure can be understood as an important scaling and influencing factor in the social, economic, symbolic and cultural realms of a society (Bettencourt et al., 2007; Feinman, 2011; Shennan et al., 2017) and vice versa.

5.3.2.1 Composite Kernel Density Estimation Models of Radiocarbon Dates

As a proxy to represent the demographic development of our study area we use the common approach 'dates as data' (Rick, 1987) employing summed radiocarbon dates from archaeological records (e.g. Crema & Bevan, 2021; Hinz et al., 2012; Shennan & Edinborough, 2007). Concerning the amount and representation of the radiocarbon data, it is not possible to operate only with dates from the Southern Cimbrian Peninsula, as especially Bronze Age contexts are highly under-represented, due to research and sampling biases. To compensate for this issue, radiocarbon dates from Southern Denmark were integrated into the data set. The geographical and cultural closeness of both regions throughout prehistory enables us to draw from the combined record conclusion for the whole aggregated region (Kneisel et al., 2019, 2022). We retrieved the radiocarbon data from the Xronos data base (https://xronos.ch/), RADON-B (Kneisel et al., 2013) and the Feeser et al. (2019) data set, further our data was completed by the compiled data set of Bunbury et al. (2023). As a proxy to represent the demographic development of our study area we use the approach 'dates as data' and employ composite kernel density estimation (cKDE) models of the radiocarbon dates. cKDE models or kernel density models in general provide a more robust alternative to summed probability distributions to assess radiocarbon dates as a demographic proxy (Crema, 2022; Parkinson et al., 2021). For computing the cKDE models we used the R package rcarbon (Bevan et al., 2022) on our site-level binned data (h = 100 years), with the kernel bandwith of 75 years and 500 simulations. Radicarbon dates with high measurement errors (>150 ^{14}C years) are excluded from the analysis. The refined data set contains 1384 radiocarbon dates from 186 sites.

5.3.2.2 Palynological Human Impact Proxy

As a further regional demographic proxy, we use the palynological human impact proxy from Feeser et al. (2019) for Lake Belau (Fig. 5.1(6)). This is based on a multivariate ordination (principal component analysis) using a selection of terrestrial pollen taxa from two well-dated, high-resolution pollen records from northern Germany. Human impact or landscape openness, respectively, as reflected in the pollen data, can be used as a demographic indicator based on the assumption that an increasing population density leads to increasing woodland clearance due to an increasing demand for resources including wood, agricultural land and settlement areas (Feeser et al., 2019; Heitz et al., 2021; Lechterbeck et al., 2014). Each sample from the pollen record used in the principal component analysis is absolutely dated and therefore the openness score (PC 1.) can be plotted as a time series, expressing human induced land clearance.

5.4 Analysis

The two main analyses are a time series of the forms of capital and the performance of a principal component analysis on the 100-year binned time series. With both of these data representations, we can explore the temporal development more comprehensively. However, as the amount of data is too vast to present in detail, the following description of the results only includes the general trends, extreme deviations, important correlations, as well as possible underlying structural behaviour. Detailed and exhaustive data analysis can be accessed and comprehended in the supplementary material.

5.4.1 Timeseries

Symbolic Capital

Shaft-hole axes made of stone have occurred since the Mesolithic (Fig. 5.2). High-quality and socially significant battle axes (hatchets, hammer axes) occur from the early 4th millennium onwards (Zápotocký, 1992). At the end of the 4th millennium BCE, they become quantitatively more frequent (Brozio, 2019, 2020) and are now also regularly found in burial contexts (Schultrich, 2022). Quantitatively they reach their highest frequencies at the beginning and the end of the Single Grave Culture Groups (SGC), a northern phenomenon of the Corded Ware groups, of the 3rd millennium BCE (Schultrich, 2018). Around 2300/2200 BCE, the number of retouched daggers began to increase in importance and overtake the social function of the battle axe (Kühn, 1979; Schultrich, 2022).

With the introduction of houses and a sedentary way of life in the Neolithic, two-aisled houses are built as single farmsteads, hamlets and from 3400 BCE in the form of villages (Brozio, 2016; Hage, 2016; Müller, 2013, 2019). This is followed by a phase between 2900 and 2200 BCE, from which only a few and then only small buildings are documented. This changes around 2200 BCE, with the construction of houses with storage buildings and associated fields (Kleijne et al., 2021).

The introduction of two-aisled houses and the later agglomeration in villages (Brozio, 2016; Hage, 2016; Müller, 2019) around 3400 BCE are in the context of an economic boom phase. The buildings represent the prestige, the economic strength, and the social cohesion of the groups. Battle axes and daggers materialise the acquired recognition of individuals within the groups. This is particularly evident in the accessories, which represent individualism and expression of personal prestige (Brozio, 2020).

The Bronze Age begins with a drop in symbolic capital, as daggers, axes/swords and house size decline. However, this may also be a data gap, as there are many daggers, especially in Holstein, that are not dated (Schaefer-Di Maida, 2023). Axes and swords increase from 1700 BCE onwards and can be interpreted as badges or emblems of prestige (Bunnefeld, 2014, 2018; Kristiansen, 1984; Kristiansen &

Fig. 5.2 Standardised time series of the single archaeological contexts representing the different forms of capital and the summed curved of each form of capital from the Southern Cimbrian Peninsula

Larsson, 2005). In this context, swords significantly predominate in the data curve compared to axes, so that a transfer of the symbolic meaning of axes to swords can be assumed with the Bronze Age. Around 1500 BCE, the size of houses from the Southern Cimbrian Peninsula increases (Kneisel et al., 2019, p. 1615, Fig. 6). This is also due to the use of three-aisled buildings and the introduction of the so-called dwelling stable house, which came into widespread use around 1500 BCE (Meier, 2013). The enlargement of the house and thus also of the household requires reorganisation. The direct (overlapping) connection of houses and barrows (e.g. domestic site Handewitt, Trappendahl, etc., cf. Svanberg, 2005, p. 79) suggest that, for example, the head of the household was buried by the household community in a barrow. The household thus represents itself in the individual, who is singled out for prestige. Symbolic capital thus reaches its zenith as titles and achievements acquire a public monumental representation that cannot be unseen in the landscape. Around 1100 BCE, swords and daggers as well as house sizes decrease considerably. There seems to be an end of elites and associated household communities and associated large houses. The highlighted personalities lose importance and with them symbolic capital changes. The collective is now in the foreground and manifests itself particularly through uniformly equipped urn graves in cemeteries.

A social transformation can be observed that is repeated several times: the transformation of societies from the individual to the collective and vice versa. This phenomenon is first comprehensible between 3800 and 3200 BCE. First, individual burials in long barrows and partly in dolmens appear. Then, collective burials in passage graves become predominant. Hereafter, 3200–2700 BCE, single burials (solely, in small or larger graveyards or at passage graves) increase again (van der Velde et al., 2020) and this development reaches a peak with the ealy SGC (Brozio et al., 2019; Hübner, 2005; Schultrich, 2018). Then, in turn, secondary extensions in the burial mounds, as well as multiple burials in burial chambers and post-burials in megalithic graves, increase until 2300 BCE (Hübner, 2005; Schultrich, 2018). In the centuries between 2300 and 1150 BCE a focus on the individual is visible again, whereas from 1150 BCE, with the urn burial grounds, a levelling of the social stratigraphy dominates, where the highlighted personality is no longer directly in focus (Kneisel, 2013; Schaefer-Di Maida, 2023; Schaefer-Di Maida & Kneisel, 2023).

Social Capital

The construction of monumental tombs on one hand is characterised by the construction of dolmens and subsequently of passage tombs between 3400 and 3100 BCE (Brozio et al., 2019). Long barrows from 3800 BCE, on the other hand, are quantitatively only comprehensible in small numbers (Müller et al., 2014). With SGC there is a construction boom of burial mounds from 2800 BCE onwards (Hübner, 2005). A decline from 2600 BCE is associated with secondary extensions of the existing burial mounds and reburials (Schultrich, 2018).

The increasing import of copper since the beginning of the Neolithic period has its first peak between 3500 and 3300 BCE (Klassen, 2000). By restricting exotic imports, triggered by changing networks, a second phase of the adaptation of metallurgy only starts around 2300 BCE (Müller & Vandkilde, 2021; Schultrich, 2019).

In the 4th millennium BCE, amber as a local resource has an important function as a traditional clothing element and prestige good within the Funnel Beaker culture (TRB) groups. Amber hoards occur often in the Early Neolithic (before 3300 BCE). In the Middle Neolithic (3300–2800 BCE), however, amber beads predominantly appear in burial contexts (Ebbesen, 1995). In the SGC of the 3rd millennium BCE, amber artefacts occur in burials frequently in northern Jutland. However, they become less frequent in a southerly direction, at an increasing distance from the secondary deposits. Thus, amber increasingly loses its importance among the societies analysed (Hübner, 2005; Woltermann, 2016).

Relationships in the form of regional and supra-regional networks undergo a fundamental change around 3300 BCE (Müller, 2022). The import of copper (Brozio et al., 2023) as well as the introduction of new technologies such as the ard (Mischka, 2013), new products such as the free-threshing wheat (Kirleis & Fischer, 2014) or ideas of social action such as the enclosures (Dibbern, 2016; Klassen, 2014) reflect the high quality of the supra-regional relationship network. With the cancellation of copper imports from 3300 BCE, an increase in the importance of regional relations arises. This is accompanied by the joint construction of collective and monumental burial grounds. However, in the late Middle Neolithic (3100–2800 BCE), collective efforts decrease again while supra-regional communication increases (Müller et al., 2020). In this phase, individual signs of power and violence (the battle axe) increase in absolute numbers and in burials (Schultrich, 2022). This phase paves the way for the SGC societies. Around 2800 BCE, the extensive networks of the SGC groups express themselves in the construction of their own architecture, which not least serve the legitimation and compliance with widely applied standards (Furholt, 2021). The increase in metal imports at the end of the Neolithic, on the other hand, enables the accumulation and expression of social capital through material culture, integrated into networks between southern Scandinavia and eastern Central Europe (Vandkilde, 2017).

With the transition to the Bronze Age, a gap in social capital seems to persist, lasting at least until 1500 BCE. It goes hand in hand with the formation of the southern periphery of the Únětice culture and the associated network breakdowns, so that transregional exchange also decreases (Kneisel, 2012; Meller et al., 2013). From 1500 BCE onwards, both burial mounds and gold finds increase markedly. Gold as a resource from outside shows the increasing connectivity of the southern Jutland peninsula and the establishment of wide-ranging contacts (Pahlow, 2006). But not everyone was entitled to a burial mound. Nevertheless, the number of Bronze Age mounds is much higher than in the Neolithic, but since only excavated mounds are included in the curve, the maxima of both time horizons are similar (cf. Holst, 2013, p. 42; Kristiansen & Larsson, 2005). Divergences in graves clearly indicate increasing social differentiation, which continued until about 1100 BCE. Both the construction of burial mounds and the addition of gold declined sharply from 1100 BCE onwards. Monumentality and networks thus lost importance again and it seems that now everyone could receive a grave in the form of an urn burial (Kneisel et al., 2019; Kristiansen, 2006). The power of the individual (chief?) as well as the sense of the group and cooperation (e.g. for the construction of burial mounds) seem to have diminished at this time. In the course of the Younger Bronze Age (1100–500 BCE), burial mounds were built only sporadically, and these were mostly so-called small mounds, which were mainly restricted to the south of Holstein (Schmidt, 1993). Large and rich burial mounds are now the absolute exception (May, 2018; Thrane, 1984). The meaning of social capital thus shows a considerable transformation around 1100 BCE.

Cultural Capital

Between 4100 and 2800 BCE, a high diversity of the shapes of vessels and decorations of ceramics can be observed within the TRB (Lorenz, 2018). High diversity is present with the Fuchsberg style around 3500 BCE and then between 3100 and 2900 BCE. From 2800 BCE there is a decline in diversity, containing the limited canon of forms of the SGC beakers, bowls and amphorae (Brozio, 2016; Müller & Peterson, 2015). From 2400 BCE, with the influence of bell beakers and the dagger groups, ceramics again become more diverse in terms of shapes and decorations (Hübner, 2005; Kleijne, 2019).

Ceramics as a means of expression of social reference is of great importance in the 4th millennium BCE. In the developing societies of the Neolithic, production and use of common forms and vessels provide opportunities to participate in regional and supra-regional sign systems. From 3100 BCE onwards, the increase is a reaction to a changing social system in which a developing shift from collective to individual consciousness can be observed, a phase in which hereditary capital transfer is obfuscated. In the following centuries, on the other hand, a strong standardisation can be observed, in which cultural capital plays an important role as knowledge of action and represents the basis for power.

Around 1800 BCE, the standardisation of pottery collapses, reflecting a loss of previously cultivated cultural capital. While there is little variation in form, individual decoration increases. A clear increase in the variance of decoration from 1200 BCE onwards may be related to the introduction of urn burial, whereby the individual design of burial vessels gained importance against the background of otherwise very standardised burial methods (Schaefer-Di Maida, 2023). However, the discontinuation of standardisation in pottery production brings with it a new cultural capital, as metal objects become more relevant and standardised.

Economic Capital

During 4100–3300 BCE, an accumulation of objects in depots can be observed. Around 3200 BCE and 2800 BCE there was a decrease followed by phases of increase. A further increase of depots begins around 1800 BCE. Axes have a special significance as tools and as objects of value in the Neolithic, a peak is reached around 3300 BCE, and in the 3rd millennium BCE axes remain of great importance (Brozio et al., 2019). The beginning of the Neolithic is marked by an increase in human impact, which decreases between 3300 and 2900 BCE. After a further increase, a new boom phase begins around 2200 BCE (Feeser et al., 2012). This phase is associated with the introduction of the surface-retouched flint sickle (Kühn, 1979).

Between 4100 and 3300 BCE we observe an increase in economic capital through land opening and increased forms of accumulation of value in depots. Economic power is reflected in the ability to remove imported objects from circulation. At the same time, this is associated with demographic growth, which manifests itself in agglomerations in villages and manifests a quantitative increase in axes. At the beginning of the 3rd millennium BCE, a decline in economic capital takes place, followed by an economic boom phase from 2000 BCE (Brozio et al., 2019).

This boom continues, especially in the Early Bronze Age, and is boosted by a further increase in hoard finds around 1800 BCE, which exhausts the economic possibility of removing finds from circulation. The introduction of bronze arguably has a central role in this, in that the use of new networks possibly encouraged the requirement to give something back in order to maintain connections (Kristiansen & Earle, 2022, p. 13). The introduction of bronze also parallels the rise of monumentality. The construction of burial mounds becomes an important part of economic capital, as it requires the distribution of raw materials (Falkenstein, 2017). Sickle finds, however, decline again at this time, accompanied by a decrease in human impact. The use of hoards reaches a low point at the end of the Early Bronze Age around 1200/1100 BCE. With the introduction of cremation burials, a relevant transformation takes place, which probably also changes networks and world views (Schaefer-Di Maida, 2023). In the course of the Later Bronze Age, however, hoards became more important again and reached their peak. The composition of the hoards resembles grave furnishings, which, in contrast to the hoards, are rather sparsely furnished. It is possible that the hoard became a substitute for burial as a result, possibly because of increasing grave robbery due to a lack of bronze.

Human Impact

In respect to the human impact (Fig. 5.3) the period between 3800 and 3500 BCE can be recognised as a clear boom phase. After that, and up to 3000 BCE, a stable phase emerges in the data, which, however, rather suggests a crisis period. Between 2900 and 2800 BCE a slight increase in the pollen data is discernible, before a stable phase is again evident. After 2500 BCE there is a decline in the influence of humans on the environment and from 2100 BCE an increase, which presumably also involves a change in land use. Subsequently, a stable human impact curve is visible until 1700 BCE. Between 1600 and 1700 BCE the human influence decreases enormously, so that a crisis during this period can be assumed. For the Southern Cimbrian Peninsula this decline can probably be characterised as more moderate than for the neighbouring province Mecklenburg-Western Pomerania. Between 1500 and 1300 BCE a renewed phase of growth set in, bringing with it a further opening of the landscape and an increase in population. From 1300 to 1100 BCE the human impact decreases slightly again, before increasing again after 1100 BCE. Within Period VI during the latest phase of the Bronze Age, i.e. around 700 BCE, the human impact curve increases sharply again.

Demography

The human impact curve (cf. Fig. 5.3) correlates well with the demography proxy curve (Fig. 5.4) up until 2100 BCE (Late Neolithic). During the Neolithisation of the Southern Cimbrian Peninsula and Southern Denmark between 4100 and 3500 BCE there is an increase in population size. From 3500 BCE onwards, a decrease in population is evident, which continues until 2300 BCE. With the beginning of the Late Neolithic, c. 2300 BCE, a steady increase of the proxy is visible. From about 1600 BCE a strong increase is characteristic until about 1300 BCE. After that, high-quality data is found lacking, since cremation burials in this region have

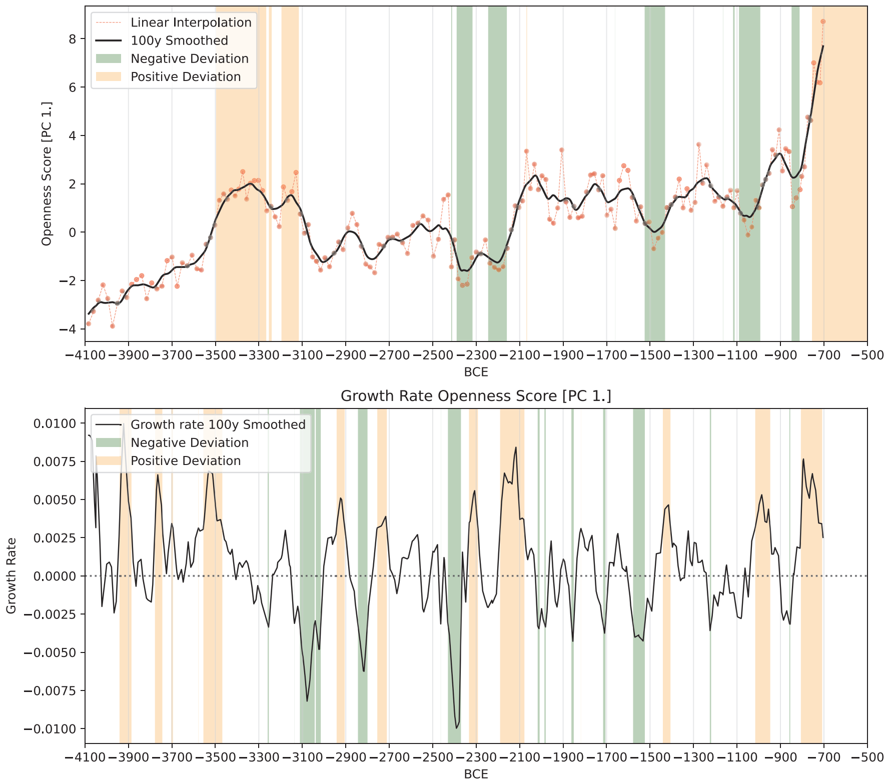

Fig. 5.3 Top: PCA spectra scores for the palynological record of Lake Belau, with indication of deviating positive (exceptional openness) and negative (exceptional closeness) events from the trend. Below: Growth rate of the 100-year smoothed time series of the PCA spectra scores, with indication of deviating positive (increasing openness) and negative (decreasing openness) events. For the event detection the approach of Parkinson et al. (2021) was used, where values in the 0.95 and 0.05 quartile are labelled as significant deviations

provided no ^{14}C data. Only Mang de Bargen, which has made a large database recently available, has shown a strong increase in graves (Schaefer-Di Maida, 2023). From 700 BCE onwards, corresponding dates are missing from the ^{14}C curve because of insufficient dating due to the cremation burial custom and the Hallstatt plateau. For population development we therefore have to refer to the human impact curve from 1300 BCE onwards, which, according to the local example of Mang de Bargen, shows good correlation with the population development in the later Bronze Age. The sudden increase in the human impact curve around 2100 BCE is not as sharply visible in the cKDE model. However, the general trend of increasing human activity is witnessed in both proxy archives. The immense peak between 1500 and 1300 BCE is not present in the human impact curve.

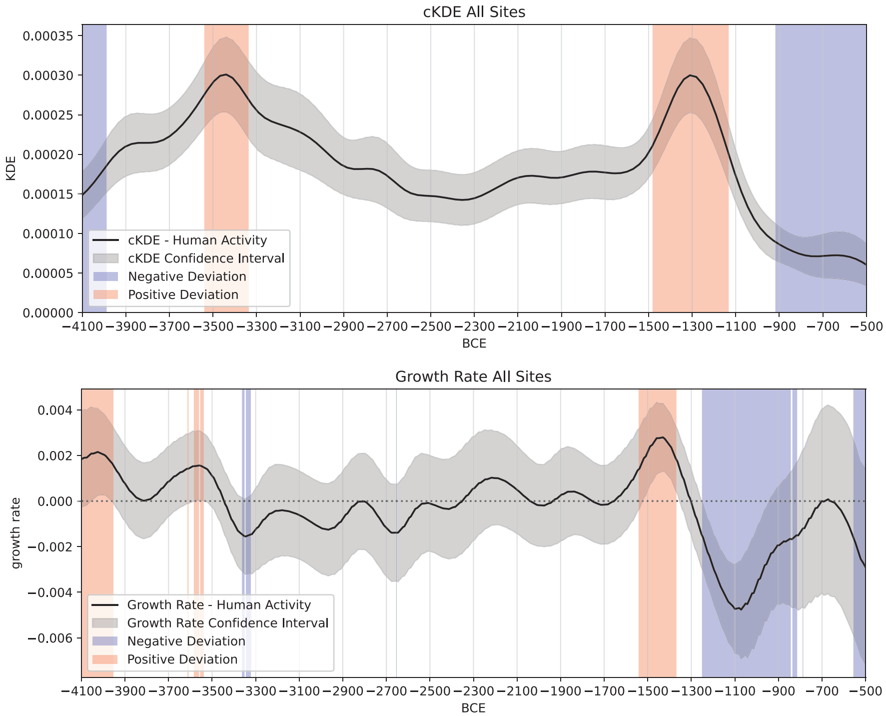

Fig. 5.4 Top: Demography proxy of a cKDE model of radiocarbon dates, with indication of deviating positive (exceptional high population) and negative (exceptional low population) events from the trend. Below: Growth rate (100-year smoothed), with indication of deviating positive (increasing population) and negative (decreasing population) events (right). For the event detection, the approach of Parkinson et al. (2021) was used, where values in the 0.95 and 0.05 quartile are labelled as significant deviations

5.4.2 *Relations*

The Z-transformation as data basis of the forms of capital were used for a principal component analysis (PCA). The objects are grouped as time slices in hundred-year bins, and the values of the individual elements of the forms of capital form the attributes. The goal was to visualise relations between time slices and the forms of capital differently than as a time series (Fig. 5.5) to uncover structuring latent factors. A mapping of the first against the second eigenvector shows a largely chronological distribution along the first eigenvector (cf. supplementary material), this is an expected result. For this reason, the second and third eigenvectors were examined. Together they describe c. 55% of the variability of our data and based on this, they are still well-suited to explore the results for meaningful patterns.

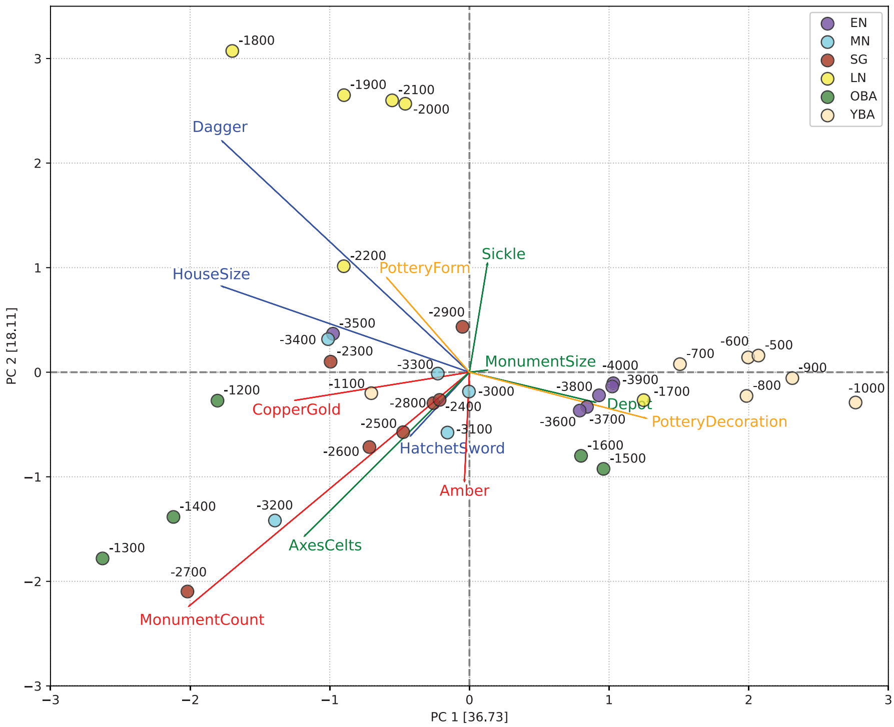

Fig. 5.5 Principal component analysis ordination plot of the 100-year bins (points). *EN* – Early Neolithic, *MN* – Middle Neolithic, *SG* – Single Grave groups, *LN* – Late Neolithic, *OBA* – Older Bronze age, *YBA* – Younger Bronze age

The PCA diagram (cf. Fig. 5.5) shows that the chronological phases cluster only partially, in many cases one time slice of the chronological phase separates along the x-axis (2. PC). These are in each case transitional periods from one chronological phase to another, which are briefly listed here:

Early Neolithic (4000–3500 BCE): The time slices of this phase are mainly located in the positive area of the x-axis, only the time slice 3500 BCE is in the negative area.

Middle Neolithic (3400–3000 BCE) and **Younger Neolithic** (2900–2300 BCE): Both chronological phases form a loose cluster in the negative area of the x-axis and show no outlying time slice.

Late Neolithic (2200–1700 BCE): It is the only chronological phase that exhibits high positive position on the y-axis. On the x-axis it is situated in the negative area of the graph. The time slice of 1700 BCE, however, separates itself from this pattern and lies in the positive area of the x-axis and negative on the y-axis.

Older Bronze Age (1600–1200 BCE): The early phase of the Older Bronze Age (1600–1500 BCE) is in the positive area of the x-axis, while the younger phase (1400–1200 BCE) of the Older Bronze Age is in the negative area.

Younger Bronze Age (1100–500 BCE): The beginning of the Younger Bronze Age (1100 BCE) lies in the negative area of the x-axis, while the majority of time horizons (1000–500 BCE) cluster in the positive area.

Turning the view to the attributes – the forms of capital – we see them arranged on the graph as distinguishable loose clusters demarcating spheres of attraction.

Social capital: Number of monuments, copper/gold and amber, are in the double negative area of the graph.
Symbolic capital: House size, number of daggers and hatchets/swords are in the negative range of the x-axis and scattered along the y-axis.
Economic capital: Number of sickles and of hoards, as well as monument size, are mainly located in the positive area of the x-axis. Different from this are the number of axes, which are placed in the double negative part of the graph.
Cultural capital: The diversity of ceramic decoration and ceramic form lie between economic and symbolic capital, diametrically opposed to each other.

What is striking is the shift of initial or final time slices of a chronological phase to an opposite part of the graph. These time slices are in each case initial or final phases of transformation processes and describe clear transition and change in importance of the forms of capital. It could be discussed in detail whether these time slices do not already belong to the next chronological phase, but we rely on the phase division of the Neolithic and the Bronze Age, which has developed in research history and saw good reasons to propose given breaks (Kneisel, 2021; Müller et al., 2012; Müller & Vandkilde, 2021; Vandkilde, 1996, 2017). The PCA shows just as clearly as the time series representation that we are dealing with a change in the composition and significance of the forms of capital at the beginning and the end of our chronological phases. However, while this might appear to be nothing new, we provide the possibility of an in-depth multi-causal and inter-relational discussion of transformation processes.

In summary, a change along the y-axis can be seen in the Neolithic, with the Late Neolithic period in the positive area of the axis, while the rest are largely in the negative area. A change along the x-axis can be seen for the Bronze Age sections. Thus, the change within the Bronze Age stages is always between social and economic, while the change in the Neolithic is between three forms of capital: social, symbolic and economic.

5.4.3 Correlations

The PCA (cf. Fig. 5.5) has shown that we must understand the chronological phases as a period in which the foundations for the transformation processes are probably laid through changes, which are then reflected in the recognisable demarcations of the transitional time slices.

In order to assess the concurrency of our chosen archaeological and demographic proxies apart from 'eyeballing' we use a pairwise Pearson's correlation of the time series in 100-year bins, within time windows of 500 years, 1000 years and in archaeologically meaningful phases thereafter (Palmisano et al., 2021). The bin size is set by the temporal resolution of the archaeological proxies. Admittedly, the 100-year binning of the proxies leads to a small sample size for the correlation test and therefore the results need to be treated with caution. The results of all possible correlations in the given time windows and the corresponding code can be accessed via the supplementary material.

Beginning with the Early Neolithic (4000–3500 BCE), and thus with the Neolithisation process, economic capital plays a major role. Towards the end of this chronological phase, a shift from economic to symbolic capital can be observed (cf. Fig. 5.2). This period is the beginning of our observations, and many of the capital forms have a rather uniform course here, which is partly due to the low dating diversity. During the Early Neolithic, we are dealing with a population growth that goes hand in hand with the opening up of vegetation and the cultivation of the landscape. The investment in the creation of a cultural landscape is expressed in economic capital. Especially during the initial phase of the Early Neolithic, economic capital is not to be seen as purely economic but is translated into a type of symbolic capital (Fig. 5.6).

From 3500 BCE onwards, the number of monuments and axes increases and with it the importance of symbolic capital within society (cf. Fig. 5.2). In the Middle Neolithic (developed TRB: 3400–3000 BCE), a change from symbolic capital to a mixture of social, symbolic, cultural and, to a certain extent, economic capital can be observed from 3300 BCE onwards. Based on this, we assume that inter- and intra-societal interactions – visible in social capital –, and political negotiations – tangible in symbolic capital – become more complex (Fig. 5.7; see supplementary material: Correlation 3400–3000).

Not least the copper boom, as well as the import stop of the same, between 3500 and 3400 BCE can be seen as a turning point in the North, which probably had a lasting impact on the importance of the different forms of capital in society. The high number of amber finds and the large number of monuments from 3300 BCE onwards are evidence of elaborate local and small-scale regional networks. In another respect, this development is simultaneously expressed in the decrease in house sizes, which suggests smaller reference groups, among other things. Power relations are now more likely to be negotiated through the sizes and number of monuments. This indicates small, eventually complexly structured, groups that cooperate intensively with each other, but at the same time also compete with each other and have fewer supra-regional networks (Brozio et al., 2023; Wunderlich, 2019). These developments partly go hand in hand with the agglomeration process of the settlement structure, which could lead to the described reorientation of capital forms. In more dense areas, communication and interaction behaviour for the negotiation of power relations must develop differently than between dispersed groups that create their space in a landscape that is hardly shaped at all. Our demographic

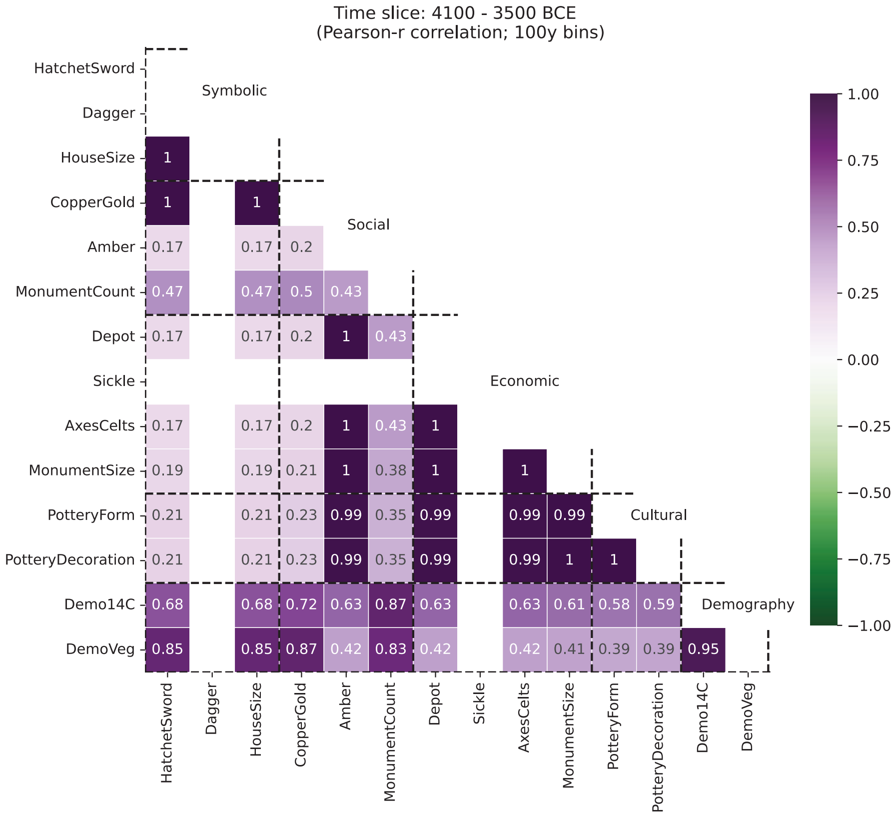

Fig. 5.6 Correlation matrix of the 100-year binned summed forms of capital, human impact (DemoVeg) and demography (Demo14C) proxy for the time slice from 4100 to 3500 BCE

proxies show a population decline during the Middle Neolithic, whereby the agglomeration of settlement communities could play a role here.

In the SGC (2900–2300 BCE) this mixed situation remains, consisting of social, symbolic and, to a certain extent, economic capital (Fig. 5.8), even though we can archaeologically recognise a different social system for this phase. During the period of the SGC groups, the communal negotiation of symbolic power shifted more towards the emphasis on the individual, evident in the construction of burial mounds with a clear individual grave character – visible in the decreasing size of monuments – and the use of battle axes as grave goods (cf. Fig. 5.2; see supplementary material: Correlation 2900–2300).

After the Middle Neolithic, the decrease in monument size suggests a reduction in the size of the reference groups, and evidence of increased mobility. We assume that the basic organisation in complexly structured small groups with their local networks is nevertheless preserved. Superregional networks are present at this time with the connections to the Corded Ware but are not recorded due to our selection of material culture for the capital forms. Vegetation opening and human activity

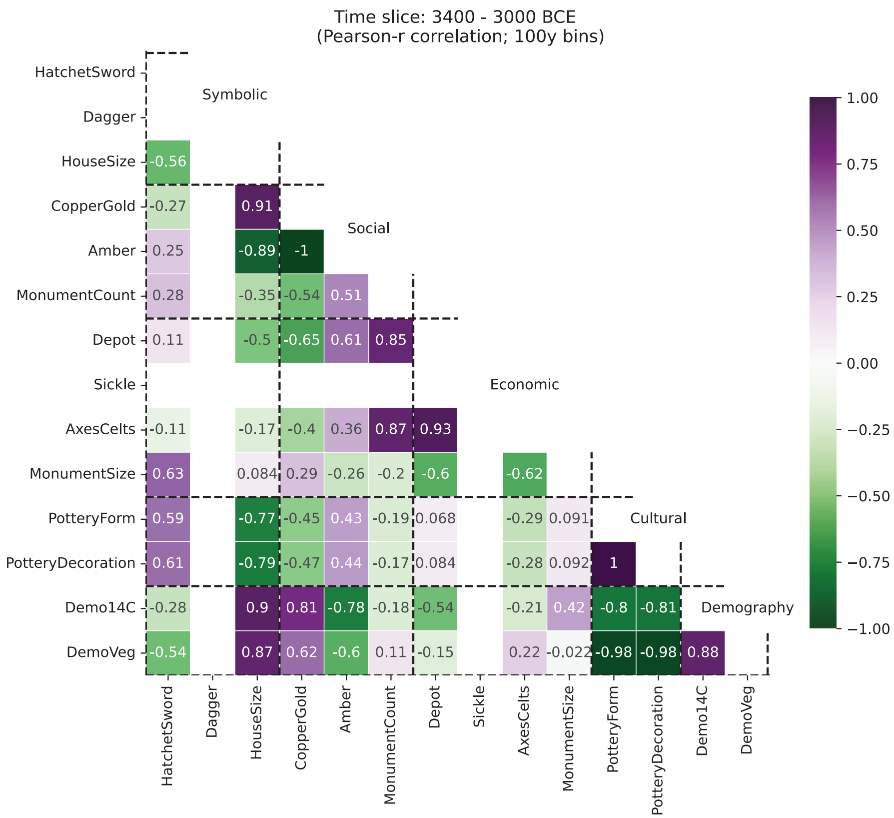

Fig. 5.7 Correlation matrix of the 100-year binned summed forms of capital, human impact (DemoVeg) and demography (Demo14C) proxy for the time slice from 3400 to 3000 BCE

records a slight increase during the beginning of the SGC (2900–2600 BCE) and decreases towards the end (2500–2200 BCE). At the same time, an abrupt cooling event took place around 2900 BCE (Chap. 6).

The dagger period (2200–1700 BCE) is mainly characterised by symbolic capital. In addition to the flint dagger as a new symbol of social rank, the crescent flint sickle appears as a novelty in agriculture, and houses become larger again (Fig. 5.9). During this time, spelt appears for the first time, hulled barley began to increase steadily in 2000 BCE and became the predominant type of barley around 1600 BCE and from 2500 to 1800 BCE highest and stable air temperatures are recorded (Chap. 6). The embedding in the supra-regional networks of the beginning Central European Bronze Age can be recognised in the increasing availability of copper objects. The rapid opening of the land at the beginning of the Late Neolithic from 2200 BCE, but low demographic increase (cf. Figs. 5.3 and 5.4), is very contrasting and can only be explained by a research-related deficit of radiocarbon data from the Late Neolithic or agricultural technological innovations that decouple population size

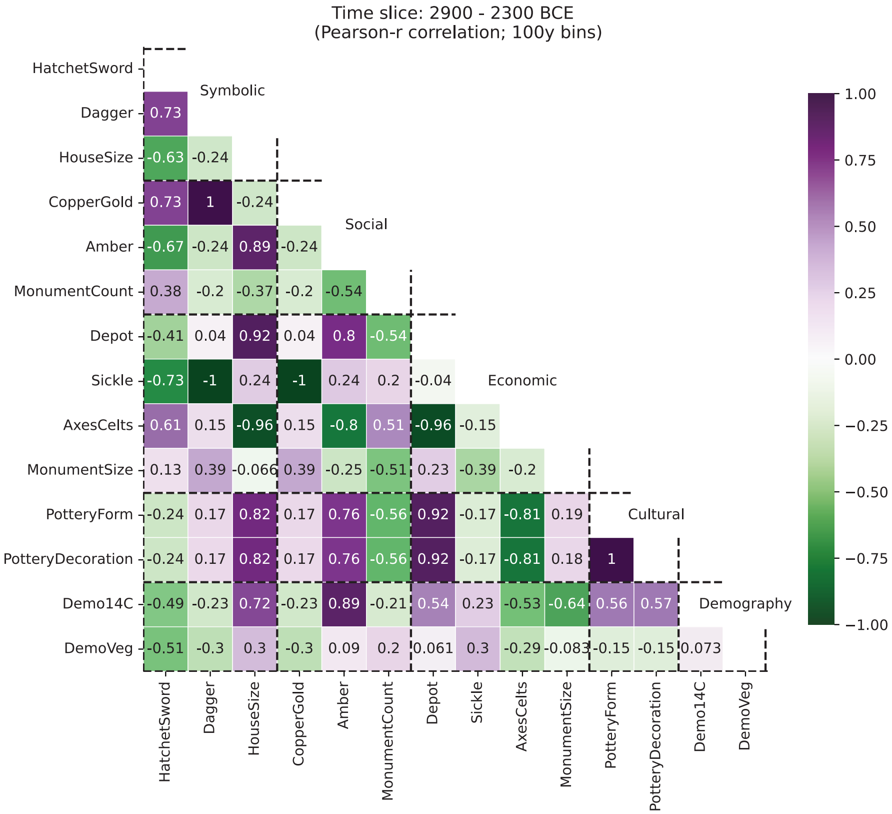

Fig. 5.8 Correlation matrix of the 100-year binned summed forms of capital, human impact (DemoVeg) and demography (Demo14C) proxy for the time slice from 2900 to 2300 BCE

and vegetation opening. The introduction of spelt and the crescent flint sickle may be expressions of such a turn in agriculture.

Towards the end of the Late Neolithic (1700 BCE), the change from symbolic capital to a phase clearly marked by economic capital can be observed, which then continues until the beginning of the Older Bronze Age (1600–1500 BCE). This very concise period from 1700 to 1500 BCE is defined above all by the increasing availability of bronze. We assume that the meanings of the forms of capital are renegotiated, which is very visibly foreseeable in the deposit custom, which increases from 1700 BCE. Economic capital is now re-emphasised as it is brought to another level with a countable exchange value such as bronze (Brinkmann, 2019). Fixed units of exchange (e.g. 'sickle money', standardised artefact types like ring ingots) can be established (Jahn, 2013; Krause, 2003; Sommerfeld, 1994) and the deliberate destruction of bronze goods in hoards serve negotiation and communication (Fontijn, 2002). As with the opening of the land in the early Neolithic, economic capital – in this case in the form of depositions – is once again a simultaneous way for the community to demonstrate its capabilities. This time, however, not in the

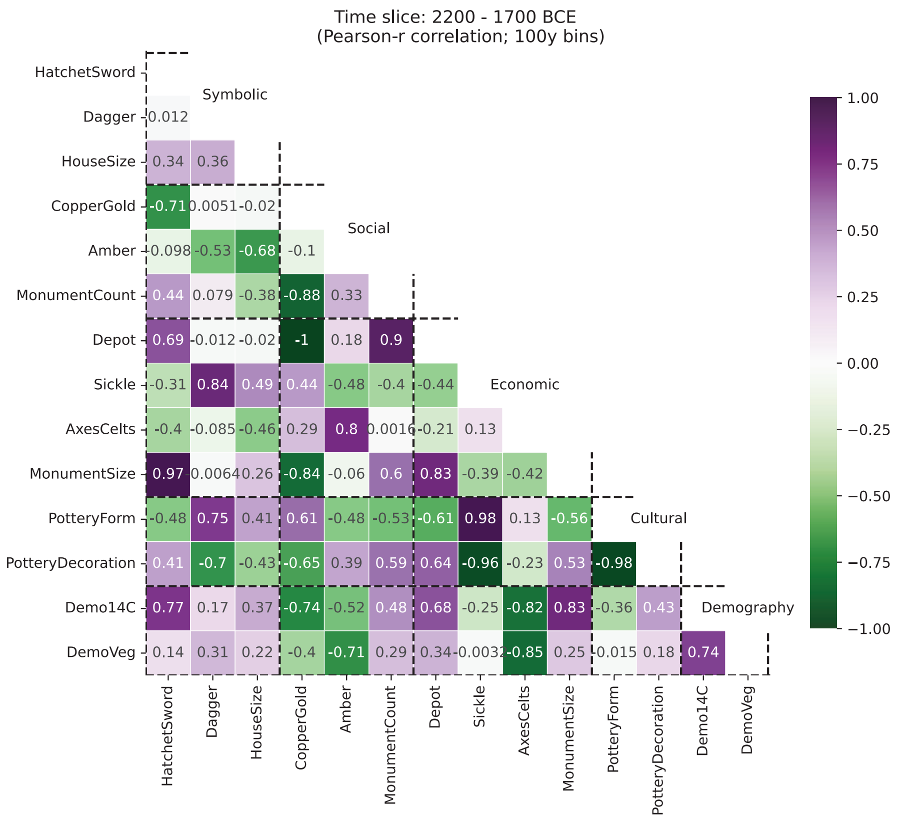

Fig. 5.9 Correlation matrix of the 100-year binned summed forms of capital, human impact (DemoVeg) and demography (Demo14C) proxy for the time slice from 2200 to 1700 BCE

development of new landscapes, but in the agglomeration of a new and valuable form of resource. This interconnectedness of capital forms is also evident in the expressive correlation of capital forms in the period from 1800 to 1400 BCE (Fig. 5.10; see supplementary material: Correlation 1800–1400). From 1400/1300 BCE onwards, this correlation pattern again declines sharply (cf. Fig. 5.2; see supplementary material: Correlation 1300–900, 1100–700 and 1000–600).

In the course of the Older Bronze Age (1500–1200 BCE), a change from economic to symbolic capital can again be detected from 1400 BCE onwards. A decrease in economic capital is indicated by fewer hoards and sickles. The rise in symbolic capital is clearly evidenced by the increasing house sizes and the high number of swords. The ambivalence of how social capital manifests is interesting, since it shows a very good integration of these societies into supra-regional networks as evidenced by gold imports; but at the same time, the increased number of monuments indicates the strengthening of local networks, proving an internal cooperation between the different communities. The social status of highlighted

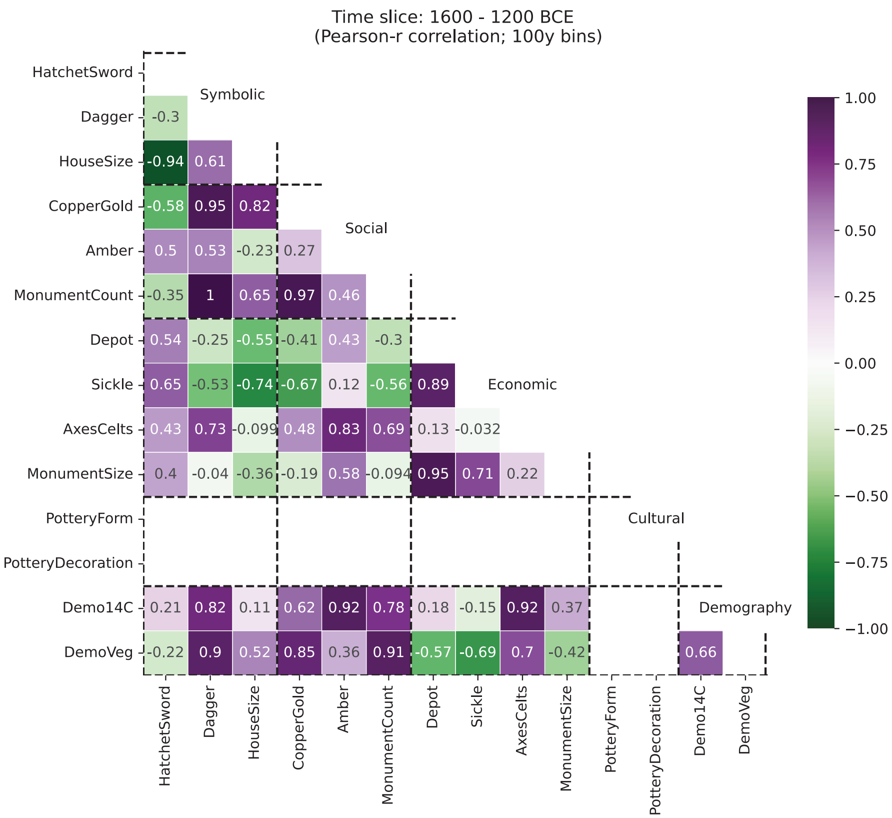

Fig. 5.10 Correlation matrix of the 100-year binned summed forms of capital, human impact (DemoVeg) and demography (Demo14C) proxy for the time slice from 1600 to 1200 BCE

personalities is shaped by local power and supra-regional relations. After a drop in land opening around 1500 BCE, there is a renewed increase in human impact, but after 1400 BCE, the radiocarbon data show a trend of decreasing population density. Nevertheless, the demographic proxy shows the highest values between c. 1500 and 1200 BCE, even if the preceeding and succeeding chronological phases may be subject to research bias, we have to assume a relatively large population. The question is whether this increase in population coincides with an increase in social inequality and the desire to accumulate symbolic capital. We know that the time horizon between 1600 and 1500 BCE is a very important one across Europe, in which transformation processes take place in many regions, which in turn have an impact on the existing pan-European Bronze Age network (Kneisel, 2012; Meller et al., 2013). A migration to the north cannot be ruled out, but it is certain that the north consumed large quantities of high-quality bronzes in graves and hoarding behaviour during this period. A demographic peak around 1400 BCE can be explained by various effects, including the migration of people to the north after the collapse of social structures in the south (Kneisel, 2013; Vandkilde, 2017). If the growth rate of the demographic proxy is taken into account, however, a positive trend can already be seen in the Late Neolithic, which reaches its peak around 1600 BCE and declines again from here on. Assuming that there is a wave of migration, there would also have to be a sharp increase, especially around 1600–1500 BCE, but that is not the case. It seems that the demographic trend is an internal one, the magnitude of which will have to be debated in the future. It is interesting to note that a negative growth rate correlates with a decrease in sickles, which may be due to changes in agricultural practices and intensification of animal husbandry. The Older Bronze Age is a period of high prosperity, which seems to have been characterised by a high degree of concurrence between communities and spheres of influence. The strong externalisation of symbolic capital in combination with the individual manifestations of the other forms of capital (e.g. high number of hoards and low number of sickles) and possible population pressure makes this reading of the data likely.

In the Younger Bronze Age (1100–500 BCE), there was a renewed change between symbolic and partly social capital to economic capital and partly also cultural capital with the diversity of ceramic ornaments. The increase in economic capital is also reflected in a strong increase in land opening from 1100 BCE onwards. At the same time, there is an increase in burials (Schaefer-Di Maida, 2023), which suggests a rise in population (Kneisel et al., 2019, p. 1613, Fig. 4). We see in our data how symbolic capital almost disappears, and is 'replaced' by economic capital, as can also be seen in the correlation calculation (Fig. 5.11; see supplementary material: Correlation 1000–600).

House sizes shrink significantly and objects indicating rank and prestige are present in significantly smaller numbers than in the previous chronological phase. The reduction of the number of houses has a great significance for the social structure of the Younger Bronze Age communities. Not only does the symbolism of the large house lose its significance, but it seems to indicate that the social units that previously inhabited the large houses emancipated themselves from each other and formed their own households (Mikkelsen, 2020). A probably similar process of emancipation and individualisation can be traced in the negotiation of ownership of farmland. During the Younger Bronze Age, so-called celtic fields are established, which demarcate agricultural land and can probably be understood as a sign of ownership. Over time, these fields become smaller, which is usually explained by the adoption of inheritance rights (Arnold, 2011; Løvschal & Holst, 2014). The change in the increased importance of economic capital is also evident in the huge rise in depositions of artefacts, testifying to the importance of negotiating and presenting exchange values and economic capabilities between and within communities. The renewed abundance of sickles fits well with the innovations in agriculture. The local networks of the Older Bronze Age seem to have been less pronounced, as the capital forms indicating collaboration and small-scale regional exchange (e.g. number of monuments and amber) are hardly developed. This is not the case for the supra-regional networks, which again seem to be less intensive than in the Older Bronze Age but can be proved by the presence of gold finds. In addition, we know connections to communities in Central Europe were present (iron, face/house urns, foreign

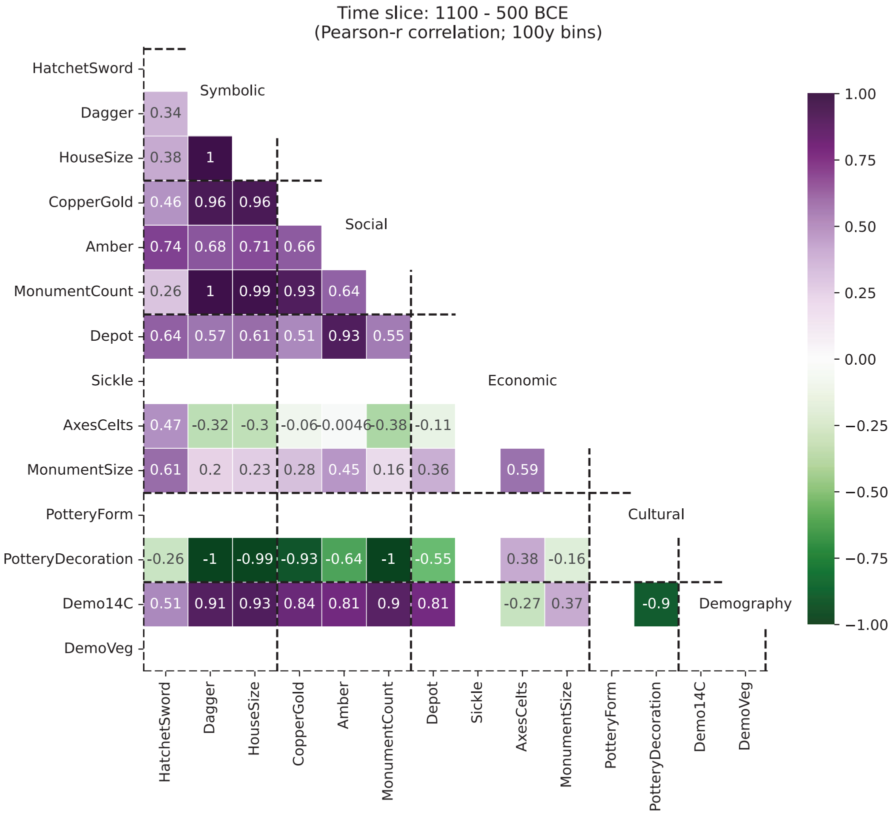

Fig. 5.11 Correlation matrix of the 100-year binned summed forms of capital, human impact (DemoVeg) and demography (Demo14C) proxy for the time slice from 1100 to 500 BCE

forms in hoards), but due to our selection of material culture they are not recorded in the capital forms. The diversity of ceramic decorations also supports the idea of extensive contacts. As already mentioned, the transition from the Older to the Younger Bronze Age is a transformation phase in which many things happen and change (Kneisel, 2021). We see this clearly in our capital forms and the proxy for land opening. What we do not show with these proxies, however, is the change in burial customs from inhumations to cremations, which can be seen as a strong marker for changes in the social and ideological-religious system (Fokkens, 1997; Hofmann, 2008; Rebay-Salisbury, 2012; Schaefer-Di Maida, 2023). The change in burial rites is most likely to be linked to the abandonment of monument construction; from 1100 BCE onwards, burials as urn graves are mainly deposited in existing mounds of the Older Bronze Age. Within the subsistence economy, the introduction of millet is certainly significant during the Younger Bronze Age (Filipović et al., 2020), and the increasing use of horses as mounts, possibly as work animals, is likely to have had an influence on social relations.

With regard to the selection of capital forms, recurring patterns can be identified in the section from the Early Neolithic to the end of the Bronze Age. The development of the SGC and the Younger Bronze Age shows parallels in the relationship of the forms of capital, just as there seems to be no change in the forms of capital between the developed TRB and SGC.

5.5 Conclusion

The structures of social space are subject to dynamic processes that characteristically change in certain periods of time: until 3500 BCE, an increase in the importance of symbolic, cultural and social capital can be observed. This is associated with a phase of economic growth. In this period, which is connected with Neolithisation, the forms of capital emerge within the new economic forms. This includes the ability to accumulate land for agriculture, the membership of networks expressed through material culture, as well as the transmission of knowledge and the representations through monuments. A prerequisite to being able to accumulate surplus and produce symbolic capital – prestige and power – is economic security by colonising the landscape and establishing a reliable agricultural system. Around 3000 BCE we observe a boom phase of cultural and symbolic capital. In contrast, there was a decline in social and economic capital. With the transition from the 4th to the 3rd millennium BCE, cultural capital is of major importance. It enables individuals or groups in society to distinguish themselves. At the same time, symbolic capital increases in societies, making it possible to acquire and consolidate power. After a boom in social capital, cultural capital declined around 2500 BCE, while economic and social capital remained stable. New cultural phenomena also lead to changes in social space. For example, cultural competences change due to the influence of the Bell Beakers phenomena, which had previously been determined for generations by belonging to pan-European networks of the social groups associated to Corded Ware Pottery. However, these new influences do not change the economy. With the transition from the 3rd to the 2nd millennium BCE, the importance of social and economic capital decreases in some areas. Cultural and symbolic capital, on the other hand, increase. The increasing adaptation of metal in societies enables new forms of display and the transmission of new emerging knowledge of action. The basis is formed by economic intensification, as a result of which the landscape is increasingly opened up to agriculture. From 1500 BCE, there is a shift in the importance of the forms of capital; symbolic capital rises first, followed by social capital and economic capital. Cultural capital in form of a wider variation of ornaments gains in importance. Around 1300 BCE, social capital and symbolic capital become more important. Cultural capital remains stable, while economic capital declines. The change in burial rites and associated transformations can be seen here as the engine of the shifts in the meaning of the forms of capital. This changes again around 1100 BCE, when the symbolic and social capital decrease sharply. The importance of cultural capital continues to grow with regard to ceramic ornamentation. At the same time, the economic capital increases drastically (the hoard finds in particular play a decisive role here) and does not decrease again until around 700 BCE. A slight change of increase and decrease in the social capital between 900 and 600 BCE is shown by the changes in networks known for the end of the Bronze Age and the transition to the Iron Age.

Overall, it is noticeable in a pattern-like manner that the curve of social capital corresponds with demographic development (Fig. 5.12), so that it can be assumed that the maintenance of networks and cooperative communities correlates most strongly with population development, i.e. it influences it and was influenced by it. Population development thus depended heavily on network expansion. Shifts in the network can be seen, for example, in the decline of social capital with the collapse of the Únětice culture. Furthermore, social capital increases together with demographic development when new networks, which can be traced back to bronze exchange in particular, are established and expanded. We can therefore state that demographic developments are decisive for the formation of different forms of capital: firstly, this includes symbolic capital, which is used to show social positions

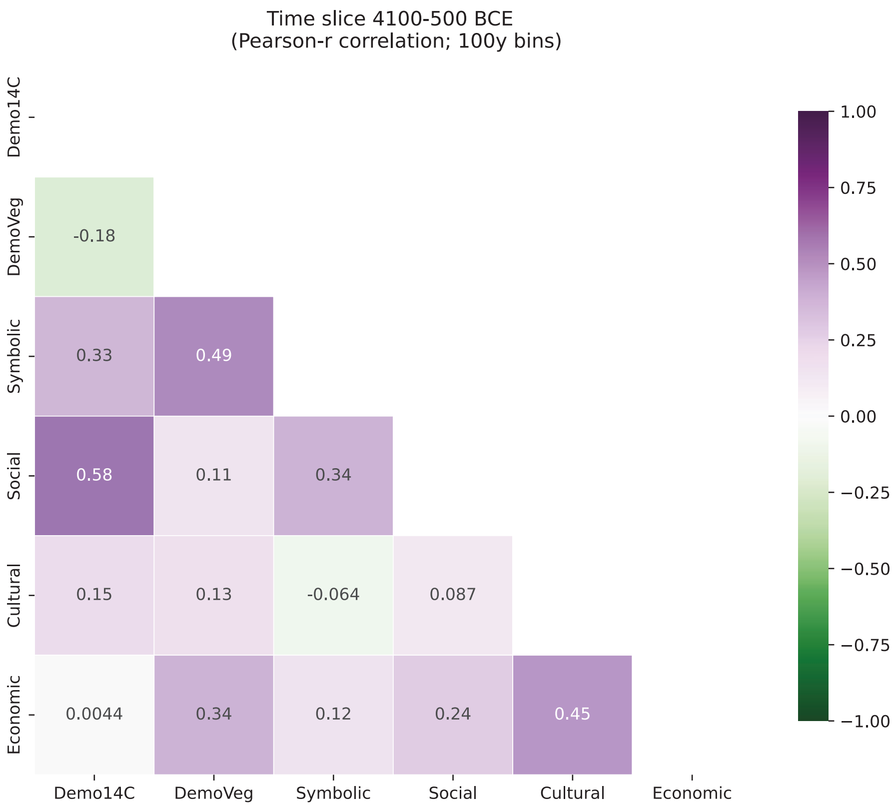

Fig. 5.12 Correlation matrix of the 100-year binned summed forms of capital, human impact (DemoVeg) and demography (Demo14C) proxy for the time slice from 4100 to 500 BCE

within society. Secondly, social capital in relation to membership of social groups. In addition, economic capital and cultural capital also show a strong correlation. In contrast, cultural capital and symbolic capital show only a low correlation. In this pattern, demographic developments are the trigger for changes in social structures that can be represented by different forms of capital.

Supplementary material The data generated or analysed during this study are included in this published article and its supplementary materials and are available online in the Zenodo repository: https://doi.org/10.5281/zenodo.10535170.

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Chapter 6
Cereal Agriculture in Prehistoric North-Central Europe and South-East Iberia: Changes and Continuities as Potential Adaptations to Climate

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6.1 Introduction

Climate change today is determining the success of agriculture on a global scale and is exerting a visible influence on agricultural decisions, from choice of cultivars to seasonality of various tasks to product price for end-consumers. Historical and modern examples point to reactions in the form of innovations in, and diversification of, the crop repertoire, including re-introductions of abandoned crops, greater emphasis on resilient crops, diversification of production strategies (e.g. inter- and multi-cropping, crop rotation, heavy manuring), cropping in areas less suitable for farming, moving agricultural tasks between the seasons, shifting to other/additional sources (greater emphasis on animal husbandry, hunting, wild plant-gathering: Duarte et al., 2017; Halstead, 2014; Hardenberg, 2021; Olesen et al., 2011; Swagemakers et al., 2012). Modern research demonstrates that manifestations of recent global warming do and will vary among regions and affect them in different ways (IPCC, 2019). Particularly, cereal agriculture is projected to struggle in many regions with increasing temperatures and decreases in precipitation (Ray et al.,

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2015). Regional heterogeneity in long-term climate developments as well as short-term events has also been noticed during prehistory (e.g. Bini et al., 2019; Davis et al., 2003; Schirrmacher et al., 2020). Therefore, it can be assumed that during prehistoric times climate change demanded modifications of agricultural methods and practices.

Previous studies have revealed some major transformations within prehistoric societies or even collapses of these (Blanco-González et al., 2018; Hinz et al., 2019; Lillios et al., 2016; Müller, 2015) – part of which might have been related to abrupt climate change (Weiss, 2017). On the other hand, climatic 'improvements' may have fostered societal innovations and population growth (Warden et al., 2017). However, the identification of possible correlations between climate and social developments is challenging from a methodological point of view. While palaeoclimatic reconstructions usually have a rather high temporal resolution and provide continuous records, archaeological data is chronologically restricted to cultural periods of several centuries. On the other hand, palaeoclimatic archives eventually record a highly local signal and occasionally are affected by past human influence as well.

In an attempt to overcome some of these limitations, we designed a detailed methodology for comparing palaeoclimatic and archaeobotanical data, which allows us to investigate common patterns in prehistoric cereal agriculture due to past climate change. In order to minimise local climatic effects and human influence in the chosen palaeoclimatic archives, we analyse regional coherent climatic developments by combining multiple archives from a certain area. We do the same with archaeobotanical records, using the aoristic approach (Mischka, 2004), which has already been applied in archaeological research (Brozio et al., 2019; Kneisel et al., 2019; Chap. 5). The aoristic approach weakens the influence of broad cultural periods on a regional scale. To further improve the chronology of the studied archaeobotanical records, we also consider radiocarbon date ranges.

Applying this methodology, we study two regions with very different climatic conditions – north-central Europe (NC Europe) and south-east Iberia (SE Iberia) (Fig. 6.1). The comparison of both study regions enables the evaluation of how prehistoric societies between 4000 BCE and 500 BCE have been adapted to climatic variability in the highly seasonal Mediterranean and the more moderate Atlantic climate zones. Still, we are aware that the cereal spectrum was not solely influenced by climate variability. Other potential factors for changes in the cereal spectrum are considered to be local or regional environmental conditions (e.g. soils, soil depletion), technical innovations of agricultural practices (e.g. ploughing), cultural preferences, and social networks influencing the availability of certain cereal taxa. A detailed discussion of these factors is, however, beyond the scope of this study. Here, we focus on the recognition of coinciding patterns in palaeoclimatic and archaeobotanic data in order to identify potential phases of agricultural adaptation to climate change.

6.1.1 Study Areas

For our archaeobotanical and palaeoclimatological assessment, we have chosen two study areas – NC Europe and SE Iberia (Fig. 6.1). The NC Europe region includes archaeobotanical data from modern-day Germany north of the German Lower Mountain Range and modern-day Denmark. In order to acquire a sufficiently large database for palaeoclimatic reconstructions, we included records from southern Scandinavia (up to 61 °N). The SE Iberian region is bordered by the Mediterranean Sea in the south and east. In the north the region extends up to 40.5 °N. The westernmost border is 5 °W.

The study areas have been chosen due to their very different climatic conditions. The following precipitation amounts and temperatures have been gathered from the WorldClim 2.1 dataset (Fick & Hijmans, 2017). SE Iberia is, since recent times, the driest region of Europe with less than 400 mm of annual precipitation. Furthermore,

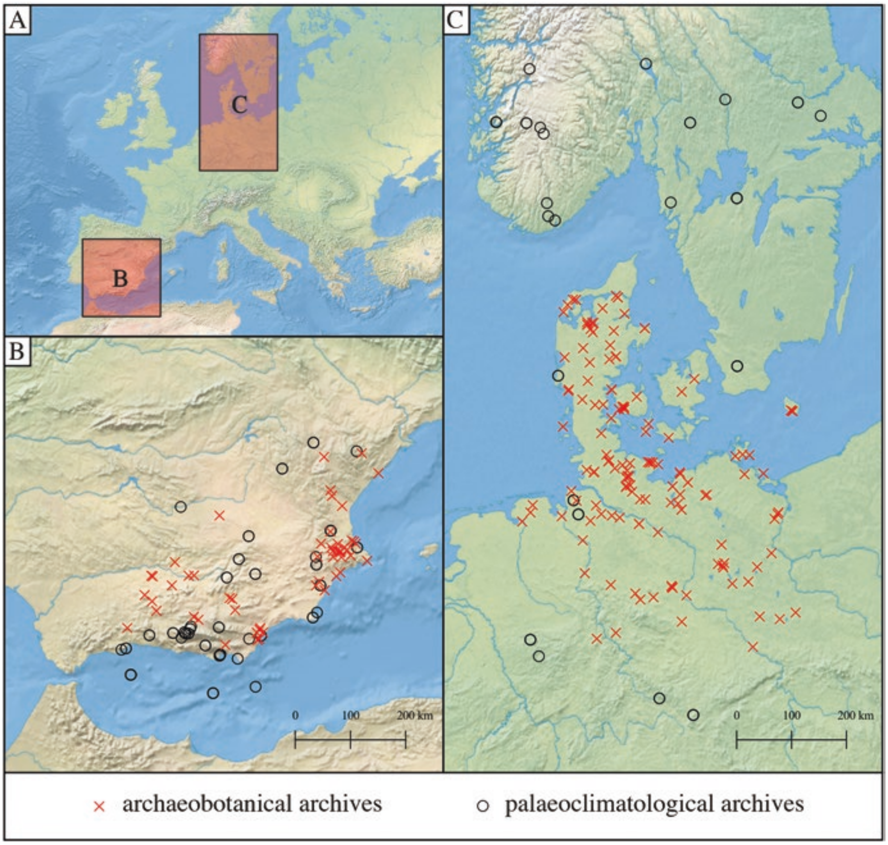

Fig. 6.1 Overview map showing the two study areas – south-east Iberia (B) and north-central Europe (C). The distribution of archaeobotanical archives is indicated by red crosses, while the location of palaeoclimatic archives is denoted by black circles. Figure by the authors

precipitation in the area reveals a marked seasonal bias, with the majority of precipitation occurring from October to March. Air temperatures in SE Iberia vary a lot with altitude. Leaving out high altitude regions of the Sierra Nevada, the average annual temperature is approximately 15 °C with a minimum of c. 7 °C in January and a maximum of c. 25 °C from July to August. In NC Europe the annual precipitation gradually increases from a minimum of 500 mm per year in the east to 900 mm per year in the west. In contrast to SE Iberia, precipitation is spread more evenly throughout the annual cycle. The average annual temperature in NC Europe is about 9 °C with a minimum of around 1 °C in January and a maximum of c. 17 °C from July to August.

In both study areas, climate has been shown to affect vegetation and cereal growth in particular. However, both regions differ in the most important climatic parameter. For SE Iberia it has been shown that precipitation events primarily affect crop yields (Cammarano et al., 2019; Frieler et al., 2017; Ray et al., 2015). In particular, reduced winter precipitation has been shown to limit plant growth (Gouveia et al., 2008). However, increasing spring temperatures may also have a negative effect on crop yields in the area (Bento et al., 2021). On the other hand, low winter temperatures impede vegetation growth in NC Europe, as the growing season tends to be reduced (Gouveia et al., 2008; Olesen et al., 2011).

6.2 Materials and Methods

Except for the data compilation and standardisation, all analytical methods described from Sect. 6.2.3 onwards have been carried out using R version 4.2.1 (R Core Team, 2022). The standardised datafiles and the R code are available at ZENODO (https://zenodo.org/doi/10.5281/zenodo.10082301).

6.2.1 Data Compilation

Archaeobotanical information for NC Europe comes from the in-house archaeobotanical database ‘ArboDat-in-Kiel’. The data derived either from the research projects conducted by Kiel University, in which case they are as detailed as possible, or have been extracted from publications and grey literature and entered into the database, in which case the level of detail and accuracy is that provided in the reports. Altogether, 1723 archaeological features containing cereal remains from 158 sites have been compiled for this chapter (Table 6.1). Archaeobotanical data from SE Iberia has been extracted from published literature. Overall, 2057 features from 52 sites have been compiled for SE Iberia (Table 6.1). Unfortunately, not all publications provided their archaeobotanical data at the feature level. Accordingly, in some cases already aggregated archaeobotanical data has been included, which during the subsequent analysis is treated as single feature. The total number of archaeobotanical records regarded as ‘feature’ is listed in Table 6.1.

Table 6.1 Summary of compiled data. Feature counts refer to features classified as such for this analysis (see Sect. 6.2.1)

	NC Europe	SE Iberia	Total
Archaeobotany			
Features	1630 (1723)	1099 (2057)	2729 (3780)
Sites	158	52	210
Radiocarbon dates			
Total	460	897	1357
Improved chronologies	437	167	604
Palaeoclimate			
Precipitation	14	65	79
Air temperature	35	4	39

Feature counts in brackets indicate the true number of features with archaeobotanical remains studied here. 'Improved chronologies' shows the number of features for which chronology has been improved by the use of radiocarbon dates

Radiocarbon dates on botanical or other materials from the selected contexts were compiled from the online databases RADON (Hinz et al., 2012), XRONOS (https://xronos.ch/), IDEArq (http://www.idearqueologia.org/), in-house repositories, and published reports. For all 210 sites in both study areas, we compiled 1357 radiocarbon dates (Table 6.1).

For both study areas, palaeoclimatic datasets reflecting either precipitation or air temperature variability have been compiled from the literature, public databases (NOAA Paleo Data Search, https://www.ncei.noaa.gov/access/paleo-search/; European Pollen Database, http://epd.imbe.fr/index.php; PANGAEA®, https://www.pangaea.de/; Comas-Bru et al., 2020), and our own data (Schirrmacher et al., 2019). Altogether, 118 datasets have been compiled for the period between 4500 and 0 BCE. From these, 69 datasets are located in SE Iberia and 49 datasets are located in NC Europe (Fig. 6.1 and Table 6.1). The datasets are based on various proxies, with the majority being pollen (n = 96) followed by geochemical measurements on speleothems (n = 8). The distribution of the datasets among the studied climatic parameters differs for the study areas, with the majority reflecting precipitation in south-eastern Iberia and air temperature in north-central Europe (Table 6.1).

6.2.2 Standardisation of Archaeobotanical Data

Altogether up to seven key cereal taxa occur in each region and their absolute grain counts have been considered. These are: emmer (*Triticum dicoccum*), einkorn (*T. monococcum*), spelt (*T. spelta*), free-threshing wheat (*T. aestivum/durum/turgidum/compactum*), naked barley (*Hordeum vulgare nudum*), hulled barley (*H. vulgare vulgare*), and broomcorn millet (*Panicum miliaceum*). In SE Iberia, no spelt has been found in any of the features considered. Regarding millet in SE Iberia, we combined the counts of broomcorn millet and foxtail millet (*Setaria italica*). A separate assessment of both millet taxa has not been considered due to their low counts. Given the findings of the radiocarbon dating of millet grains from NC Europe (and other parts of Europe), the records of millet grains from contexts attributed to the Neolithic (c. 4000–1700 BCE) were removed from the respective datasets used in this study (Filipović et al., 2020).

All tentative identifications (denoted as ‘cf.’) were added to the respective precise identifications. Counts of rachis and glume bases have been converted to grain counts. To do so, rachis counts have been multiplied by 2 to account for the minimum of two grains per rachis segment (in case of barley and free-threshing wheat). The counts of glume bases have not been divided, because the majority of them belong to emmer, where one glume base holds one grain. We have not done the conversion for einkorn either (where normally two glume bases enclose one grain), in order to account for the possible occurrence of two-grained einkorn. These chaff-converted-to-grain counts have only been considered if the sample or feature contained no grains of the respective species, or if the converted count was higher than the count of grain present in the sample/feature. In such cases, the converted grain counts replaced the ‘real’ grain counts. There were no records for millet chaff in either of the study areas. In the case of spelt, only the counts of chaff (glume bases) have been considered since the identification of grains is ambiguous. Indeterminate cereal grains such as *Hordeum* sp., *Triticum* sp., or other ambiguous identifications (e.g. *T. dicoccum/monococcum*) have been proportionally re-assigned to the respective precisely identified species. In cases where the total grain count consists only of indeterminate remains, it was re-assigned to all of the possible/relevant species.

6.2.3 Archaeobotanical Analyses

6.2.3.1 Chronological Refinement

Along with the archaeobotanical data, the archaeological chronology of the respective contexts has also been standardised. In order to improve the chronological resolution of the archaeological chronologies, the available radiocarbon (^{14}C) dates have been considered. If possible, the radiocarbon dates were assigned to a ‘structure’ (e.g. a certain house, pit, or site-phase) and/or even to an individual ‘feature’ (i.e. an archaeobotanical entry). Radiocarbon dates have been calibrated with the ‘clam’ package (Blaauw, 2022) using either the intcal20 (Reimer et al., 2020) or the marine20 calibration curve (Heaton et al., 2020).

Based on the calibrated two sigma (2σ) ranges of each radiocarbon date, outliers have been identified as those dates that do not overlap with the archaeological chronology of the respective feature, structure and site allowing for a tolerance of ±100 years. They have been omitted from further analysis. From the remaining radiocarbon data, ^{14}C age ranges were calculated on a feature, structure and site level. In the case of multiple radiocarbon dates per site, structure, or feature, the minimum and maximum limits of all 2σ ranges were used. In cases where the age range of the radiocarbon dates is narrower than the respective archaeological dating range, the radiocarbon age range replaced the archaeological chronology for further analyses. Otherwise the original archaeological chronology has been used. The number of features with refined chronology is listed in Table 6.1.

6.2.3.2 Application of the Aoristic Approach to Archaeobotanical Data

In a second stage of the data standardisation, the aoristic approach (Mischka, 2004) was applied. First, cereal taxa counts from all features were distributed into temporal bins of 100 years according to their chronological ranges. Afterwards, the distributed counts from all features belonging to a particular site were summed in order to receive site-based counts for each 100-year bin within the studied period (4000–500 BCE). Finally, we derived cereal counts of each taxa for 100-year bins for each site, which built the basis for further analyses.

The further examination of the archaeobotanical data was aimed at identifying changes in the relative proportions of the different cereal taxa in the two study regions. Therefore, three different approaches to data representation and calculation were applied. The first approach is the summing up of all counts per 100-year bin in each region for the selected cereal taxa. The results of this are shown in Figs. 6.2 and 6.3.

Secondly, site-based relative proportions of the cereal taxa were calculated for each 100-year bin and, subsequently, averaged for the respective region. For this, the average percentage of each cereal taxon was calculated per site and temporal bin. Afterwards, the mean of all site-based relative proportions within a 100-year bin was calculated for each region (shown in Figs. 6.2 and 6.3). In this approach, sites with very low cereal counts are likely overrepresented. This, however, can be partially overcome by omitting sites with low counts. We tested the effect of such sites on our results using various thresholds for minimum counts. Ultimately, we decided that the threshold of a minimum 20 cereal counts per site in each 100-year bin is satisfactory because it removes very small assemblages and rare or insecure occurrences, whilst maintaining reasonably high number of sites represented in each 100-year bin. Results of alternative settings using no threshold (a minimum count of 0) and a stricter threshold of 100 counts are available in the Appendix (Figs. 6.A1, 6.A2, 6.A3, and 6.A4).

Another bias might be introduced by mass finds (i.e. storage finds with very high counts of a single cereal taxon), which tend to have strong effect on both previously described approaches. The third approach, which has been shown to neutralise a possible effect of mass finds, is the calculation of a so-called representativity index (RI). It factors in the different archaeobotanical processing and sampling strategies as well as depositional processes at archaeological sites. It conducts a semi-quantitative evaluation of the importance of crops in cultivation, taking into account the underlying number of samples (Stika & Heiss, 2013a). For the calculation of the RI, we adopted the refined approach developed by Effenberger (2018a, b) for the Bronze Age of northern Germany (Table 6.2). As in the original approach by Stika and Heiss (2013a), every taxon is attributed a RI score according to its quantity and proportion. Whereas Stika and Heiss (2013a) originally used a 4-point

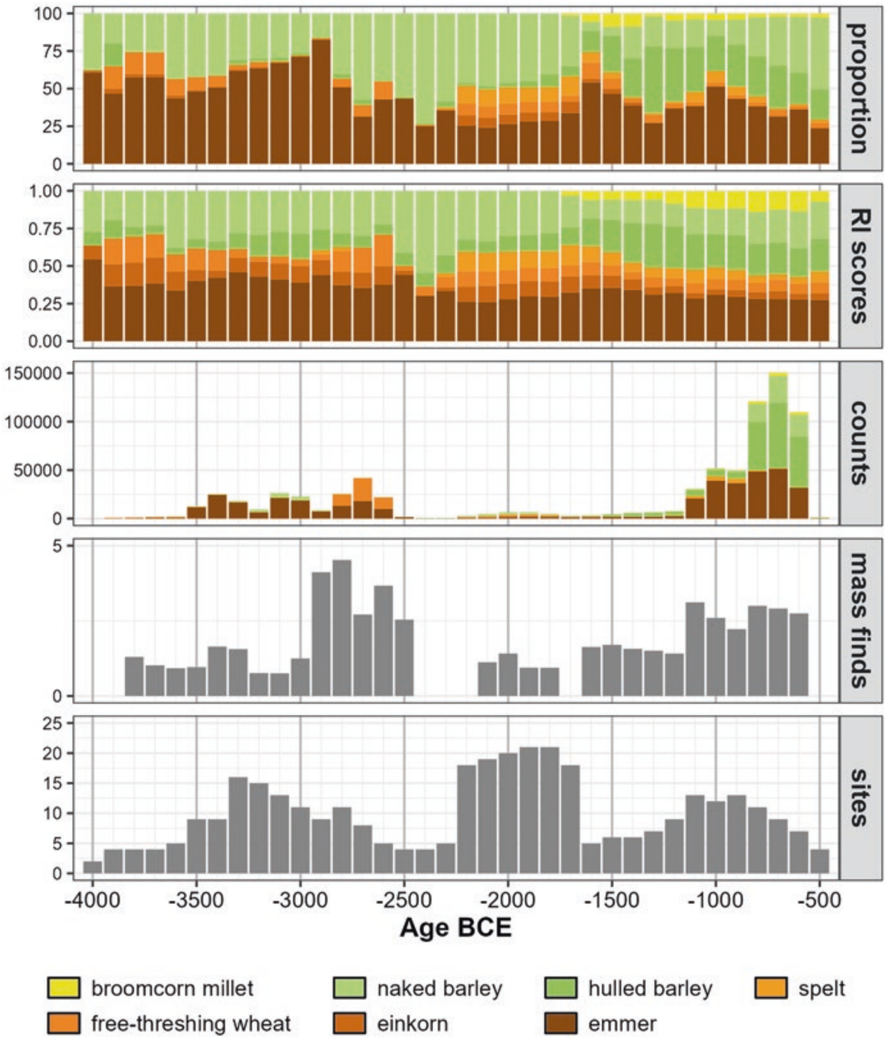

Fig. 6.2 Archaeobotanical results from north-central Europe applying a threshold of 20 minimum counts. From top to bottom the relative proportion of each cereal taxon per 100-year bin is shown, followed by the representativity index (RI), the total number of counts per 100-year bin, the proportion of features characterised as mass finds (more than 1000 grains per bin and site), the total number of sites providing archaeobotanical data for each temporal bin

scoring scale, Effenberger (2018a) used a refined 7-point scoring scale to avoid overrepresentation of rare taxa. The RI scores are subsequently multiplied by a factor, which depends on the number of features and the quantity of finds. Unlike the previous applications of the method, where the RI scores were calculated for rather long periods (i.e. archaeological periods spanning several centuries), we reduced the limits for the scoring system with respect to our 100-year temporal bins.

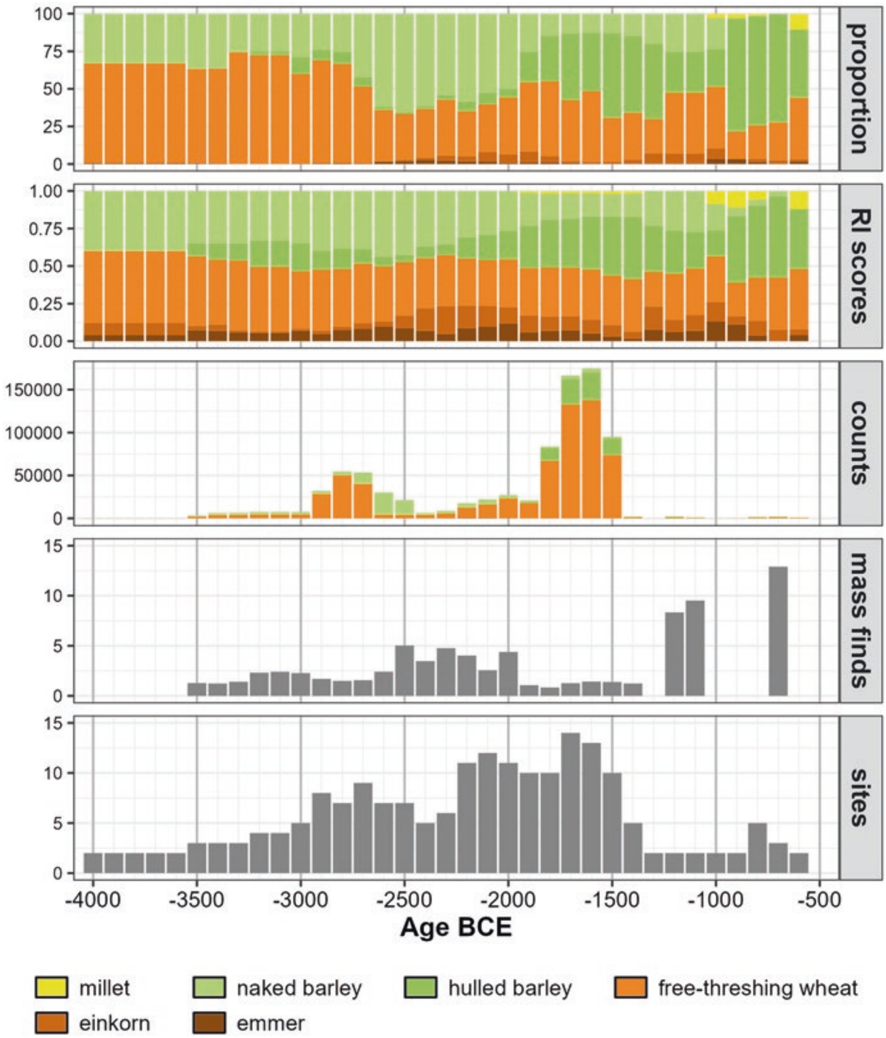

Fig. 6.3 Archaeobotanical results from south-east Iberia applying a threshold of 20 minimum counts. From top to bottom the relative proportion of each cereal taxon per 100-year bin is shown, followed by the representativity index (RI), the total number of counts per 100-year bin, the proportion of features characterised as mass finds (more than 1000 grains per bin and site), the total number of sites providing archaeobotanical data for each temporal bin

As in the analyses of Effenberger (2018a) the investigated time periods span generally about 500 years, we reduced the limits by a factor of five (Table 6.2). Due to the lack of data on the archaeobotanical sample volumes for many of the features, the representativity factor is in this study solely based on the number of features and the cereal counts. Accordingly, we calculated the RI scores for every cereal taxon per 100-year bin and site. Subsequently, the RI scores have been averaged per 100-year bin for each region. The RI scores for each region are shown in Figs. 6.2 and 6.3.

Table 6.2 Comparison of scoring and factor systems used in the calculation of the representativity index (RI) in previous studies and in this study. S: number of seeds/fruits

	Stika and Heiss (2013a)		Effenberger (2018a, b)		This study	
Score	ΣS < 1000	ΣS > 1000	ΣS < 1000	ΣS > 1000	ΣS < 1000/5	ΣS > 1000/5
1	<100 S	<100 S	<10 S	<10 S	<10/5 S	<10/5 S
2	>100 S	>100 S	10–49 S	10–49 S	10/5–49/5 S	10/5–49/5 S
3	–	–	50–99 S	50–99 S	50/5–99/5 S	50/5–99/5 S
4	–	25–49%	>100 S	100–499 S	>100/5 S	100/5–499/5 S
5	–	>50%	–	>500 S	–	>500/5 S
6	–	–	–	25–49%	–	25–49%
7	–	–	–	>50%	–	>50%
Factor	Requirement per site					
x2	>20 samples or > 1000 litre sample volume				>20 features	
x3	–		>40 samples or > 5000 litre sample volume		>40 features	
x4	>40 samples or > 5000 litre sample volume		>100 samples		>100 features	
x5	>100 samples		–		–	
x2	<20 samples or < 1000 litre sample volume, but >10,000 S				<20 features, but >10,000/5 S	

6.2.4 *Palaeoclimatological Analyses*

The methodology for reconstructing the palaeoclimatic variables has been adopted from Schirrmacher and Weinelt (n.d.). Here, we give a short description of the most important steps. Where possible, we calculated updated age-depth models for the compiled archives (n = 110) using the 'Bacon' package (Blaauw & Christen, 2011). Some datasets have a very high temporal resolution. To account for the overrepresentation of such archives in the subsequent analysis, archives with a temporal resolution of less than 25 years have been downscaled to a resolution of 25 years. Datasets with a very low temporal resolution (more than 900 years on average) have been removed from analysis. In order to achieve a uniform data structure, datasets have been normalised if necessary. For this, the respective datasets have been multiplied by a factor of −1 to ensure that drier or cooler conditions are always associated with negative values. Subsequently, the datasets have been transformed into z-scores to allow a direct comparison of all the different proxies. The z-score has been calculated after Clark-Carter (2014). Afterwards, a mean as well as the 95% probability distribution has been determined based on a bootstrapped local gaussian regression using the 'locfit' package (Loader, 2020).

6.2.5 Pearson Correlation

Spearman correlation tests have been conducted among the archaeobotanical and palaeoclimatic datasets using the 'Hmisc' package (Harrell Jr., 2022). Before determining possible correlations, the palaeoclimatic data has been binned to 100-year time slices in order to match the archaeobotanical data. Subsequently, correlation tests have been carried out for undetrended as well as linear detrended datasets.

6.3 Results

6.3.1 North-Central Europe

The results of the archaeobotanical assessment for NC Europe are shown in Fig. 6.2. The relative proportions of the cereal taxa show emmer and barley as the dominant taxa throughout the studied interval. There is an overall decreasing trend of emmer in favour of barley. Similar long-term trends are visible in the RI-based reconstruction. Regarding the trajectories of barley and emmer (or wheat in general) some periods of change can be noted. Particularly, since 3600 BCE there is a gradual increase of emmer culminating at 2900 BCE, which is followed by its decrease and an associated increase in (naked) barley at 2800 BCE. A similarly high increase in naked barley is observable at around 2400 BCE. This particular change is the only one captured within the RI data. Some contraction of barley (and rise in emmer) proportions can be seen around 1600 BCE and again at 1000 BCE. Notably, at around 2000 BCE, hulled barley starts to increase steadily and becomes the dominant barley species between c. 1600 and 800 BCE. After 1000 BCE there is an increase in the naked barley proportions again. Prior to 1600 BCE, naked barley is by far the dominant barley species. At 1700 BCE our results indicate the first grains of broomcorn millet in NC Europe, which are present until the end of the studied period in low quantities. However, the pre-1300 BCE millet 'presence' in our overview is a result of imprecise chronologies (Filipović et al., 2020). Apart from emmer, other wheat species are also present in variable proportions. Particularly, the RI data indicates that free-threshing wheat and einkorn are present throughout the studied interval, while spelt appears around 2200 BCE for the first time. The relative proportions of these minor wheat species exhibit higher values between 3900 and 3400 BCE for free-threshing wheat and between 2200 and 1500 BCE for all three minor wheat species.

Both palaeoclimatic parameters reveal no long-term trends but overall variable conditions for NC Europe (Fig. 6.4). Overall, no correlation of precipitation and air temperatures is obvious. However, between 3000 and 1400 BCE it appears that higher air temperatures are associated with reductions in precipitation. Regarding precipitation, four major reductions can be noted from c. 3800–3700 BCE, 2600–2400 BCE, 2000–1800 BCE, and 1100–1000 BCE. Inbetween these periods, the precipitation levels are elevated. With respect to the air temperature

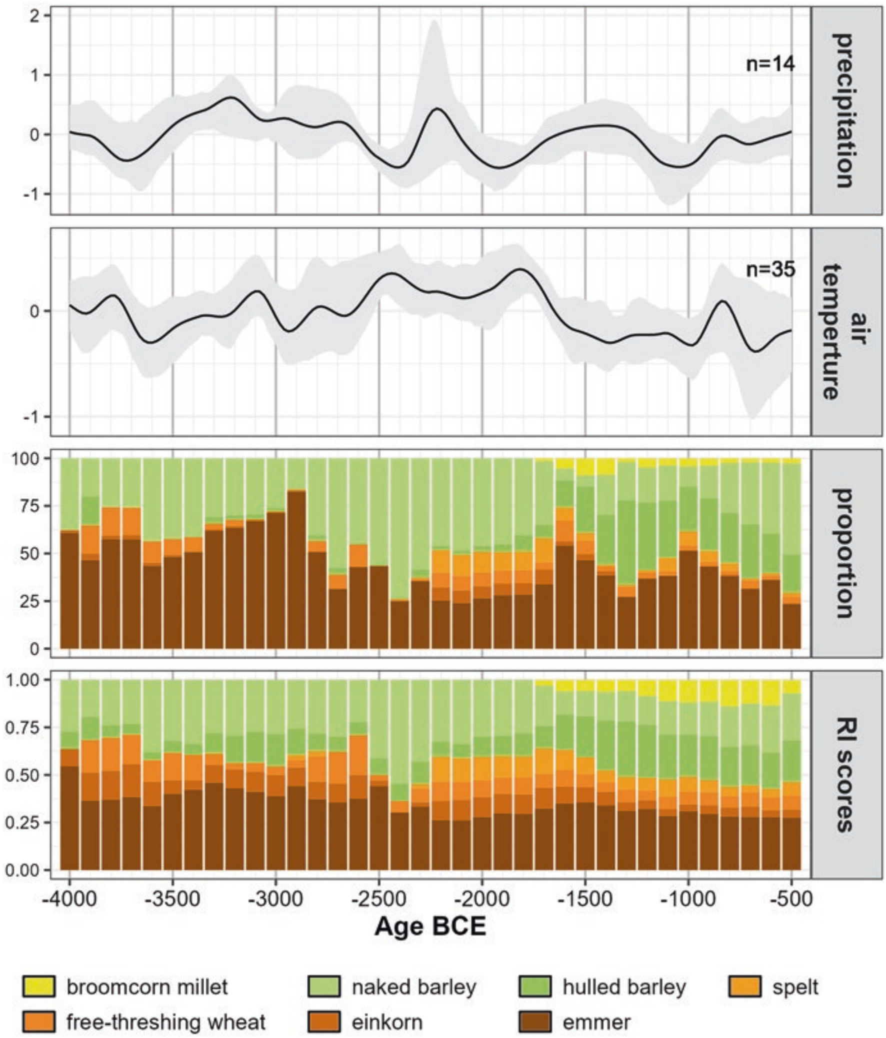

Fig. 6.4 Comparison of archaeobotanical and palaeoclimatic data for north-central Europe. From top to bottom the reconstructed precipitation, the reconstructed air temperature, the relative proportion of cereal taxa, and the RI scores of the archaeobotanical data are shown. The grey shading of the palaeoclimatic reconstructions denote their 95% probability interval

development, the period between 4000 and 2500 BCE is highly variable. Two abrupt cooling events are apparent at 3600 BCE and 2900 BCE. From 2500 to 1800 BCE, the highest and stable air temperatures are recorded. After 1800 BCE, a remarkable cooling is suggested, which remains stable until 500 BCE. The only exception is a brief warming episode at 800 BCE.

6.3.2 South-East Iberia

The results of the archaeobotanical examinations for SE Iberia are shown in Fig. 6.3. Both the relative proportions and the RI data show an overall increasing (decreasing) trend of barley (wheat) throughout the studied period. While free-threshing wheat is the dominant wheat taxon during the entire period, naked barley is the dominant barley taxon until 1900 BCE when it was almost entirely replaced by hulled barley. Based on the relative proportions of cereal taxa, some major short-term changes can be noticed. The most prominent change around 2700 BCE is the decrease of free-threshing wheat in favour of naked barley. After this time, free-threshing wheat (and wheat in general) does not reach pre-2700 BCE proportions again and barley remains dominant. Nevertheless, some periods of increased free-threshing wheat proportions are evident from 1900 to 1600 BCE and between 1200 and 1000 BCE. Other species, such as einkorn, emmer, and millet, are present in very small amounts. While millet appears in noticeable proportions only after 1000 BCE, RI scores indicate that emmer and einkorn are present throughout the studied period. Within this general pattern, two periods of increased emmer and, particularly, einkorn proportions are evident between 2600 and 1800 BCE and from 1400 to 900 BCE.

The palaeoclimatological parameters show dynamic and diverging developments (Fig. 6.5). The reconstructed regional precipitation reveals a long-term decreasing trend, which is punctuated by several short-term fluctuations. The highest precipitation levels are reached at 3500 BCE and are followed by a decrease to relatively low precipitation levels at 3200 BCE. Another decrease is visible around 2250 BCE, followed by a long period of reduced precipitation from 2000 to 1500 BCE. Another prominent reduction in precipitation occurred around 900 BCE. The air temperature reconstruction reveals no long-term trends, but highly variable conditions. Air temperatures are relatively warm and even slightly increasing between 4000 and 3000 BCE. After 3000 BCE a sudden reduction in air temperatures can be noticed, which remained cool until 1300 BCE. During this period an additional cooling event around 2100 BCE is suggested. Notably, the uncertainty in the air temperature reconstruction is large between 2300 and 1600 BCE. From 1300 to 900 BCE, air temperatures suggest a return to warmer conditions. After 900 BCE, air temperatures decrease until 500 BCE. Again, uncertainty of the reconstruction for this period is large.

6.4 Discussion

6.4.1 Prehistoric Cereal Agriculture in North-Central Europe

The overall dominance of emmer and barley in NC Europe agrees with the findings of previous related studies (Effenberger, 2018a, b; Kirleis, 2019; Kirleis & Fischer, 2014; Kirleis et al., 2012). The same is true for the overall, but minor, presence of free-threshing wheat and einkorn throughout the studied period (Kirleis & Fischer, 2014; Kirleis et al., 2012). Our results also indicate that, until 2900 BCE, emmer

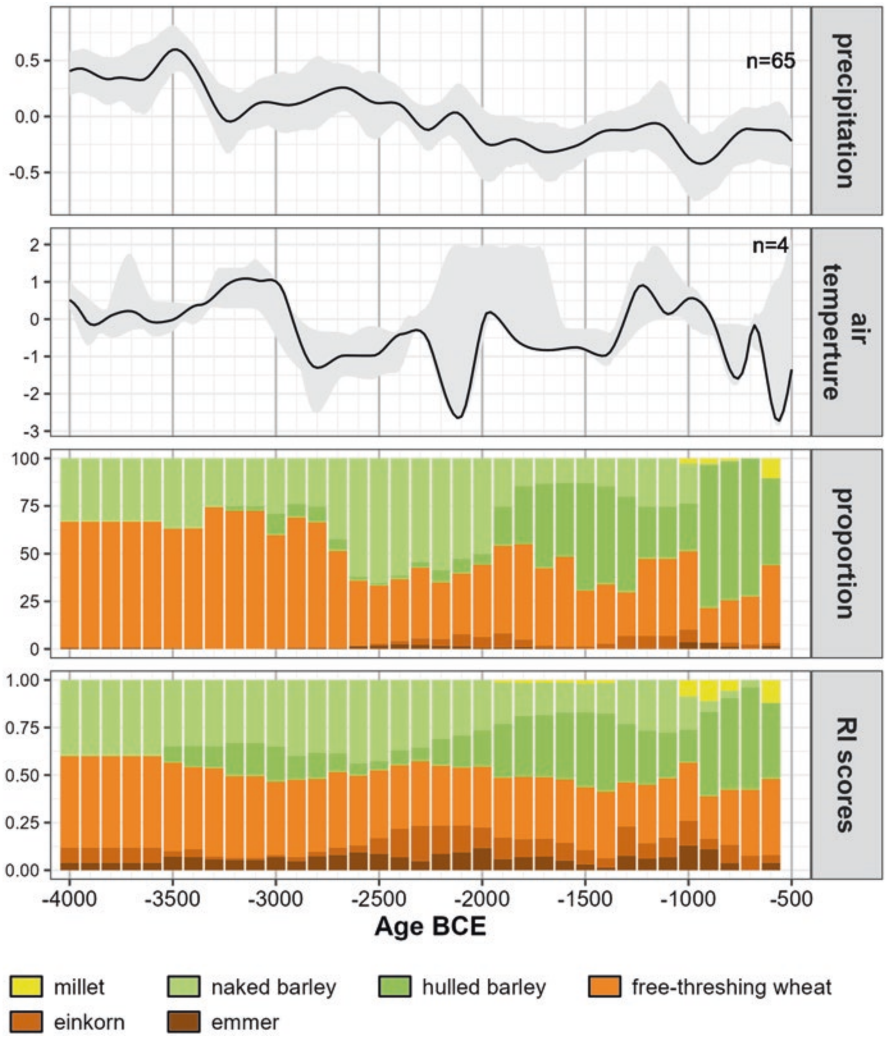

Fig. 6.5 Comparison of archaeobotanical and palaeoclimatic data for south-east Iberia. From top to bottom the reconstructed precipitation, the reconstructed air temperature, the relative proportion of cereal taxa, and the RI scores of the archaeobotanical data are shown. The grey shading of the palaeoclimatic reconstructions denote their 95% probability interval

prevails over barley. There may have existed intra-regional variation in the extent of use of emmer and barley. For instance, Kirleis et al. (2012) conclude that barley was the dominant cereal in the central part of our study region (the state of Schleswig-Holstein). On a regional scale, the emmer dominance changed at 2800 BCE, when barley became to be the dominant taxon throughout the studied period (with potential short-term interruptions at 1600 BCE and 1000 BCE). An overall increasing trend of barley cultivation during the studied period is known (Zohary et al., 2012). The increase in hulled barley proportions after c. 2000 BCE in NC Europe was observed by Zohary et al. (2012). Around that time our archaeobotanical results point towards a diversification of the cereal spectrum along with the introduction of spelt and increased proportions of free-threshing wheat and einkorn (Fig. 6.2). This trend has been observed in earlier studies (Effenberger, 2018b; Feeser et al., 2022; Filipović, 2023). Here, we note that the sites containing significant counts of spelt have a rather broad chronology of more than 500 years. Accordingly, it should be considered that spelt was introduced in the region sometime between 2200 BCE and 1700 BCE. Short-term increases in emmer proportions at 1600/1500 BCE and 1000 BCE are indicated by our results. So far it has only been noted that emmer proportions were higher during the Early Bronze Age (1800–1100 BCE) than during the Late Bronze Age (1100–600 BCE) (Effenberger, 2018b). While our results corroborate the overall higher emmer proportions during the Early Bronze Age, they add some more detail to this picture by pointing to the two short-term increases. For example, the apparently increasing trend in naked barley proportions after 1000 BCE; although naked barley indeed represented an important taxon during this period in NC Europe, such a marked increase was not detected by previous studies (Effenberger, 2018b). Notably, the increase in naked barley proportions agrees strongly with a decrease in sites with archaeobotanical remains (Fig. 6.2). Also, the total counts clearly point towards hulled barley being the dominant barley taxon on a regional-scale. Accordingly, the increase in naked barley after 1000 BCE is most likely an artefact introduced by some sites with exceptionally large finds of naked barley.

6.4.2 Prehistoric Cereal Agriculture in South-East Iberia

The total summed counts of cereal remains in SE Iberia (Fig. 6.3), as well as the temporal distribution of sites with cereal remains (Fig. 6.3), indicate a high research focus during the Chalcolithic and the Bronze Age – particularly between 3000 and 1500 BCE. This is in line with the overall archaeological research intensity in the area (e.g. Blanco-González et al., 2018). Nonetheless, no associated changes in cereal proportions or RI-scores are obvious. Consequently, we assume that research intensity had no major influence on the long-term trajectories and short-term changes of our archaeobotanical results.

The overall developments in the archaeobotanical record of SE Iberia have already been recognised in previous studies. The general predominance of free-threshing wheat and barley, along with the minor, but steady, importance of einkorn and emmer, has been suggested by numerous studies (Montes Moya, 2014; Peña-Chocarro, 1999; Peña-Chocarro & Pérez-Jordà, 2018; Pérez-Jordà, 2013; Rovira Buendía, 2007; Stika & Heiss, 2013a, b). Similarly, the increase in barley has been intensely described. However, regional differences are proposed within the study area. It appears that barley and free-threshing wheat reach rather equal proportions in western Andalusia and the Valencian region during the Bronze Age (after c. 2200 BCE; Montes Moya, 2014; Pérez-Jordà, 2013). This might be the reason for the elevated free-threshing wheat proportions between 1900 and 1600 BCE (Fig. 6.3). In eastern Andalusia, on the other hand, barley becomes the dominant cereal taxon – probably already during the

Chalcolithic (Castro et al., 1999; Peña-Chocarro, 1999; Rovira Buendía, 2007; Stika, 2003; Stika & Heiss, in press). This would be in line with the rapidly increasing barley proportions after 2700 BCE (Fig. 6.3). The replacement of naked with hulled barley has also been proposed for the Late Chalcolithic/Early Bronze Age before (Montes Moya, 2014; Pérez-Jordà, 2013; Peña-Chocarro & Pérez-Jordà, 2018; Rovira Buendía, 2007; Stika & Heiss, in press). Our results based on the relative proportions of both barley varieties suggest that the replacement started on the regional scale at around 1900 BCE. Although einkorn and emmer have only been present in very small quantities, the minor increases suggested by our results in the periods c. 2600–1800 BCE and 1400–900 BCE have also been identified in earlier studies (Montes Moya, 2014; Pérez-Jordà, 2013; Rovira Buendía, 2007; Stika et al., 2017). On the other hand, the sudden increase in free-threshing wheat proportions at 1200 BCE has not been noted before. Noteworthy is that this increase diminishes when applying a stricter threshold of 100 minimum counts (see Appendix). Thus, the increased free-threshing wheat proportions between 1200 BCE and 1000 BCE are likely an artefact due to sites with only a few cereal remains. Our results suggest that millet was introduced after 1000 BCE, which agrees with previous studies (Pérez-Jordà, 2013; Rovira Buendía, 2007). Consequently, millet seems to have been introduced later in SE Iberia than in the northern part of the Peninsula (Peña-Chocarro & Pérez-Jordà, 2018). After 800 BCE, cereal cultivation in SE Iberia becomes more diverse (Pérez-Jordà, 2013), which is captured within our data by increasing proportions of free-threshing wheat and millet.

6.4.3 Potential Adaptations to Climate Change in both Regions

In general, our results for both study regions agree with the observations available in the literature. Furthermore, they improve the chronological framework of some developments discernible in archaeobotanical datasets. They thus allow for a comparison to the regional palaeoclimatic developments.

A fundamental difference between the regions is that free-threshing wheat and barley are the dominant taxa in SE Iberia, while in NC Europe emmer and barley are the dominant taxa. The reason for this could potentially be the prevailing climatic conditions. Apart from the general variability in air temperature and precipitation in each of the regions, it is clear that, similar to today, SE Iberia was confronted with generally warmer and drier conditions than NC Europe. Barley is known for its tolerance of a wide range of climatic and environmental conditions, including aridity, salinity and cool temperatures (Riehl, 2019; Zohary et al., 2012). Cool temperatures, and possibly salinity in the coastal lowlands, were certainly factors contributing to the apparent success and long duration of barley cultivation in NC Europe. In SE Iberia, on the other hand, aridity and salinity probably determined the high importance of barley. In this regard, it is also noteworthy that the long-term increase of barley proportions (considering naked and hulled barley together) in SE Iberia is in accordance with the long-term decrease in precipitation (Fig. 6.5). Based on the significant positive correlation of increased barley cultivation and aridity in SE Iberia (rho = 0.50; $p > 0.05$) a causal relationship seems likely. This is in line with previous assumptions that barley possibly outperformed free-threshing wheat in SE Iberia with increasing aridity (Rovira Buendía, 2007; Stika & Heiss, in press). Another interesting detail for both regions is the increasing importance of hulled barley after c. 2000 BCE, outnumbering the naked variety during the following centuries. The beginning of this phenomenon coincides with dry episodes in both regions, which would probably have been favourable for both barley varieties, but hulled barley is more resistant to diseases and easier to store (Riehl, 2019). Perhaps, these were some of the reasons for the increasing prominence of hulled barley in both regions (Rovira Buendía, 2007).

Apart from these overall long-term developments between climate and cereal cultivation in both study areas, the short-term fluctuations reveal variable patterns in each region. Focusing on NC Europe, we can observe that free-threshing wheat proportions increase during the first dry and cool episode from 3800 to 3500 BCE (Fig. 6.4). Favourable climate could have acted as a trigger for this development, if we assume that the free-threshing wheat cultivated at the time here was *T. durum*. Naked barley increased, perhaps at the expense of emmer, at 3600 BCE, coincident with the onset of cooler air temperatures. This is in line with barley being more adapted to cool temperatures than emmer (Riehl, 2019; van der Veen & Palmer, 1997). Additionally, a contemporaneous increase in barley cultivation during cooler conditions has also been noted on the British Isles (Bevan et al., 2017). The next notable increase in naked barley and decrease in emmer in NC Europe between 2800 and 2300 BCE is also contemporaneous with a period of cooler air temperatures between 3000 and 2600 BCE and a subsequent reduction in precipitation levels (2600–2300 BCE). When dry conditions are accompanied by higher air temperatures, this could have increased soil evaporation and, thus, salinity in certain areas. In this view, the increased barley cultivation in NC Europe between 2800 and 2300 BCE would have taken advantage of the prevailing climatic conditions. The time after 2200 BCE is characterised by the diversification of the cereal spectrum in NC Europe, the continuous increase in spelt and hulled barley and greater importance of free-threshing wheat and einkorn until 1500 BCE. Air temperatures remained high throughout this period (Fig. 6.4). Precipitation levels varied, however, with an increase at 2300 BCE and a sudden decrease after 2100 BCE, culminating at 1900 BCE. The farmers may have diversified their cereal spectrum in order to account for the variable precipitation pattern. The diversification of the cereal repertoire would have been facilitated by the expanding social networks characteristic of this period (Effenberger, 2018b; Müller & Vandkilde, 2020; Nørgaard et al., 2021). After 1600 BCE, cooler conditions manifested until 500 BCE, with the exception of a brief warming episode around 900/800 BCE. Again, during this cooler period, there were phases of increase in barley – 1500–1100 BCE and 900–500 BCE. The introduction of broomcorn millet, which is known for its great adaptation potential to dry conditions (Miller et al., 2016), at 1300 BCE in NC Europe coincides with a reduction in precipitation levels (Fig. 6.4). In the following centuries, the quantities of millet in the region are higher than initially, and the precipitation is also higher than before. The millet from this period is found mainly in storage deposits, which might be due to its lower ability to become carbonised. If there was a connection between climate conditions and millet cultivation, it might be that the growing of millet became less reliable and incentivised its storage (in greater quantities).

In addition to the long-term decreasing trend in precipitation, people in SE Iberia were also confronted with short-term fluctuations in precipitation and air temperature. According to the archaeobotanical proportions, the first major change occurred at around 2700 BCE, when barley supersedes free-threshing wheat as the dominant cereal taxon. This is coincident with the onset of an aridity trend and a sudden decrease in air temperatures (Fig. 6.5). However, the air temperature reconstructions are just based on four datasets and, thus, have a large uncertainty. Furthermore, it can be assumed that dropping air temperatures did not cause regular frosts in SE Iberia. Accordingly, if we assume climate played a role, precipitation probably has to be considered as the main driver in this development. This having been said, it is worth noting that during the abrupt dry event around 3300 BCE no respective increase in barley has been noted. However, until c. 3000 BCE just a few sites provided archaeobotanical data (Fig. 6.3). Another increase in (hulled) barley during a reduction in precipitation is obvious at around 900 BCE. Accordingly, the common patterns in precipitation levels and barley suggest that precipitation variability was the main driver for long-term and short-term developments within the cultivation of barley in SE Iberia. On the other hand, increased free-threshing wheat (and decreased barley) proportions between c. 1900 and 1600 BCE are obviously confronting such a general dependency as precipitation levels during this period are very low. However, as noted in the previous chapter the reason for increased free-threshing wheat cultivation during this period is probably not climate-driven. Intra-regional differences are one possible explanation (Montes Moya, 2014; Pérez-Jordà, 2013). Another potential explanation might actually point towards an adaptation of agricultural habits to aridity. This is because free-threshing wheat might have been grown primarily in the fertile river lowlands of the Guadiana during that period, where at the so-called ‘motillas’ people managed to extract groundwater from the subsurface (Aranda et al., 2008; Benítez de Lugo Enrich & Mejías, 2017). Using groundwater for irrigation would have enabled the people to cultivate free-threshing wheat even during very dry periods. As the ‘motillas-culture’ is proposed to be connected to the El Argar culture, the free-threshing wheat products could be easily distributed among multiple sites in the study area (Aranda et al., 2008; Benítez de Lugo Enrich et al., 2022). The increased cultivation of einkorn and emmer between 2600 and 1800 BCE has been hypothesised to be related to drought (Rovira Buendía, 2007). Indeed, we note increasing aridity during this period. However, such a simple dependency is questioned during 1400–900 BCE, when increased emmer and einkorn proportions are coincident with more humid conditions. However, an increase in air temperatures is also indicated during this time, which could have counteracted the higher precipitation levels. Still, a general relationship on this regional scale of emmer and einkorn cultivation to climate in SE Iberia remains questionable. Today, emmer and einkorn are often cultivated together (Jones & Halstead, 1995), which would explain their congruent developments. Both taxa have also been proposed as resistant to diseases and poor soil conditions (Nesbitt & Samuel, 1996). Because of this, they have likely been cultivated (as fodder) until recent times in the mountainous environments in SE Iberia (Peña-Chocarro, 1996). Thus, their increased cultivation during 2600–1800 BCE and 1400–900 BCE could have been as well related to either increased cultivation practices in mountainous regions or to their resistivity against diseases. Similar to NC Europe, the introduction of millet at around 1000 BCE is coincident with a reduction in precipitation and possibly decreasing air temperatures (Fig. 6.5). However, for a detailed evaluation of whether millet cultivation in SE Iberia was related to climatic conditions, the record is simply too short.

6.5 Conclusion

This chapter has evaluated potential adaptation strategies of past human societies in south-east Iberia (SE Iberia) and north-central Europe (NC Europe) to climatic variability between 4000 and 500 BCE. This was achieved by designing a specific approach that enables standardisation and direct comparison of the archaeobotanical and palaeoclimatic data. Our results capture the main archaeobotanical developments in each of the regions. They confirm the findings of previous archaeobotanical studies, but go beyond and add more detail to certain archaeobotanical developments, including the refinement of the chronology.

The main findings of our analysis are the overall dominance of free-threshing wheat in SE Iberia, of emmer in NC Europe, and of barley in both regions. It is possible that the prevailing climatic conditions in SE Iberia and NC Europe shaped the spectrum of cereals, depending on how suitable they were for individual species and landraces. Importantly, there was a fundamental shift around 2800/2700 BCE in both regions, when naked barley superseded the main wheat taxon. This change and the similar later developments – the increase in barley in both regions – suggest a potential relationship between barley and climate variability in both regions. Interestingly, the possibly determining climatic parameter differs between the regions. In SE Iberia, phases of increase in barley appear closely linked to reductions in precipitation. In NC Europe, phases of barley increase mainly coincide with times of cooler air temperatures. Additionally, interrelation between higher air temperatures and reduced precipitation may have also promoted barley in NC Europe. We further observe that the almost contemporaneous increase in hulled barley around 2000/1900 BCE in both regions, as well as the introductions of millet (both regions) and spelt (NC Europe), coincide with times of potential environmental stress in both regions, principally due to reduced precipitation levels.

Our comparison of the long-term trajectories of cereal cultivation and climate within the two regions is an initial attempt at identifying changes in agricultural methods and practices as possible reactions to changing climates. We recognised several periods during which climate conditions may have been favourable for growing some species but not others. This study offers a basis from which further, more detailed considerations can follow, particularly those looking at smaller temporal and spatial scales.

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Appendix (Figs. 6.A1, 6.A2, 6.A3, 6.A4, 6.A5, 6.A6, 6.A7, and 6.A8)

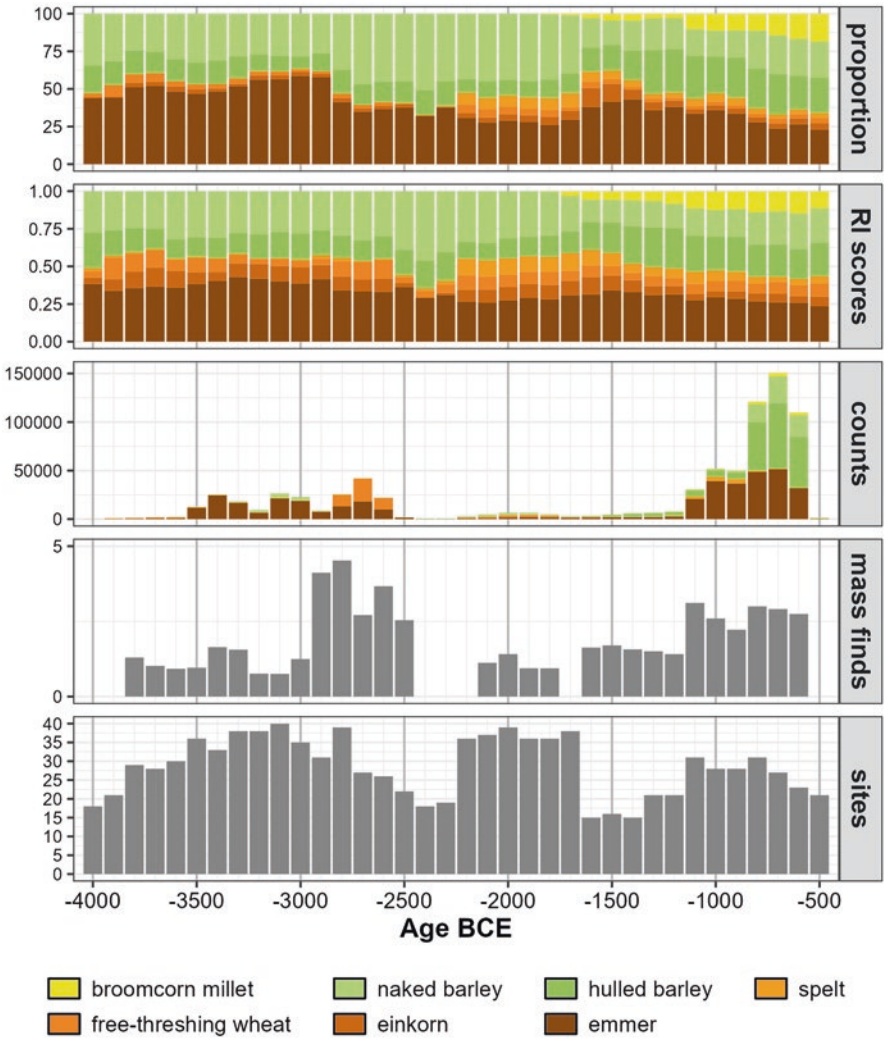

Fig. 6.A1 Archaeobotanical results from north-central Europe applying no threshold

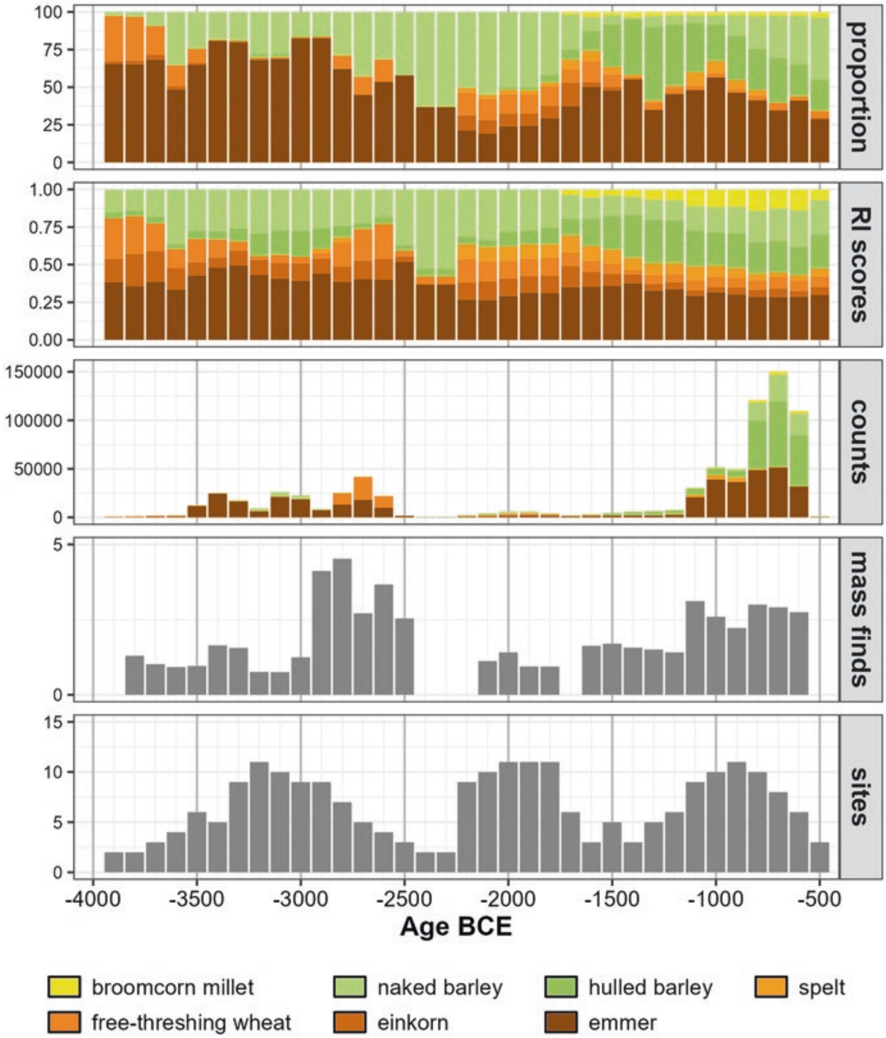

Fig. 6.A2 Archaeobotanical results from north-central Europe applying a threshold of 100 minimum counts

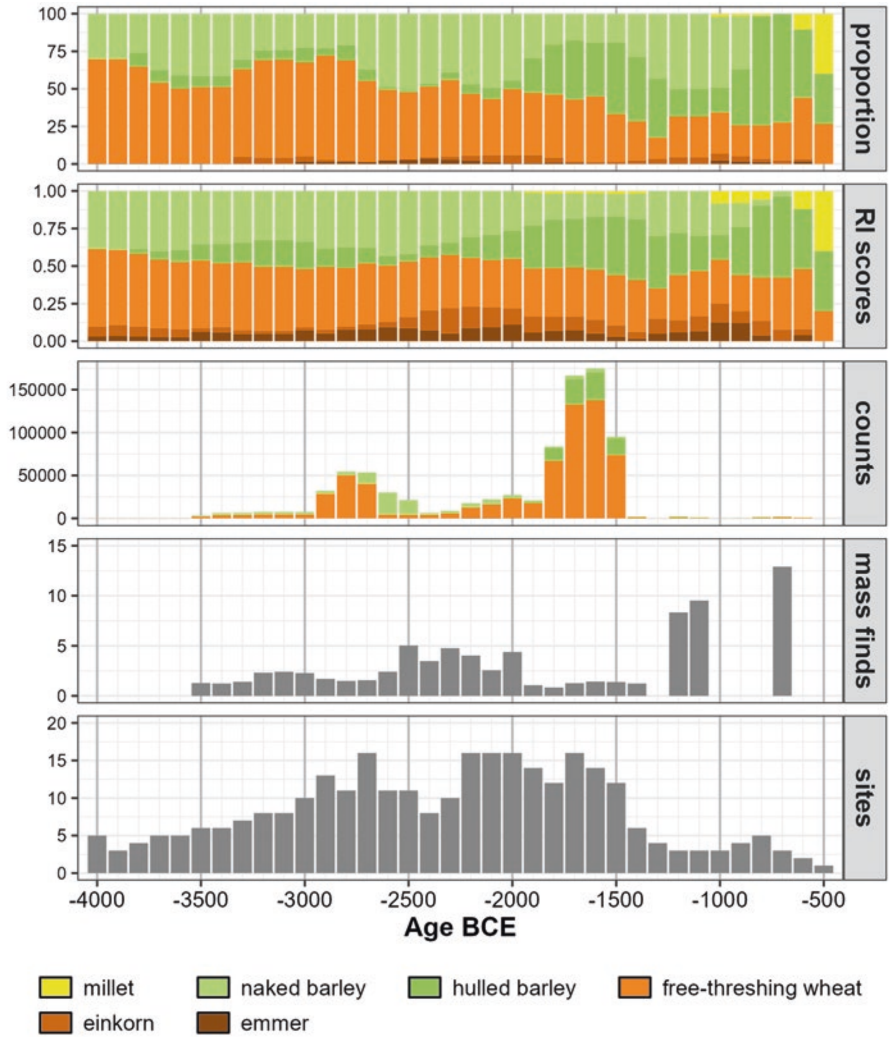

Fig. 6.A3 Archaeobotanical results from south-east Iberia applying no threshold

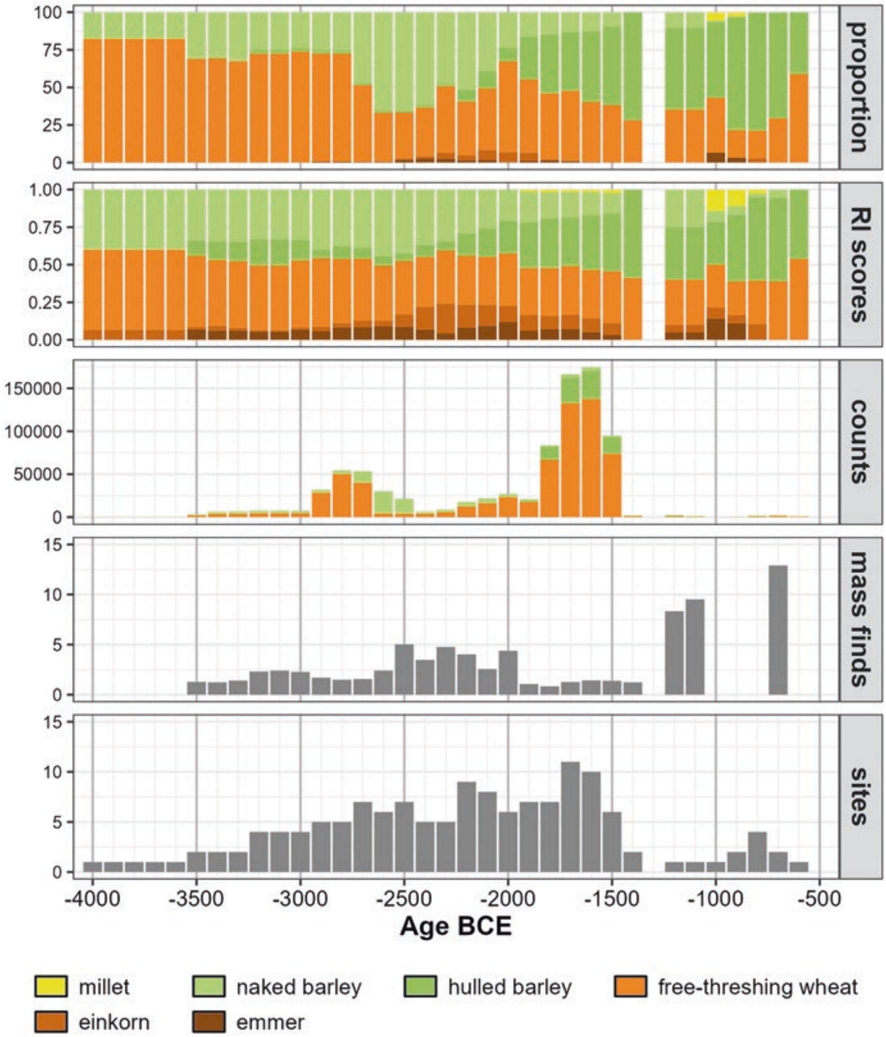

Fig. 6.A4 Archaeobotanical results from south-east Iberia applying a threshold of 100 minimum counts

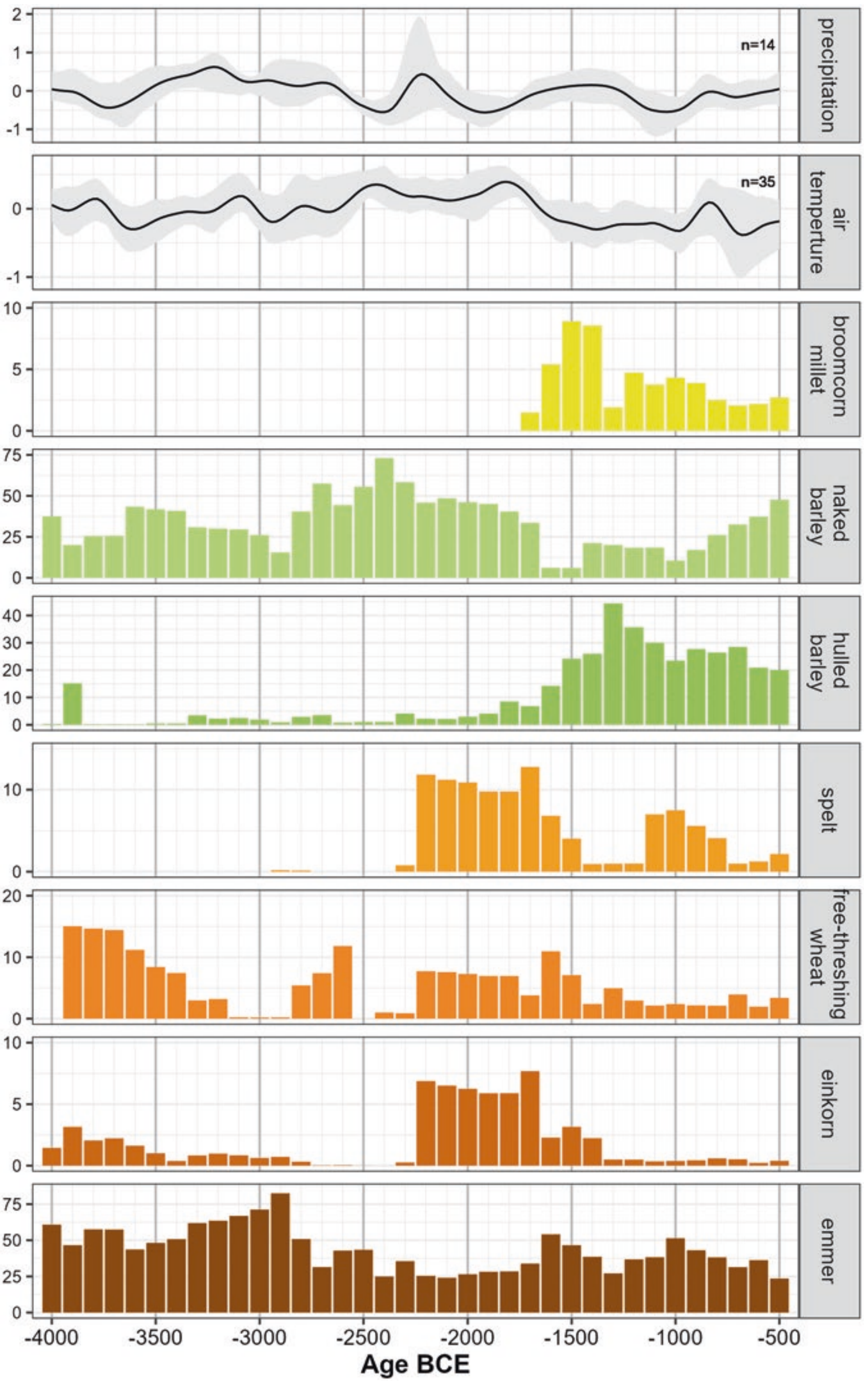

Fig. 6.A5 Archaeobotanical proportions for NC Europe applying a filter of 20 minimum counts separated per taxon

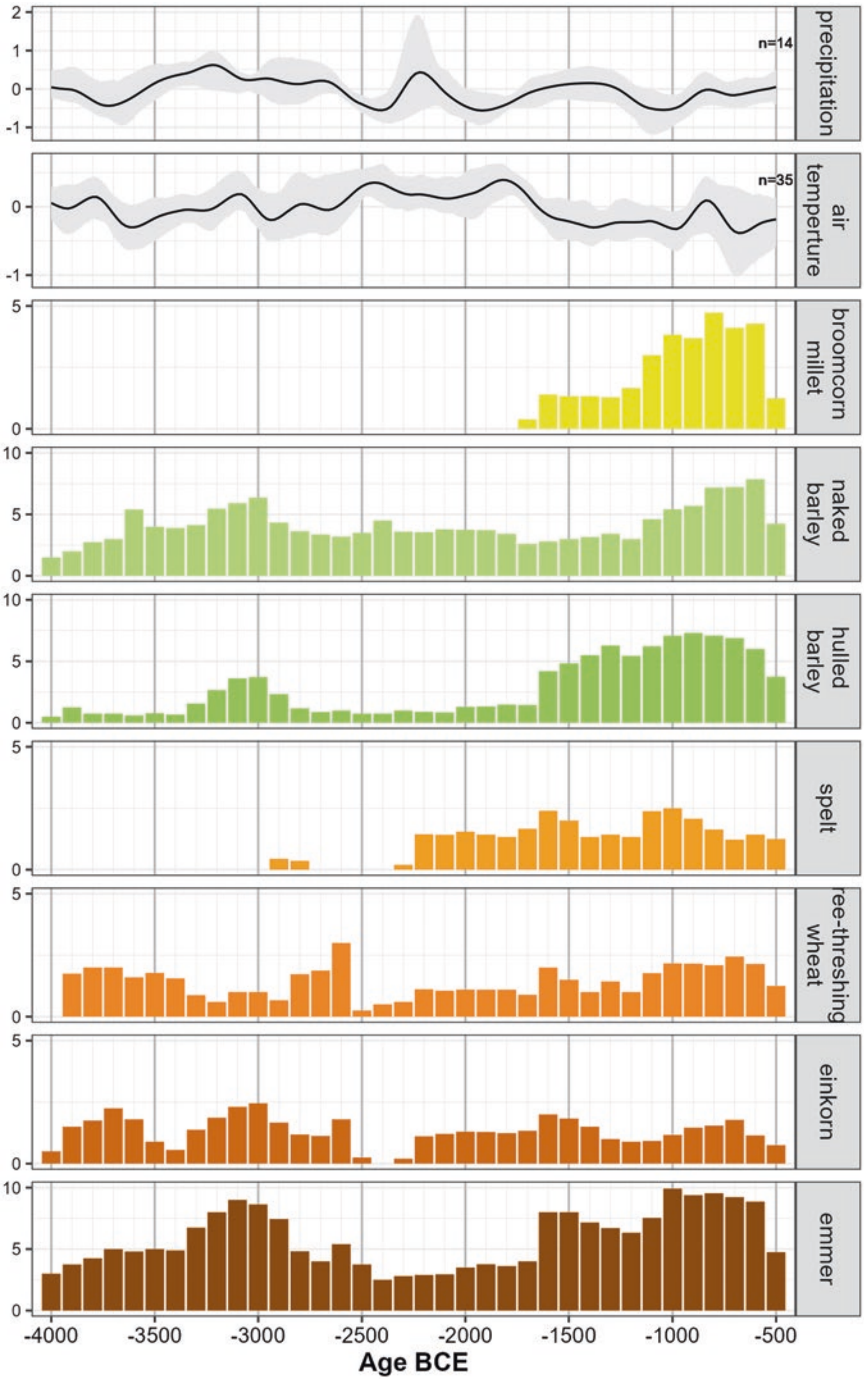

Fig. 6.A6 Archaeobotanical RI-scores for NC Europe applying a filter of 20 minimum counts separated per taxon

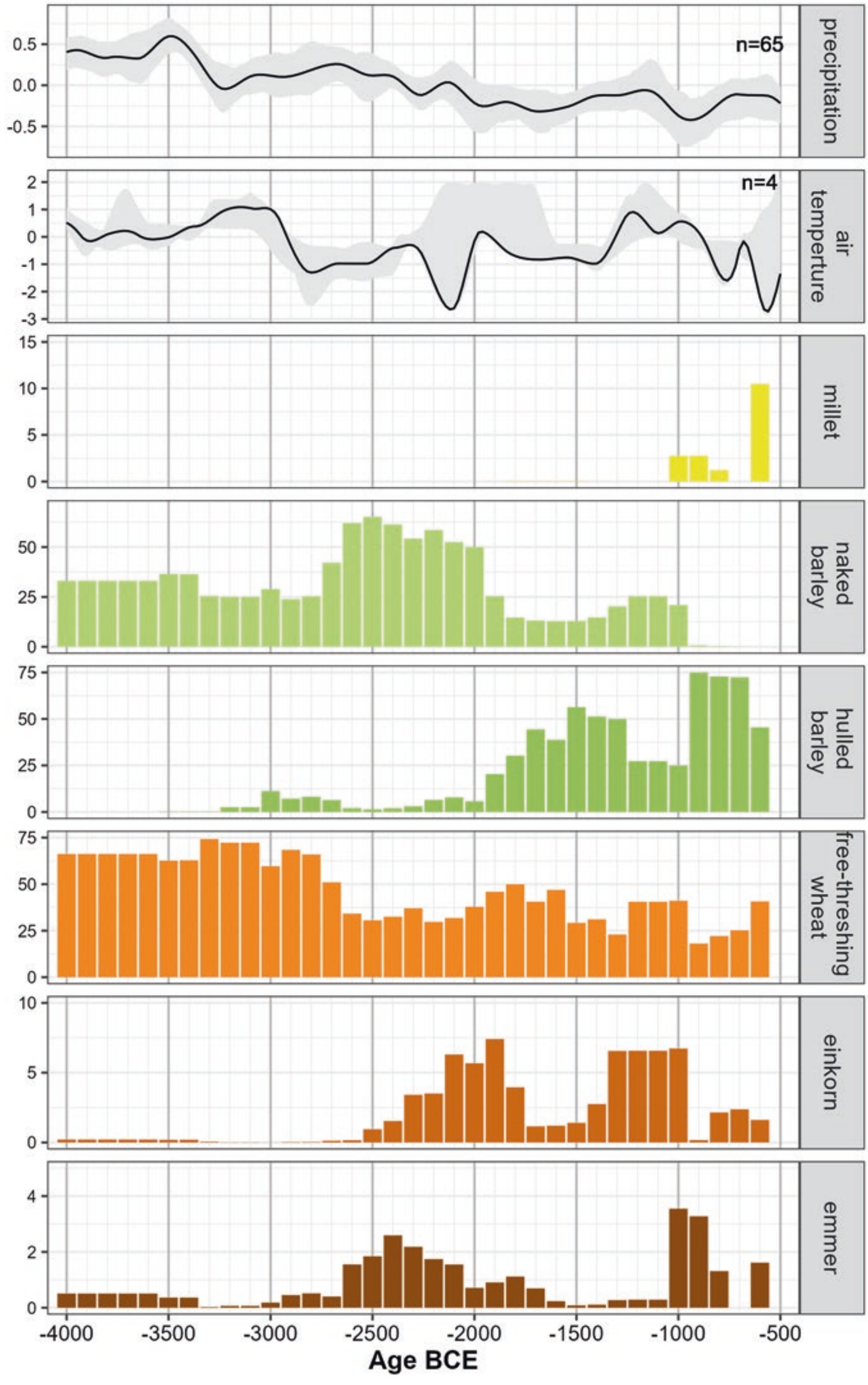

Fig. 6.A7 Archaeobotanical proportions for SE Iberia applying a filter of 20 minimum counts separated per taxon

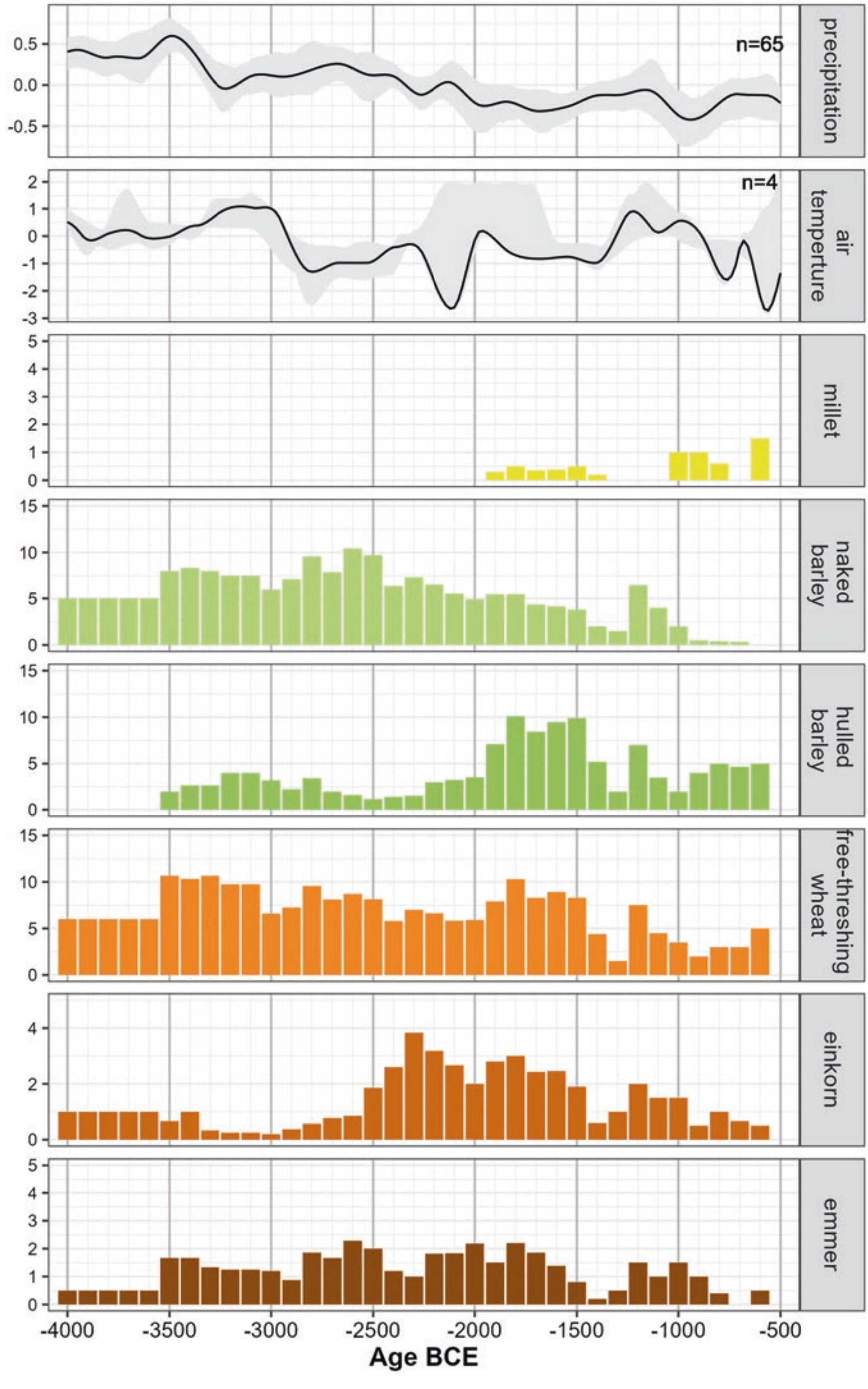

Fig. 6.A8 Archaeobotanical RI-scores for SE Iberia applying a filter of 20 minimum counts separated per taxon

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Part III
Perspectives on Decision-making Processes in Socio-environmental Transformation

Chapter 7
Creation of Cultural Landscapes – Decision-Making and Perception Within Specific Ecological Settings

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7.1 Introduction

The topic of this chapter is the creation of cultural landscapes through the interference of humans with the natural environment— in the form of direct manipulation but also through their animals and techniques. In our understanding, the creation of a certain cultural landscape is based on intended (agency) and unintended (activity) effects of human behaviour on a medium time scale beyond a single year or even decade. In this attempt we will try to differentiate between conscious and unconscious effects of the behaviour with respect to cultural and environmental transformations. Since the perception of a landscape is an important factor for the awareness of the effects of human behaviour, we will discuss this aspect as well.

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7.2 The Concept of Creation and Perception of Cultural Landscapes

Most of our human past can be described as a process of cultural creation, a process by which humans create the cultural conditions in which they live. This idea can be somewhat controversial, namely its reliance on the concept of 'culture'. While this concept had precursors in thinkers such as Pico della Mirandola, Pascal, and Montesquieu, the first definition with clear sociological and anthropological overtones comes from Edward Tylor's 'Primitive Culture' (1871). As he states, culture is 'that complex whole which includes knowledge, belief, art, morals, law, custom, and any other (capabilities and habits) acquired by man [sic] as a member of society' (Tylor, 1871, p. 1). Part of the controversy over the standard definition of culture, such as that of Tylor and like-minded individuals, is that it ontologically separates humans and their culture from the natural world. Additionally, culture also carries an enclosed and exclusive view of how societies operate, as if human societies can be categorically bound by homogenous cultural aspects. This has led to the view that past human populations could be grouped as 'beaker' or 'LBK' societies, when in truth, the archaeological record denotes much more variety and heterogeneity among human people in the past (Furholt, 2018, 2020). Much of archaeology today still operates according to this culture concept, but it does not suit our purposes here. Our view of culture is one that is polythetic (Clarke, 1968/2015, p. 36), where past populations follow various forms of knowledge, beliefs, arts, morals, laws, and custom, but never have a complete assemblage of these forms of culture, nor are these forms of culture always present at all times in the history of a given society, and nor are they always exclusive to a group of people. Furthermore, culture is something that develops through contacts, mobility and translations of other cultural forms (Nederveen Pieterse, 2009, pp. 84–85).

With regards to the ontological distinction of nature and culture, one can view culture as a naturalist process, as it has been understood among advocates of niche construction theory (NCT). In and of itself, NCT is a logic or heuristic term by which we can understand the active modification of ecological niches by living organisms (Odling-Smee et al., 2003). Unlike standard evolutionary theories, where natural selection exerts influence over which characteristics allow organisms to survive in a given environment, NCT presupposes that organisms actively affect their environment, which in turn shapes these organisms' evolutionary trajectory. There are some similarities between NCT and other theories derived from ecology and evolutionary biology, such as gene-culture coevolution or the extended phenotype (Gupta et al., 2017; Spengler, 2021, p. 929), but for the purposes of this chapter we will be following the concepts and heuristics of NCT.

Naturally, NCT has caught the eye of archaeologists (e.g. Groß et al., 2019; Shennan, 2011, 2018), and has fit very well into the standard narratives and methodologies promoted by evolutionary archaeology (Boone & E. A. Smith, 1998). The premise underlying NCT from an archaeological perspective is that since humans dispersed from East Africa more than 100, 000 years ago, humans must have had to modify their environments in order to survive. The engineering of new ecological niches was only possible through culture – by manufacturing tools, controlling fire, creating clothes, devising agricultural practices, and domesticating livestock (Laland & O'Brien, 2010, p. 307).

Unlike standard evolutionary narratives, which oftentimes view evolution as a singular directed process into which humans are subsumed, NCT provides an evolutionary framework that recognises the agency of the organisms it studies (Laland & O'Brien 2010, p. 318). However, in the NCT literature, there is no mention as to how, and under what conditions, this agency operates. Agency in archaeology has relied largely on the work of Anthony Giddens (1979, 1984). In short, according to Anthony Giddens, agency is an aspect of being human – a being that has reasons for their activities and can elaborate discursively upon those reasons (Giddens, 1984, pp. 3, 9). This means that the agent is knowledgeable and acts with that knowledge. However, being knowledgeable does not mean being aware of all consequences of their actions. Additionally, agency according to Giddens follows a stratified model, where the agent's motivations occur on one level, their rationalisations on another, and the agent monitors the ongoing effects of their actions on a top level. This, in turn, leads to unintended consequences of action and to unacknowledged conditions of action (Giddens, 1984, p. 5). Agency is viewed in opposition to structure, which operates as some sort of constraint upon the actions of agents. Structures are rules and institutions people must follow, thus constraining them. At the same time, structures also enable agency (Giddens, 1984, p. 162).

Giddens' conception of agency is structured according to a sociological tradition, which foregoes the ecological conditions in which the agents operate. Thus, we see a natural alliance between the premises of NCT and Giddens' conception of agency. From a methodological standpoint, Bruce Trigger has conceived an archaeology that presupposes that past people had agency, reasons, and motivations, but were constrained by a series of factors – such as ecological, demographic, and physical constraints (Trigger, 1991). Following this line of thought, the creation of cultural landscapes concerns those actions by humans that alter the landscape in a way that it affects them and their survival.

One of the challenges of understanding the creation of cultural landscapes, is recognising to what extent humans in the past could perceive the effects of their actions. Certain actions had immediate effects and obviously these were known to the agents in question and would be considered in future actions. Changing the landscape could also have effects that lasted months, years, or even decades, but these must have been harder to perceive by the agents. Furthermore, the effects that are long-term, effects that last centuries or even millennia, must have been impossible to perceive by agents. Archaeology has tended to favour long-term processes and histories, most of which must have been nigh-impossible for the agent to perceive (Robb & Pauketat, 2013) and this had led to a limiting view of how agents actually contributed to these processes and histories.

In sociology, there is an idea that has been helpful in dealing with this phenomenon, known as 'unintended consequences of action' (Boudon, 1977; Merton, 1936;

Weber, 1921/1978). This is also an idea present in Anthony Giddens' work. As he describes, agency is usually described as being intentional, however, in many cases, intentional actions have consequences that are unintended (Giddens, 1984, p. 8). As Todd and Christine VanPool (2003) point out, there is the possibility of combining both evolutionary/ecological and agency approaches, but for this to be operable, it must consider intended and unintended consequences of action. In the process of cultural creation, actors will intentionally try to 'adapt' to their surrounding environment, in large measure, to increase their reproductive success. As mentioned earlier, both natural and social factors will affect this success, be it natural conditions such as access to freshwater or specific social institutions such as hierarchy and private property. Regardless, past agents will have found ways to overcome or take advantage of these factors in their strategies. These adaptive strategies, however, can shape the history of past groups in ways they did not conceive (VanPool & VanPool, 2003, p. 96). In a way, from the perspective of evolutionary success, the past is a history of trial and error – a spectrum of adaptive actions within specific ecological settings that were beneficial or deleterious to the survival of the group.

Overall, the idea of cultural creation within specific ecological contexts tries to combine what, in archaeology, has been conceived of as mutually exclusive. The history of archaeological thought, namely the dominance of processual archaeology in the 1960s to 1980s, and postprocessual archaeology from the 1980s to the 2000s, has led to a perception of incommensurability between evolutionary and ecology-based approaches and those involving the agency of past peoples (Arkush, 2011; Arponen et al., 2019). As pointed out above, NCT and unintended consequences of action can help us re-think how agency operates in ecological settings, furthermore, they can help us conceive of human culture in a naturalist manner; that is to say, culture as a process that is recognisable and researchable in the landscape, yet nevertheless still part of the natural world.

While these ideas are helpful from a theoretical standpoint, some tools are still required to make them operable. One way is through the anatomy of transformations (Chap. 3). The anatomy of transformations operates according to four pillars: DPSIR (the concept of *Driving forces, Pressures, States, Impacts and Responses;* Smeets & Weterings, 1999; see also Fig. 7.1), theorisation, semiotics, and emergence. Of particular relevance to explaining and understanding the creation of past landscapes is the role played by DPSIR and emergence.

Smeets and Weterings (1999, p. 6) describe the concept as follows: 'According to this systems analysis view, social and economic developments exert Pressure on

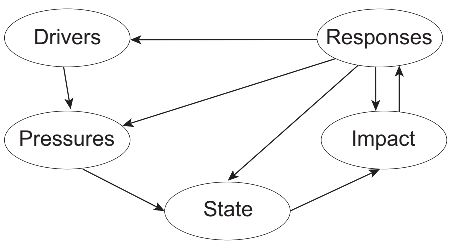

Fig. 7.1 The DPSIR Framework for reporting on environmental issues. (From Smeets & Weterings, 1999, p. 6, Fig. 1, licensed under CC-BY-4.0)

the environment and, as a consequence, the State of the environment changes, such as the provision of adequate conditions for health, resources availability and biodiversity. Finally, this leads to Impacts on human health, ecosystems and materials that may elicit a societal Response that feeds back on the Driving forces, or on the state or impacts directly, through adaptation or curative action'.

According to DPSIR, the creation of a cultural landscape is a process of transformation of a human society. Rather than recognising this transformation simply as a result of the environment acting on the agents and the agents acting back, that is to say, as a two-way causal feedback loop, DPSIR breaks down this process into several drivers, pressures, states, impacts and responses. By itself, DPSIR does not provide the tools to explain how and why transformations occur, but what it does is create a model that more accurately reflects the various conditions and factors that play a role in human-environmental interaction. For example, when describing how a society faces an environmental event, such as drought, there is risk of reducing the explanation to 'famine' or 'hunger'. It might be true that a drought could have led to famine or hunger, but certainly several actions must have been taken by the society under analysis, leading the society to different states of affairs, and to try to respond. Similarly, when humans affect the environment, such as by building infrastructure along the coast, this leads to unintended long-term effects such as coastal erosion, which in turn leads to new states and impacts, and responses from socials agents.

Emergence, on the other hand, is helpful in understanding how processes of cultural creation occur at a variety of scales, especially at a larger scale. Oftentimes, human-environmental research focuses on phenomena at a small and medium scale, while ignoring widespread changes on a much larger-scale. Neolithisation is such a phenomenon. Naturally, Neolithisation was a very large-scale phenomenon that occurred in diverse parts of the world, and standard theories of diffusion of the 'neolithic package' have become quite limited. Through emergence, instead of recognising the Neolithic as simply that which was copied by other human groups, we can start recognising it as mutual and reinforcing practices that allowed neolithic ways of life to emerge (Robb, 2013). Underlying this emergence are the very actions of agents mentioned above, actions that gave shape to a large variety of cultural landscapes.

In the following we will provide examples for this creation of cultural landscapes from our research in the frame of the CRC 1266 on *Scales of Transformation* and will estimate the consequences of the observed changes. An evaluation of human environmental interference of Stone Age hunter gatherers will be the starting point. As the effect of human agency on the landscape is difficult to trace at this time and is hard to differentiate from climatic or other natural changes, we will focus on on-site studies. They show clear effects in the form of vegetation changes and traces like micro-charcoal that support the hypothesis of an anthropogenic origin of these changes. Thus, the time-scale covers very short (days or weeks) recurring interactions on a very local spatial scale. In comparison to this, Neolithisation is a very strong interference with the environment and a much more obvious creation of a cultural landscape. Neolithisation in northern Germany was a stepwise process with very different scales in woodland manipulation and opening up the landscape in the single phases of the establishment of agriculture based on different portions of animal husbandry and arable farming. This study is based on on-site as well as on near- and off-site studies representing a regional spatial scale and a time window spanning several centuries. The history of anthropogenic heathlands is the topic of the third example. Intensive agriculture from the Neolithic onwards resulted in a degradation of soils and, in susceptible environments with sandy soils, to early establishment of heathlands. Even today, this open, steppe-like landscape only exists because of human agency and is a classic example for a cultural landscape. In comparison to this, we discuss how the human interference in south-eastern Europe has transformed a forest-steppe into an anthropogenic steppe due to population agglomerations around the Chalcolithic mega-sites. In opposition to the depletion of sandy soils, here a side effect of the deforestation was the development of a very fertile soil. This built the basis for sustaining agriculture in the context of Neolithic mega-sites. Both the temporal and the spatial scale of the last two examples are great, spanning several generations and centuries, as well as large geographic areas. In all the examples it will be discussed whether people were aware of the consequences of their behaviour and how they may have perceived the landscape changes.

7.3 Cultural Landscapes of Stone Age Hunter-Gatherers

The cultural landscapes in the Palaeolithic and Mesolithic have been considered for a long time as mainly based on human groups' interaction with the environment. This is prominently represented, for instance, through papers that investigate climatic setbacks and their effect on hunter-gatherer societies (e.g. Budja, 2007; Gehlen & Schön, 2005; Griffith & Robinson, 2018; Manninen, 2014; Tallavaara & Seppä, 2011; Wicks & Mithen, 2018; Wild et al., 2022) and thus indirectly implying eco-deterministic effects on cultural evolution. At the same time, studies are increasingly showing how hunter-gatherer groups were already impacting their environment and left more or less significant footprints in the bio-archaeological dataset (e.g. Boethius, 2017; Bos & Janssen, 1996; Day, 1993; Groß et al., 2019; Heidgen et al., 2022; Law, 1998; Schmölcke, 2019; Sobkowiak-Tabaka et al., 2017; Wieckowska-Lüth et al., 2018). In general, it is widely accepted in archaeology that early on, humans influenced biomes by their simple annidation (Arribas & Palmqvist, 1999; Boivin et al., 2016). Originating in biology, niche construction theory is a tool to decipher the delayed and immediate, short-term and long-term impact of the presence of specific species – and in the case of archaeology of the human species – on their environment (e.g. Groß et al., 2019; Laland & O'Brien, 2010; Riede, 2011). Hardesty (1972) already stated that culture is the human ecological niche, thus, even the smallest changes of landscapes by niche-building of ancient hunter-gatherers must be considered as creation of cultural landscapes. However, the scale of landscape transformation by hunter-gatherers differs from that of agricultural and industrial societies. Due to a high seasonal mobility and expected small group sizes of Late Upper Palaeolithic, Final Palaeolithic and Early Mesolithic hunter-gatherers (e.g. Pedersen et al., 2022; Eriksen, 1996; Hamer et al., 2019; Schmölcke, 2019; Wild, 2020), we must expect a landscape that was quite resilient to human manipulations and that changes of the landscape were only visible for a short period of time. This also means that most of the anthropogenic manipulations have had an immediate *ad-hoc* effect on a very restricted area and were not meant to be long-lasting nor having a large-scale consequence. Besides possible examples of landscape manipulations by the construction of large-scale ambush systems helping a hunting party to drive animals into a certain direction (c.f. Baales, 1996; Binford, 1978; Grønnow et al., 1983; see also Street & Wild, 2015), whose existence is almost impossible to prove, palynology allows a rough insight into short- to long-term transformations of the environment and the creation of cultural landscapes.

Nevertheless, it is crucial to be aware that regional and temporally insufficiently resolved pollen records may not adequately reflect human-induced disturbances within the vegetation, as these changes are regarded to be local and/or temporary in nature. Furthermore, the influence of natural processes makes interpretations difficult (Brown, 1997; Kalis et al., 2003). However, pollen data from smaller environmental archives offering quantitative information from a catchment area, coupled with a more detailed application of additional local palaeoenvironmental proxies (e.g. charcoal particles, non-pollen palynomorphs, macroremains), as well as zoological assemblages and archaeological records on the qualitative use of specific locations, provide a rewarding approach to disentangle human and natural effects. The efficiency of this approach has been illustrated recently by Krüger (2020), where the temporary increases in human activity of Late Palaeolithic hunter-gatherers were reflected in the palynological data coinciding with the rapid changes in vegetation at the Late Glacial-Holocene transition. A longer on-site human presence, while adapting to the changing behaviour of reindeer herds brought about by this environmental transformation, at the same time left more distinct imprints in the Nahe palaeolake archive (Krüger et al., 2020). Consequently, at least at the local level, more use of the landscape is conceivable.

With the onset of the Holocene, climatically and edaphically induced modifications in vegetation and animal composition and structure, as well as the intensified colonisation of the lakes and rivers and adjacent habitats with different plant and animal communities, led to the emergence of different biotopes that offered a wide range of natural resources. Vice versa, the environmental changes will also have had an impact on the presence of certain natural resources, for instance in the form of wild plants that used to be economically important. These changes in the availability of certain wild plants and animals certainly induced humans to adapt or change their land use strategies by transformation of their economy. However, the changing environment has not only resulted in human adaptations to nature, but apparently in a transformation of the woodland by human agency. In fact, the potential role of hunter-gatherers in influencing the natural abundance and distribution of certain plant species is assumed for different European regions: Numerous studies on human-environment interactions in the Mesolithic period come from North-West Europe. In Britain and Ireland, the environmental impact of hunter-gatherer groups has been the subject of intensive palaeoecological research for several decades. The majority view among researchers is that Mesolithic humans were not essentially passive inhabitants of the forest landscape, but that they had at least locally a significant impact on the vegetation (Barnett, 2009; Bishop et al., 2013, 2015; Blackford et al., 2006; Brown, 1997; Caseldine & Hatton, 1993; Edwards, 1990; Hather, 1998; Innes & Simmons, 2000; Innes & Blackford, 2003; Innes et al., 2010; Mighall et al., 2008; Moore, 2000, 2003; Ryan & Blackford, 2010; Simmons, 1975, 1996; Simmons & Innes, 1987, 1996a, b; Smith, 1970; Smith, 2011; Warren et al., 2014; Whitehouse & D. Smith, 2010; Wiltshire & Edwards, 1993).

Charcoal-analytical as well as archaeobotanical studies show that hunter-gatherer groups systematically used forest plants as food and fuel sources, thereby actively shaping their environment (Bishop et al., 2013, 2015; Groß et al., 2019; Holst, 2009, 2010; Mason, 2000; Moore, 2003; Mithen et al., 2001). Some researchers even go a step further, claiming that Mesolithic people may have managed wild resources in a similar way to cultivated plants to increase the production of economically important species (Boethius, 2016, 2017; Boethius et al., 2021; Göransson, 1983; Harris, 1989; Magnell, 2005; Schmölcke, 2016; Simmons & Innes, 1987; Zvelebil, 1994). The most common example of plant management concerns *Corylus*.

Due to the weight of the fruits, hazel does not by itself spread as quickly as, for example, pine and birch, the lightweight fruits of which are spread by the wind (Eriksen, 1996). In view of this, Firbas (1949) already pointed out the remarkably rapid spread of hazel over Central Europe. He remarked that this could have been considerably influenced by man, either intentionally or unintentionally, since such a fast dispersal could not have been caused by small mammals. Eriksen (1996) also considered it probable that the much faster spread of *Corylus* in the south-east area of Scandinavia, while still absent in the north-west, was due to human agency. In line with Firbas she suggested that this may be due to the fact 'that the collecting, storing, and transporting of hazelnuts by prehistoric man was an important factor in the early Boreal spread of hazel in the south-eastern part of the region' (Eriksen, 1996). The numerous remains of hazelnut shells at various Mesolithic sites leave no doubt that they constituted an essential part of subsistence. As early as 1925, Schwantes stated that the hazelnuts may have played the role of the later cereals (Firbas, 1949). The use of the hazel was not limited to its fruits. *Corylus avellana* grows as a tree in occasional cases (e.g. Düll & Kutzelnigg, 1992). Due to this fact, it is assumed that hazel spread as a tree, not as a bush into mixed birch and/or pine forest (Firbas, 1949; Küster, 1995; Tallantire, 2002). However, as coppiced hazel shoots not only grow faster but become fully reproductive more quickly (cf. Firbas, 1949; Tallantire, 2002), manipulation of hazel shrubs by coppicing may have been undertaken to increase the production of hazelnuts. (Bishop et al., 2013; Blackford et al., 2006; Holst, 2010; Huntley, 1993; Warren et al., 2014).

Moreover, coppiced hazels grow long straight stems, and therefore young hazel shoots may also have been an important raw material for the construction of structures, such as shelters, fences, walls, baskets or fish traps (Klooß, 2015; Regnell, 2012; Wilkinson & Vedmore, 2001). In the area of ancient Lake Duvensee, for instance, continuous use of the surrounding landscape is evidenced by several palynological records of camp sites for the early Boreal – the period in which the hazel becomes increasingly present. The increases in the abundance of ruderal herbs (*Artemisia*, *Urtica*, Chenopodiaceae, *Rumex*, *Epilobium*, *Melampyrum*, etc.) in particular, but also of grasses, corresponding with the habitation layers with their bark mats, flint artefacts, charcoal pieces and partly charred hazelnut shells, indicate human disturbances of the local vegetation for resource exploitation (Wieckowska-Lüth & Dörfler, accepted). The use of hazel stands is suggested by the fact that the rises in secondary anthropogenic indicators coincides with the peaks in *Corylus* occurrence. This pollen pattern may indicate human manipulation on the one hand, but of course also naturally fluctuating local availability of hazel shrubs on the other. However, along the lines of Firbas' (1949) hypothesis it is also assumed for the Duvensee area that humans were partly responsible for the early Boreal spread of hazel, because the camp sites document an intensive autumn exploitation of hazelnuts, even as early as the late Preboreal. This is approximately 500 years before the pollen-analytical hazel maximum (Bokelmann, 1980; Bokelmann et al., 1981).

Knowledge on the properties or behaviour of particular wood species is exemplified clearly by the case of Star Carr, eastern England. Here, the split timbers used in the dwelling platforms came from willow and aspen trees, selected for their straight growth and lack of side branches (Bamforth et al., 2018). Another example demonstrates the use of Mesolithic woodlands as a resource extraction area for wood material at archaeological sites in south-eastern Norway. Here, the recurrent reductions in *Tilia* pollen, which are concurrent with the production of Nøstvet axes indicate selective use of lime wood for the production of these implements (Wieckowska-Lüth et al., 2018).

There is also a debate about deliberate burning of vegetation during the Mesolithic. This type of forest manipulation is indicated in numerous palynological records by the simultaneous increases in microcharcoal, pyrophilous fungal spores, and fire-adapted plants, such as *Pteridium*, *Calluna*, *Melampyrum* and *Corylus* (e.g. Blackford et al., 2006; Bos & Urz, 2003; Innes & Simmons, 1988, 2000; Innes et al., 2010; Mellars, 1976; Moore, 2000; Wieckowska-Lüth et al., 2018). Hazel, for instance, is resistant to burning due to its relatively deep rooting system and its regeneration ability (Tallantire, 2002). Deliberate burning to promote the growth of hazel bushes is therefore under debate (Rowley-Conwy & Layton, 2011). Additionally, there is even an assumption that hunter-gatherers played a certain role in the rapid process of hazel expansion by using fire (e.g. Huntley, 1993; Iversen, 1973; Smith, 1970; Zoller, 1960), as in none of the older interglacials did hazel spread as fast as in the Holocene (e.g. Firbas, 1949; Huntley, 1993; Iversen, 1973; Smith, 1970; Zoller, 1960). Human impact has also been suggested as the possible cause of a secondary rise in hazel pollen abundance around the time of the Boreal-Atlantic transition after the initial maximal *Corylus* values (Firbas, 1949). The fact that this secondary increase is a less common feature in the pollen records (Smith, 1970) adds to its significance as a possible indicator of human activity (Edwards & Ralston, 1985).

Surely, fire will also have promoted the spread of other understorey plants with edible fruits or berries (Edwards & Ralston, 1985). Burning of vegetation to encourage growth of ground vegetation, such as herbs and grasses, for the control of prey populations is also proposed. In this regard, Barnett (2009), for example, points out the deliberate repeated burning of the lowland riverine and occupied terrace environment to create clearings when more resources might have been needed. Similar considerations exist for coastal areas where burning may have been used to maintain or extend the openness of the seashore vegetation (cf. Edwards et al., 2009; Mellars & Dark, 1998). Further examples come from islands in the lakes of eastern Schleswig-Holstein, Germany. Here, large quantities of microcharcoal in Mesolithic stratigraphies, emerging together with evidence of coprophilous fungal spores, plant disturbance and erosion indicators, suggest that vegetation at these isolated sites may have been intentionally modified to attract hunting prey (Wieckowska et al., 2012; Wieckowska-Lüth et al., 2014). There are comparable reports from the Mesolithic site Dudka, north-eastern Poland, where a high proportion of charcoal and elk bones is interpreted as a sign of burning forests to produce young shoots to attract prey (Gumiński & Michniewicz, 2003). In addition, it is assumed that this fire-supported hunting strategy was combined with the cultivation of hazel (Fig. 7.2).

During the Late Mesolithic in the area of north-western Europe, burning is even thought to have reached its most mature form and an elaborate land-use system was supposed to operate with permanent manipulation of vegetation by fire. By concentrating certain wild plants in useful stands, active management of the forest ecosystem may have been established, allowing for some control of food production and

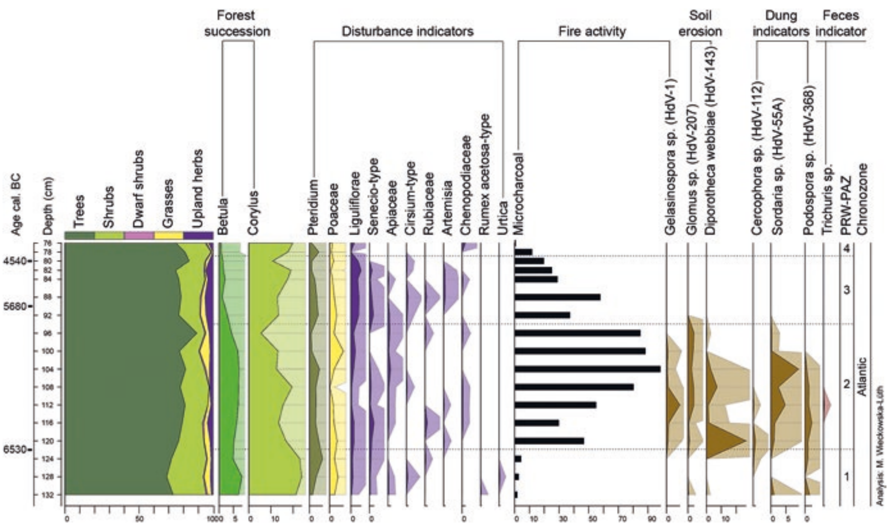

Fig. 7.2 Percentage microfossils diagram (pollen, spores, NPPs [% total terrestrial pollen], microcharcoal [particles/cm^3]) for the mire on the island Probstenwerder in Lanker See, Schleswig-Holstein, showing selected curves for the Atlantic period. (Wieckowska et al., 2012, modified)

maximisation of resource yield (Innes et al., 2010; Jacobi et al., 1976; Mason, 2000; Simmons, 1975, 1995, 1996; Rowley-Conwy & Layton, 2011).

Other influences on the landscape can be found through the selection of prey species (e.g. Schmölcke, 2016; Magnell, 2005), so that specific cohorts of a population are targeted. This might increase reproduction pressure (cf. Rowley-Conwy & Layton, 2011) but can also be seen in connection with the woodland manipulation when, for instance, the forest edges are cleared for more easy targeting of roe deer (cf. Groß et al., 2019).

Another example concerns the perception of the landscape by the Mesolithic people. The choice of site for the establishment of the resting place of Groß Fredenwalde, Brandenburg – a prominent Mesolithic cemetery in northern central Europe – was due on the one hand to its prominent location on a morainic hilltop, but also apparently to the naturally open vegetation structure of its slope (Wieckowska-Lüth et al., n.d.). A kind of forest-steppe micro-environment enabled the visibility of this exceptional burial site and suggests the deliberate use of this particular landscape for centuries (Wieckowska-Lüth et al., n.d.).

Although none of these approaches can provide unequivocal evidence of anthropogenic manipulation of vegetation, they do inform us through inference about interpretational possibilities.

7.4 Neolithisation in North-Western Europe

With respect to NCT, Neolithisation implies a radical transformation in the human-environment relationship. Even though hunter-gatherers used the resources in their environments to enhance game density, and manipulated it with a view to better resource extraction (see the preceding section), with Neolithisation this resource extraction reached a new level. Keeping livestock in the form of cattle, pigs, sheep and goats makes it necessary on the one hand to stockpile winter fodder, and to enhance grazing possibilities on the other. In a densely wooded landscape most of the potential food sources — leaves in the crowns of trees — are unavaible for both wild game and browsing livestock. Humans had to make them available by cutting branches, and they produced leaf hay as winter fodder, establishing a leaf fodder economy (Dörfler, 2022; Haas et al., 1998). As a side effect, the woodland becomes more open and undergrowth spreads, providing better grazing conditions. Grazing will also have prevented the regeneration of trees in the surroundings of settlements. Thus, dying trees are not replaced and the landscape takes on an increasingly open character. Through this behaviour people created a cultural landscape that enabled a much higher population density — for humans as well as for livestock, in comparison to wild game density. They built their own niche and adapted to it through new techniques and exploring new resources. Despite new subsistence stragies, woodland would have remained an important resource in many different ways. Table 7.1 summarises potential forms of woodland exploitation and their consequences. Grazing and leaf hay production will have had the strongest effects on woodland composition in this list.

Table 7.1 Potential uses of woodland in the Neolithic and their effects on the creation of cultural landscape

Woodland uses	Effects on the creation of cultural landscape
Selected timber for construction purpose (e.g. houses, trackways, carriages, boats)	Local changes in woodland density and composition
Wood as raw material (e.g. tools, buckets, vessels, music instruments)	Negligible effect
Wood as fuel (e.g. cooking and heating): Primarily deadwood and litter from other wood consumption	Minor effect on local changes in woodland density and composition; Impoverishment of soils by withdrawal of nutrients and prevention of composting
Wood as raw material for the production of tar	Negligible effect
Wood as raw material for the production of ash as fertiliser	Mobilisation of nutrients in a slash and burn process
Wood as raw material for the production of ash as a stain for dyeing, and as a soap substitute	Negligible effect
Bark for tanning	Negligible effect
Bark and bast as fodder (especially twigs in wintertime)	Local changes in woodland density and composition
Bast (fibres) as raw material for ropes and textiles. Preferred lime and oak bast	Local changes in woodland density and composition
Leaves as fodder (coppicing, shredding, pollarding, etc.)	Local changes in woodland density and composition; Potential effect on pollen production and dispersal
Fallen leaves as animal litter	Impoverishment of soils by withdrawal of nutrients and prevention of composting
Mast fodder, especially acorns as pig food	Dependent of grazing intensity, potential effect on woodland regeneration
Fruits and seeds as source of high caloric food (especially beech, hazel, and pine)	Dependent of gathering intensity, potential effect on woodland regeneration; Impoverishment of soils by withdrawal of nutrients
Resin, fruits, herbs and mushrooms as food, spices and medicine – In time of emergency, even bark and acorns as food	Negligible effect
Woodland as pasture for livestock, potentially supported by pollarding	Impoverishment of soils by withdrawal of nutrients; Local changes in woodland density and composition
Temporary woodland clearances for arable land	Local changes in woodland density and composition; Initiation of primary woodland succession after abandonment
Woodland as a hunting ground (birds, eggs and game)	Negligible effect; Potentially positive effect on woodland density
Woodland as source of pollen and nectar for honey production	Negligible effect
Woodland as a holy grove, including particular trees for the worship of gods	Negligible effect

When considering Neolithisation in the area of modern Germany, two different trajectories have to be considered. In the South, Neolithisation began in the middle of the sixth millennium BCE with the so-called linear-pottery people (LBK). The settlement area is restricted to the distribution of the fertile loess soils. Due to the lack of natural archives there are just a few investigations into the history of this landscape. Pollen analyses indicate an only slightly thinned out forest, so that the settlements can be imagined as clearing islands in a forest landscape (Beug, 1992; Kreuz, 1990; Meurers-Balke & Kalis, 2001; Zimmermann et al., 2005). The model for Neolithisation describes this process as the arrival and establishment of a neolithic package with arable farming, cattle breeding, ceramics and further technological innovations. According to Bogaard (2004) arable farming was practiced as intensive gardening at small permanent spots and animal husbandry was small scale and intensive as well.

North of the distribution limit of loess soils, on the old and young moraine soils of northern Germany, the appearance of the Funnelbeaker phenomenon at about 4100 cal. BCE is regarded as marking the beginning of the Neolithic. The use of ceramics is already documented for the Late Mesolithic Ertebølle 'culture' from c. 4500 cal. BCE onwards. As mentioned above, this is also the time of micro charcoal peaks in the pollen records, indicating the use of fire as a hunting strategy and a form of landscape manipulation. Neolithisation in the form of a productive economy started with a main emphasis on animal husbandry in the Early Neolithic (Feeser & Dörfler, 2015). Even though there is evidence that late Mesolithic groups already had access to domesticated animals (Krause-Kyora et al., 2013; Jensen & Sørensen, 2023), bone assemblages from archaeological sites indicate that animal husbandry became important during the Early Neolithic (Sørensen, 2014). Agriculture played a minor role and cereal cultivation might have been practiced in form of gardening. Additionally, it seems that at this stage fire played a role in woodland management, as indicated by micro charcoal in pollen records (Wiethold, 1998). It was not before 3700 cal. BCE that larger openings for arable fields were established and cereals became a major component of nutrition (Kirleis et al., 2011). In the partly open and park-like landscape around the settlements it was possible to establish arable fields, as no tree roots hampered ploughing. It is at around the same time that there is evidence for the introduction of the ard (Sørensen & Karg, 2014). Thus, centuries of grazing by domestic animals may have been the precondition (i.e. building a niche) for arable farming. Indicators for disturbance of the soil, like *Plantago lanceolata*, established very quickly with the onset of this larger-scale agriculture around 3700 cal. BCE (Feeser & Dörfler, 2015). From this time onward, the pollen records show clear signs of open, permanently used areas, even though most of the landscape still was covered by woodland (see above).

Whether the adoption of animal husbandry as a first step towards a production-based lifestyle and the forming of a niche for this type of economy was introduced by an invading population or if this was an adaptation of indigenous people is still a matter of debate. According to Allentoft et al. (2022, 2024) the genome of inhabitants of the Danish area changed rapidly at around 3900 cal. BC. Isotope studies on the same skeletons show a drastic change in δ13C and δ15N values, indicating a shift from marine-dominated nutrition to terrestrial food resources at around the same time. This relates to individuals with Italian ancestry ("HG Europe S") as well as those with Anatolian ancestry ("Farmer Anatolia"). After a short time, the incoming "farmers" replaced the "hunter gatherers" in the genomic record of the investigated samples. This picture might, however, be biased by a lack of grave finds from late Mesolithic times. Jensen and Sørensen (2023) speak about "cultural duality" during the Early Neolithic transformation. Given the evidence for early access to domesticated animals already in the mid-fifth millennium BCE, it seems plausible that indigenous hunter-gatherer communities adopted animal husbandry at around 4000 BCE. This might have been triggered by a short climatic deterioration around the same time, recorded in archives from northern Germany (Dreibrodt & Wiethold, 2015) and central Europe (Affolter et al., 2019), probably associated with the so-called Bond 4 event (Bond et al., 2001). The later adoption of arable farming, however, which was associated with new cultural phenomena (e.g. megaliths and causewayed enclosures; Müller, 2011), could well have been related to incoming of new cultural groups. With respect to NCT this could imply that the incoming farmers took advantage of a niche created by other communities.

By the erection of megalithic graves and the establishment of causewayed enclosures the landscape became culturally loaded by the incoming communities and might express a manifestation of a territorial claim by installation of landmarks (cf. Rothstein, 2023). Likewise, prominent landforms such as the island of Heligoland, erratic blocks, trees or bogs were probably natural landmarks with a spiritual meaning that determined the perception of landscape even as early as during Palaeolithic and Mesolithic times (see also Menenga et al., 2023).

7.5 Anthropogenic Heathlands – History of a Cultural Landscape in Context of New Evidence from Schleswig-Holstein

Atlantic heathlands are an open, generally treeless vegetation type dominated by dwarf shrub communities and in particular common heather (*Calluna vulgaris* (L.) Hull). They generally occur in areas with a relatively cool, humid climate on poor soils and are found from the Iberian peninsula up to the coast of Norway, including Ireland and Great Britain (Gimingham et al., 1979; Loidi et al., 2020). In areas with raised bog occurrence since the early Holocene (Schlütz et al., 2021) a wet heath form is found, also with *Erica tetralix* along with *Calluna vulgaris* as dominant species, associated with other bog plants. Despite evidence for local natural wet heathlands in coastal situations with natural disturbance regimes, the establishment of dry inland heathlands, including juniper (*Juniperus communis* L.) as a typical representative, is generally regarded to be the result of human forest degradation and soil depletion (e.g. Birks, 1996; Birks & Madsen, 1979; Bunting, 1996; Kaland, 1986; Peglar, 1979). In the present day, heathlands have little economic value and are therefore threatened by changing land-use practices (Fagúndez, 2013). Due to their recreational and biological value, however, they are partially actively maintained by nature conservation practices, as land use abandonment would inevitably lead to woodland regeneration.

Our knowledge of the origin and long-term history of dry anthropogenic heathlands in Europe relies mainly on palaeoecological studies. In order to understand the underlying human-environmental dynamics of this type of cultural landscape, both their environmental and archaeological context has to be considered (e.g. Løvschal, 2021). In the present case study, based on new results from the CRC 1266, the history of heath development in Schleswig-Holstein is summarised and briefly discussed in a broader north-western Central European context.

Recent palaeoecological investigations in the context of archaeological rescue excavations at a megalithic grave complex at Oeversee LA 29 (the number indicates the site reference of the local archaeological heritage council) in northern Germany, c. 9 km south of Flensburg, (Fig. 7.3, site 1) provide evidence for anthropogenic heathlands as early as during Middle Neolithic times (Klooß & Feeser, 2023). The site is located at the western edge of the limit of the last glaciation and is characterised by sandur deposits. Pollen samples have been analysed from a buried podzol with a pronounced hard pan horizon preserved under the burial mound (Fig. 7.4). High proportions of *Calluna* pollen (Fig. 7.5) indicate the local presence of heathland dominated by common heather. Although sporadic finds of Cereal-type pollen indicate some agricultural activity at or in the vicinity of the site, it is argued that extensive pastoral activity was the local predominating form of land use. Elevated concentrations of micro-charcoal particles in the subfossil Ah horizon indicate local fires and could relate to repeated burning of the vegetation, a practice which is often regarded as being responsible for the establishment and maintenance of anthropogenic heath (Kaland, 1986; Karg, 2008; Odgaard, 1992, 1994; Prøsch-Danielsen & Simonsen, 2000). Similar and even higher concentrations of micro-charcoal, however, are also found in subfossil Ah horizons under Neolithic barrows, with evidence for former agricultural activities or cereal cultivation (Feeser & Dörfler, 2016, 2019). This indicates that the burning of vegetation was probably a common land-use practice and more generally applied for clearing, maintaining and preparing agricultural land. Despite a similar archaeological and cultural context, the investigated sites differ with respect to their environmental preconditions. Whereas Oeversee is situated in a sandur area, the other sites are located in areas with predominating loamy sands and thus better soil conditions. Although pollen preservation in these more fertile soils is much worse – higher pH values favour the microbial decomposition of pollen – the palynological results provide evidence for former cereal cultivation and the beginning of soil depletion. In these cases, former agricultural activity is often also indicated by additional evidence of plough marks under the barrows (Feeser & Dörfler, 2019; Feeser et al., 2022). Evidence for *Calluna*, however, is generally sparse and provides no evidence for anthropogenic heathland during the Neolithic on the more fertile soils. It is only with an intensification of agriculture in the late Bronze Age and especially the early Iron Age that palynological records indicate a spread of heathland in the generally more fertile young moraine landscape of Schleswig- Holstein (Dörfler et al., 2012; Feeser et al., 2022; Wiethold, 1998; Fig. 7.6; see also Fig. 7.3, site 2 for location of Lake Belau). This

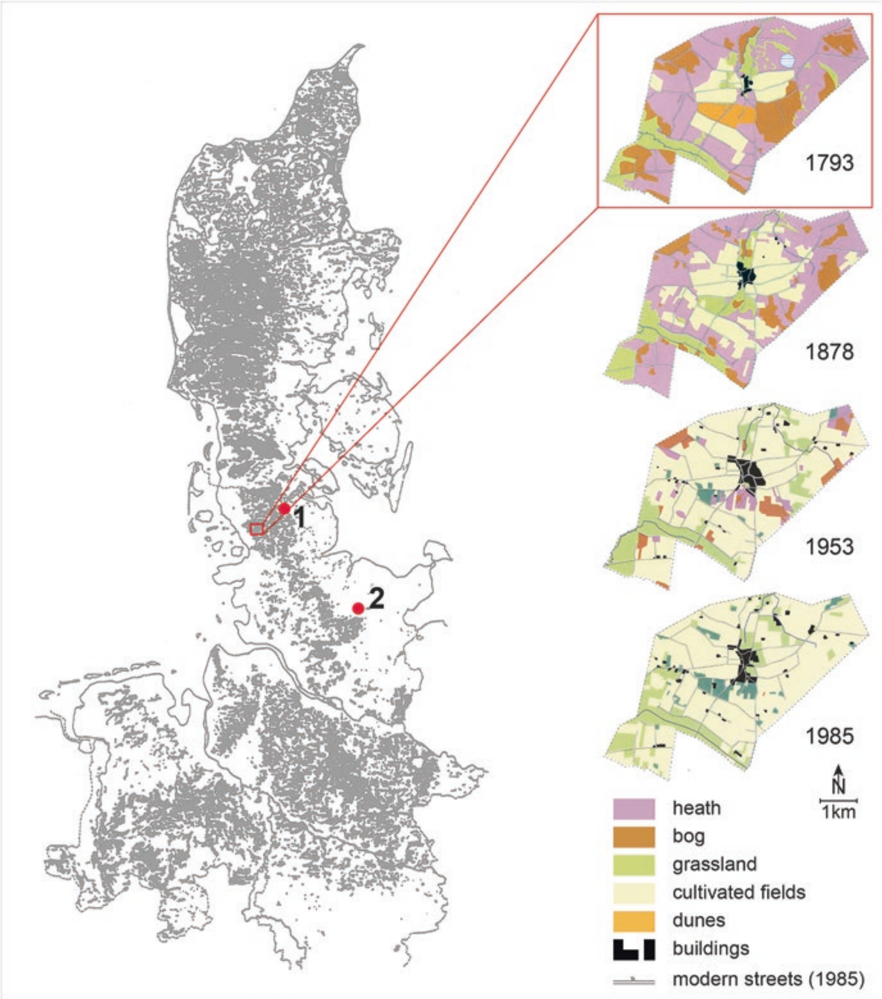

Fig. 7.3 Maximum heathland extension in north-western Germany and Denmark at around 1760 CE (left, in grey) after Behre (1995) and an overview of vegetation development in the Joldelund municipal area (right, in colour) after Dörfler (2000). Sites mentioned in this case study are also indicated: 1. Oeversee; 2 Lake Belau

is in agreement with pedological studies in the area which suggest a first phase of podzolisation during the Iron Age (Dreibrodt & Wiethold, 2015). A first maximum of *Calluna* in the pollen diagrams of eastern Schleswig-Holstein is reached around the second century BCE with a following decline until the fourth century CE, i.e. the migration period. Interestingly, this decline coincides with increasing and regular records of Secale pollen and is, therefore, possibly a reaction to progressive soil depletion. Rye, in comparison to wheat species, grows better and produces better

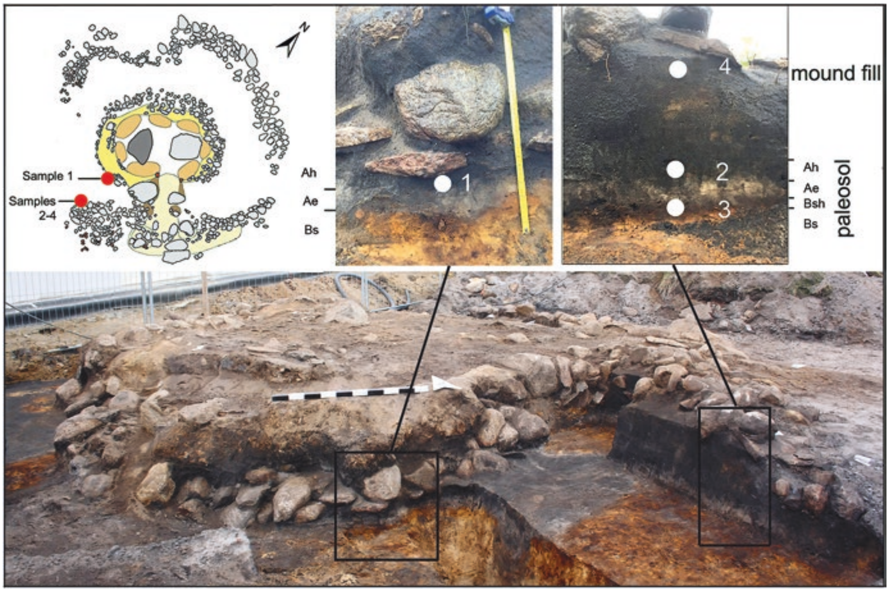

Fig. 7.4 Excavation plan of a megalithic tomb at site Oeversee LA29 (top left) and overview of context and location of pollen samples taken from the buried podzol and barrow mound. (From Klooß & Feeser, 2023, licensed under CC-BY-4.0)

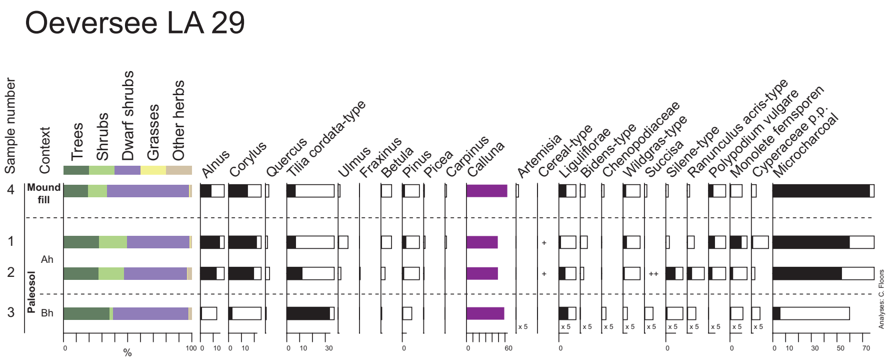

Fig. 7.5 Percentage pollen diagram (% total terrestrial pollen) of soil samples from a megalithic tomb at the archaeological site Oeversee LA 29. (From Klooß & Feeser, 2023, licensed under CC-BY-4.0) for selected pollen taxa. Non-filled background curves show values exaggerated x10 (high values truncated). Taxa noted outside the counting routine are indicated by '+'

yields on poor soils (Behre, 1992). A second maximum of heathland expansion is indicated for the period between c. 1350 and 1850 CE, which reflects increased agro-pastoral activities but also increased woodland exploitation for timber and especially fuel. At the end of the nineteenth century, efforts were made to change

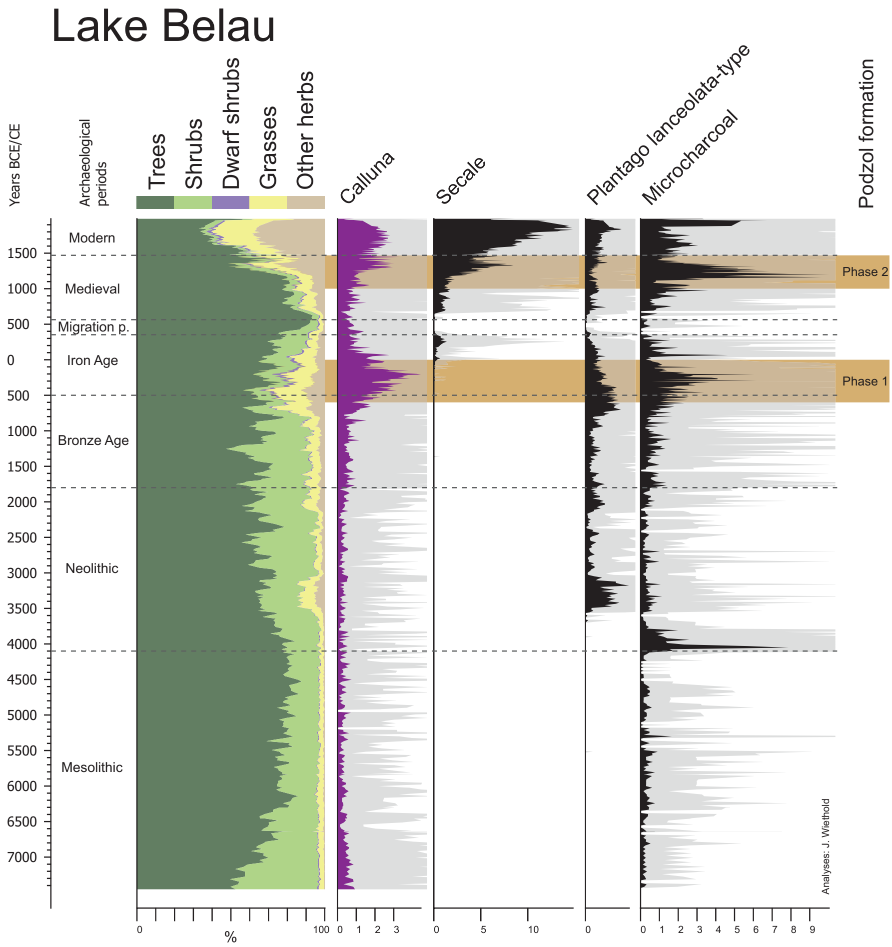

Fig. 7.6 Percentage pollen diagram (% total terrestrial pollen) of Lake Belau (Dörfler et al., 2012; Wiethold, 1998) showing selected curves. Grey background curves show values exaggerated x10 (high values truncated). Phases of podzol formation in the lake catchment after Dreibrodt and Wiethold (2015) are indicated

heathlands into arable land by soil melioration practices, such as the application of calcareous glacial drift (Lange, 1996). This resulted in a widespread decline of heathlands in Schleswig-Holstein (Fig. 7.3).

The presented evidence for the history of heathland development in Schleswig-Holstein is well in agreement with previous studies from north western Central Europe (i.e. the Netherlands, southern Scandinavia and Northern Germany). Generally, the development of heathlands seems to have been a metachronous phenomenon on this supra-regional scale, often beginning with the onset of agriculture and cumulating during the Late Bronze Age/Early Iron Age (Doorenbosch, 2013;

Doorenbosch & van Mourik, 2016; Hjelle et al., 2010; Prøsch-Danielsen & Simonsen, 2000; Tveraabak, 2004). As regards early evidence for heathland development, comparable findings of podzols and/or *Calluna*-rich pollen spectra from palaeosoils under Funnel Beaker megalithic graves are known from regions with poor, sandy soils in the Netherlands and northern Germany (Averdieck, 1980; Waterbolk, 1964). Also, in Denmark, the earliest evidence of anthropogenic heath vegetation under graves dates back to the Middle Neolithic (Andersen, 1995). This suggests that primarily environmental preconditions, such as well-drained, nutrient-poor sandy soils, favoured the establishment of early anthropogenic heathland communities. Furthermore, it seems that agricultural activities were not a necessary factor. Sevink et al. (2013) provide evidence from the Netherlands for probable anthropogenic heathlands as early as during the Boreal period, i.e. before c. 6500 BCE. Further indications come from Norway, where heath development already began during Mesolithic times, probably resulting from repeated burning of the vegetation (Prøsch-Danielsen & Simonsen, 2000). Intentional establishment and maintenance of heathland by recurring burning of the vegetation, rather than heathland development due to gradual soil depletion or accidental fires, is also discussed for later periods after the introduction of agriculture, i.e. the Neolithic and Bronze Age (Kaland, 1986; Odgaard, 1992, 1994). Given the Neolithic evidence from Schleswig-Holstein, however, with heterogeneous development in a region with a similar cultural background, it seems likely that the development of heathland was mainly predetermined by environmental preconditions, with no intentional creation but rather opportunistic land use.

The widespread supra-regional evidence for heathland expansion during the Late Bronze Age and Early Iron Age, even in landscapes with generally better soil conditions, possibly cannot be explained only by progressing land use and associated soil degradation. Despite some evidence for manuring practices with the beginning of agriculture already, soil quality generally seems to have decreased, especially since the Late Bronze Age, due to continuous arable exploitation (cf. Gron et al., 2021). Manuring and supplementing with organic material seem to have had a longer-lasting positive effect on soil quality (Gron et al., 2021) only in context of fundamental changes of land-use practices during the Younger Bronze Age (i.e. from the thirteenth/twelfth century BCE onwards), including the establishment of small permanent field systems (Celtic fields) during the Younger Bronze Age (Arnold, 2011; Nielsen et al., 2019) and a shift from woodland grazing to openland pastoral activities (Feeser et al., 2022). However, this was probably only the case for selected arable plots, as at the same time the palynological record suggests a spread of heathland. In this case, it seems plausible that continuous grazing of open- and grasslands, and the collection and usage of dung for manuring of such selective plots, probably favoured the establishment and spread of heathlands. The associated evidence for a change in woodland exploitation with decreasing importance of woodland pasture – as expressed by a shift in woodland composition (Feeser et al., 2022; Meurers-Balke, 1992, pp. 136 f.; Overbeck, 1975, pp. 486 f.) – could well result from an increased demand for wood and charcoal since the beginning of local metal production and processing during the later Bronze Age. The declining evidence for heathlands with the introduction of rye as a new cultivar during the second half of the pre-Roman Iron Age could point to a rather unintentional spread of heathlands due to land use intensification. Nevertheless, heathlands were probably an essential and important element of the land use regime, as is known from historic times. In the old moraine areas of northern Germany, for example, which have generally poorer soil conditions, during the tenth–nineteenth century large areas of heathland were used as pasture, in particular for sheep, and for apiculture (beekeeping). At the same time, however, they were used for collecting plant material for the manuring of relatively small permanent arable fields (plaggen fertilisation: *Plaggendüngung* and *Eschkultur*). The complete destruction of the vegetation cover by sod cutting often resulted in the initiation of soil erosion by wind and the formation of inland dunes (Dörfler, 2000). Using this technique, for the creation of one acre of arable land up to 30 acres of heathland were needed. Therefore, heathlands have not only had an economic value with respect to pasturing activities, but also played an important role for arable farming. In some areas, this remained the case until synthetic fertilisers could be applied in the early twentieth century. At present, anthropogenic heathlands are generally perceived as a cultural landscape worthy of protection. The evidence for long-term persistence of heathlands, especially in the context of burial landscapes (Casparie & Groenman-van Waateringe, 1980; Doorenbosch, 2013), suggests that these landscapes probably already had an economic and cultural value during prehistoric times.

In summary, the creation of anthropogenic heathlands was the effect of different land-use practices. Generally, it is the result of soil degradation in vulnerable environmental settings. Although soil degradation, as a generally negative effect, has not been intentional, people adapted to this new vegetation type and developed new land-use practices. Evidence for long-term persistence of heathlands indicates long-term continuing land use. Without the latter, heathlands would have disappeared again due to successional woodland regeneration. Under moderate grazing pressure and frequent burning, heathlands persist and remain open landscapes. Orians (1980) argues, from an evolutionary point of view on human behaviour and landscape perception, that there is an innate tendency in human species to favour open, savanna-like landscapes. Unlike dense woodland, it enables distant views and a 'high sky'. Potential game or enemies can be seen from afar, but such a landscape also lacks protection and shelter. Based on this evolutionary theory, the perception of and human interaction with such landscapes have to be considered when evaluating modern human behaviour with respect to landscape selection and management (Moura et al., 2017). Nowadays, this cultural landscape has a strong aesthetic value and is used for recreation and sentimental transfiguration (Fig. 7.7). Thus, this landscape type may also in prehistoric times have had a value that was not just economic; the heath may have been perceived as something positive that influences the relation of people to their environment.

Fig. 7.7 Romantic view on heathland in the mid twentieth century. Photo: W. Dörfler, reproduced with permission. © E. Krüger – www.maylicensing.com

7.6 Prehistoric Farming and the Genesis of Chernozems and Agricultural Soils

The fourth case study deals with a continent-scale landscape transformation associated with the conversion of wooded landscapes into open agro-pastoral landscapes. The deforestation triggered the onset of azonal Chernozem formation. This was first discovered during investigations of Chalcolithic mega-sites in central Ukraine. It serves as a case study for explaining azonal Chernozem occurrences in temperate humid Europe.

Chernozems (Mollisols, black earth soils) cover c. 7% of the Earth's land surface. They are among the most fertile agricultural soils, providing a large percentage of humankind with nutrition nowadays. They provide an important terrestrial carbon reservoir (e.g. Driessen et al., 2001; FAO, 2014). These soils have a comparatively simple stratification: fertile, organic-rich topsoil horizons of up to 1.5 m depth (A horizons) are developed over weakly weathered, calcareous, unconsolidated sediments (often Loess). Chernozems or Chernozem-like soils cover large parts of mid-latitude steppe and forest steppe regions in eastern Eurasia, North and South America, and parts of Africa. Additionally, Chernozems are present in the interior of semi-humid to humid southeast and central Europe. The genesis of Chernozems has been ascribed to the limited decomposition of organic litter, produced by a rich steppe grass and herb vegetation (e.g. Dokuchaev, 1883; Eckmeier et al., 2007). Bioturbation by small mammals (e.g. *Citellus citellus*, *Cricetus cricetus*) is common and is considered to contribute significantly to Chernozem formation. However, the quasi-linear age-depth profiles of organic matter in Chernozems (e.g. Scharpenseel et al., 1986) contradicts substantial soil relocation by digging animals, which would produce randomly inverted ages. The Chernozem distribution in temperate humid Europe has been considered to reflect early Holocene relict soils (e.g. Altermann et al., 2005; Kabała et al., 2019); however, radiocarbon ages and palaeoecological studies (summarised in Eckmeier et al., 2007) challenge the early Holocene interpretation of many temperate humid Chernozems. Charred organic matter, called 'black carbon' (BC), is quite widespread in temperate humid Chernozems. This led to the idea of fire-related Chernozem formation (e.g. Schmidt et al., 2002), even attributed to early farmers (e.g. Gehrt et al., 2002). Ambiguous BC-radiocarbon ages and, in particular, the lack of a process explaining the accumulation of the thick organic horizon, renders this idea insufficient to explain Chernozem genesis.

Considering the phenomenon that the 6000-year old Chalcolithic settlement of Maidanetske, central Ukraine, became covered by an archaeologically 'sterile' Chernozem over time, we developed a new model of Chernozem formation. This model is able to explain Chernozem genesis in humid central Europe as a result of human-environmental interaction (Dreibrodt et al., 2022).

With a size of 200 ha and population of about 10,000 people, the mega-site Maidanetske (c. 3960–3650 cal. BCE), located in the catchment of the Sinyukha River (a left tributary of the Southern Bug) is one of the largest settlements of the 'Trypillia cultural complex' and indeed in the whole of prehistoric Europe at this time (e.g. Gaydarska, 2019; Kruts, 2012; Menotti & Korvin-Piotrovskiy, 2012; Videjko, 1995). As a key site, this settlement was the focus of a Ukrainian-German cooperation within the CRC 1266 (Hofmann et al., 2018; Müller et al., 2016c, 2017, 2018, 2022; Ohlrau, 2015, 2020a; Rassmann et al., 2014; cf. Chapman et al., 2014). Following the gradual colonialisation of the forest-steppe ecotone northwest of the Black Sea, that started c. 5000 cal. BCE, mega-sites of the Chalcolithic Trypillia culture – such as Maidanetske – represent a demographic climax stage (Dębiec & Saile, 2015; Diachenko, 2012, 2016; Dreibrodt et al., 2020; Müller et al., 2016a; Ohlrau, 2020b). Besides their planned concentric layouts (e.g. Hofmann & Shatilo, 2022; Hofmann et al., in press), these settlements were characterised by a high-quality material culture (e.g. Korvin-Piotrovskiy & Ovchinnikov, 2020; Korvin-Piotrovskiy et al., 2016; Rud et al., 2019; Shatilo & Hofmann, 2021; Ţerna et al., 2019b) and a large number of technological innovations (Shatilo, 2017, 2021, pp. 225–231). A hierarchical system of integrative multi-functional assembly houses revealed the existence of socio-political forms of organisation within these settlements (Hofmann et al., 2019, n.d.; Müller et al., 2016b). Economically, these giant settlements were based on integrated agriculture with cereal cultivation and animal husbandry centred on cattle (Benecke et al., in press; Dal Corso et al., 2018; Kirleis & Dal Corso, 2016; Kruts et al., 2001; Pashkevich & Videiko, 2006; Zhuravlov, 2004). Isotopic studies indicate dual livestock management strategies with intensive and extensive components, and an increasing opening of the landscape (Makarewicz et al., 2022). Despite the enormous size of local communities, it remains questionable whether or not the carrying capacity of the landscape was ever reached (Dal Corso et al., 2019; Ohlrau et al., 2016). However, given the scarcity of palaeoenvironmental archives, we still have limited knowledge about the supply of key resources, e.g. water accessibility. The abandonment of the mega-sites led to a dispersal into smaller settlements (Hofmann & Shatilo, 2022; Shatilo, 2021). In the Maidanetske region, the Chalcolitihc settlement density was not exceeded again until Roman Times (Dreibrodt et al., 2020).

Trypillia mega-sites like Maidanetske had a strong influence on the local and surrounding vegetation due to their high demand on natural resources concerning areas for the settlement, pastures and arable land, as well as fire wood. The high daily demand for firewood, especially, might have played a crucial role in human-induced landform transformations with far reaching influence on the sensitive forest-steppe environment.

As seen by original forest soils below the houses of Maidanetske (Dreibrodt et al., 2022), a formerly wooded site was transformed into an open settlement area with a ruderal vegetation. High numbers of phosphatic mineralised seeds of, for instance, white goosefoot (*Chenopodium album*) point to nitrogen rich locations with a thriving vegetation of accordingly herbal weeds (Dal Corso et al., 2019). As the seeds are phosphatised, they might have been consumed by domestic animals browsing in the settlement or nearby and mineralised in the phosphate rich droppings (Schlütz & Bittmann, 2015). Domestic animals like cattle, sheep/goat and pig were the main source of meat, while remains of wild animals are infrequent (Dal Corso et al., 2019). As the main browsing ground, we can expect natural open and anthropogenically thinned-out forests, including, here as at other Trypillia sites, elements of feather grass steppe, as well as intensive pastures for dung management (Dal Corso et al., 2019; Makarewicz et al., 2022; Ţerna et al., 2019b; Schlütz et al., 2023).

Emmer was the dominant cereal on arable land, followed by Einkorn and Barley. Beside those cereals, pea played an very important role in the subsidence of the Maidanetske people (Schlütz et al., 2023). How intensely cultivation took place in Neolithic times is still under debate (Baum et al., 2016; Jacomet et al., 2016) and needs further investigation, especially for Trypillia sites. Weeds like cleaver (*Galium aparine*), brome (*Bromus* cf. *secalinus*), common knotweed (*Polygonum aviculare*), black nightshade (*Solanum nigrum*), black henbane (*Hyoscyamus niger*) and others point to nutrient-rich cultivated soils. Nevertheless, the found diaspores may at least partly originate from the ruderal vegetation of the settlement as well. Bitter vetch (*Vicia ervilla*), known from the earlier Trypillia phases, is seemingly replaced in Maidanetske by pea; climatic or anthropogenic explanations for this are still unknown (Dal Corso et al., 2019).

The archaeobotanical charcoal spectra in Maidanetske are dominated in the beginning by ash (*Fraxinus*). With the occupational peak in Maidanetske, finds of deciduous oak (*Quercus*) and elm (*Ulmus*) become more frequent and increase even further in the last occupation phase under a reduced number of inhabitants. Presumably the tree stock in ash was too low to meet the wood requirements of some 10,000 people and was too depleted to recover afterwards. It seems that the inhabitants needed to explore new sites, for instance in the flood plain (elm) and on the plateau (oak), to cover their wood demands (Dal Corso et al., 2019). In addition, the required wood qualities were possibly altered by, for instance, changes in operating pottery kilns (Ţerna et al., 2019a).

While the diameters of the wood used as fuel are mostly unknown, that of construction wood is preserved as imprints in daub. The used log wood was mostly 5–10 cm in diameter, split wood below 15 cm. To obtain enough construction wood in these small diameters, we may have to think about some kind of forest management, including coppiced trees of, in particular, ash with stump shootings (Out et al., 2013). Despite the intense use of wood leading to a transformation in forest structure and species composition, it seems most likely that the residents of Maidanetske managed the forest sustainably to a certain degree and did not experience a significant shortage of wood (Dal Corso et al., 2019). More uncertain is when and whereby deforested areas like the settlement site itself were kept open to allow the demonstrated Chernozem development that buried the archaeological remains. A shift to a drier climate could be one conceivable scenario.

The mineral assemblage of the Chernozem at Maidanetske, and the regional soil stratigraphy, provided no indication of aeolian burial of the site (Dreibrodt et al., 2022). Instead, the excretion (casting) activity of anecic earthworms is found to provide the best explanation for burial of the archaeological record and thus Chernozem growth. Anecic earthworms are an ecological group of earthworms (e.g. *Lumbricus terrestris, Aporrectodea longa*) that dig deep vertical burrows (c. 1–2 m, Fig. 7.8 I). To clean the burrows of material that falls in, they ingest these mineral particles, digest it together with their nutrition (fresh dead biomass aboveground) and excrete it all together at the soil surface around the entrance of their burrows. This process adds mineral material enriched in organic matter to the soil surface at rates of 0.36–6.1 $mm*a^{-1}$ (Paton et al., 1995; data from European sites in $t*ha^{-1}*a^{-1}$ converted into $mm*a^{-1}$ assuming a bulk density of c. 1.5 $t*m^{-3}$). Growth rates of Chernozems, inferred from radiocarbon ages of the soil organic matter, vary between 0.09 and 0.35 $mm*a^{-1}$ (Dreibrodt et al., 2022, 2023; Lisetskii et al., 2013; Scharpenseel et al., 1986). The difference between observed earthworm casting rates and long-term Chernozem growth might be explained by compaction of the loose earthworm aggregates when they become part of the soil matrix by burial, as well as secondary root growth or trampling. Thus, the casting process of anecic earthworms, as originally already proposed by Darwin (1840, 1881), explains the formation of Chernozem soils, including the archaeologically 'sterile' humus-rich layer above Chalcolithic finds.

To identify the triggering processes leading to the onset of earthworm surface casting, we used clues about landscape dynamics induced by the inhabitants of the Chalcolithic mega-site Maidanetske. Approximately 10,000 people lived contemporaneously during a settlement phase lasting c. 350 years. Their demands (nutrition, wood) will have resulted in a remarkable change of the surrounding landscape. Cutting of trees, cattle breeding and the establishment of arable fields were among their main subsistence strategies to fit with their demands. This transformed the formerly partial forest into an increasingly open landscape. This landscape transformation promoted anecic earthworms and the start of Chernozem formation (Fig. 7.8). The observed occurrence of earthworms in general increases in the following order: 1. modern agricultural fields (heavy machinery, chemicals), 2. deciduous forests, 3. grasslands, 4. orchards/pastures (Edwards & Bohlen,

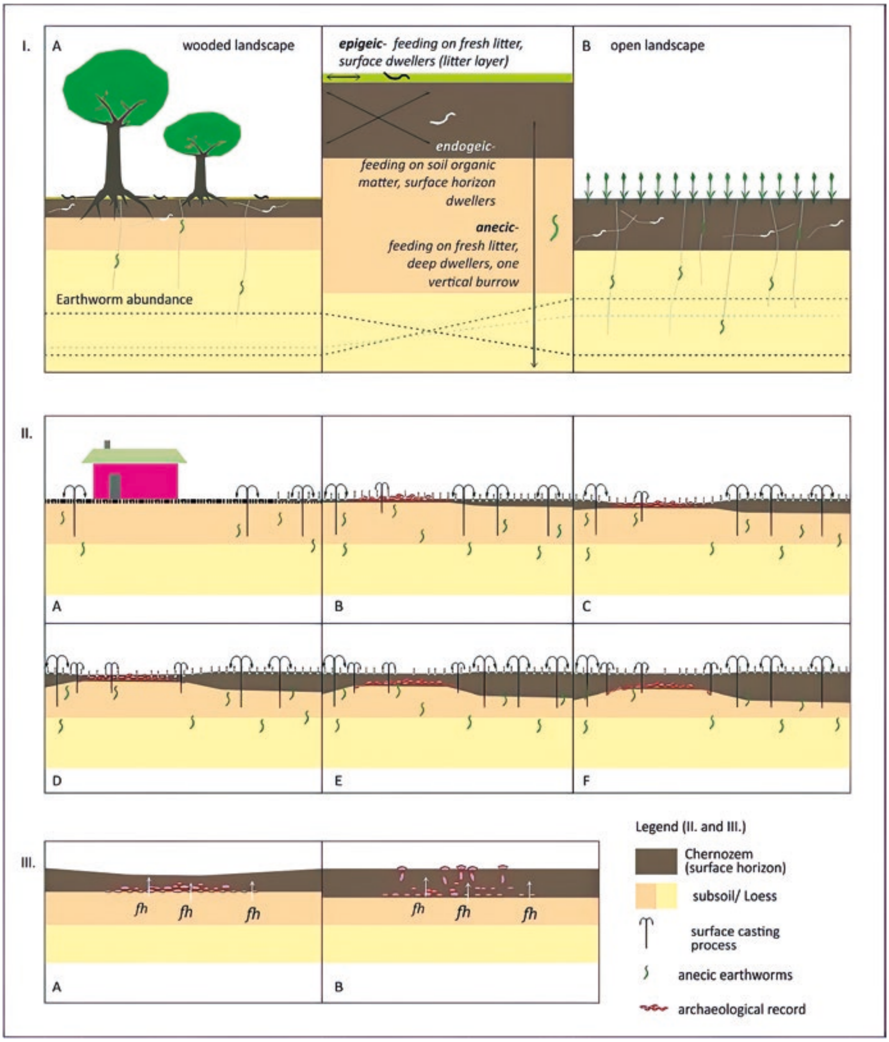

Fig. 7.8 Formation of Chernozems and agricultural soils by surface subsidence due to anecic earthworms, I. Three different ecological groups of earthworms, their environments and movement patterns; II. Burial of an archaeological context by anecic earthworm surface cast, A to F development stages of surface dropping process (Chernozem formation) over time, note that sites with archaeological artefacts are sinking in slower rates compared to areas free of archaeological remains, in particular at the centers; III. Frost heave (fh) of artefacts

1996; Evans, 1948; Knollenberg et al., 1985; Satchell, 1967, 1983). This suggests that pre-industrial agriculture, in general, benefitted from a fostering effect by earthworms, in particular in pastures where dung is present (Satchell, 1967). Grassland-like and garden-like landscapes provide the worms with more food during the entire vegetation period, compared to deciduous forest with only one phase of annual litter fall. The creation of open landscapes ('agricultural steppe') particularly explains the facilitation of anecic earthworms. The soil microclimate is a critical factor affecting living conditions of earthworms in general. They cannot bear high summer temperatures and related low soil water contents (e.g. Bouché, 1971, 1977). As the temperature amplitudes become more pronounced in an open landscape, compared to a woodland, anecic earthworms are favoured at the expense of epigeic or endogeic earthworms. In contrast to the near-surface-dwelling epigeic and endogeic species, anecic earthworms can escape disadvantageous seasonal topsoil conditions by digging deeper into the ground (Fig. 7.8 I.). Accordingly, global surveys prove a predominance of anecic species in open landscapes (Phillips et al., 2019). If anecic earthworms are provided with a proper environment over a critical time-period, they will prosper and start to excrete layers of surface casts. Despite being a time-consuming process, decade by decade this places some millimetres of organic-mineral-soil on top of the surface. After millennia, archaeological layers become buried and a thick Chernozem has formed via an anecic surface casting process (Fig. 7.8 II. A-F).

At the Chalcolithic mega-site settlement of Maidanetske, the archaeological features (daub layers) are covered by a thinner Chernozem than areas without archaeological remains. The edges of the daub layer ('ploshadka') features are sunken deeper than the centre (Fig. 7.8 II. F). These observations reflect the limited penetration of the ploshadkas by the anecic earthworms (e.g. C. A. Edwards & Lofty, 1977). Processes of surface sinking (subsidence, compaction of abandoned burrows) compensate the addition to the soil surface. The net process is rather a cycle, and the archaeological remains are 'sinking' rather than being buried by a covering (Dreibrodt et al., 2022). An additional process is frost heave (e.g. Washburn, 1979), which raises larger particles and artefacts in respect to the fine soil matrix. This places once-buried artefacts on the soil surface. As long as the effect of frost heave exceeds the surface subsidence rates, artefacts accumulate at the soil surface and can become objects of archaeological field surveys.

While the observations from central Ukraine refer to the Chalcolithic cultural period and the ecotone between steppe and forest steppe in Eastern Europe, we claim that the observed processes can be analogously transferred to other European landscapes and prehistoric periods of deforestation. The promoting effects of pre-industrial agricultural land use on anecic earthworms explains the occurrence of Chernozems of differing ages in sub-humid to humid regions along with the Neolithic colonisation from southeast to central Europe (Dreibrodt et al., 2022). Longer-lasting openings of landscapes in central Europe resulted in the formation of Holocene Chernozem, while openings which were too short in duration did not. This explains the occurrence of Holocene Chernozems of varying age in central Europe (e.g. Eckmeier et al., 2007) but their absence at short-lived Linear Pottery sites (e.g. Lorz & Saile, 2011). Some relict early Holocene Chernozems and anecic earthworms in wooded areas were already present at the onset of the outlined prehistoric landscape transformation. The spread of Chernozem over large parts of humid central Europe is a result of the dramatic change of soil and landscape ecology due to the fostering effects of prehistoric agriculture. The discovery of this long-term human-environmental interaction inspired us to add earthworms to the Neolithic package (Dreibrodt et al., 2022).

At varying intervals of the Holocene, prehistoric and early historic farmers settled in European loess landscapes, used them and changed their carrying capacity by unintentionally fostering the formation of Chernozems. The pan-European record of temperate humid Chernozems points to a clear predominance of land-use triggered landscape transformation over any influences of climate variability or vegetation succession. Considering the pace of the outlined process, it is improbable that it was recognised by prehistoric farmers. The landscape transformation resulted in a change of available resources. That is, in particular, the case with timber supply, which led to the implementation of adaption strategies related to woodland management (e.g. need for fuel, architecture). Our results imply that the creation of Holocene Chernozems reflects a long-term, continent-scale, landscape transformation.

7.7 Conclusion and Discussion

In this chapter, we have seen different examples how human agency has contributed to or caused transformations of landscapes towards a more and more cultural landscape. Of course, there is no boundary between a natural and a cultural landscape, as any landscape that is used and perceived by humans is a cultural landscape. The anthropogenic intervention in ecological cycles creates a cultural landscape, even if these interventions are short term and small. The presence of other people will also have been obvious for hunter gatherers, as humans leave typical traces like hearths or manipulated plants and landmarks. These traces in the landscape will have influenced the perception of the landscape by its residents and roaming people. The need for exploitation of natural resources makes it highly probable that in the Palaeolithic, and even more so in the Mesolithic, humans manipulated their environment for optimal availability, as shown in the examples. Interventions in natural competition to support, for instance, hazel yields or prey, will have been intentional, as a consequence of intense observation of nature. With respect to the DPSIR concept, the driver would be the optimal nutrition for a preferably growing population. This generates pressure that influences the state of resource availability (hazelnut harvest) and causes impact on the environment (influencing the competitional conditions), which responses in a negative (over exploitation or shading) or positive (enhanced yields) way, which itself further influence the drivers, pressure, state and impact in a feedback loop.

In the Neolithic, the interventions in the environment for the production of food and the exploitation of raw materials like timber, wood or bast, are much more obvious and traceable in palaeoecological records. The Neolithic way of life does not just require settlement areas and fields but also communication pathways, and the forest remains an important source of resources – with all the traces these exploitations effect. The erection of causewayed enclosures and megaliths is one more element that makes the landscape cultural. The 'clearing up' transforms the traces of the glaciation into man-made monuments that structure the environment. Humans create places of remembrance and instrumentalise landscape for the creation of identity. This may have been the case also in the Palaeolithic and Mesolithic but it becomes obvious in the Neolithic. With respect to the DPSIR concept, the economic developments, in the form of arable farming and animal husbandry, exert pressure on the environment with woodland opening and transformation of suitable areas into settlements, cemeteries and fields. As a consequence, the state of the environment changes, with fewer resources for hunting and gathering but many more resources for a producing way of life, enabling population growth. This leads to impacts on human living conditions and ecosystems. The effect will have been a societal response that fed back into the driving forces, or on the state or impacts directly, through adaptation or curative action. The system seems to have been stable for a few centuries, which might have influenced the vulnerability. Abandonment of settlements and fields, as well as settlement agglomeration, around 3200 cal. BCE indicate a transformation after several generations of relative stability. Given the duration of this transformation, during the Neolithisation process the awareness of humans about human-induced changes and deteriorations will have played no role.

This will also have been the case in the development of anthropogenic heathlands, which lasted several centuries. To draw a conclusion based on the observed changes requires an awareness and understanding of causes and effects. An adaptation to the changing cultural landscape was inevitable, as the resource availability was strongly connected to the form of land use. In Medieval times, extensive animal husbandry and the concentration of arable farming on small manured locations were the best adopted strategy.

Even though the development of heathland as a wide and treeless landscape can be compared with the establishment of steppe in south-east Europe, here we see a different effect. Due to the more favourable ecological conditions for earthworms, the soil is not depleted but becomes a very productive source of economic wealth. Arable faming with high yields must have been the basis for the population agglomerations which made new forms of social institutions necessary.

In our examples we see different forms of human agency. Most often this intentional behaviour has had consequences that were unintended, but these are not always negative. The ability of humans to adopt to changing conditions has ensured our survival up to the present – even though the history of humanity often was a history of failures, wars and setbacks.

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Chapter 8
Depicting Trypillia: Emergence and Transformation of the Realistic Style

Liudmyla Shatilo and Robert Hofmann

8.1 Introduction

In the course of prehistory and history, one can observe numerous ‘episodes’, limited in space and time, in which attempts were made to enhance the ‘transmission of reality’ through artistic means. During these phases, among other things, the number of objects with ‘realistic’ details or characteristics increases, the means of artistic expression (objects, types, techniques, etc.) become more diverse; an increased realism in the depiction of objects/subjects can be observed; that is, more attention was paid to the accurate presentation of details. Additionally, the size of some objects, for example sculptures, increases. In contrast to these phases, we can observe other periods when artistic representations become more schematised and the number of forms of the images decreases.

The stylistic development of objects from Neo-Chalcolithic settlements in South-Eastern and Eastern Europe falls within this observation, particularly in Trypillia, where a number of artefacts depict people and surrounding objects or their individual elements in a realistic manner, such as anthropomorphic figures, as well as sledge and house models. At least some of these images/representations have limited temporal and spatial boundaries. In order to better understand the context of the emergence of ‘realistic’ images, the dynamics of their development, the circumstances of their disappearance, their connection to transformation processes,

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and other issues, we identify and analyse different categories of such representations originating from prehistoric settlements dating back to 4700–3100 BCE from the territories of modern Ukraine and Moldova, which are united under the name ‘Trypillia’.[1] To discuss possible interpretations of the phenomenon, similar images in other socio-cultural contexts have also been considered, as this stylistic development can be an important indicator reflecting the specifics of transformations in ancient communities.

First, the topic of realistic/naturalistic style in Trypillian studies was raised in connection with the study of ‘realistic’ figurines, which were part of a much larger array of anthropomorphic representations, mostly ‘schematic’ ones, conveying the human image in general terms. The research on this category of finds is associated with the name of T. G. Movsha (1973), who believed that realistic and schematic-realistic sculptures were endowed with personality traits, as they have thoroughly modelled faces, hairstyles, arms, torsos, and legs. In contrast, N. B. Burdo (2010) included only figurines with detailed modelled heads in this category of figurines, stressing that it would be more correct to call this category ‘*anthropomorphic plastics with realistic details*’ (our translation: Burdo, 2010, pp. 124–125). The topic of depicting real/constructive elements on ceramic objects has also been considered in the context of house and sledge models (e.g. Balabina, 2004; Passek, 1938; Shatilo, 2016). In one of the most recent works on this topic, I. V. Palaguta and E. G. Starkova (2017, pp. 68–77), analysing a house model from Popudnia, concluded that not only the interior but also the characters of the model are shown in a ‘naturalistic way’.

In line with some other authors, we refer to the phenomenon of depicting objects with fine attention to detail as ‘realism’ (e.g. Burdo, 2013; Buzian & Bilousko, 2009; Gusev, 2009; Movsha, 1973; Pogoševa, 1985) or also ‘naturalism’[2] as a synonymous term (e.g. Balabina, 2004; Bibikov, 1953; Majewski, 1947; Palaguta & Starkova, 2017), although we are well aware of the complexity and ambiguity of these terms. The concept of realism in art is particularly complex.

8.2 The Concept of ‘Realism’

In a general sense, the term *realism* refers to a specific relationship of art to reality, for example by depicting ordinary objects or everyday life situations, and by attempting to provide a truthful, non-idealised representation of the oobject which is free of speculative fiction and supernatural elements (Alscher et al., 1977, pp. 55–60). Of course, there are specific ‘realisms’ in certain epochs and regions. Here are just some of them: Archaic and classical Greek art with large sculptures

[1] Trypillia cultural complex including Usatovo sites (after e.g. Diachenko & Harper, 2016).

[2] When we use the term ‘realism’ or ‘realistic’ style in relation to certain artistic depictions in prehistory and Trypillia in particular, we mean (1) images that reproduce real objects or scenes; (2) objects that depict realistic details; and (3) artefacts with a certain quality of depiction of plastic corporeality.

(e.g. Boardman, 1978; Bol, 2002), Flemish painting of the fifteenth century with its 'disguised' symbolism (Panofsky, 1953), the Italian Renaissance with perspectives (the illusion of reflecting reality: e.g. Gombrich, 2001), or the realist art of the nineteenth and twentieth centuries, which was decidedly political and educational (e.g. Nochlin, 1971). The latter realism is linked to the 'social question' and the critique of capitalism as a system, and consists of realistic depictions of everyday life and 'unadorned' representations of social conditions.

In contrast, we can trace periods in the history of art when the 'representation of reality' was less prevalent and the variety of artistic products was reduced; they became more schematic, and the emphasis was more on the 'decorative', which can of course have also ideological reasons, such as a general 'hostility' to images (e.g. Mellink & Filip, 1974). In prehistory, this applies to, for example, the Bronze Age of some regions, which, compared to the previous period, lacks a wide range of diverse images (e.g. Fokkens & Harding, 2013; Kneisel, 2012; Kossack, 1954). In historical times, similar trends can be observed, for example, in late antiquity and the following centuries.

For each of these periods, as well as others, there were specific links between the political, social or religious intentions of producers and the social perception and interpretation of the artworks. These connections are the subject of attempts to interpret artworks iconologically in the sense of E. Panofsky (1939) or socio-historically from the point of view of M. Baxandall (1972). While considering these phenomena, it is also important to (1) spatially delineate the centres of innovative artistic production, and (2) keep in mind the context of the production of objects and images and their recipients.

In order to understand whether it is possible to trace a similar connection between the 'realistic' style and social processes in Trypillia, we will turn to the consideration of Trypillia artefacts with more 'naturalistic' details.

8.3 Sources

Ceramic *house models,* depicting the exterior or interior of a building or a part of it, can be considered as objects with certain manifestations of 'realism'. Many objects of this type show the building or its separate parts in general (walls, roof, entrance). This is especially true of some objects from Neolithic settlements in Macedonia and some of the North Bulgarian models (e.g. Trenner, 2010, pp. 136–145, 154–155, 159). In contrast to these finds, a number of Trypillia models depict buildings in more detail. These artefacts are traditionally divided into 'closed' models with a roof – type 'A' – and 'open' models without a roof – type 'B' (Gusev, 1996, p. 18). Structurally, the models consist of the floor, walls, roof (type A), entrance, and often a round 'window' in the wall opposite the entrance (a small opening under the roof, possibly for ventilation). In addition to these parts, which reflect the 'general idea' of the building, in a number of models there are additional 'realistic' elements. They include: the division of the model into two parts (the 'entrance hall' and the main room), details of wall construction (pillars), details of roof construction in type A (a canopy over the 'entrance hall', beams, zoomorphic elements of the roof decor, etc.), and the interior of buildings in type B. The reflection of real parts of houses in these elements has been repeatedly discussed in literature (e.g. Palaguta & Starkova, 2017; Passek, 1938; Shatilo, 2016). Thus, a number of more 'realistic' elements can be distinguished among the models.

Several special studies have been devoted to models of houses, including the catalogues of finds (Gusev, 1996; Shatilo, 2005; Yakubenko, 1999). In total, 74 models are known so far, but a critical analysis of the finds has shown that some artefacts (e.g. fragments of 'legs') interpreted as 'house models' do not have distinctive building features (21 in total, see Shatilo, 2021). Therefore, the total number of known Trypillian models can be reduced to 53, of which at least 24[3] have additional 'realistic' features.

The next category is ceramic *sledge models*. Structurally, they consist of at least two parts – a 'body' made in the form of a round/oval bowl or a rectangular vessel, fixed on two runners. The third optional part of the artefact is single or double zoomorphic application(s) on the front part of the 'body'. The existence of elements of real sledges – above all runners, which are curved up in the front and protrude in the back – is a basic criterion for distinguishing this type of finds.[4] In addition to the runners, there are other, rather rare images of constructive elements on the 'bodies' of the models (graphic and three-dimensional) – *stanchion* or *sledge posts* and *side rails* or *stringers,* and some models have an image of a *harness* on the zoomorphic applications (Balabina, 2004; Kruts et al., 2013, p. 82; Shatilo, 2017).

Several works have been devoted to sledge models (e.g. Balabina, 2004; Burdo, 2003; Shatilo, 2017). This category of artefacts is often used in the study of prehistoric means of transport (Gusev, 1998). One of the most recent works is a study by N. Chub (2018) on the invention of the wheel. In total, at least 123 models are known (Shatilo, 2021), a significant number of which are represented by fragments.

The following categories of 'realistic' details are represented on some of the clay anthropomorphic figurines. *Anthropomorphic statuettes* is a widespread category in the inventory of the Cucuteni-Trypillia complex: as of 2017 about 9222 figurines are known (Ţerna, 2017, pp. 223–224). From this array of material, S. Ţerna used 5979 figurines for his research, 3289 of which belong to the 'Trypillian' part of the cultural complex (Ţerna, 2017, pp. 225–230). A large series of Cucuteni-Trypillian anthropomorphic figurines are presented in a number of publications (e.g. Burdo, 2014; Monah, 2016; Pogoševa, 1983, 1985; Ţerna & Vasilache, 2019).

Among these finds, the researchers distinguish between figures made in a realistic or naturalistic style – with detailed modelled heads, arms, torsos, legs and other elements (for a history of the question, see Burdo, 2013) – and the general array of 'schematic' figures; only the 'realistic' and 'schematic-realistic' ones were described

[3] Accurate estimates are complicated due to the fragmentation of the finds.

[4] A number of artefacts that do not have this characteristic but have been interpreted as 'sledge models' are not considered in this chapter (e.g. Kruts et al., 2001, p. 60: Figures 54.4, 54.6; Kruts et al., 2005, p. 40: 16.3).

at the level of individual objects. N. B. Burdo compiled a catalogue of such terracottas (109 artefacts in total: Burdo, 2013, pp. 119–346), in which she included Cucuteni-Trypillian anthropomorphic plastic with detailed modelled heads ('*figurines, sculptural details in the vessels decoration, ceramic ladles, and pottery made in the form of a sculpture that realistically reproduces the human face*', our translation: Burdo, 2013, pp. 22).

This chapter considers the following categories of 'realistic' elements or details on anthropomorphic figurines: detailed modelled heads, depictions of hairstyles and hair accessories, headgears, jewellery, various clothing and footwear details.[5] Each of these elements (for example, jewellery or hip belts) is considered in the chapter regardless of whether the figurines bearing such depictions are classified as 'realistic', 'conventionally realistic' or 'schematic',[6] as each of them obviously conveys real details. In addition, sometimes several of these details can be represented on a single find (for example, a necklace and a detailed modelled face), sometimes only one of these elements can be found on a single figurine. Despite the fragmentation of the material, there are some whole unfragmented or almost undamaged figurines where only one or two elements are 'realistically' shown (e.g. Pogoševa, 1985, Figs. 106a, 760, 795). That is why it seems appropriate to consider each category of realistic details depicted on anthropomorphic figurines *separately*. The main sources for the calculation and further analysis of these categories have been the catalogues by A. P. Pogoševa (1985, pp. 134–242) and N. B. Burdo (2013, pp. 224–345), as well as other publications (Burdo, 2001, pp. 98–143; Burdo, 2010, pp. 129–136; Burdo, 2011, Figs. 1–3; Burdo, 2015, pp. 29–31; Buzian & Bilousko, 2009, p. 335; Buzian & Yakubenko, 1998, p. 60; Gusev, 2009, pp. 310–322; Kandyba, 1937, pp. 150–152; Korvin-Piotrovsky & Menotti, 2008, pp. 71–130; Kruts, 1977, pp. 57–58, 60; Kruts et al., 1985, Fig. 40; Kruts et al., 2001, pp. 57–61; Kruts et al., 2005, pp. 7–93; Kruts et al., 2008, pp. 49–50; Kruts et al., 2009, pp. 42–44, 47, 49; Kruts et al., 2011, pp. 37–59; Kruts et al., 2013, pp. 60, 83; Markevich, 1981, Figs. 12, 63, 74, 85; Monah, 2016, pp. 156–423; Ovchinnikov, 2014, pp. 341–352, 356, 381; Passek, 1949, pp. 6, 93–94; Shmagliy, 2000, pp. 20, 23; Starkova, 2020, Fig. 1).

The 'realistic' heads of anthropomorphic figurines contrast strongly with the 'schematic' ones, which depict the head very schematically in the form of a small disc with a protrusion for the nose. N. B. Burdo divides figurines with thoroughly modelled head details – nose, eyes, lips, ears, etc., which are shown in plastic – into '*realistic'* (with a relief head: chin, back of the head) and '*partly realisti*c' (with a head in the form of a disc and only some more naturalistic elements: Burdo, 2010, 2013). In total, there are 76 figurines with such 'naturalistic' heads.[7]

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[5] In the future, for completeness of the study, realistically depicted parts of the body (e.g. torso, arms, legs) should also be taken into account.

[6] The traditional division of plastics into these categories is not used, instead each element described below is considered *independently* as a manifestation of 'realism'.

[7] Figurines without information about the settlement from which they originate are not included in the list.

The depictions of hairstyles and *hair accessories* on anthropomorphic figurines show/depict the ways of styling hair. They can be moulded, sometimes with drawn lines showing the hair, and painted. A fairly standard hairstyle is represented on a number of anthropomorphic figurines, which depict long hair pulled together at the back below the level of the shoulders. This method of hair fixation requires a special object to hold the hair. Many figurines depict various accessories apart from the hair, or ways of fixing the hairstyle with special objects that hold the hair in the same way (e.g. Burdo, 2015, p. 31, Figs. 2.7, 2.8, 2.10; Kruts, 1977, pp. 58, 60, Fig. 23.1; Monah, 2016, p. 273, Figs. 118.3, 118.322, 167.4, 167.337; Ovchinnikov, 2014, p. 346, Fig. 113.1; Passek, 1949, p. 6, Table 93, Fig. 48; Pogoševa, 1985, Figs. 652, 706a; Starkova, 2020, p. 97, Fig. 1.19). At the Cucuteni site Traian-Dealul Fântânilor, a bone object was found that may have been used for pinning hair (Mantu et al., 1997, p. 227). The lower part of the hair, up to the point where it is put (pulled) together, can be depicted in the form of letters 'U' and 'V'. The accessory and/or hair at the lowest part of the hairstyle may be in the form of a circle or of two triangles with their peaks connected. Some figurines with long hair do not have such an element that could represent a special accessory for forming the hairstyle, in that case the hair has the outline of the letter 'U' in the lower part (e.g. Passek, 1949, p. 94, Fig. 49.4c; Pogoševa, 1985, Figs. 746, 760; Ovchinnikov, 2014, p. 341, Fig. 108.2). At least 38 figurines with such a hairstyle are known.

A separate group is represented by *images of headgears* on figurines, which are shown quite naturalistically and are similar to each other. Unlike hairstyles, 'hats' are found exclusively on figurines with 'realistically' modelled heads and are sculpted, sometimes painted (Burdo, 2010, pp. 195–198). The known headgear are small caps that cover only the back and the top of the head. In seven cases, they are high, i.e. ending above the level of the head (e.g. Movsha, 1973, Figs. 5.2, 6; Pogoševa, 1985, Fig. 937), in two cases – on the figures from Krutukha-Zholob and Kostesht IV – such a 'cap' is low and resembles a small skullcap or tubeteika (Buzian & Yakubenko, 1998, Fig. 3.1; Markevich, 1985, Fig. 74.9). Two figurines have headdresses with 'horns' (from the site Brynzeni IX: Markevich, 1985, Fig. 110; and maybe from the site Hrymiachka: Buzian & Bilousko, 2009, Fig. 3.1). Among the figurines with high hats, two have a rounded hole in the upper part (from the sites Brynzeni III and Pavoloch: Markevich, 1981, Fig. 63; Pogoševa, 1985; Fig. 1012). This small group includes 10 representations.

Jewellery on anthropomorphic figurines is represented by necklaces. A. P. Pogoševa (1985, p. 130) has identified nine types of necklace depictions, which can engraved or painted. Among the identified types, one depicts a decoration (or other element) on the back. The most common type is a single line drawn around the neck. Other types of decorations are represented by rows of dots, parallel strokes and other types of images. In this study, at least 94 figurines with necklaces have been recorded.

The most prelavent category of 'realistic' images on anthropomorphic figurines is the representation of *clothing, clothing details* and *footwear.* A. P. Pogoševa illustrated variations in each type of representation of (1) *lines on the neck – upper chest* (hereinafter *neckline)*, (2) *shoulder belts*, (3) *hip belts*, (4) *loincloths* and (5) *shoes,* which could engraved or painted (Pogoševa, 1985, pp. 131–133). Apart from the necklines and partially the loincloths, all the other details of the outfit listed above usually encircle the body of the figures. The quantitative distribution of these representations in this study is as follows: 99 hip belts, 61 necklines, 28 loincloths, 18 shoulder belts, 11 shoes; in total 217 realistic details depicted on at least 165 anthropomorphic figurines.

The last category of objects with realistic details is *images on zoomorphic artefacts.* This category is the least numerous and is represented by representations of various elements of animal use equipment (e.g. for pulling by the traction method) or for other purposes (e.g. 'clothing' and/or decorations(?) for cattle), which can be interpreted as images of *headbands, collars, headrests, shabracks/blankets*, *straps* (for harnesses, fixing shabracks, or cargo attached to the animal's back), *halters*, *bridles, harnesses*, and *belts*. In other words, this category includes images on zoomorphic artefacts that may show a variety of *special equipment* used by ancient population to facilitate the use of animals (for pack or draft transportation) or for other purposes (e.g. 'clothing' or decoration). Such details are found on zoomorphic figurines, zoomorphic applications from sledge models and vessels, zoomorphic pottery, and on rattles (Balabina, 1998, pp. 84–86, 94, 98; Balabina, 2004, Figs. 5, 11.3, 11.4, 11.6; Gusev, 1998, pp. 16–17; Kravets, 1951, pp. 128–130; Kruts et al., 2013, pp. 78–82; Kruts et al., 2008, p. 124; Ohlrau, 2020, Plate 62.7; Patakova, 1979, Fig. 14.19). In total, there are 19 objects showing such equipment, which are made mainly using the painted technique (a few are engraved).

8.4 Analysis

For the analysis of the selected categories of finds, lists were compiled, which included 53 house models, 123 sledge models, 435 'realistic' images on anthropomorphic figurines (each type separately – 'realistic' heads, images of hairstyles and hair accessories, headgear, jewellery, hip belts, shoulder belts, necklines, loincloths, shoes) and 19 images of special equipment on zoomorphic artefacts; in total 630 images originating from 521 artefacts.

Each settlement where realistic artefacts were found and included in the study was dated according to the available absolute dates (mainly after Chapman et al., 2018; Diachenko & Harper, 2016; Harper, 2013; Millard, 2020; Müller et al., 2016b, 2017; Ohlrau, 2020; Rassamakin, 2012; Rud et al., 2019; Shatilo, 2021; Ţerna et al., 2019; Tkachuk, 2014; Uhl et al., 2014), and in the absence of ^{14}C dates, based on relative chronological data (mainly after Chernysh, 1982; Dergachev, 1980; Markevich, 1981; Movsha, 1984; Ovchinnikov, 2014; Rizhov, 2007; Tkachuk, 2005b, 2014). As suggested by T. Harper (2013, pp. 28–46), the data from the Kyiv Radiocarbon Laboratory were not considered, as they often show extremely large deviations from the largely consistent dates of other laboratories. In addition, we took into account that the existence of a single settlement could last more than 50–100 years, and ceramic styles, traditionally considered chronologically sequential, could have existed, at least partially, synchronously (see e.g. Shatilo, 2021; Tkachuk, 2014).

When dating some of the settlements of the late C1 period, T. Tkachuk (2014) used the hypothesis of the rapid spread of the *Badrazhy ceramic style* from the Prut region to other territories after 3700–3650 BCE, where the features of this style can be traced at the settlements of the Kosenivka group, and such sites as Krutukhy-Zholob, Konovka, Polyvanyn Yar I, Kolodyazhne, etc.

The Koshylivtsi-Oboz site, from which a significant number of the realistic images originate, was dated from the end of the C1 stage to the beginning of C2 stage because its ceramic complex includes both artefacts typical for the sites of the Final Trypillia (Tkachuk, 2005a, pp. 116–117) and finds that are characteristic for earlier stages of Trypillia (Chernysh, 1982, p. 297: Plate LXXVII: Figs. 1, 29; Kozlowski, 1939, p. 36, Fig. 8; Tkachuk, 2005a, Figs. 21.11, 21.12).[8]

8.4.1 Chronological Assessment of the Material

The chronological analysis was carried out by dividing the number of artefacts of a certain category, according to their dating, into time steps of 100 years. This made it possible to draw up a series of graphs, where the horizontal axis represents the chronological scale, and the vertical axis the number of different object categories. All graphs show certain chronological patterns of distribution and are divided into two groups.

The first group includes house models, depictions of hairstyles, 'realistic' heads, hip and shoulder belts, and necklines on anthropomorphic figurines. The second group includes sledge models, depictions of animal use equipment on zoomorphic objects, as well as headgear and shoes on anthropomorphic figurines.

The images from the first group are quite numerous, all of them are present in small numbers in Early Trypillia, after which they almost completely disappear (Fig. 8.1). Around 4000–3900 BCE, they reappear, but in much larger numbers, which increase over time. The exception is the necklines, which are not recorded up to 4000 BCE, and between 4000 and 3800 BCE are present in small numbers, which rapidly increase in 3800–3700 BCE. Around 3600–3500 BCE a rapid drop in the number of these objects and elements could be observed; though they are still found in very small quantities up to 3300 BCE. At the same time, there are different peaks in the maximum amount of the material: for example, house models and images of hairstyles and 'naturalistic' heads reach their maximum number around 3800–3700 BCE, and images of necklines and hip belts at around 3700–3600 BCE. Shoulder belts have several peaks by these parameters, which is most likely due to the small amount of material available.

8 That is, in Koshilovtsy there are objects that are not typical for C2 complexes such as, for example, the binocular-shaped objects (e.g. Palaguta, 2007, p. 134), or pear-shaped vessels with small straight or gently inward-sloping collars without additional elements on the shoulders (e.g. Dergachev, 1980, pp. 178–202).

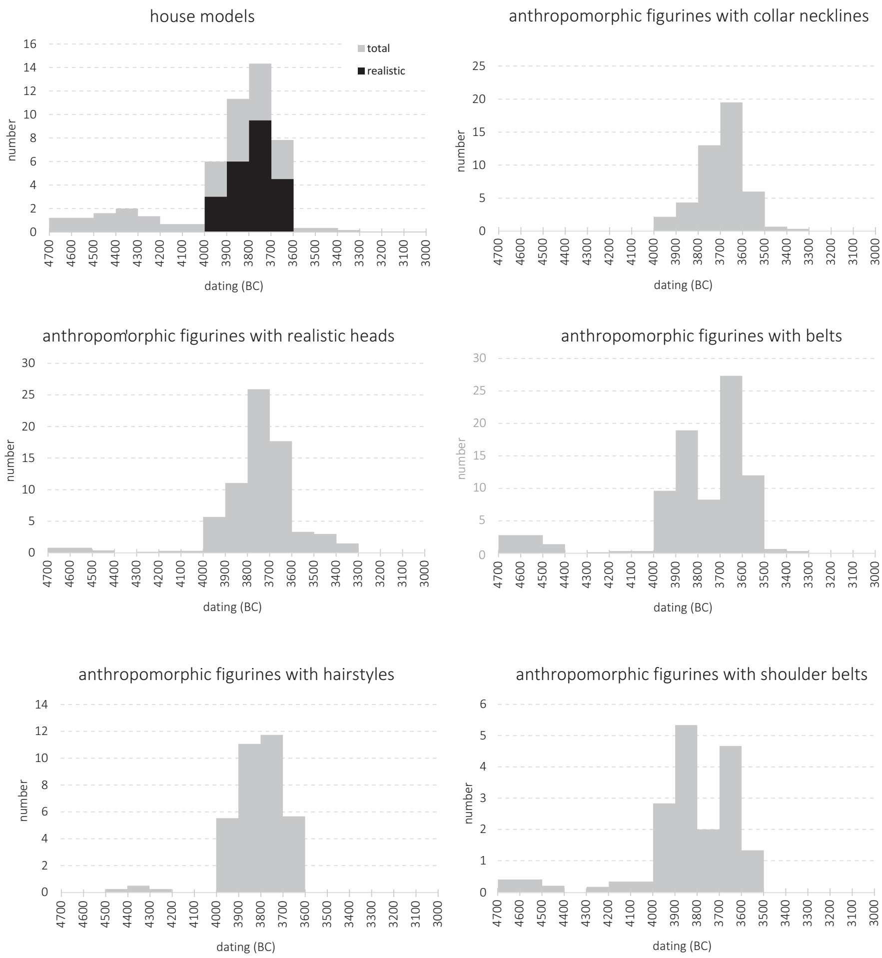


Fig. 8.1 Bar plots showing the chronological distribution of the following realistic objects or elements: house models, anthropomorphic figures with collar necklines, 'realistically modelled' faces of anthropomorphic figures, anthropomorphic figures with belts, anthropomorphic figures with hairstyles and related accessories, anthropomorphic figures with shoulder belts

The artefacts and details from the second group are less numerous, except for sledge models (Fig. 8.2). They are united by the fact that they are all 'new' categories of the material that were hardly found on Trypillian sites before 3800 BCE.[9] Almost immediately after their appearance, these objects and elements reach their

[9] Two or three sledge models are chronologically related to an earlier period, but they are difficult to evaluate due to the lack of images, descriptions, the context in which they were found, and other problems (models from the settlements of Nezvysko, Konovka, and Selyshche, see e.g. Balabina, 2004; Gusev, 1998; Shatilo, 2021).

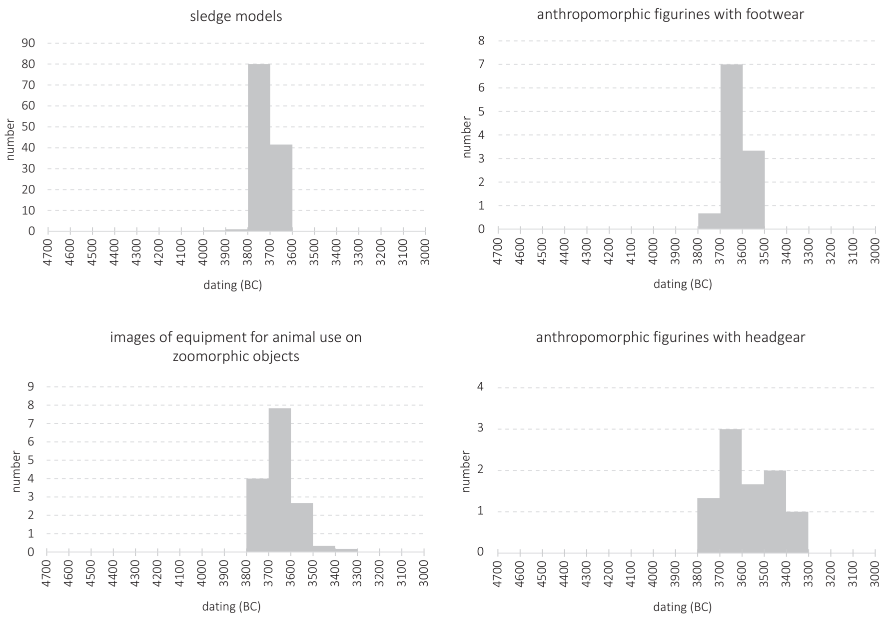


Fig. 8.2 Bar plots showing the chronological distribution of the following realistic objects or elements: sledge models, anthropomorphic figurines with footwear, images of equipment for animal use on the zoomorphic objects, anthropomorphic figurines with headgear

maximum number around 3700–3600 BCE, after which their number gradually decreases. Some of them exist up to 3300 BCE. Unlike the first group, where the growth of the total number of items is gradual and the decline is rapid, the second group shows a completely opposite trend – rapid growth in number, slow decline.

Separate from these groups are images of jewellery and loincloths on anthropomorphic figurines (Fig. 8.3). The first element shows some similarities with the first group: a large number of images of necklaces can be traced starting from 4000–3900 BCE, followed by a gradual increase to a maximum number in 3700–3600 BCE. After that, however, there is a gradual decrease in the number of images, rather than a rapid one, until c. 3300 BCE. A significant proportion of the images of necklaces from this chronological period decorate highly stylised figurines, the lower parts of which are made in the form of a parallelepiped (e.g. from Usatovo, see Patakova, 1979, pp. 36, 38, 77).

As for the second element, loincloths, their distribution does not fit into the identified trends, with the exception of the disappearance of such images after c. 3300 BCE. This may have been influenced by the small sample size, a significant proportion of which is represented by anthropomorphic figurines from the Polyvaniv Yar II settlement layer of the B1–B2 period.

Thus, different categories of 'realistic' representations have both common and different patterns of chronological distribution. In the general graphs, where the minimum number of anthropomorphic figures with (1) clothing elements (Fig. 8.4)

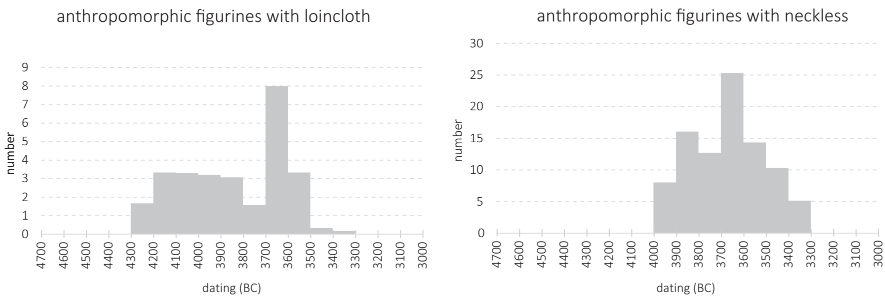


Fig. 8.3 Bar plots showing the chronological distribution of the realistic elements on anthropomorphic figures: loincloths, necklaces

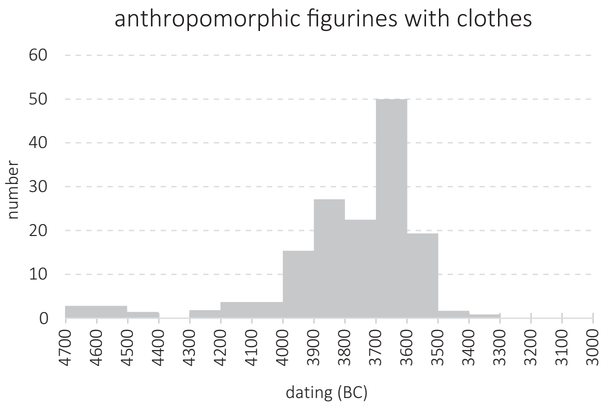


Fig. 8.4 Bar plot showing the chronological distribution of the realistic elements on anthropomorphic figures (total)

and (2) all realistic elements (Fig. 8.5) are counted in total, the trends of small samples of material (e.g. images of shoes or loincloths) are not noticeable. Both graphs show a similar distribution to the first group.

8.4.2 Frequency of Finds

To estimate the frequency of 'realistic' images among the total number of anthropomorphic figurines, let us consider the graph, where the horizontal scale is a chronological scale and the vertical scale is the number of figurines.[10] In general,

[10] After Burdo, 2001, pp. 98–143; Burdo, 2011, Figures 1–3; Burdo, 2013, pp. 224–345; Burdo, 2015, pp. 29–31; Gusev, 2009, pp. 310–322; Kandyba, 1937, pp. 150–152; Korvin-Piotrovsky & Menotti, 2008, pp. 71–130; Kruts, 1977, pp. 57–58, 60; Kruts et al., 2001, pp. 57–61; Kruts et al.,

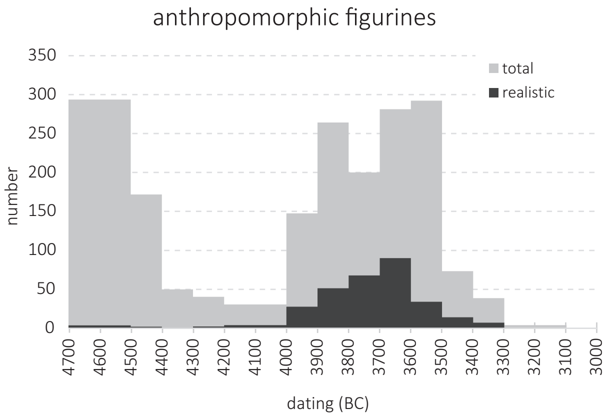


Fig. 8.5 Bar plot displaying the chronological distribution of the studied sample of anthropomorphic figurines and of specimens with realistic features

the sample is distributed over the period under study very unevenly: although the time period between 4700 and 4450 BCE and between 3950 and 3550 BCE is very well represented, the number of finds from 4450 to 3950 BCE is much lower (Fig. 8.5). This uneven distribution is difficult to assess, since the number of settlements included in the consideration for phases B1 and B1–B2 is by no means much smaller than in Trypillia A (sample size: Trypillia A = 14; B1 = 10; B1-B2 = 14; B2 = 31.5; C1 = 38.5 and C2 = 25 settlements). S. Ţerna (2017, p. 223) believes that the density of figurines per 100 m^2 of excavation area does not fundamentally change in different Trypillia periods and averages five finds. Accordingly, the lower number of figurines between 4450 and 3950 BCE may be due to the data sampling, lower research intensity of this phase, or other factors. At the same time, the sampling is geographically quite representative, as it includes settlements from different regions (Fig. 8.6).

In contrast to the total number of figurines, the frequency of figurines with realistic elements can be well estimated (Figs. 8.5 and 8.7): their number is very small during the early stages, but between 3950 and 3550 BCE, a significant increase is noticeable. For realistic figurines, the median value at this stage ranges from 12% to 27%. The peak of their frequency is between 3800 and 3650 BCE, after which their frequency decreases again.

It should be noted that a large number of realistic images on anthropomorphic figurines from the end of C1 and the beginning of C2 come from the settlement of Koshylivtsi, which dominates some categories.

2005, pp. 7–93; Kruts et al., 2008, pp. 49–50; Kruts et al., 2009, pp. 42–44, 47, 49; Kruts et al., 2011, pp. 37–59; Kruts et al., 2013, pp. 60, 83; Markevich, 1981, Figures 12, 63, 74, 85; Ovchinnikov, 2014, pp. 341–352, 356, 381; Passek, 1949, pp. 6, 93–94; Pogoševa, 1985, pp. 134–242; Shmagliy, 2000, pp. 20, 23; Starkova, 2020, Figure 1; total of c. 2350 figurines.

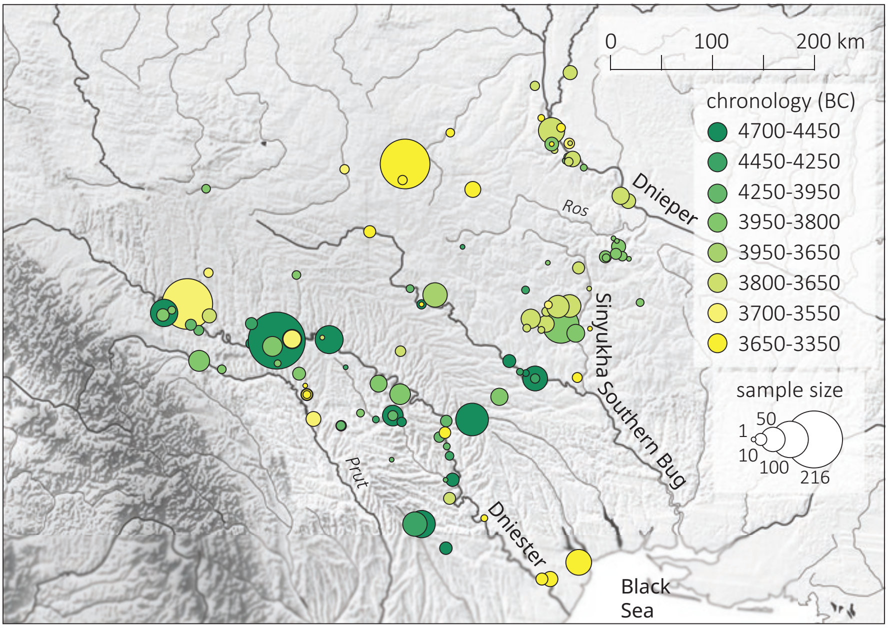
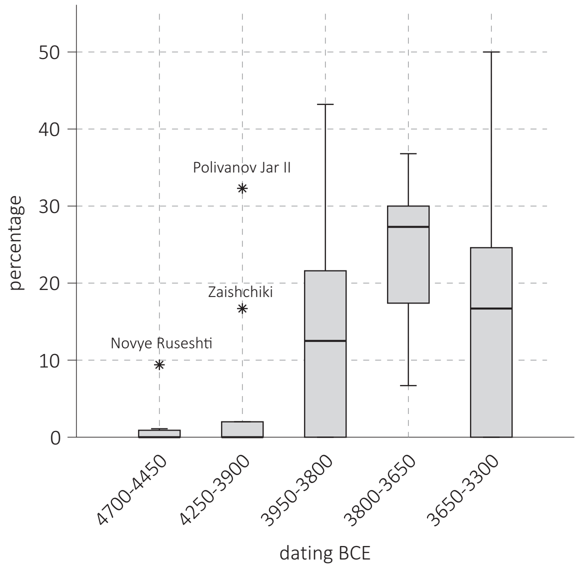


Fig. 8.6 Spatial distribution and dating of the examined samples of anthropomorphic figurines. (Figure by the authors)

Fig. 8.7 Boxplot diagram comparing the percentage of anthropomorphic figurines with realistic characteristics within the studied assemblages for different periods



To estimate the number of house and sledge models, one can calculate the number of finds per 100 m^2 of excavation area, as it was done for anthropomorphic figurines (Ţerna, 2017), or calculate the number of finds per 1 excavated dwelling (Shatilo, 2021). The latter approach has been tested on the materials from Trypillian settlements in the Syniukha River basin, where (some of) the models were found.[11] Thus, it was shown that at the settlements where large-scale research was carried out and more than 20 sites were excavated (Volodymyrivka, Popudnia, Talianki), the number of models is quite stable and fluctuates within the range of one house model per 9–12.5 excavated houses (3950–3650 BCE). At the same time, the proportion of the models showing more realistic details is quite significant (Fig. 8.1). In contrast to this category, sledge models are very common (mainly at large settlements): on average, 1–1.2 models were found per fully excavated house (3800–3650 BCE, Dobrovody, Maidanetske, Talianki settlements).

Finally, the least numerous are the images of equipment for animal use on zoomorphic objects dating from 3800–3300 BCE. In her monograph, V. I. Balabina (pp. 246–248) analyses about 292 zoomorphic figurines from Trypillian settlements of the C1 and C2 periods. Only 3% of these figurines have images that can be interpreted as real things, namely harnesses, bridles, belts and other equipment for cattle.

8.4.3 Spatial Distribution

Mapping of the different categories of 'realistic' images showed that some of them were typical for the entire area covered by the study, while others were typical for smaller regions. This is particularly noticeable after 4000 BCE, mainly for stages B2 and C1 in the terms of relative chronology.

In the time period 4000–3700/3650 BCE, house models, realistic heads and representations of hairstyles on anthropomorphic figurines are concentrated mainly in the Sinyukha River basin and in smaller number on the Dnipro (Figs. 8.8, 8.9, and 8.10), while sledge models and images of equipment on zoomorphic artefacts have been found almost exclusively in the Sinyukha River region (Fig. 8.11).[12]

[11] The sites of the Volodymyrivka, Nebelivka and Tomashivka groups, where more than two sites were excavated.

[12] *Anthropomorphic plastics*: e.g. the sites Chapaivka, Kazarovychi (Kruts, 1977, pp. 57–58, 60); Volodymyrivka, Valyava, Kocherzhyntsi Pankivka (Pogoševa, 1985, Figures 568–570, 710, 744); Ploniste, Vasylkiv, Rozkoshivka, Maidanetske, Dobrovody, Sushkivka, Tomashivka, Talianki, Chychyrkozivka, Pekari, Kolomyishchyna I (Burdo, 2010, pp. 129–135, Figures 30, 38, 39, 41–45, 56–70, 78, 83–86); hutir. Nezamozhennyk, Kvitky II, Vilshana I, Khlystunivka, Zelena Dibrova; hutir Khmilna, Kaniv-Novoselytsia I (Ovchinnikov, 2014, Figures 110.3, 112.1, 112.6, 113.1, 113.6, 114.9, 115.2, 115.3); Nebelivka (Burdo, 2015, Figures 2.1, 2.7, 2.8, 2.10); *house models*: e.g. Volodymyrivka. Andriivka, Volodymyrivka, Hrebeny, Dobrovody, Kolomyishchyna II, Kolomyishchyna I, Kocherzhyntsi Pankivka, Maidanetske, Popudnia, Rozsokhuvatka, Sushkivka, Talianki, Chychyrkozivka (Shatilo, 2005, pp. 130–139); *sledge models and images of special equipment*: e.g. the sites Sushkivka, Maidanetske, Talianki, Chychyrkozivka, Dobrovody (Balabina, 1998, pp. 84–85; Balabina, 2004, pp. 188, 191; Kruts et al., 2005, p. 63; Ohlrau, 2020, Plate 62.7).

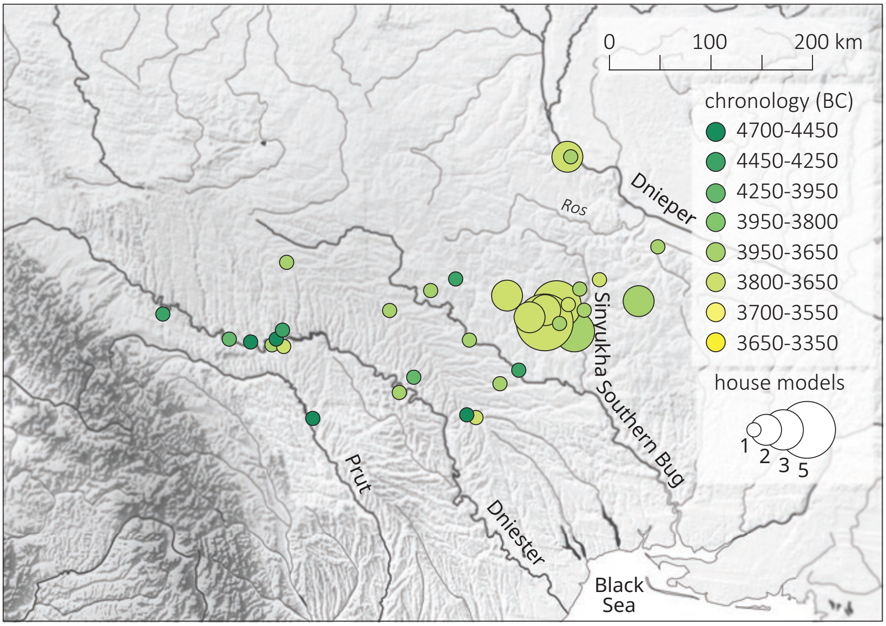


Fig. 8.8 Spatial distribution and dating of house models. (Figure by the authors)

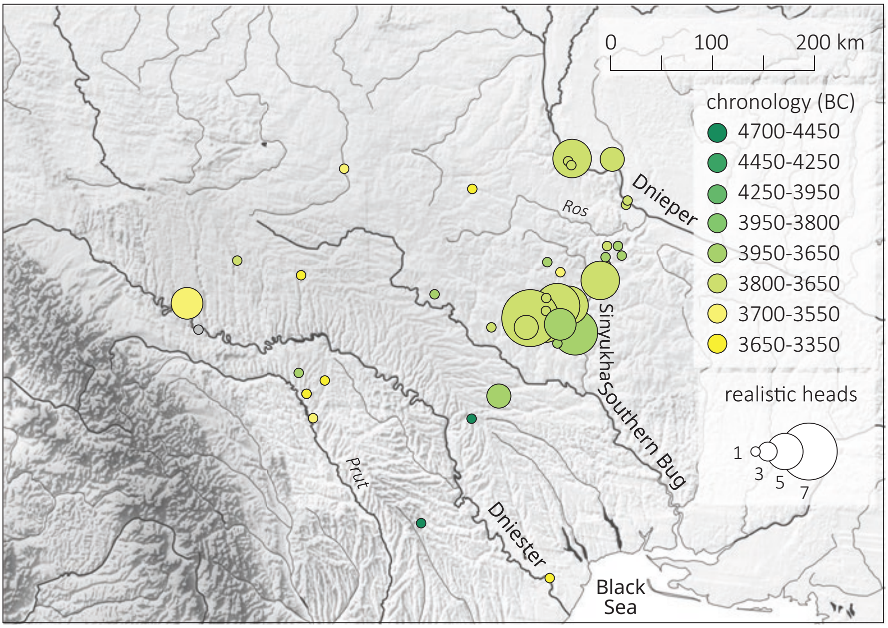


Fig. 8.9 Spatial distribution and dating of realistic heads on anthropomorphic figurines. (Figure by the authors)

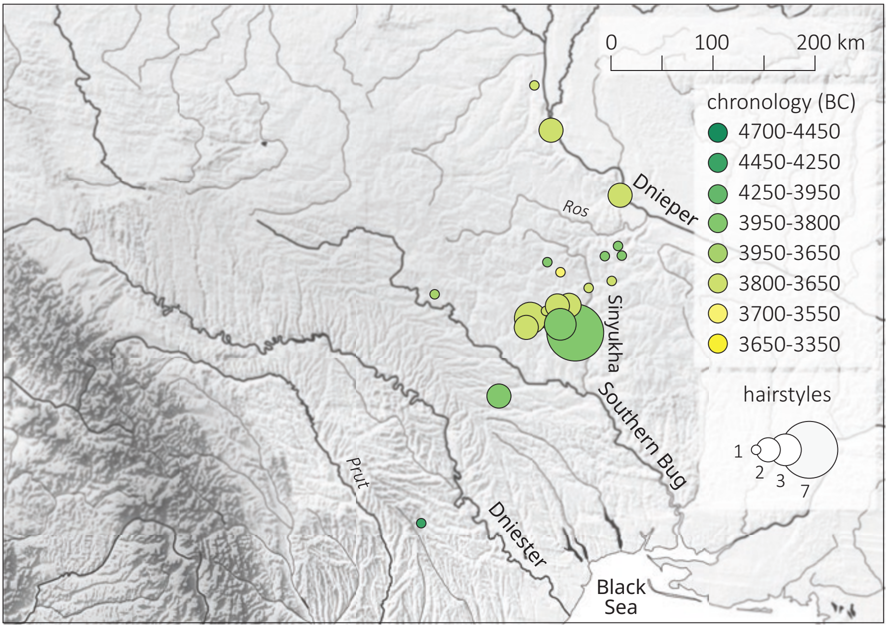


Fig. 8.10 Spatial distribution and dating of hairstyles images on anthropomorphic figurines. (Figure by the authors)

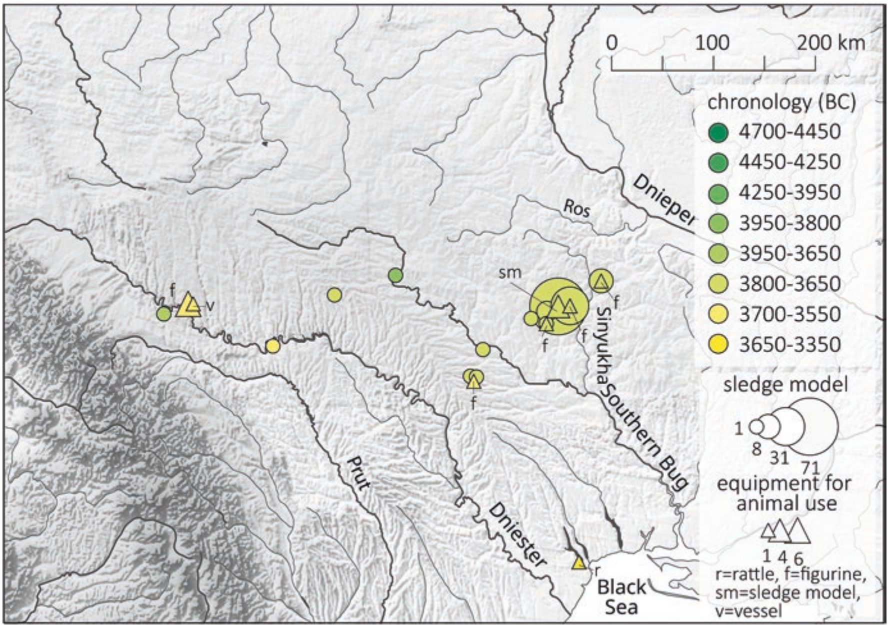


Fig. 8.11 Spatial distribution and dating of sledge models and pictorial representations of equipment used to exploit animal labour. (Figure by the authors)

A number of researchers have pointed to the concentration of 'realistic figurines' and models in the aforementioned territories, where mega-sites also existed (e.g. Burdo, 2010, p. 148; Movsha, 1973, pp. 19–20; Palaguta & Starkova, 2017, p. 75). Outside these areas, the listed artefacts have also been found on the Dniester and Southern Bug,[13] but they are less numerous and do not form clusters, which may partly reflect the state of the research in these areas.

After 3700/3650 BCE, some of the listed categories of the material are found outside the Sinyukha River basin and the Dnipro region, but in smaller numbers,[14] and mainly in the 'western' areas of Trypillian sites.[15]

To a certain extent, the described tendencies are also typical for the depictions of headdresses on anthropomorphic figurines. Thus, the earliest of them are known for the settlements of Molodetske and, possibly, Kvitky 2 (Movsha, 1973, Fig. 5.2; Ovchinnikov, 2014, Fig. 112.1). Later representations were found mainly much more to the west[16] and to the north[17] of these settlements (Fig. 8.12).

Slightly different patterns can be traced for the depictions of jewellery (Fig. 8.13) and clothing on anthropomorphic figurines (Fig. 8.12). Thus, representations of necklaces, necklines and hip belts are typical for many settlements from different regions, which are generally located throughout the territory under consideration. To generalise, in stage B2 they are found at the settlements from the Prut to the Ros (necklaces, necklines) and the Dnipro (hip belts), in C1 they are more present on the Sinyukha and Dnipro rivers, and at the end of C1 and C2 they dominate the Dniester and partly the Prut.

[13] *Anthropomorphic figurines*: the sites Stari Karakushany, Nemyriv, Krynychky (Pogoševa, 1985, Figures 617a, 638, 649, 652), Mala Mochulka, Kalaharivka (Burdo, 2013, pp. 245–250, 271–272, 335–336); *sledge models*: the settlements Nezvyssko, Chechelnyk (Balabina, 2004, p. 188); Kryvytske (Rud, 2018); *house models*: the settlements Voroshylivka, Konivka I, Mykhaylivka, Nemyriv, Trostyanchyk, Cherkaskiy Sad II (Gusev, 1996, pp. 27–29).

[14] As an exception, images of special equipment were found on seven different zoomorphic artefacts (mostly figurines) at the Koshylivtsi site, which makes up a significant proportion of the sample.

[15] *Anthropomorphic figurines*: the sites Brynzeni III, Rusiany, Kostesti IV (Markevich, 1981, Figures 63.5, 63.9, 74.9), Brynzeni IX (Markevich, 1985, Figure 110), Koshylivtsi, Kolodyazhne, Pavoloch (Pogoševa, 1985, Figures 937, 1008, 1012), Hrymiachka (Buzian & Bilousko, 2009, Figure 3.1), Mayaki (Burdo, 2013, pp. 340–342); *zoomorphic objects*: the sites Usatovo (Patakova, 1979, Figure 14.19), Koshylivtsi (Balabina, 1998, pp. 85–86, 94, 98); *house models*: Kosteshty IV, Konovka II (Gusev, 1996, p. 28).

[16] Settlement Kalagarivka (Movsha, 1973, Figure 6), Koshylivtsi (Pogoševa, 1985, Figure 937), Kostesti IV (Markevich, 1985, Figure 74.9), Hrymiachka (Buzian & Bilousko, 2009, Figure 3.1), Brynzeni III (Markevich, 1981, Figure 63), Brynzeni IX (Markevich, 1985, Figure 110).

[17] The sites Pavoloch (Pogoševa, 1985, Figure 1012) and Krutukha Zholob (Buzian & Yakubenko, 1998, Figure 3.1).

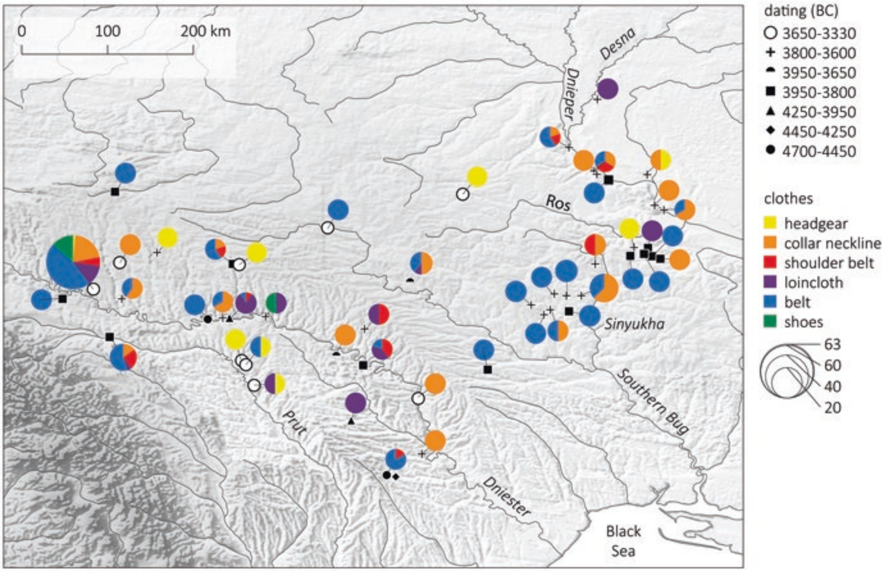


Fig. 8.12 Spatial distribution, dating and classification of clothing images on anthropomorphic figurines. (Figure by the authors)

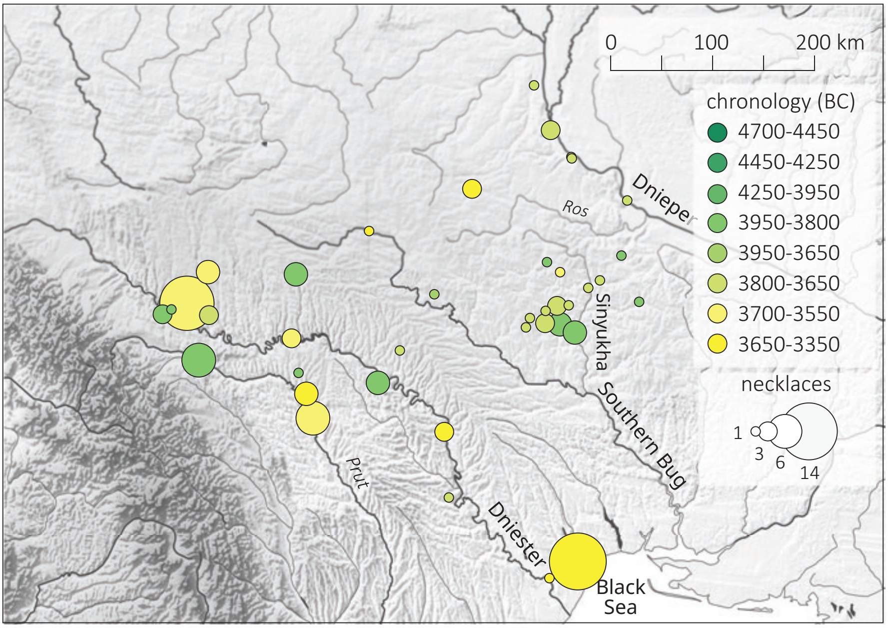


Fig. 8.13 Spatial distribution and dating of necklace representations on anthropomorphic figurines. Figure by the authors

As for loincloths and shoulder belts, the trends of their distribution are not entirely clear – they were mainly found on the figurines from the Prut-Bug interfluve,[18] they are also found in small numbers up to the Dnipro[19] and even the Desna,[20] but are almost completely absent in the Sinyukha River basin.[21]

8.4.4 Dimensions of Anthropomorphic Figurines

In general, stylistic changes during the process of transition to the 'realistic' phase of art can be seen in the appearance of large sculptures associated with architecture, in addition to small sculptures that had existed much earlier. Similar changes can be observed, for example, in Greece, where in the seventh century BCE significantly larger, up to life-sized, sculptures appear for the first time (Pedley, 1999). Our next consideration is whether similar changes are also happening with Trypillia figurines.

For more than half of the figurines considered in this chapter, we have taken measurements of their size. The size estimation method is based on the presumption that the height ratios of the different body parts show certain regularities. This allows estimation of the likely overall height of the statuette, for example, from the height of the head, torso, or lower body. We considered the development of three-part figurines (with head/neck, torso and lower part) and separately we examined two-part figurines (with head/neck and lower part from late Trypillia period assemblages, which were made in the form of a parallelepiped; cf. Fig. 8.14).

The proportions of different body parts were determined for 69 complete figurines, from which we calculated scaling factors by using median values to calculate the *likely overall height*. For example, when measuring fragmented statuettes consisting of three parts, the size of the head was multiplied by a factor of 6.8, the torso

[18] *Loincloths* – the settlement Shypentsi (Kandyba, 1937, Photography 51), Kostiesty IV (Markevich, 1985, Figure 74.13), Rakovets, Lomachentsi, Stina, Koshylivtsi (Pogoševa, 1985, Figures 542, 543, 738, 755, 800, 808, 836, 836, 879, 887, 897, 899), Nemyriv (Starkova, 2020, Figure 1.9); *shoulder belts* – the settlement Shypentsi, (Kandyba, 1937, Photographies 45, 46, 49, 65, 66), Rakovets, Stina, Koshylivtsi (Pogoševa, 1985, Figures 541, 544, 755, 821, 823, 828).

[19] For example, the settlement Chapaivka (Pogoševa, 1985, Figure 769) and Petropavlivka (Ovchinnikov, 2014, Figure 109.4).

[20] The site Yevminka (Pogoševa, 1985, p. 132).

[21] This distribution can be explained to some extent by the small sample of these representations, based on works with high-quality drawings of figurines, mainly by Pogoševa (1985), which did not include a significant amount of material from the region of giant settlements, which were just actively studied, Markevich (1985), Ovchinnikov (2014), and where these elements were clearly visible (e.g. Kandyba, 1937).

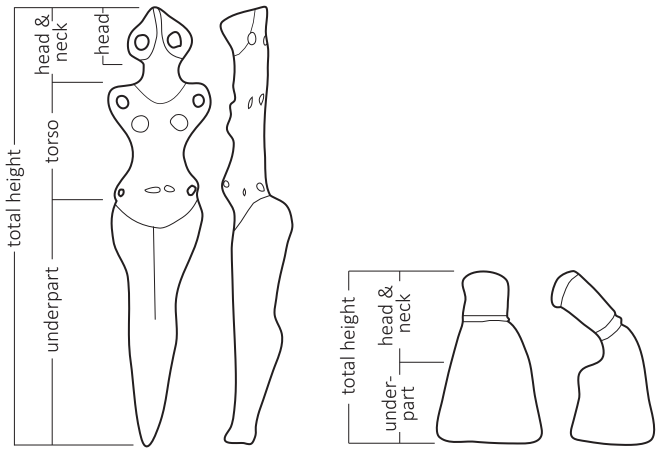


Fig. 8.14 Scheme illustrating the way in which measurements were taken on three-part and two-part figurines

by a factor of 3.4, and the lower part by a factor of 1.9.[22] For two-part figurines, the height of the neck and head was multiplied by a factor of 2.25, and the height of the lower part by a factor of 1.8. Similar results for three-part figures were obtained for Maidanetske by N. B. Burdo (2011, p. 11), who, however, analysed the proportions separately for each of the subtypes of anthropomorphic figurines she identified.

As a result, five classes of statuette sizes have been identified (Table 8.1). Not all of them are represented by completely preserved specimens. In particular, large and very large figurines have never been fully preserved. About 83% of the figurines are very small and medium-sized figures ranging from 1 cm to 18 cm, while only 17% of the figurines in the sample are large (18–30 cm) and very large (over 30 cm). The largest figurine (c. 70 cm high) is from Karakušany, of which only the head survived (after Pogoševa, 1985, Fig. 617a).

A chronological comparison of the frequency of occurrence of the different size classes shows an uneven distribution of the number of figurines measured for different chronological periods, with a particularly low number of figurines in the period between 4450 and 3950 BCE (Fig. 8.15). The early period between 4700 and 4450 BCE is characterised by a very large proportion of small figurines, a moderate number of medium-sized figurines and a very small number of large figurines. Later, the percentage of medium and large figurines increases significantly. After 3950 BCE, very large figurines appear for the first time, but they are not very common. Again, between 3800 and 3600 BCE, there is a significant increase in the frequency of large figurines, which together with very large specimens account for 40% of the sample.

[22] The calculation of the height of the figurines may not be entirely correct in cases where only the upper parts of the objects have been preserved, where it is unclear whether we are dealing with a standing type or a sitting figure type. However, in our opinion, this source of error can be dismissed in our study, as the proportion of seated figures is less than 10%, and calculating height in this way still gives a general idea of the size of the figures.

Table 8.1 Size classes of anthropomorphic figurines and their number in the analysed sample

Size categories	Dimensions	Quantity	Percentage
Very small	<5 cm	51	9,9
Small	5–10 cm	194	37,6
Medium	10–18 cm	184	35,7
Large	18–30 cm	78	15,1
Very large	>30 (to 70 cm)	9	1,7
Size is not determined		511	

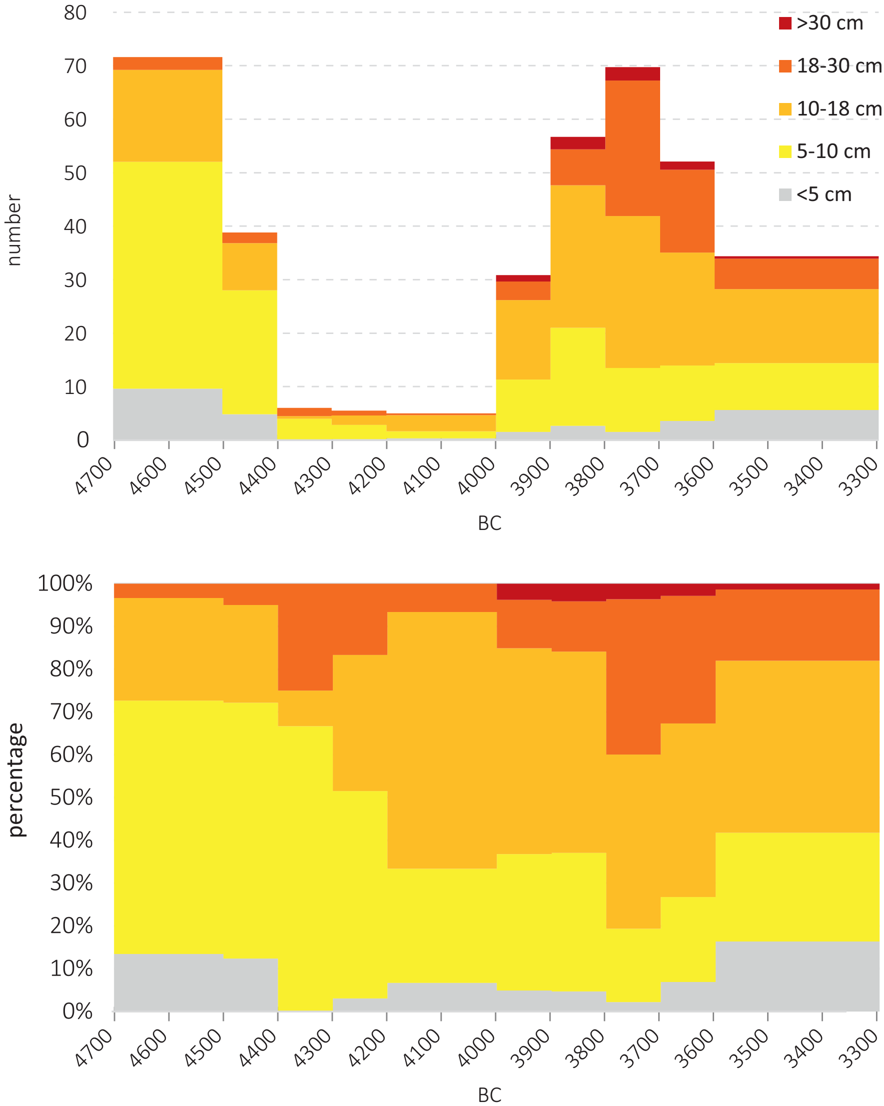


Fig. 8.15 Absolute and relative chronological distribution of size classes of anthropomorphic figurines

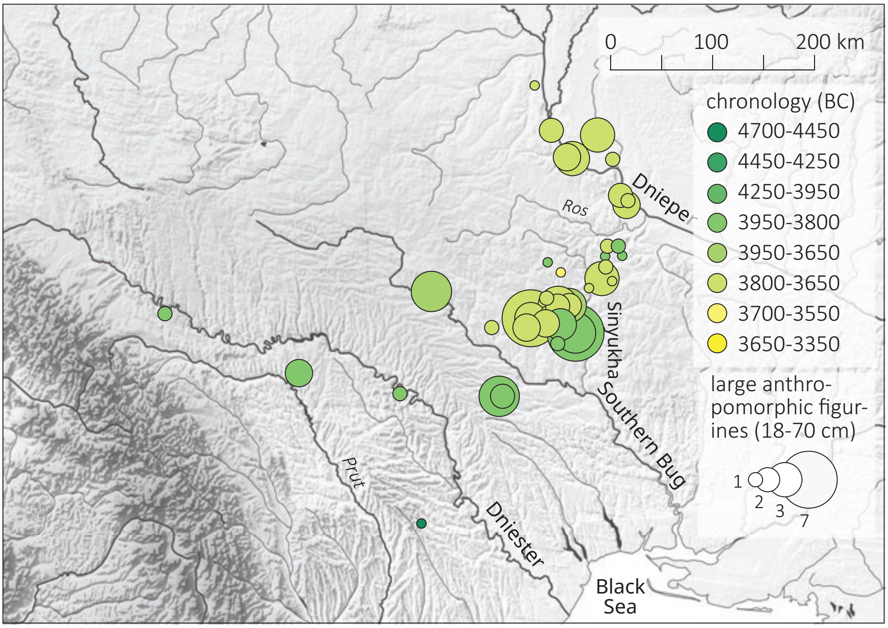


Fig. 8.16 Spatial distribution and dating of large anthropomorphic figurines (18–70 cm). (Figure by the authors)

After this peak, the size of the figurines decreases again, but the number of small figurines (less than 10 cm) is not as dominant as in the early Trypillian period.

The large and very large specimens may have been partly characterised by other 'realistic' features, such as plastically shaped heads and carefully modelled faces (Burdo, 2013, pp. 29–30). In terms of time, such figurines are concentrated in the phase between 3950 and 3600 BCE, and spatially they are most often found at settlements of the Sinyukha River basin, and slightly less frequently at settlements of the Dnipro region (Fig. 8.16).

8.5 Discussion and Conclusion

The chronological, quantitative and spatial distribution of 'realistic' categories in Trypillia is very heterogeneous. The Early Period (4700–4400 BCE) is characterised by a minimal number and small range of images from the settlements of the Dniester basin.[23] With the beginning of the Middle Period and up to 4000 BCE, there are even fewer representations, and most of them are still originating from the

[23] *Anthropomorphic figurines with realistic details*: sites Aleksandrovka, Luka-Vrublivetska, Novi Ruseshty, lower layer (Pogoševa, 1985, Figures 123, 322, 390, 392–394, 410); *house models* (depicting only the general idea of the house) from the sites Luka-Vrublivetska, Timkovo, Okopy (Gusev, 1996, pp. 28–29).

Dniester region.[24] This period is characterised by an overall lower number of anthropomorphic sculptures, both in this sampling and in more complete collections (Ţerna, 2017, p. 232). However, around 4000 BCE a new stage in the development of 'realistic' style begins.

Objects and images between 4000–3700 BCE can be divided into 2 groups:

1. *chronological,* which are typical for the entire Trypillian zone;
2. *specific* or *regional,* concentrated in the Sinyukha River basin and, in some cases, on the Dnipro River.

The second group is characterised by the following patterns:

- Their number gradually increases many times and drops rapidly after the maximum peak;
- The different categories are characterised by increased realism and an emphasis on details (e.g. models show numerous constructive elements);
- The assortment of images increases significantly and reaches its maximum around 3800 BCE with the emergence of new representation types (e.g. on zoomorphic objects);
- The development towards more realistic style here is also associated with enlarged anthropomorphic sculptures, which could also have additional realistic features.

After 3700 BCE, some of the representations that had been typical for settlements in the Sinyukha River basin expanded their territory at the expense of, first of all, the 'Western Trypillia' ones and, partly, of more northern territories (see above). After 3500 BCE, the phenomenon gradually fades away: a number of images continue to exist in the same areas, as well as in the Northern Pontic region (Usatovo sites), but in smaller numbers, after which they disappear around 3300 BCE.

Thus, we can say that there was a certain 'realistic' phase in the development of Trypillian art, and which, moreover, was concentrated on the sites of the Sinyukha River basin (before 3700 BCE). Such phenomena were not unique in history. A similar trajectory of anthropomorphic sculpture stylistic development can be traced for Middle and Late Neolithic Vinča figurines (5400/5300 to 4600/4500 BCE).

Anthropomorphic figurines from Vinča-Belo Brdo and Southeastern Europe have already been described in detail (e.g. Hansen, 2007, pp. 203–223; Höckmann, 1968, pp. 50–88; Parzinger, 1993, pp. 332–343). The basis for our study were 570 whole and fragmented anthropomorphic figurines from the publications of M. Vasić (1932, 1936a, b, c). The analysis of these sculptures enabled us to make a number of observations, in particular, about the development trends similar to Trypillian ones within a rather short chronological period between 5050 and 4700 BCE, when:

[24] *Anthropomorphic figurines*: sites Novi Ruseshty, upper layer, Zalishchyky, Polivaniv Yar II (Pogoševa, 1985, Figures 461, 477, 487–492, 495–496, 511); *house models* from the settlements Berezivska GES, Borysivka, Velyka Muksha, Vilshanka (Gusev, 1996, pp. 27–28).

1. The number of figurines increases significantly for a certain time;
2. The frequency of statuettes with more detailed plastic elements such as plastically formed heads, masks, ears, noses, eyes, arms, pelvic parts, spines, etc. grows considerably;
3. The frequency of figurines with perforation (holes for hair or jewellery on heads, arms and hips) and images of clothing increases;
4. The number of types of figurines increases: in addition to the standard type (standing statuette), there is a wider range of figurines that have, for example, a different body position (sitting on the floor, on chairs, or on pedestals)[25];
5. In addition, there are different classes of statuette sizes, the largest of which are approximately 1 m high (Hansen, 2007, p. 211).

This development of sculptures coincided with the specific historical processes that took place in this area at the settlements with Vinča-type ceramics, one of which was the eponymous tell. The so-called 'Vinča culture' (5400–4500 BCE) was an extensive regional network of human communities with a rich material culture (Tasić et al., 2015, 2016; Whittle et al., 2016), to some extent a 'central region' and an 'innovation core' of a much wider peripheral area where its influences were felt (Hofmann, 2020).

The period 5050–4700 BCE in the area of Vinča-type pottery settlements is characterised by increasing population density, the emergence of increasingly agglomerated settlements and a significant intensification of contacts between different settlements (Borić, 2015; Chapman, 1981, pp. 52–83; Hofmann et al., 2019; Porčić, 2020; Whittle et al., 2016). This development towards greater social and economic intensification contributed to the emergence of important innovations, for example, in metallurgy (Borić, 2009; Pernicka et al., 1993; Radivojević, 2015; Rosenstock et al., 2016), and led to increased intensification and specialisation in the production of, for example, ceramics and flint (Kaiser & Voytek, 1983, p. 347; Spataro, 2018, p. 264; Vuković, 2011, p. 96). These trends spread to large peripheral areas throughout the central and western Balkan region (Hofmann, 2020).

The crisis of this system between 4700 and 4600/500 BCE led to a number of changes: a decrease in population, in particular when many tells cease to exist (Borić, 2015; Hofmann et al., 2020; Link, 2006); a growing number of conflicts, seen in more frequently recorded cases of house fires and an increase in the number of fortified settlements (Arponen et al., 2016; Whittle et al., 2016); dispersed settlement patterns emerge and the 'disconnection' of peripheries can be observed (Hofmann, 2020). This crisis is accompanied by changes in the stylistic development: the number of figurines is decreasing very rapidly, and schematised figurines without realistic characteristics are increasingly used (Fig. 8.17).

Coming back to Trypillia, it should be emphasised that the Syniukha River basin also represented a separate region where a rich network of large and smaller settlements with very similar material and symbolic culture existed 4100–3650/3550 BCE (e.g. Kruts, 2012; Müller et al., 2016a, b, 2018; Ryzhov, 2012; Shatilo, 2021).

[25] In the future, it is important to take these parameters into account for Trypillia artefacts as well.

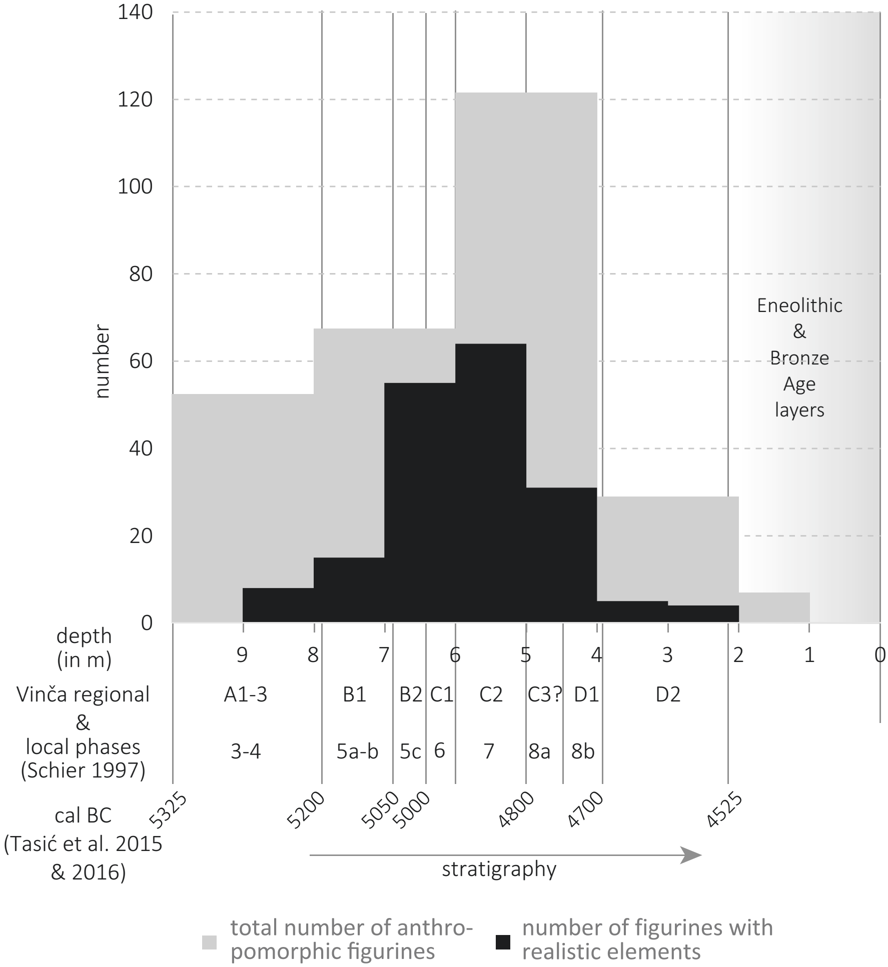


Fig. 8.17 Chronological distribution of the studied sample of anthropomorphic figurines and figurines with realistic features in the stratigraphy of Vinča-Belo Brdo, in relation to the highest absolute dating probability after Tasić et al. (2016) and local and regional phases after Schier (1997)

The scale of population concentration and agglomeration, both at a single large settlement and at the level of the whole region, was probably much greater than we know for other Trypillian territories (Hofmann & Shatilo, 2022). The area and number of Trypillian settlements in the Syniukha River basin region gradually increases with each chronological phase, reaching a maximum at c. 3800–3700 BCE, when the largest giant settlements (150–320 ha), located in close proximity to each other (c. 15 km), partially coexist (e.g. Kruts, 1989; Nebbia et al., 2018; Shatilo, 2021).

There were constant intensive interactions and exchanges of symbols, knowledge, technologies and possibly objects between different settlements. Due to this, innovations and developments that can be traced, for example, in the period

3950–3650 BCE in social organisation (e.g. Hofmann et al., 2019; Müller et al., 2018), ceramic production (e.g. Ellis, 1984; Korvin-Piotrovskiy et al., 2016; Ryzhov, 2012), and transport (e.g. Maran, 2004) were rapidly spreading to all settlements within the region.

This tendency towards increasing population density in the growing large settlements culminates in the rise of crisis phenomena after 3700 BCE and the crisis (3650–3550 BCE) which occurred, for example, in the process of hierarchisation and the resulting collapse of the social system (e.g. Hofmann et al., 2019), the degradation of settlement structures (Ohlrau, 2015, pp. 48–49, 2020, pp. 242, 245–246), the rapid decline of the population (Kruts, 1989, p. 129), and finally the depopulation of the territory. Similar changes can also be traced in the material culture in general (see, for example, Kushtan, 2015; Ryzhov, 2001–2002) and in miniatures in particular: house and sledge models disappear, and the few anthropomorphic figurines lose their 'realistic' characteristics.

Thus, the 'realistic' style in both cases *is associated with* densely populated regions of agglomerated and smaller settlements where networks of intense interactions were created. As a possible *explanation for the emergence* of this style, I. V. Palaguta and E. G. Starkova (2017, p. 75) consider it a *change in social reality* – the formation of large collectives, and, as a result, the need to specify images by giving them individual features.

The stylistic development towards greater realism also implies that the objects under consideration received greater 'stylistic attention' in the sense of Wobst's information-theoretic interpretation (Wobst, 1977). The increased 'attention' paid to these objects may indicate that they had a certain significance in the societies characterised by a high degree of interaction. To get closer to understanding which innovations and processes led to greater realism (and to its decline), it is necessary to consider the functions of these objects in different social processes and the scope of their use, as well as the question of who the recipients and producers of such objects were (e.g. conditions of production, decentralised or specialised).

For Trypillian sites, there is extensive evidence for the existence of specialised pottery production, at the latest from 3950 BCE (Ellis, 1984; Korvin-Piotrovskiy et al., 2016). This 'professionalisation' of production could be one of the mechanisms and explanations for the higher quality and more detailed style of clay sculpture.

The gradual increase in both the number and variety of realistic objects and images may indicate an increasing need for social interaction to maintain the 'sense of community' (ideology) that is characteristic of large socio-cultural settlement networks with high population density (Watkins, 2008). The intensive exchange (including innovation) and growing symbolic entrainment between Trypillian settlements of the Syniukha River basin can be clearly seen in the prevalence of ceramic styles of the respective chronological periods and the use of similar objects, including clay figurines (Shatilo, 2021). In the case of realistic representations, this may mean that their number grows through imitation and borrowing, and when new items (e.g. a sledge) are introduced, they rapidly enter into widespread use within these settlement networks.

Similar trajectories of stylistic development, for example, at the sites of the Butmir culture (Bosnia) or Ain Ghazal (Jordan), show similar social contexts (Hofmann, 2013; Simmons et al., 1988). Further detailed consideration of these transformative contexts can both correct and offer new explanatory models for understanding the 'realistic' style.

8.5.1 Conclusions

This study once again raises the long-standing debate about the driving forces of stylistic transformations. In our opinion, they are most likely to be found in the social processes with the use of these objects in different practices.

The consideration of different categories of material from two contexts – Trypillia and Vinča-Belo Brdo – showed that objects with 'realistic' characteristics were widespread within a time-limited period and geographical regions characterised by specific historical development. Among other things, this development is marked by: agglomerated settlements, high population density, innovations and active interactions of large groups of people, both in the extended networks of communication and exchange of complex societies and within the communities of separate settlements. The development ends with a crisis, during which the processes of disintegration of settlements and depopulation of regions take place. At this time, clay sculptures partially disappear and partially decrease in quantity, as well as losing their 'realistic' characteristics.

8.6 Summary

This study, once again, raises the question of the driving forces of stylistic development. For that, we focused on two prehistoric contexts, more specifically on Trypillia and the Late Neolithic site of Vinča-Belo Brdo where we analysed various objects with 'realistic' images.

For Trypillia, we included the following categories: house models, sledge models, depictions of equipment for animal use on zoomorphic objects (figurines, vessels, etc.), 'realistically modelled' faces of anthropomorphic figures, and depictions on anthropomorphic figures (hairstyles and accessories for hair, necklaces, footwear and clothing). Based on the latest findings on chronology, we trace the aforementioned realistic features in time and space by means of quantifications and mapping. Additionally, we investigate the changes of anthropomorphic figurines in terms of size.

In the case study of Vinča, the frequency of realistic features in different depths of the tell stratigraphy is placed in relation to the total number of figurines and the historical dynamics of late Neolithic societies.

The consideration of different material categories shows that objects with 'realistic' characteristics mainly occur in certain periods and geographical regions that are characterised by specific historical developments. These include high population densities in large agglomerated settlements, increased innovativeness, intensive interaction in densified far-reaching communication and exchange networks.

In both case studies, the developments ended in fundamental crises and were associated with the disintegration of large settlements and population decline. Related to this, some types of 'real' objects disappear, while others become fewer and lose their 'real' characteristics.

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Chapter 9
Scales of Political Practice and Patterns of Power Relations in Prehistory

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> *[…], the political is that dimension of social life in which things really do become true if enough people believe in it.*
> *David Graeber (2011, p. 342), Debt. The first 5000 years.*
> *Politics: A strife of interests masquerading as a contest of principles. The conduct of public affairs for private advantage.*
>
> Ambrose Bierce *(1906/2000), The Unabridged Devil's Dictionary.*

9.1 Introduction

Politics is the negotiation of shared or conflicting interests and values between people and groups in collective decision-making processes. Although such negotiations, today as in the past, are manifold and dependent on specific historical settings, they are also influenced by a number of social patterns and structures which can be archaeologically determined in order to investigate the politics of prehistoric societies.

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However, a blatant gap in our knowledge of prehistoric Europe comes from the lack of a substantial discussion about politics, decision-making, conflict resolution and reconciliation of particular and collective interests. While there is, for example, a lot of research into Bronze Age and Iron Age chiefdoms, elite networks, violence and war (e.g. Earle, 1997, 2017; Earle & Kristiansen, 2010; Earle et al., 2015), it seems that beyond the question of when and where centralised rule can be identified, there is very little interest in how social groups actually organised their decision-making processes every day and everywhere: beyond the palaces or chiefly halls. It seems that most archaeologists implicitly assume that only top-down, centralised domination in the form of militarised princely chiefs, as they are discussed in younger prehistoric periods, would be worth investigating in terms of political processes. All other prehistoric communities seem to be viewed as some kind of 'people without history' in the sense discussed by Eric Wolf in 1982 (Wolf, 1982/2010): as people who are just 'not yet' capable of conceding power to one individual self-aggrandiser. Sporadically, Big Men have been invoked for Neolithic communities (Iversen, 2015), once more reinforcing the impression that views on prehistoric politics are very much reduced to the topic of individualised male dominance. There is not much doubt that the long-outdated, yet inherently still ever-present, social evolutionary narrative (Fried, 1967; Service, 1968) plays its role here by equating the apparent lack of individual male leaders with 'simple' and egalitarian societies that are regarded as a kind of primordial apolitical equilibrium (Wengrow & Graeber, 2015).

This described view is strongly influenced by narrow and rather one-sided perceptions of political agency in (pre)historic contexts; there is a real need to broaden these views on political structures and to investigate more thoroughly how the political process in and between prehistoric people, their seasonal stations, villages, farms, lineages, clans and regional networks actually functioned. What kind of power structures and institutions existed, how was power distributed, how were conflicts resolved, how were diverging or opposing interests reconciled, how were decisions made and how were they actualised and enforced? Socio-cultural anthropological literature and case studies do offer various angles on how to approach these questions, yet they remain underrepresented in archaeological interpretations, despite the prominence of specific models (such as Big-Man societies). With our enquiry, we aim to expand our scope for political possibilities beyond the currently dominating hierarchical systems. We explore the past for alternatives to find out how they worked, what patterns of dynamics may indicate structural entanglements, and what possibilities arose from particular historical constellations (i.e. general or universal patterns vs. particularities, individual action, historical events). We do have a large body of anthropological evidence (e.g. Amborn, 2019; Clastres, 1974/1989; Evans-Pritchard, 1940; Fortes & Evans-Pritchard, 1940/2015; Graeber, 2004, 2007; Richards & Kuper, 1971; Sigrist, 1967) for such political processes in all kinds of communities, a source that so far has not been properly tapped for an understanding of European prehistory. In this chapter we want to define a spectrum of possible forms of political decision-making (polities), drawing specifically on the archaeological record for non-state, acephalous societies. We then want to define a set of possible archaeological parameters for the identification of such polities and use a number of case studies to explore their applicability. By drawing on these case studies, we will discuss possible issues of political negotiations (policies) and processes of decision-making (politics), which might have taken place in those specific social settings. We will then, tentatively, discuss the question of to what degree we can recognise regional or diachronic changes, dynamics and transformations in decision-making processes and political practices across space and time. In addition, we would like to show how political dynamics and the transformations of these go hand in hand with further changes, so that the interconnectedness and complexity of the different politically active prehistoric societies and their environments become clear.

9.2 Approaching Power and the Political in the Past

9.2.1 Perspectives on Political Practices in Anthropology

For the past few decades, evolutionist anthropologists, together with archaeologists, have imposed different classifications on societies – such as bands, tribes, chiefdoms, and states – and also have debated the merits of such typologies (Fried, 1967; Service, 1975). Conflict is often accorded a central, if not catalytic, role in virtually all these schemas. A large body of literature has argued that such classification is a tool used by a hegemonic West to assert power over the designated groups. More recent trends in post-colonial and globalization theory have questioned such traditional typologies; the emphasis has shifted to fluidity, hybridity, and change rather than the static structures denoted by classification systems (e.g. Bhabha, 2012; Jullien, 2016). Radcliffe-Brown had conceptualised society in terms of a 'system in equilibrium', where every single institution was part of the 'whole' structure (Spencer, 2007).

Regardless of categories, the role of political systems and their formal mechanisms may vary in every society. As mentioned by Gary Ferraro (1992), all societies differ in their political organisations based on the following dimensions:

- The degree to which political institutions are separate from other components of the social structure; for example, political structures in some societies are closely entangled with economic, kinship, or religious structures.
- The extent to which power is concentrated in specific political positions/roles.
- The level of political integration (i.e. the size of the territorial group that comes under the control of political structure).

With respect to the study of political/social organisation present in prehistoric societies, the question is not whether these societies were politically organised – all societies are – but rather which institutions and/or mechanisms there were and how they functioned. Political anthropology may help to identify relevant parameters of enquiry, as well as the interplay and interconnectedness of different socio-political spheres and their institutionalised forms (e.g. kinship structures, village councils). It can also be stated that political institutions are not secluded components, but they are a part of wider social frameworks and thus interconnected with other subsystems in a society.

In anthropology, inductive and comparative approaches are used in studying political institutions and for explaining the uniformities and differences found between them, as well as to interpret their interdependencies with other features of social organisation (Fortes & Evans-Pritchard, 1940/2015, p. 5).

When describing the political authority in particular societies, we focus on their political systems. Political organisations are those institutions and/or mechanisms (formal and informal) which perform various activities concerning decision-making and conflict resolution, in order to create and maintain social order and cope with social disorder. Some of the central institutions of political organisation and the execution of power known from social and cultural anthropological research are the following:

Village councils: Village councils and caste councils are some of the political institutions well-defined by Bailey (1960) in his study about political systems (cf. also Richards & Kuper, 1971). Tribes commonly have village headmen who perform leadership roles, but these individuals have relatively limited authority. Political power stems largely from their senior position within kin groups and their ability to persuade or harangue others into doing what they want (Amborn, 2019; Franks, 2002; Sigrist, 1967).

As villages tend to have small populations occupying a local space, having common needs and interests, where livelihood and social interactions overlap, a local body with first-hand knowledge is needed to maintain decorum and smoothly run the daily activities (Krishna, 2002).

Socio-political networks: The networking between neighbouring groups of people or along lineages and clans is one of the important aspects of the study of politics in non-state societies. Paige (1974) supported the argument of anthropologists regarding understanding the relationship between systems of kinship and forms of political organisation. He further emphasised that the organisation of kinship and the organisation of the polity are closely integrated in stateless societies. Kinship roles frequently determine patterns of group interests and solidarity, as well as lines of political cleavage and conflicts. Kinship is an important constituent of social structure and plays a significant role in determining political behaviour in non-centralised/tribal societies (Hughes, 1988). Groups based on clans or kinship, living in different territories or villages, play a distinguished role in the socio-political networks across the wider area. Balandier (1967/1970) has cited

Van Velsen's case of the Tonga of Malawi, where the political relations were expressed in terms of kinship, and the manipulations of kinship are one of the means employed in political strategy. Non-state societies are typically characterised and defined as essentially kin-based societies (e.g. Earle, 1997; Francisconi, 2006; Grinin, 2011; Kottak, 2002; Milner, 1998; Sneath, 2011), with 'the role of the kinship system as a model for political organization' being characteristic (Bargatzky, 1985, p. 300).

Social subgroups based on shared attributes (age-based etc.): Apart from the central political organisation, there are other age/sex-based groups which can also hold noteworthy power in decision-making processes within a society. Groups, such as family groups, interest groups, pressure groups, peer groups – or variants suggested by colleagues, such as lodges, and clubs – exist in all societies, with different groups and communities regularly benefitting from them. Yet, it should not be omitted that those groups might also serve different interests, and therefore might stand in conflict with each other. For example, youth dormitories can be important institutions among tribal societies, which are quite common across areas of Northeast India (Lalchhanhima., 2020). Although these groups are not strictly political bodies, youth dormitories aid in training the youth in various aspects of socio-cultural, economic, religious and political activities, and also play an important role in the decision-making processes of matters related to the society or group of people. Among the Dimasa Kachari of Assam, Hangsao, the bachelors' dormitory, is an important institution and also plays the role of the village defence. They are trained to become leaders and organisers, to undertake public works and community works. In this sense, youth dormitories can be regarded as quasi-political units (von Fürer-Haimendorf, 1950).

9.2.2 Manifestation and Features of the Political: Parameters of Asymmetrical Power

Power is a crucial and much-discussed topic in archaeology (e.g. Earle, 1997; Lund et al., 2022). Most of the time, archaeologists tend to identify it as represented in the form of rich finds and buildings, betraying a flawed conflation of power and wealth. The resulting interpretations of asymmetry in the distribution of power are portrayed as definite and unambiguous. However, as discussed in the introduction, interpersonal processes such as human interaction, and entanglement in material practices and spheres of life, have been less explored with regard to their power dimension. In fact, the whole area of symmetrical power (Lund et al., 2022) is missing from the discussion. In addition, the social processes connected to asymmetrical power relations are unclear so far and pose the question: How can uneven power distributions be manifested in the prehistoric archaeological record?

In order to answer this question, it is first necessary to establish how 'power' is defined for prehistory in this chapter. As is usual in many articles on prehistoric power relations, Max Weber (1980) is at the beginning of the discussion with his concrete definition: Weber sees power as every opportunity to assert one's own will within a social relationship, even in the face of opposition, regardless of what this opportunity is based on. Although Weber briefly discusses non-coercive forms of power, he practically ties power to institutionalised coercive rule (M. Weber, 1980, p. 28). His concept of power is individualistic, confrontative and antagonistic (Lund et al., 2022). It is an inherently male, patriarchal view of power backed by the threat of violence, and it is not difficult to see the authoritarian state and patriarchal family of nineteenth century Germany in which Weber grew up as the main model for his idea of power. Weber's concept largely disregards the collective nature of power without which no society can exit, which in contrast is emphasised by Hannah Arendt (1970). We hold this Weberian concept, which largely conflates power with coercive domination backed by an all-encompassing state monopoly of violence, as reductive in general, and specifically as unsuitable for the analysis of prehistoric societies where such a monopoly did not exist. That is why we found the approaches of Hannah Arendt (1970) and Michel Foucault (1983, 1994, 2004) more suitable for our study (see also Lund et al., 2022). Arendt emphasises the collective and consensus-based nature of power, which she sees as the essence of, and a necessary prerequisite for, any kind of society. She famously differentiates between power and violence, positioning the latter as the opposite of power. While they usually appear together, these two forces are seen to be complementary; where one prevails, the other is diminished, as violence destroys the collective base of power. This parallels the concept of Foucault. According to Foucault, power is the name given to a complex strategic situation in a society. In this, power is an open, more or less coordinated bundle of relationships (Foucault, 1994, p. 302) and thereby acts as the relationship of interacting forces in all social spheres. Thus, power is not at all reduced to violent oppression, but rather regulates and channels life through certain power techniques (exclusion, controlling surveillance, security systems: Foucault, 2004, pp. 6ff.). In addition to this, Niklas Luhmann (1975, pp. 3–12) should be mentioned, who states that power is inherent in every communication process and a necessary precondition for social development. Furthermore, according to Pierre Bourdieu (1982–1984/1991, p. 164), fixed positions of power (e.g. in language or symbolic actions) can only be maintained if agents are not aware of the implication. The relationship between us and others is thus what conveys something to us about the other and ourselves. However, there is no relationship without a power relationship.

As already mentioned in the introduction, the top-down perspective cannot be the only way to reconstruct power relations for prehistory. The pioneer of the assumption that power is not a one-way movement, as in a hierarchised ladder from top to bottom, is again Foucault, who says: 'pour qu'il y ait mouvement de haut en bas, il faut qu'il y ait en même temps une capillarité de bas en haut' [for a movement from top to bottom to take place, there must necessarily be a capillary rise from bottom to top at the same time] (Foucault, 1994, p. 304). In this context, people's freedom of action, as well as the concepts that guide people in everyday life, must be considered as possibly less integrated (Joyce & Lopiparo, 2005, p. 369).

For our study, we have compiled the following parameters as influencing factors of power as based on our research.

9.2.2.1 Community Size

The size of a community is decisive for the assessment of political processes and accordingly a central aspect of our contribution.

Community size strongly correlates with power distributions and cooperation relations (Stanish, 2017), as well as the need for regulations of coexistence – in whatever form and at whatever time.

With an increasing number of members, the complexity and dynamics of a community will most probably rise (Feinman, 2011, pp. 41ff.). An increasing population can also be a reason for the emergence of social inequalities (Brown, 1981, p. 27). Alberti (2014) summarised the emerging stressful effects of increasing group size based on the theories of Johnson (1982) and Dunbar (1993; Hill & Dunbar, 2003), as well as drawing on a variety of sociological studies. According to Johnson (1982, 1983), the larger the group, the greater the potential for stress due to competition, disagreement, dissension and communication problems. According to Hill and Dunbar (2003), a group that is too large reaches its cognitive limits when it comes to the maintenance of social relations and thus decision-making. Decision-making and task completion are thus made more difficult, although the diverse group constellation can, of course, also offer a more productive generation of ideas for problem-solving. A group that is too large can also be counterproductive, as the quality of ideas has been shown to decrease above a certain group size. As groups increase in size, they also tend to form subgroups, which can lead to a decrease in overall community cohesion and cooperative consensus, as larger groups are more likely to contain non-cooperative individuals (Alberti, 2014, pp. 2ff.). Concrete numbers that give a good group size are between 100 and 200 people (cf. Dunbar, 1993; Kosse, 1990; Olsen, 1987). Such a group size could also do without centralisation of power or institutionalised authority (Gonzalez, 2014, pp. 147 f.). More people may also not need centralisation, but rather organisational structures like 'nested networks', where subgroups or segments of a community are represented by designated individuals in community councils or similar organs of higher-scale decision-making. The forming of subgroups within a community can be best traced archaeologically if it shows up in the arrangement of settlement space (Haude & Wagner, 2019). Such segmental societies are probably best conceptualised as heterarchical systems, which can include varying degrees of intra-group and inter-group hierarchical relations (e.g. Feinman, 2011; R. Hofmann et al., 2019).

However, if decision-making were reduced to a few individuals, the large community could be relieved of this, but it would restrict the freedom of action for the large mass (Alberti, 2014, pp. 2ff.). Yet, Amborn (2019) has shown how even very large communities can maintain decentralised forms of decision-making, and largely avoid social inequality, for example through strongly internalised norms and codes of conduct. Amborn's findings align well with other social and cultural anthropological studies, which show that although subgroups and structures such as neighbourhoods and clans might gain importance within power structures of large communities, there is no simple correlation between large groups and growing social inequality (Green, 2021; Hodder, 2014; Hofmann et al., 2019; Sigrist, 1967). Yet, an important factor for the overall power of a given group is the territory linked to it. Higher authority and/or power might be achieved through a larger population and/or territory (Dillian, 2003; Malmberg, 1980).

The reconstruction of group sizes is undoubtedly dependent on the information from the features that are still available to the archaeologist. The extrapolation of numbers of people based on house sizes and house and settlement numbers are indispensable for prehistoric reconstructions, but often bring with them the problem that contemporaneity cannot be guaranteed for all houses or settlements. With mobile or semi-sedentary groups, additional difficulties in estimating community size are posed by dynamic settlement systems with various seasonal sites and ephemeral stations, and by cyclical group size fluctuations. The use of grave numbers is similarly problematic, as not all members or subgroups of a community might be represented in the (preserved) burials (cf. Metzner-Nebelsick, 2019).

However, the measurement of food stocks, which could be traced, for example, with the help of storage pits or buildings (cf. Prats et al., 2020, p. 19), calls into question surplus gain and surplus profit (Risch, 2018, pp. 48 f.), which could lead to an over-calculation of the population. Indeed, surplus food production may have arisen from much more complex motivations and been regulated (Bogaard, 2017). Due to these circumstances, the combination of clear stratigraphy with scientific dating and the use of extrapolations, and especially the comparative use of different types of finds, is essential to approach prehistoric community sizes.

9.2.2.2 Conformity/Diversity

This parameter is important for our study because measurable standardisation or deviation from a measurable norm plays an important, politically relevant role. A crucial archaeologically measurable parameter in this context would be, for example, architectural elements such as house or grave sizes, shapes, structural elements or furnishings. While standardisation of such elements points towards a centrally regulated or communally established conformity, practically it communicates and enforces equal treatment of people. Deviations may reveal social differences or individual autonomy, while a total lack of uniformity would attest to a pronounced decentralisation and autonomy of households.

Archaeologically, regulation can be shown, for example, by size uniformity, such as the Bronze Age burial mound sizes of southern Germany, which always measured approx. 7 m in diameter and thus show centrally regulated construction methods (Falkenstein, 2017, p. 81).

The situation is similar when dealing with material culture. Conforming objects, such as ceramic styles – be they based on shaping and decoration (Graves, 1998) or even diets (Twiss, 2012) – can be subject to central regulation and carry social or symbolic meanings (e.g. marking the contents of vessels). Deviance, on the other hand, can signal other cultural diversities or particular social identities in a society (e.g. weapons).

In terms of personalities, supporting shared social norms and minimising divergence among members is, following Arendt (1970), the main source of power; it can help coordinate the group's response to external threats (such as pandemics and natural disasters). When it comes to decision-making, individuals often adapt their opinions to those of other members and even change their minds in group discussions (Levitan & Verhulst, 2016).

In smaller groups, there might also be a 'conformity pressure' (Mallinson & Hatemi, 2018), as one is obliged to – or possibly even vitally dependent on – the community. Archaeologically, the social challenge of the individual in forming opinions is not visible, but can be considered along with continuous developments and – for instance – grave construction or burial rites. Broader transformations, on the other hand, will necessarily go along with changes in the prevailing opinion.

9.2.2.3 (Critical) Resources: Access and Distribution

Resources from basic to self-fulfilment needs (Maslow's hierarchy of needs: Maslow, 1943) (e.g. land, water, certain materials such as wood, flint or bronze; rare objects such as amber; prestige objects; luxury goods such as salt) can be subjected to the political process of a society by centrally controlling their distribution, access or withdrawal as opposed to decentralised access and sharing. Access to resources, such as land to grow specific kinds of plants, also fulfils a central role regarding the possibilities for members of a given community to engage in politically critical activities such as feasting (cf. Hayden, 2014).

Archaeologically, such regulation or control of resources, or the sharing thereof, is evident, for example, in their centralised or decentralised placement. This may involve the distribution of wells, storage buildings, storage pits, hoards or tombs. Furthermore, the strategic placement of settlements or buildings can represent the control of access routes to waterways or trade routes.

Depending on the form of society, decision-making institutions or power structure, systematic distribution of resources or surplus products can be equal or unequal; as in the comparison of universal sharing, Big man (accumulation and asymmetric generous distribution) or Chiefly societies (restricted/unequal distribution) (Hansen, 2018, pp. 227 f., Fig. 5). According to the prevailing institutions and power structure, such regulations can also be ideologically determined and – similar to the importance of regularities in the construction of graves or houses (see above: conformity vs. autonomy) – presuppose standardised and possibly ideologically determined resource uses and access (Falkenstein, 2017, pp. 81 f.) and thus also reflect social differentiations in terms of investments (Brown, 1981, p. 29).

Communication, the negotiation of distribution and claims on economic costs and resources, or the adaptation to external factors can be seen, for example, in the transformation of the economic efficiency or productivity of a society; as in a change in economic practices, measurable, for example, by a change from arable to livestock farming, or the reduction of house sizes, which would mean less building material. The separation of lower- and higher-value modes of food production can also reveal different regulations of important resources, as can be seen, for example, for salt extraction at the Erdeborn site in central Germany, when different qualities of salt were produced for export. (Ettel et al., 2019, p. 386).

Hunger riots and looting, as well as protests, boycotts and physical resistance, are not directly detectable in the findings, but can be discussed on the basis of upheavals in social conditions or sudden migrations (see below). The relocation of trade routes or hoards may also indicate a supra-regional redistribution and reshaping of political relevance.

9.2.2.4 Networks Configurations

Network studies enable the exploration of dynamics between interpersonal and geographical space at the micro, meso, macro and global scales. For our study, the focus lies on the political relevance of the construction, maintenance and expansion of networks, which is also linked to economic interactions. In contrast to well-known approaches that try to infer large-scale 'network types', the present study employs a bottom-up perspective: What did the individual's or household's network look like in relation to other individuals and households (family, friends, neighbours, community members)? What was the relationship to external networks, such as other settlements, regions, etc.? How was access to one's own and external networks regulated or controlled? Maintaining contact with the outside world, i.e. with other communities, may have been important, e.g. against the background of wanting to keep open the option of moving to another community or region (Furholt et al., 2020b, pp. 171, 176ff.).

In addition, networks may have served to procure objects, but also knowledge, technologies or specialists. Both reasons (threat of migration; possession of important relationships) may have represented a position of power in a society, as they could bring the economy of the society into an interdependency. Find distributions at different sites, or hoard finds along so-called 'trade routes' (e.g. Amber Road), show how far-reaching and intensive such connections were, and how carefully they were established and maintained. Travelling specialists also show how certain technologies were exchanged (e.g. travelling flint specialists during the Early Bronze Age in the Thy region: Eriksen, 2018). Differences in burial and household arrangements within a society may also reveal a difference in individual rights of access to, and control over, certain objects.

9.2.2.5 Organisation of Decision-Making

'Decision making is a dynamic and interactive process incorporating a sequence of events from the time when decision makers recognize the need to solve a problem until the time when they authorize a course of action to solve it.' (Elbanna, 2017, p. 163).

Decision-making is a fundamentally basic political tool, and the manner of its organisation shows the influence of power and politics in social life. Processes of decision-making in non-centralised societies are usually connected to specific institutions (such as village councils: e.g. Richards & Kuper, 1971) and involve complex negotiations, discussions and deliberations, where dissent might be seen as forbidden by custom and the requirements of group loyalty.

Depending on the form of society, decisions can be authoritarian/hierarchical or anti-authoritarian/non-hierarchical (Blanton, 1998, pp. 151 f.). However, this does not mean that anti-authoritarian/non-hierarchical decisions cannot also be centralised. They are merely organised differently, in that centralisations, for example, must always be renegotiated (Angelbeck & Grier, 2012, pp. 549ff.).

For the study at hand, this parameter is very important, as it enables the identification of decision-makers and dynamics in political decision-making processes and poses questions such as the following for discussion: Were decisions centralised? Who had decision-making power? Did decision-making power lie with specific individuals or groups, or was the entire community involved in the decision-making process? Where and when were decisions made? Were there specific houses or places, as well as specific times, for decisions? How and by whom were decisions made, communicated and implemented?

Depending on the social dynamics and impact on areas of life, the effects of decisions can be reflected as changes in find situations and environmental data. This can be, for example, a change in ideological concepts in the burial system or new economic approaches in housing construction. Such a structural change can be seen, for example, in the fact that at first a few representatives slowly assert themselves before the great masses decide to adopt the new custom and only stragglers remain. Such a process can take a long time, whereby even decisions that were necessary ad hoc, for example, to avoid an ecological or economic crisis, can show up as a drastic change in the data (e.g. settlement destruction at the Bronze Age site of Bruszczewo, Poland: Kneisel, 2013, pp. 95ff.).

9.2.2.6 Property Rights

'A common definition of property is twofold: something possessed, and the exclusive right to hold, use, and/or dispose of that something' (Earle, 2000, p. 40). In addition to that, it 'can be seen as a cultural manifestation of territoriality that develops to defend and regularize rights to scarce and valued resources' (Earle, 2000, p. 43). For our study, the focus is on political relevance in the emergence and implementation of property rights. How did property rights influence the development of social institutions and were they in turn influenced or controlled by them? What was the significance of property in the development of political economies? 'We know that property rights are a critical dimension of the evolution and materialization of social institutions and political relationships' (Earle, 2000, p. 53), because they are responsible for the invention of social inequality – as Rousseau (1755/1992, pp. 28ff.) already noted – and therefore the creation of hierarchy.

Less wealth, for example, can lead to a decreasing obligation to share and thus an increasing sense of ownership (Wiersma, 2020, p. 143). The representation of wealth is based on the principle that individuals, households and social groups accumulate and possess wealth in different ways. Furthermore, levelling mechanisms must be considered that can counteract the accumulation of wealth by a few (Clastres, 1974/1989). Possession thereby represents symbolic and social capital for political control (Earle, 2000, p. 45).

In the archaeological record, property and its access or disposition are recognisable in a variety of ways. An explicit representation of the claiming of property is evident in warfare for the defence or acquisition of goods, insofar as patterns of warfare correlate with property rights (Earle, 2000, pp. 49 f.). Junker (1999, pp. 336ff.) has pointed to a connection between the development of prestige goods economies and the emergence of a warrior elite. Another indicator of the politics of property rights and their shifts are settlement distributions, and arrangements that reflect land ownership and access (Earle, 2000, pp. 50ff.). Furthermore, physical markers may serve to mark territories, land (e.g. fields) and objects through constructions such as walls, cairns and mounds, ditches, hedges and the like. Land may also have been marked by special boundary ceremonies, enclosures, and the construction of villages and/or cemeteries associated with communities (Earle, 2000, pp. 51ff.). Field boundaries may have been marked, for example, by rows of pits, as known for the Bronze Age of Central Germany (Schunke, 2017, pp. 79ff.).

9.2.2.7 (Violent) Conflict and Reconciliation

The implementation of political decisions in a society, which also affects aspects already discussed, such as population pressure or access to resources and possessions, may have been the trigger for conflict. Conflict and reconciliation, therefore, form an important parameter in the study of policy implementation.

What situations led to conflicts within a society or between societies? When and how did violence play a role? Did conflicts serve to defend a society or to enforce political decisions within one's own society? And how were conflicts resolved or was there reconciliation? Were there strategies for conflict avoidance or resolution (confirmation of the status quo/change of the situation)?

The discourse on prehistoric conflict has prominently focused on the Bronze and Iron Ages. Warriors and so-called warrior elites (Earle, 2002, p. 363; Vandkilde, 1996, pp. 288ff.) as well as warrior ideologies play a concise role, whereby corresponding grave furnishings do not necessarily have to be warlike, but can also be social assignments of identity (Vandkilde, 2006, p. 69). Under this aspect, weapons in particular play a central role. In addition to weapon finds in graves that point to a single powerful, politically relevant identity (e.g. so-called 'princely graves'), weapon hoards are sometimes interpreted as an indication of a politically organised military (Meller, 2019a, pp. 146ff.) that served to defend a society and/or symbolised its troop strength (Meller, 2019b, pp. 109 f.). Furthermore, the appearance of fortifications can be an indicator of troubled times.

The assertion of interests can be reflected in the archaeological record in the form of violence with warlike confrontations as a political instrument of conflict for power. Evidence for the direct use of violence can be found primarily at battlefields (e.g. the Tollense Valley battle: Jantzen et al., 2011), mass graves (e.g. the Talheim massacre: Wahl & Trautmann, 2012) or on the basis of bone trauma and symbolically violent treatment of the dead (e.g. the circular grave complex at Pömmelte-Zackmünde: Spatzier, 2019, pp. 415 f.) – although the interpretation of such findings is difficult and must be discussed anew from case to case (Johannesson & Machicek, 2010, pp. 15 f.). Reconciliation, on the other hand, is much more difficult to capture and reconstruct. The question is also whether there was political reconciliation at all, or whether a conflict situation between societies was repeatedly reignited by political and military violence. Reconciliation also depends on whether the ideology of a society even considers reconciliation an option and has a plan for it. Depending on the definition, reconciliation can also represent a change or renewal (e.g. new networks) in archaeological data or, quite pessimistically, the absence of war (Johannesson & Machicek, 2010, p. 16 f.). Ethnographic comparisons would be decisive here, as there are many examples with war-reconciliation-war-reconciliation-… sequences that could provide us with clues for prehistoric political processes.

9.2.2.8 Knowledge

One of the most contentious issues in social theory is the relationship between power and knowledge (Garcia, 2001). Barnes defines power as 'the distribution of knowledge' within society, and claims that 'to possess power, an agent must be known to possess it.' (Barnes, 1988/2002, p. 126). Superior/specialised skill, knowledge, or success in locally valued domains, including domains related to social norms and rituals, often confer prestige on individuals. Hunting, oratory, shamanic knowledge and combat are all domains associated with prestige in small-scale societies. The production and application of these kinds of special knowledge influence the main sources of social power. Therefore, knowledge should be seen as a significant factor in the transformation of human societies through time and space.

A specific aspect of the role of knowledge within societies concerns highly specialised knowledge and social roles, such as religious or ritual specialists. Within social and cultural anthropological research, cosmological and/or religious aspects form a significant part of everyday life. Persons who are related to this kind of position, or who posses knowledge in this area are often given a voice regarding matters related to the community.

9.3 Approach

For our analysis, we will first present five case studies in a descriptive way, guided by the defined parameters. The case studies cover a large spatial framework, which is shown in Fig. 9.1.

The aim is to pick out the most important political aspects for our analysis, rather than to develop an overall presentation of the respective societies. For discussions of our case studies in general, we refer in each case to the extensive

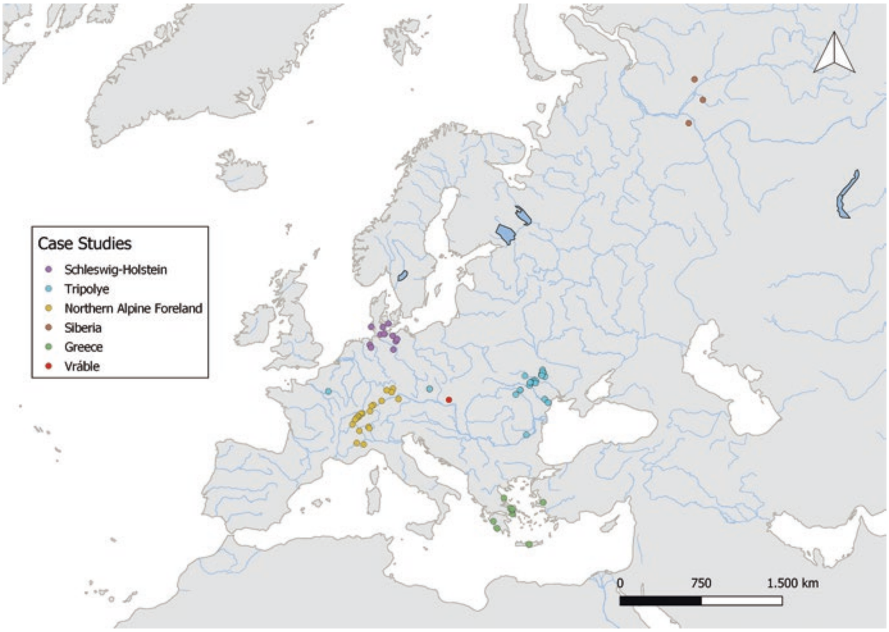

Fig. 9.1 Map of the case studies: Neolithic and Bronze Age Schleswig-Holstein, Neolithic and Bronze Age in the Northern Alpine Foreland, Neolithic and Bronze Age West Siberia, Neolithic Trypillia (Tripolye) and Iron Age Greece. In addition to that, the site of Vráble was used for comparison (see below). (Figure by the authors)

literature database. To compare our results based on the parameter description, we have numerically broken down our data to a presence or absence of political attributes defining the parameters. These attributes are listed and defined in Table 9.1.

For further analysis, we have used this table to develop a dendrogram of a hierarchical cluster analysis that best shows how the different parameters defined in our case studies co-occur, in order to discuss patterns of social organisation and their influence on the different political concepts, dynamics and transformations. This might also identify the most influencing factors in our parameters.

9.4 Case Studies

9.4.1 Case Study 1: Political Practice and Power Relations in Neolithic and Bronze Age in Schleswig-Holstein

The period of the Neolithic on the central North German Plain is characterised by diverse transformation processes ranging from Neolithisation to the full adaptation of metallurgy (Brozio et al., 2019b; Müller, 2019). For the following study of political practice and power in the Neolithic, the focus is on the transition from the fourth to the third millennium BCE on the southern Cimbrian peninsula (Brozio, 2020). The main subject is the developed Funnel Beaker (FBC) phenomenon between 3300 and 3000 BCE and the end of this phenomenon c. 3000–2800 BCE, as well as the Globular amphora (GAC: Müller et al., 2020) and Single Grave groups (SGC: Schultrich, 2018) in the region. With the Bronze Age, the new metal becomes a central factor of influence in socio-political events and promotes, in particular, a social differentiation during the Older Bronze Age (1800–1150/1100 BCE), which is transformed again with the burial change and the transition to the Younger Bronze Age (1150/1100–500 BCE) and gives rise to a new socio-political image of society that appears egalitarian (Fig. 9.2, c.f. Schaefer-Di Maida, 2023, 274f.).

9.4.1.1 Community Size

In contrast to the Mesolithic, the Neolithic from 4100/4000 BCE onwards is linked to an increase in people (Hinz et al., 2012), which peaks around 3400–3200 BCE, followed by a stable population until 3000 BCE (Müller, 2011). This can be attributed to the introduction of the plough, specialisation in certain cereals (Kirleis, 2019; Kirleis et al., 2011) and an increase in the importance of domestic animals in the subsistence economy. At the same time, villages such as Büdelsdorf LA 1 (Brozio, 2016; Hage, 2016) and Oldenburg LA 77 (Brozio, 2016), which are connected to population agglomerations, develop until 3000 BCE (Müller & Peterson, 2015). This phenomenon is also reflected in a building boom around 3200 BCE, in which about 1200 megalithic tombs were built in only 50 years (Brozio et al., 2019b). Estimates of the population density assume a total of up to one person per km^2 (Schiesberg, 2012).

Table 9.1 Definition of attributes

	Attribute	Definition	
Community size – (CS)	Small	>25	
	Medium	25–150	
	Large	150–500	
	Very large	500–2000	
	Mega	2000–10,000	
Conformity/ non-conformity – (CNC)	House configuration	Describes construction and internal division and internal organisation	
	Spatial distribution of pottery styles: uneven	Clustered within certain units	
	Spatial distribution of pottery styles: even	Crossing borders of households, quarters	
	Grave size/house size: low variability	To be defined within each case study	
	Grave size/house size: medium variability		
	Grave size /house size: high variability		
	Settlement layout: planned	Measures for community cohesion	
	Settlement layout: semi-planned/unstructured		
	Settlement layout: unstructured		
	Internal settlement density: single farms	e.g. BA SH	Measuring distance between house units
	Internal settlement density: low	e.g. Neo SH	
	Internal settlement density: medium	e.g. Vráble, Trypillia	
	Internal settlement density: high	e.g. Catal Hüyük, CH pile-dwelling, Athens	
	Dietary habits uniform	All eat the same	
	Dietary habits differentiated	Some eat ‘better’ than others	
(critical) resources: Access and distribution – (RAD)	Centralised	Pooling resources somewhere	
	Differentiated	Some places have more/different R than others	
	Decentralised	Evenly distribution of R	
	Unrestricted	Everybody can go to the mine and extract R	
	Restricted	A specific group has access to the source of R	

Network configurations – (NC)	Imports: low	
	Imports: medium	
	Imports: high	
	Mobility: low	
	Mobility: medium	
	Mobility: high	
Organisation of decision-making – (DM)	Meeting places	e.g. assembly houses, cooking stone pits, rondels
Property rights – (PR)	Pens and fences	Keeping livestock in the house or separated from others
	Continuity of house locations	
	Land divisions	
Conflict and reconciliation – (CR)	Enclosures/facilities of clearly fortified character	e.g. palisades, deep ditches or combinations etc.
	Enclosures/facilities of perhaps merely demarcating character or with other functions	e.g. causewayed enclosures
	Weapon-tools	
	Weapons for war	
	Traumata: no burials, low	
	Traumata: medium	
	Traumata: high	
	Regional population aggregation ongoing	Measures for community cohesion
	Regional population dispersal ongoing	
Knowledge – (K)	Network-embeddedness: low	Embeddedness in an over-regional worldview/ideology (e.g. shared symbolism)
	Network-embeddedness: medium	
	Network-embeddedness: high	
	Craft specialisations	e.g. workshops, kilns

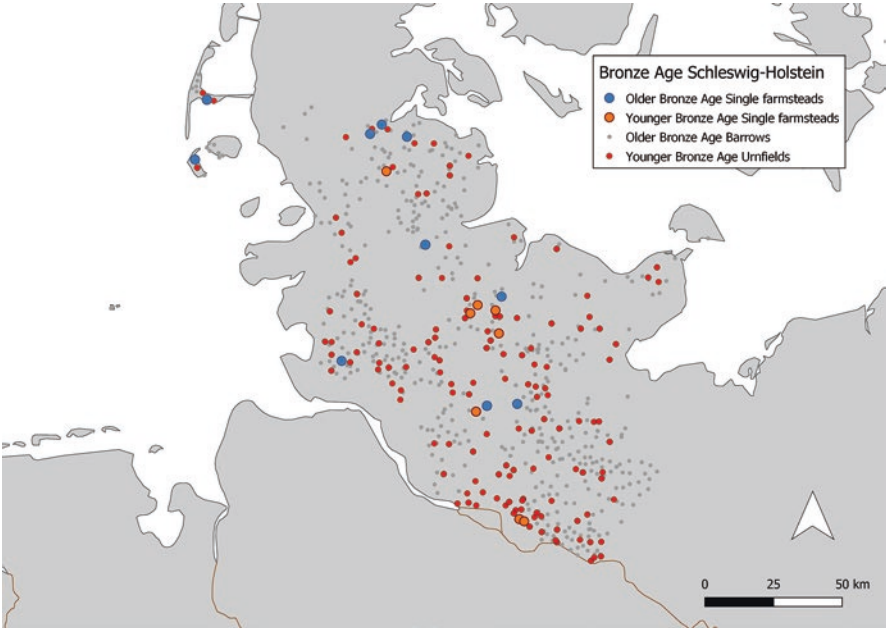

Fig. 9.2 Map of Bronze Age barrows and settlements in Schleswig-Holstein. (Figure by the authors)

Around 3000 BCE, a decline in the human impact is first recorded, which is associated with a decline in population (Hinz et al., 2012). Villages begin to disappear and smaller domestic sites start to develop (Brozio et al., 2019a). At the same time, more and more flat graves and burial mounds are being constructed which, with individual burials, contrast with the collective burials of the passage graves.

Older Bronze Age burial mounds (1800–1150 BCE), which stand out visibly in the landscape, probably represent only 10 per cent of a society, according to Kristiansen (2018, p. 110), while the remaining 90 per cent either received a flat grave (that are not easy to find in the landscape) or – which probably applied to the majority of the population – no grave at all. Therefore, calculations of household sizes and person numbers in communal activities such as barrow or house construction make more sense for the reconstruction of community sizes than the number of graves. For the construction of a medium-sized barrow, which measured about 20 m in diameter, about 37 people were needed, if a person-hour number of 10 is assumed (Falkenstein, 2017, pp. 80 f.; Schaefer-Di Maida, 2018, p. 39, Table 2; Schulze-Forster & Vorlauf, 1989, pp. 261 f.). A smaller group of people would have sufficed if two days were planned for the construction. By comparison, for houses of 150 m^2, which can be proved for the transition from period I to II (around 1300 BCE) in Schleswig-Holstein (Schaefer-Di Maida, 2023), about 15–20 inhabitants will be assumed (by considering stable areas of about 10–15 persons), i.e. enough people to cover the numbers necessary for a grave mound construction within two to three days. Examples of burial mounds built on the remains of houses highlight the connection between households and grave mounds (e.g. Handewitt, Trappendal, Hyllerup: Svanberg, 2005, p. 79). Therefore, the number of people who could live in a household may have been limited in order to have had enough space in the house for everyone, as well as not to exceed a fixed number of people for rituals related to barrow construction. Accordingly, a community (household) size of a maximum 20 persons can be assumed between 1500 and 1200 BCE. Between 1200 and 500 BCE, burial mounds are no longer or rarely built and the houses become smaller, so that smaller, more variable community sizes must be assumed.

9.4.1.2 Conformity/Diversity

The phase between 3300 and 3000 BCE is characterised by strong conformity. The houses do not display distinct differences, and no political buildings like assembly houses etc. are evident. The burials were mainly collective burials and there was no separation of sexes or ages. Also, ceramic vessels with standardised shapes and decorations were very common. From 3000 BCE onwards, however, single burials in flat graves became the norm, as well as increasingly in burial mounds (Hübner, 2005; Mischka, 2022; Schultrich, 2018). The groups are becoming more and more separate from each other, symbolically and spatially, not least due to the dissolution of villages. Through Store-Valby, there is also a process of intentional dissociation from FBC culture, through a turning away from a centuries-old symbolic identity and social practices (Brozio et al., 2019a).

During the Older Bronze Age, graves were very probably a privilege and the effort put into their construction, as well as their furnishings, indicate strong social differences. The burial mounds stand out not only because of their monumentality but also because of their rich equipment, which strongly contrasts with the small and inconspicuous flat graves; which in turn also represent a privilege compared to the individuals who were not given a grave at all. This changes with period III (1300–1100 BCE), when cremation becomes established and not only the treatment of the dead (cremation) but also the grave construction (urn grave) and furnishings (dress elements and personal objects) become uniform. The new uniform grave construction, which leaves behind any monumentality and significance, may signify the new egalitarian social-political structures (visible at least in the grave construction), as well as an economic reduction (Fig. 9.3). At this point, there are hardly any differences in the grave goods between all the graves, so that a social standardisation without certain stratification can be assumed – at least for the afterlife. In addition, the number of burials also increases significantly, so that a grave no longer seems to be a privilege, but becomes the norm, affordable for more people – or even everyone – and shows the establishment of a new socio-political system.

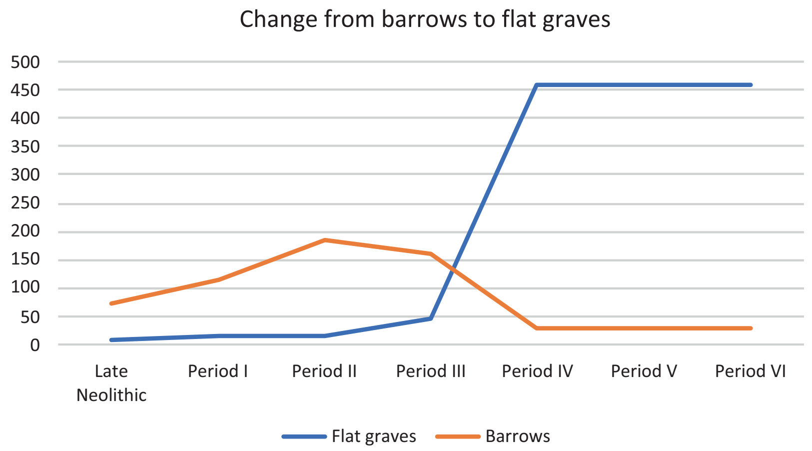

Fig. 9.3 The Bronze Age burial rite changes from barrows (Older Bronze Age) to flat graves with urns (Younger Bronze Age) in Schleswig-Holstein

9.4.1.3 (Critical) Resources: Access and Distribution

The capacities of the examined regional landscape were at no time reached by the Neolithic economic system (Knitter et al., 2019). After a phase of importing copper, including the ability to process it, imports stopped from 3300 BCE onwards (Klassen, 2000). This is attributed to declining mining in the raw material areas and changing networks (Radivojević & Grujić, 2018).

For the Bronze Age, a central factor in the resources parameter is graves. The monumental burial mounds could reach a width of up to 50 m and sometimes contained complex stone constructions, as well as a wooden coffin and even coverings with sods. These burial monuments are associated with high resource use, as well as energy expenditure for which several people would have been needed. Accordingly, access to a grave mound also meant access to resources, land and labour. Decisions regarding such access rights would have to have been centrally regulated and accepted, otherwise a joint construction would not have been possible. The organisation could also have been subject to a fixed ritual that followed certain rules, such as the size of the mound, as well as its exact construction, and certain people to carry it out (Falkenstein, 2017). The unequal sizes of the northern German barrows may have signified gradations in social structure, which may also reflect different access and property rights. This contrasts with the majority of people who received a poorer grave or no grave at all. These socio-political regulations change around 1300/1200 BCE with the introduction of cremations and urn burials, which can stand both for the new egalitarian social structures with less social differentiation, and for an economic reduction in general, as urn graves require fewer resources, space and labour in comparison to the big barrows in northern Germany (Schaefer-Di Maida, 2018).

9.4.1.4 Networks Configurations

The groups between 3300–3000 BCE were integrated into networks that served less for material exchange than for the transfer of information. This is expressed in vessels with shapes and decorations that indicate far-reaching communication structures, the dimensions of which decreased more and more until 3000 BCE (Furholt, 2012; Lorenz, 2018). Around 3000 BCE, there is an integration of other ideas and people, in the form of the FBC (Brozio, 2016; Müller et al., 2020). With the foundation of the SGC, participation in wide-ranging European networks begins to become more important (Furholt, 2021).

The introduction of bronze and the related exchange relationships probably occur at the beginning of transformative socio-political changes in the Bronze Age. Metallurgy not only brought new labour sectors, but also a monopolisation of raw materials, products and communication, which favoured social hierarchies and new political structures. The new material was considered desirable and is primarily found in deposits and graves. It might have directed geographic orientation and the extent of networks (Johnston, 2020, p. 44). Period I (1800–1500 BCE) depot finds often show signs of wear and tear, and thus show that bronze was not so widely available at first. Only with Period II (1500–1300 BCE) did the depot finds increase in abundance and distribution. The increased import of metals made society dependent on bronze mining activities in other regions, on suppliers and traders as well as on its ‘own’ local bronze casters and bronze workers. Access to such a network may have been regulated by individuals or small groups, who also eventually regulated access to metal objects. The increase in bronze finds in general with Period II (1500–1300 BCE) was probably driven by increased demand, as well as an enlargement or multiplication of networks. With the change in burial rite (1300/1200 BCE) these networks seem to collapse, as there are almost no depot finds anymore and grave goods mostly consist of personal everyday objects. Within the course of the younger Bronze Age new networks are established and depot finds predominate over grave goods.

9.4.1.5 Organisation of Decision-Making

There are only a limited number of indications for individual personalities between 3300 and 3000 BCE, possibly represented by axes in collective burials. An important role may have been played by gatherings such as the construction of monuments, which may have been connected with feasting and served not only to pass on rules and norms, but also to discuss decision-making processes. From 3000 BCE onwards, the individual emerges in the burials. Equipped with battle axes and beakers, symbols of a network extending over large parts of northern, central and south-eastern Europe, a single man in the group is presented in a specific way as the decision-maker.

For the Older Bronze Age, questions about decision-making processes become clear, especially in the grave analyses: who received a burial mound, who received a grave of any kind, and who received none at all? These decisions must have been strictly regulated and also recognised, otherwise cooperation in the construction of a burial mound would not have been possible in the first place. It required certain economic and group identity-forming cooperative structures and associated orders such as planning, control, logistics, division of labour and technical experience. Authority may have been important with such a large group of people, although it may not necessarily have been hierarchical, and it is unclear whether this authority or group structure existed outside the cooperative relationships at the burial mounds (Stanish, 2017, pp. 97ff.). The same applies to house building, which required a similar cooperative structure. The decisions about the roles in such actions may have been part of a household, while its head may have been the one who made the decisions and was the one who received a barrow. After his or her death, the successor may have been able to direct the construction of the burial mound. The other household members, on the other hand, must all have had a similarly fixed position that assigned them a specific activity in this process and also in other contexts. Therefore, the household can be seen as a social and political institution of economic activities. With the transition to the Younger Bronze Age, these decision-making arrangements seem to change greatly, not to mention break off and form anew. At the centre of the changes is the transition to cremation, which cannot to be seen as a decision of the individual, but as a common, almost simultaneous change in the community's world view (*Weltanschauung*) of a community. The moment of adopting a new worldview brings with it the possibility of overturning other structures of a society, and power relations that were previously subject to a general consensus, by linking them to the new ideology. In contrast to the decision to build graves only for certain people, simple urn graves are now made accessible to all. The decrease in house sizes goes hand in hand with this and underlines once again that house communities were probably responsible for the graves. Due to the lack of cooperation in grave maintenance, it can be assumed that a corresponding structure also disappeared or changed in the household, and there was no longer a head of household, but decisions were discussed and made in the group.

9.4.1.6 Property Rights

Between 3300 and 3000 BCE, common households are the norm, with only minor differences in material culture. The separation of settlement and ritual landscapes with megalithic graves indicates territories belonging to individual groups that may have been passed down through generations (Brozio, 2016). With the third millennium, higher mobility is associated with the groups of the SGC, combined with stronger livestock husbandry. Linked to the stronger focus on livestock, there is a lower intensity of monumentality (Schultrich, 2018) with smaller burial mounds in the landscape.

Bronze Age possessions include graves, but also houses, animals and land. The aforementioned use of graves, which in the Early Bronze Age were apparently only accessible to certain people, thus seems to represent a kind of property right. The resources flowing into them in the form of land, building materials and the grave goods come first. The more valuable these resources were, the stronger were probably the property rights. The uneven size of the burial mounds, for example, could reflect the ownership of a household. In addition, houses may also show property rights belonging to a house, a household, the household goods or an entire settlement area. It took on an expanded economic meaning with the representation of livestock ownership against a background of economic efficiency and competition. From Thy we know of clear evidence of stable pens in this context (Bech & Haack Olsen, 2018, pp. 161–184). The collection of dung (for farming and fuel) and the protection of animals from robbery or bad weather in the house may also have been important. Besides animal husbandry, agriculture was also an important part of a household. Small field units of 20 to 50 m, the so-called ‘celtic fields’, were marked by boundary walls (Arnold, 2011, pp. 439ff.). Traces of secondary subdivisions and mergers of fields may indicate ownership-oriented, rather than cooperative, use (Arnold, 2011, p. 449).

9.4.1.7 (Violent) Conflict and Reconciliation

Between 3300 and 3000 BCE, the organisation of society can generally be described as egalitarian prestige societies (Brozio et al., 2019b; Müller, 2019). A central aspect could have been the obtainment of prestige by feasting (Weber et al., 2020), as well as the construction of monuments as an expression of power. This tendency towards peaceful cooperation and/or competition between individuals and groups is manifested in the construction of graves and decoration on vessels as distinctive features. In addition, jewellery and highly decorated ceramics (1 weapon vs. 50 vessels in the passage grave Wangels LA 69 in Eastern Holstein) are medial mediums of expression, rather than weapons (Brozio, 2019). From 3000 BCE onwards, an increase in weapons in the form of battle axes can be observed (Brozio, 2020; Schultrich, 2022). This is probably linked to the development that the number of authorities in power rises, based on small groups with single authorities.

The conflict potential of the North German Bronze Age is only moderately known. For the Older Bronze Age, the grave goods show an increase in weapons. In particular, the weapon burials of Period II have often been associated in research with a ‘warrior elite’ (Earle, 2002, p. 363). As Vandkilde (2006, p. 69) already noted, such an identity need not have been warlike, but may also have symbolised a social role in a society. Anthropological investigations are also insufficient for the study area, so there is no evidence of injury rates. A clear but singular find is the battlefield in the Tollense Valley in Mecklenburg-Western Pomerania (Jantzen et al., 2014), which occurs around 1250 BCE and thus alongside the change in burial. The location of this battle indicates a conflict over the control of trade routes. In Schleswig-Holstein, the breakdown of networks is noticeable at this time, with a collapse in depot finds; however, no battle was triggered. In addition, everyday conflicts at the household level are to be suspected, although they are even less verifiable. Regular or irregular meetings held at gathering places such as the cooking stone pit fields (Kruse & Matthes, 2019; Schaefer-Di Maida, 2022) might have served to resolve conflicts.

9.4.1.8 Knowledge

Even though there are many indications for an egalitarian society between 3300 and 3000 BCE, some cases of special knowledge can be identified. This includes knowledge about the production of individual tool types, such as polished flint axes, as well as architectural knowledge about the construction of megalithic tombs or longhouses. Also connected with this is a way to create, present and consolidate social order and power (Müller, 2018). Around 3000 BCE, on the other hand, an increasing symbolic separation from the ancestors and rule systems of previous generations has to be noted (Brozio et al., 2019a).

Innovative knowledge and new ideas probably spread together with artefacts and resources in the Bronze Age in Schleswig-Holstein and were thus in constant circulation. Those who had connections also had access to them. Traditional knowledge, such as on burial rituals, was probably passed on internally (family, household, social group). Certain knowledge was thus reserved for certain people and gave them a certain special position. Knowledge of house and grave construction meant power on the one hand, but also dependence on cooperation, in order to be able to carry out construction activities, on the other hand. Innovative constructions, such as the three-aisled houses, might have been demonstrated by local or non-local travelling craftsmen. Such craftsmen have been identified, for example, by Eriksen (2018, pp. 281ff.) for flint technology at Bjerre sites during the Early Bronze Age. Rare findings in barrow construction, such as certain sod-laying structures (e.g. in Skelhoj: Holst & Rasmussen, 2012, pp. 260ff.) or the formation of an iron core through regular watering of barrows, which led to mummification (Breuning-Madsen & Holst, 1998, pp. 1108ff.), must be attributed to the knowledge of certain leading and executive persons. The burial change around 1300/1200 BCE was probably introduced into society through new rituals, knowledge (cosmology) and beliefs. It is possible that the knowledge of a new burial method, combined with a new cosmology, went hand in hand with new socio-political structures.

9.4.2 Case Study 2: Neolithic and Bronze Age in the Northern Alpine Foreland

Archaeological, bioarchaeological, dendrochronological and paleoenvironmental studies conducted on Neolithic (4300–2200 BCE) and Bronze Age (2200–800 BCE) lakeshore settlements in Switzerland and the northern Alpine Foreland provide us with the possibility of creating a comprehensible and well-founded, but contestable, picture of past human-environment interactions during that period. The prehistoric communities of the Northern Alpine Foreland show a distinct settlement behaviour which prefers locations at the shores of bodies of water, and short-lived phases of occupation of about 10–20 years, resulting in a high residential mobility within a given territory spanning several kilometres – *Siedlungskammer* (Ebersbach, 2013; Köninger, 2015). The reciprocal social and environmental conditions, and choices to create and maintain such a settlement system, are debated (e.g. D. Hofmann, 2013; Röder et al., 2013; Trachsel, 2005) and belong to the sphere of investigating socioecological systems and socio-political organisation.

9.4.2.1 Community Size

The Neolithic and Bronze Age community sizes in Switzerland can only be estimated from the number of houses in the well-investigated lakeshore settlements; there are no full settlement plans from mineral soil preserved sites that provide information about community sizes further from the lakeshores. Based on the excavated and well-known sites, Neolithic settlements have about 5–25 houses, where 6–10 houses can be expected on average. The houses are rather small, with 3–6 m in width and 6–13 m in length (33–55 m^2), and in general 3–7 inhabitants are expected per house (Hasenfratz & Gross-Klee, 1995; Hofmann, 2013; Hofmann et al., 2016). The picture changes for Late Bronze Age houses, which are in many cases larger than Neolithic ones. Late Bronze Age houses can have an area of up to 100 m^2 and 5–15 people are expected to inhabit one house. During the Late Bronze Age, the settlement size increased with respect to the upper limit of houses, where 5–50 houses could make up a settlement and 15–20 houses could be regarded as usual (Benkert et al., 1998; Köninger, 2015).

From these numbers we might expect Neolithic community sizes ranging between 15 and 175 people, and Bronze Age community sizes ranging between 25 and 750 people. The community size of Neolithic lakeshore settlements seldom exceeded 200 people (outliers e.g. Sutz-Lattrigen, Hauptstation (Fig. 9.4:1), Marin-les-Piécettes (Fig. 9.4:2), and therefore ranged in most cases within the proposed size of Johnson (1982) and Dunbar (1993), where aggregated or institutionalised decision-making is not necessary. This picture changed during the Late Bronze Age; lakeshore settlements during that period could be constituted of up 50 houses (e.g. Hautrive Champréveyres (Fig. 9.4:3)) which suggests community sizes closer to or exceeding proposed limits, where either a fission process occurs within the community or aggregated decision-making levels would need to be introduced (cf. Alberti, 2014).

Although there is much conformity in the settlement layout (see below), the sizes of the settlement communities show variability during all phases of the Neolithic and Bronze Age (Hafner et al., 2016; Hofmann et al., 2016; Köninger, 2015). Together with the known brevity of many of the lakeshore settlements, this variability indicates a dynamic system where the mobility of individuals and whole household groups is to be expected; this is especially well-researched for the Neolithic periods (Ebersbach, 2010a, b, 2013).

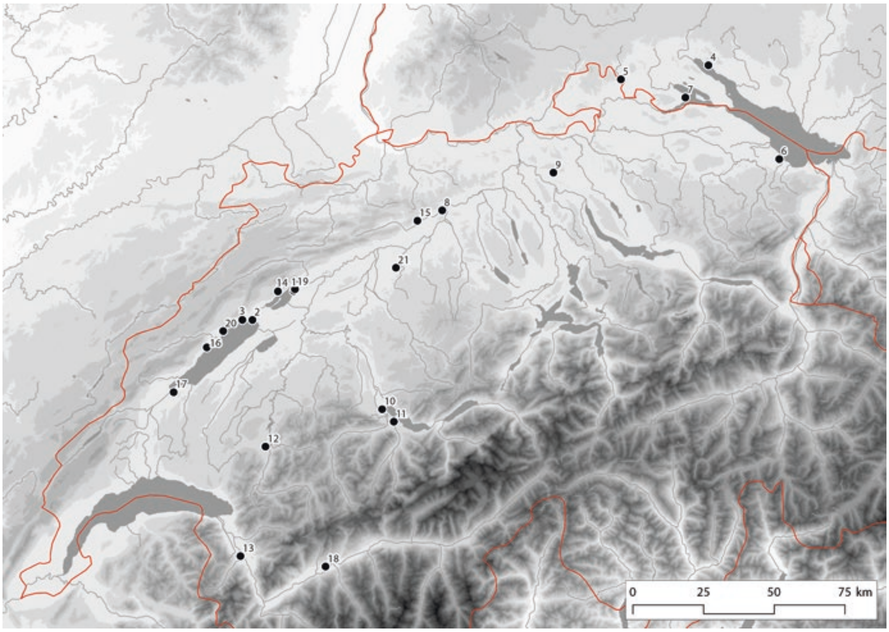

Fig. 9.4 Map of Neolithic and Bronze Age sites in the Northern Alpine Foreland mentioned in the text. (Figure by the authors)

9.4.2.2 Conformity/Diversity

The houses in lakeshore settlements can be described as uniform. During the Neolithic and the Bronze Age, the houses within a settlement exhibit similar dimensions and can be described as rather lightweight constructions (Benkert et al., 1998; Hasenfratz & Gross-Klee, 1995; Hofmann, 2013). Diverging from this statement are so-called ‘pioneer houses’; the first houses to be built and shelter a group of initial settlers. These houses are slightly bigger than the ‘late-comer houses’, as it is thought that the initial settlers were responsible for preparing the location for following members of the settlement community. The larger size of initial houses is a pattern that can be traced over the whole Neolithic (Bleicher, 2009; Ebersbach et al., 2017; Hofmann, 2013). Singularities in the conformity of lakeshore settlement houses are ‘cult houses’, of which two good examples are known. One from Marin-les-Piécettes (Fig. 9.4:2) where a larger house was erected on an artificial heaped mound, the mound and the house show several phases of use (Honegger, 2001, 2007). Another example is the ‘cult house’ of Sipplingen Osthafen (Fig. 9.4:4); it does not exceed the dimensions of a usual house, but its interior was highly decorated, with seven representations of female bodies as wall decoration. This is not known – at least in this abundance – from other sites (Schlichtherle, 2016). For many Younger Neolithic (4300–3500 BCE) settlements in western Switzerland, it is known that small house-like structures are constructed a few meters away from the dwelling-houses, facing them ridge-sided. Those structures are smaller than the dwelling-houses and often are interpreted as storage buildings or workshops. However, there is no clear evidence in the material culture as to what activities those buildings were used for (Crivelli et al., 2012; Hafner & Suter, 2000; Hasenfratz & Gross-Klee, 1995). For the Neolithic settlements on the eastern Alpine Foreland, smaller buildings are also known but do not appear in such reoccurring and clear embeddedness within the settlement's structure (Schlichtherle et al., 2010). Diversity in the realm of the house is witnessed in the architectural features, which show differences across the regions (Hasenfratz & Gross-Klee, 1995; Hofmann, 2013).

The settlement as a whole very much shows conformity and very probably a cultural model of settlement layout. Earliest lakeshore settlements already show the basic layout that was repeatedly built during the Younger Neolithic (4300–3500 BCE); one or more rows of tightly packed houses with their ridge side facing the lake, or parallel to the shore. There are exceptions – so-called *Haufendörfer* – where houses are arranged seemingly chaotically. From the Late Neolithic (3500–2400 BCE) onwards, most excavated settlements resemble the so-called *Strassendorf* type of settlement, in which two rows of houses parallel to the shore oppose each other. These settlement layouts are already known from earlier phases (e.g. Sutz-Lattrigen Hauptstation (Fig. 9.4:1), Marin-les-Piécettes (Fig. 9.4:2)) but the pattern first becomes obvious and repeated in the Final Neolithic (2750–2200 BCE) (Ebersbach et al., 2015; Hafner & Suter, 2003; Hafner et al., 2016; Hasenfratz & Gross-Klee, 1995; D. Hofmann et al., 2016). Bronze Age settlements still share the Neolithic idea of a denselybuilt settlement structure; however, no clear layout repetition can be observed (Benkert et al., 1998; Köninger, 2015). In the context of the settlement, Neolithic communities show a high level of conformity in their way of living. Similar-sized houses and dense settlement structure of houses in parallel rows dominated settlement layouts across the Neolithic and were also present during the Bronze Age.

Most of the lakeshore settlements exhibit structures that are probably communally built and maintained, such as trackways, platforms, fences and palisades (Eberschweiler & Heumüller, 2016; Hofmann, 2013).

Due to the settlement dynamics at the lakeshore – at least during the Neolithic – the uniformity of settlements may result from the repeated – at least once in a lifetime – relocation of a settlement. A clear layout model of how the settlement should be 'rebuilt' at a new location makes things easier to organise, as one already knows where houses, etc. will be constructed. Furthermore, a densely-built structure reduces the labour investment requires for preparation of a new settlement location by reducing the actual ground area.

9.4.2.3 Resource Access and Distribution

Within Neolithic settlements there are hints of differentiated resource access and consumption; however, until thus far no patterns emerge that would speak to institutionalised inequality in access to resources. The Late Neolithic Settlement of Arbon Bleiche 3 (Fig. 9.4:6) shows a distinct distribution of animal bones, suggesting a differentiated consumption of meat within the settlement community. While the southern quarter of the settlement had more open-water fish and pig, the northern quarters show more bankside fish, cattle and goat. This distribution could be a sign of restricted access rights to fishing and grazing grounds for respective parts of a settlement community (Doppler et al., 2012; Röder et al., 2013). The example of Arbon Bleiche 3 (Fig. 9.4:6) shows the possible differentiated animal husbandry strategies of different parts of the settlement community. Such a differentiation also leads to differences in manure availability for cereal fields. At the Younger Neolithic site of Horstaat Hörnle IA (Fig. 9.4:7), cereal storage finds showed that some households had the ability to manure their field plots more intensely than others. Owning more animals, especially cattle, not only had the advantage of owning and using them for dietary products, traction and food, but also of increasing the yield of cultivated plants (Ebersbach, 2002; Styring et al., 2016). Material culture such as pottery, flint or ground stone tools seem to be normally distributed in the settlements (Hochuli et al., 1998; Stöckli et al., 1995).

During the Neolithic, flint sources might have been a critical raw material that provided communities who had access with advantages in trade and socio-political relations. In Switzerland there are two flint mines, or regions with better flint exploitation, around Olten Chalkofen (Fig. 9.4:8) and Otelfingen-Weiherboden (Fig. 9.4:9), that show signs of intensive settlement activity in the area around the sources during all Neolithic periods. However, no well-preserved sites have been excavated to date which could hint at different or richer inventories within the communities around that economically important area compared to other communities (Affolter, 2002; Lötscher, 2015). From the Early to the Late Bronze Age (2200–800 BCE), the overall settlement structure on the Swiss plateau changed and a shift of settlement activities towards the Alps, on higher elevated areas, took place. Core settlement regions, however, are established in the entrances to inner-alpine valleys. These choices of location hint at a will or need to control resources and flows of commodities such as copper ore, but also pasture land or timber, coming from the inner-alpine valleys (Köninger, 2015; Rychner, 1998). It can be assumed from rich grave finds that settlement communities holding economically important locations at the valley entrances (e.g. Thun (Fig. 9.4:10), Spiez (Fig. 9.4:11), Bulle (Fig. 9.4:12), Monthey (Fig. 9.4:13)) accumulated 'wealth' and deposited it with (some of) their dead (David-Elbiali, 2000; Hafner, 1995). Yet other communities, located away from valley entrances, also had the opportunity to gain 'wealth'; as shown, for example, by the extraordinary find of the bronze hand of Prêles (Fig. 9.4:14), at the Jura lakes (Schaer et al., 2019). Over the course of the Bronze Age, an increase in the density of sites – maybe *Siedlungskammern* – can be traced, leading from the fringes of the alpine area to the low-lying lake landscapes. However, Bronze Age settlements far from the lakeshores show locations of controlling geographies, indicating claims to manage the flow of goods and people (Laabs, 2019).

9.4.2.4 Network Configurations

For the whole of prehistory, the lakeshore settlements in particular show a very dense network between settlement communities. High mobility of entire communities and households reflects the short-lived nature of settlements and the patterns of settlement growth and decline (Ebersbach, 2010b, 2013). Ebersbach (2010a) suggests a socio-spatial dynamic where individuals and household groups can move more easily between settlement groups, as the relationship between communities of practice are not bound to a single residential group. Individual mobility is hard to trace, but the aDNA and isotopic investigation into the burials from the dolmen of Oberbipp (Fig. 9.4:15) (c. 3350–2950 BCE) hint to a virilocal community (Lösch et al., 2020). The interconnectedness of communities around the lake is shown by pottery decoration and forms, and during the Bronze Age in the ornamentation of bronzes, as well as the finds of sickles in different locations fitted to a single (and known) casting mould (Jennings, 2012). Ebersbach's (2002) findings concerning Neolithic cattle husbandry show that many of the reconstructed herd sizes are not sustainable if the settlement communities do not bring them together from time to time. Isotopic evidence from Neolithic cattle also suggests that differentiated grazing modes were present, but the pooling of herds over winter seems reasonable (Gerling et al., 2017). All in all, we can expect intense local networks of exchange and collective strategies in regard to animal husbandry, and maybe even beyond.

Due to finds in most of the material culture types (pottery, flint, metal, etc.) it can be shown that the Neolithic and Bronze Age Northern Alpine Foreland was connected with many parts of Europe. The Europewide networks of exchange and communication are shown by the presence of materials from a great distance (e.g. amber, jade, Grand Pressigny flint) and stylistic forms of objects (e.g. *Ösenkopfnadeln*), as well as influences of Pan-European cultural changes (e.g. Corded ware, Bell Beaker, Urnfield: Brunner et al., 2020; Hafner & Suter, 2003; Hochuli et al., 1998; Köninger, 2015; Stöckli et al., 1995). However, there are major differences between the West and the East of the Alpine Foreland that show their embeddedness in different parts of those Pan-European networks (Ebersbach et al., 2017; Heitz & Stapfer, 2016). In general, due to the gradient of temporal development and the increased importance of metal, the Bronze Age networks seem to be more intense and the Alpine Foreland better integrated into far-reaching trade and exchange (Jennings, 2014).

9.4.2.5 Organisation of Decision-Making

There are few indications as to how decision-making processes during the Neolithic may have looked. The general uniformity in house sizes and little differentiation between household consumption does not speak to any stratified institutions. Places of gathering, where one or more settlement communities may come together to organise, debate, conciliate and make decisions are maybe larger or special houses (see above) or menhir alignments (e.g. Bevaix/Treytel-À Sugiez (Fig. 9.4:16), Yverdon-les-Bains (Fig. 9.4:17), Sion-Petit-Chasseur (Fig. 9.4:18)). menhir alignments, or single menhirs, are often erected in Neolithic times, but used over the whole of prehistory (Burri-Wyser, 2016; Grau Bittleri & Fierz-Dayer, 2011). Their locations remain stable over time and might be seen as a reference point for communities, given their mobile lifestyle. As mentioned above, the population of Neolithic settlements normally did not exceed the expected size for nested decision-making to emerge. Therefore, we would expect decentralised networking communities with non-institutionalised hierarchies in the Neolithic Northern Alpine Foreland.

The picture seems to change with the Bronze Age. First, we see differentiated wealth, status and prestige consumption in graves (David-Elbiali, 2000; Fischer, 1998). Individual power – or the power of an associated group – is represented not only in grave goods but also in grave monuments, such as stone cists or burial mounds. From the Early and Middle Bronze Age we know of very rich burials with exceptional equipment for the alpine regions. Examples are graves from Thun, Renzenbühl (Fig. 9.4:10) (David-Elbiali, 2000; Hafner, 1995) and the sensational grave find from Prêles (Fig. 9.4:14), where the first European bronze hand sculpture was found (Schaer et al., 2019). Settlement sizes, however, do suggest larger communities, but there is no sign of centralisation processes, and the distribution of settled areas on the Swiss plateau even becomes denser (Laabs, 2019). This picture suggests that decision-making in a settlement community became more authoritarian; centred around economically powerful people and groups. However, although their location on trade routes and their access to resources played an importation role in allowing communities to thrive, it is unclear if such communities extended their influence over other adjacent settlement communities.

9.4.2.6 Property Rights

For Neolithic and Bronze Age settlements it seems to have been common to keep some parcels for houses free in the course of settlement growth, while others were built upon (Ebersbach, 2010a; Köninger, 2015). It is known from multiple settled sites that houses are placed over the remains of older house structures (Ebersbach, 2013). These findings suggest that the neighbourhood was planned and might indicate that space in the settlement was reserved for a specific group.

Access to patches of soil that provide good substrata for cereals in particular, and plant cultivation, pasture and woodland in general, was crucial to sustaining the community with basic sustenance. If we accept the idea of the *Siedlungskammer* as a long-term stable reference territory in which a settlement community changes repeatedly locations over decades or centuries, such as the bay of Sutz-Lattrigen (Fig. 9.4:19) or Auvenier (Fig. 9.4:20), those territories and their integrity towards other communities might have been a communal property (Trachsel, 2005). One argument for such a concept is the resettling of locations when the best building wood is available, which indicates woodland management of sites that were not occupied and long-term labour investment into the landscape (Billamboz & Köninger, 2008; Suter & Francuz, 2010).

9.4.2.7 (Violent) Conflict and Reconciliation

Defensive structures for settlements are known from the whole of prehistory. During the Bronze Age palisades become more common and seem to have real fortification purposes (Hafner, 2010). The locations of some non-lakeshore settlements in the Bronze Age exhibit a more defensive location on hilltops (Benkert et al., 1998; Köninger, 2015). Additionally, weapons of war became more common during the Bronze Age, but tool-weapons are customary throughout the Neolithic and Bronze Age (Rychner, 1998; Stöckli, 1995). There are only a few traumata investigations on prehistoric skeletons; however, those that do exist indicate more violent deaths during the Bronze Age (Simon & Kaufmann, 1998; Simon et al., 1995).

Features that can be connected to acts of reconciliation may be the menhir alignments, as places of gathering. These are often already erected and used in the Neolithic, but then reused during the Bronze Age (Besse, 2014; Burri-Wyser, 2016). In the inner-alpine areas votive deposits are frequent during Bronze Age; they can be found between two settlements (Ballmer, 2010), and maybe represent places of reconciliation.

9.4.2.8 Knowledge

From the archaeological evidence, we can expect a distribution and level of knowledge similar to that in many other Neolithic and Bronze Age societies in Central Europe.

Craft specialisation is to be assumed for metallurgical tasks, especially during the Bronze Age, but also in resource extraction for the whole of prehistory (Affolter, 2002; Fasnacht, 1998). The distribution of tool finds in settlements suggest that most were used equally by households and there was little specialisation in everyday tasks (Hafner & Suter, 2000; Trachsel, 2005). Specialisation in animal and plant husbandry is indicated by the differentiated distribution of species in the settlements, but does not follow clear patterns that would hint at the restriction of knowledge (Doppler et al., 2016; Kerdy et al., 2019). During the Bronze Age the increased consumption of weapons of war in graves and the fortification of settlements can be seen as the presence of a specialised warrior-status (Primas, 1998; Vandkilde, 2018).

A specific kind of knowledge that can be shown by the unique preservation circumstances of the lakeshore settlements, but surely existed in prehistoric societies in general, is the long-term forest management and understanding of forest growth-cycles (Billamboz & Köninger, 2008; Suter & Francuz, 2010).

For the Neolithic lakeshore settlements, the existence of cult houses connected to maternal features (Schlichtherle, 2016) suggests the presence of ritual specialists. Additionally, the possibility of meaningful alignment of menhirs in accordance with the yearly positions of the sun (Besse, 2014; Burri-Wyser, 2016) suggests ritual specialists during the use of such places.

Potential socio-politically influential knowledge is represented by the so-called pioneer houses during the establishment of a new settlement location. These houses are slightly bigger and exhibit a different composition of animals, dominated by game. It has been suggested that a group of experts moved first to clear the new settlement location, and to start building the first structures, and that during this time this group was more reliant on hunting (Ebersbach, 2013).

9.4.2.9 Cluster Analysis

The results of the cluster analysis for Swiss prehistory show that all three differentiated time slices – Younger Neolithic (Neo_I; c. 4300–3500 BCE), Late to Final Neolithic (Neo_II; c. 3500–2200 BCE) and Bronze Age (BA; 2200–800 BCE) – share many given features. However, the distinction between the Neolithic and Bronze Age is clear. The Neolithic time slices can be differentiated by the increased supra-regional network embeddedness, also represented by increased imports. During the Late to Final Neolithic this is represented by the rather regional Horgen (c. 3300–2800 BCE) and later the pan-European Corded Ware (2800–2400 BCE) and Bell Beaker (2400–2200 BCE) phenomena. The hints for differentiated dietary habits during the Younger Neolithic derive from the Hornstat-Hörnle IA (Fig. 9.4:7) evidence of differentiated access to manure (Styring et al., 2016), but also more game-dominated settlements such as Burgäschisee, Süd (Fig. 9.4:21) (Kerdy et al., 2019). In addition, we observe occasional larger settlements in the Younger Neolithic and Bronze Age, which are not seen during the Late and Final Neolithic. The Bronze Age is mainly differentiated from the Neolithic by an increased embeddedness into European networks of trade and exchange, and specialisation in crafts due to metallurgy and ore extraction. Clear defensive fortification of settlements hints at increased conflict. Furthermore, the duration of Bronze Age lakeshore settlements is longer and hints at a decreased mobility of the overall settlement community.

9.4.3 Case Study 3: From Complex Forts to Defensive Homesteads in Neolithic and Bronze Age West Siberia

In the West Siberian taiga, some of the earliest instances of territoriality and stratified social structures emerged among Stone Age hunter-fisher-gatherers in the Early Holocene. At the end of the seventh mill. cal. BCE, local groups started to fortify some of their settlements, many centuries before the appearance of comparable enclosures in Europe (Dubovtseva et al., 2019; Piezonka et al., n.d.). These incipient defensive structures are part of a pre-farming horizon of innovation taking hold of the West Siberian basin at that time: a population expansion, settlement intensification, and technical innovation including the adoption of pottery, bear witness to major socio-economic, political and cultural transformations (Chairkina & Piezonka, 2021; Piezonka et al., 2020a). From these earliest instances onwards, fortified sites continue to occur through the ages in the Siberian taiga up until the historical times of the Russian imperial colonisation in the 16th/17th cent. CE (Schreiber et al., 2022). They represent an exceptional regional phenomenon that is unprecedented worldwide in its early onset, scale, and almost unbroken continuity over eight millennia.

The Stone Age fortified sites appear from c. 6200 cal. BCE onwards and continue to be erected into the fourth and early third mill. Cal. BCE. They were situated on promontories and high river banks above adjacent floodplains, and consist of pit-house clusters with ditches and embankments (Fig. 9.5). In local terminology, this period is defined as Neolithic/Eneolithic, based on the presence of pottery, but with an economy that continues to be entirely based on hunting, fishing and gathering. In the following Bronze Age (c. 2500–750 cal. BCE), when foraging economies still prevailed across most of the region, a stark change in settlement organisation took place: the promontory forts with pit-house settlements disappeared, and instead, large single houses that are often enclosed by multiple rings of banks and ditches became common (Fig. 9.5). In both phases, unfortified settlements that are archaeologically visible due to their pit houses also exist.

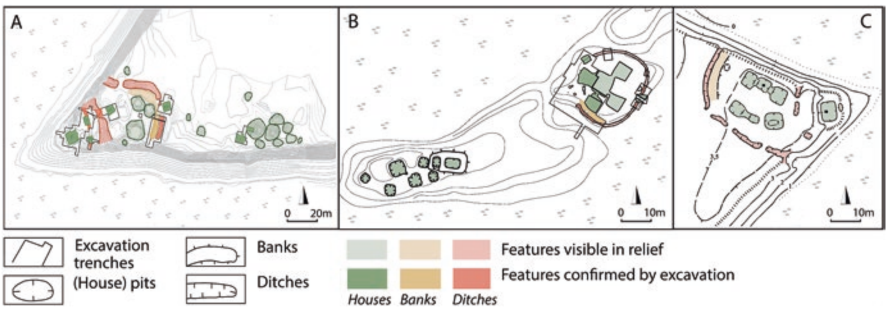

Fig. 9.5 Three Stone Age settlement sites in West Siberia of the sixth and fifth mill. cal BCE showing a motte-and-bailey-like structure: (**a**) Amnya, (**b**) Kayukovo, (**c**) Imnegan (Illustration: Sophie Juncker and Henny Piezonka)

By comparing these two modes of settlement organisation, we will trace possible socio-economic and political dynamics behind these changes. More ephemeral sites, such as short-term hunting or fishing stations, existed in both phases but are underrepresented in the archaeological record. Burial sites of the period in question are extremely rare in the study region and provide only limited information due to the unfavourable preservation condition of bone and other organic materials in the acidic forest soils.

9.4.3.1 Community Size

Compared to the preceding Mesolithic, which has few and ephemeral stations especially in the eastern and northern parts of the study region, the period around 6000 cal. BCE is characterised by a population increase, manifested in the general increase in number of settlements with pit houses, especially in the central and eastern parts of the region, and their more substantial character (Chairkina & Piezonka, 2021; Piezonka et al., n.d.).

An estimation of community size for the Neolithic/Eneolithic and Bronze Age groups in this region is hampered by the unclear degree of seasonality or permanence of the known settlements and by likely fluctuations in community compositions throughout the year. Such fluctuations are suggested by ethnohistoric evidence from both North Eurasia and North America, and by sub-recent and current mobility patterns of the Indigenous inhabitants of the study region itself. While ethnographic studies illustrate binary mobility systems in this region, with seasonal winter and summer settlements (Golovnev, 1995; Piezonka et al., 2020b), some characteristics of the well-investigated Stone Age fortified complex of Amnya – such as pit houses with large central hearths (winter occupation) and thick cultural layers between houses (use in the snow-free period) – possibly point to year-round occupation (Stefanov, 2001). Another obstacle is posed by the fact that without excavation and absolute dating, the contemporaneity of pit houses at a given settlement site can be suspected, e.g. based on regularities in layout, but it cannot be proven (Schreiber et al., 2022). Often, archaeological evidence shows that such sites have been occupied repeatedly in different periods, and pit-house depressions have been re-used by later settlers (Kosinskaya, 2006).

With these restrictions in mind, rough estimates of the number of people occupying the archaeologically visible pit-house settlements can be put forward. In the Neolithic/Eneolithic period, fortified settlements, of which to date approximately ten examples are known across the region, encompass roughly three to ten pit dwellings in the enclosed areas (Borzunov, 2020; Schreiber et al., 2022). New dating results suggest that some of the fortified settlements have broadly contemporary outer settlements, such as the Amnya complex in the northern taiga, where the fortification encloses seven buildings on a cape on the river terrace and a close-by outer settlement encompasses a further ten pit-house structures (Dubovtseva et al., 2020; Piezonka et al., n.d.). Open pit-house settlements from this period consist of two to over twenty houses. House sizes (measured on the sunken floor area) typically range between c. 20 and 40 square meters, with some double houses reaching c. 65 square meters per chamber, and some fortified sites having one larger house of up to 70 square meters (Borzunov, 2020; Kosinskaya, 2006; Schreiber et al., 2022). Based on ethnographic space per capita observations (Hayden, 1996), group sizes at these settlements would have ranged between small collectives of less than ten persons to larger communities of more than 100 individuals.

The single fortified homesteads that emerged at the end of the Eneolithic and in the Bronze Age have average house floor areas of around 100 square meters, with single houses measuring up to 200 square meters (Borzunov, 2015; Schreiber et al., 2022). This would equal groups of c. 20–50 individuals. Open settlements during this period rarely encompass more than two buildings.

9.4.3.2 Conformity/Diversity

Interpretations of social structure and subgroupings within these communities draw on settlement structure, house size distributions and patterns in the material culture. The Neolithic/Eneolithic fortified sites regularly consist of two distinct parts: a separately enclosed 'citadel' area and a close-by, 'bailey'-like agglomeration of further pit houses that can be enclosed or open (Fig. 9.5). The fortified sector is usually located at the tip of a promontory or cape above a river floodplain, and is cut off towards the land by one or several fortification lines consisting of ditch, bank and palisade. As mentioned above, this most prominent part of the settlement often encompasses one larger dwelling alongside the smaller-sized ones (Borzunov, 2013). Such hierarchical layouts have been observed at several enclosed sites in the region, e.g. at Amnya 1 & 2, Kayukovo 1 & 2 and Imnegan 2.1 (Kardash et al., 2020). It is likely that these structured layouts reflect the existence of different groups that cover various social roles within these communities. The large houses may indicate the existence of socially distinct persons or families, although other interpretations e.g. as communal buildings are also possible.

The existence of social stratification in this period is underpinned by the results of a new diachronic study on hunter-gatherer fortifications in the Siberian taiga (Schreiber et al., 2022). Based on house size distributions, the fortified sites of the Neolithic/Eneolithic period show clearly elevated Gini indices compared to the open settlements, which might be explained by wealth inequalities among the community members. In the subsequent Bronze Age, Gini indices are lower, hinting at new social arrangements towards increased homogeneity.

A relevant observation concerning diversity within the early communities of the beginning Neolithic is the fact that on some of the settlements, such as the abovementioned Amnya complex, clearly distinct types of pottery (comb ware and strokeornamented ceramics) occur in one site and even one house pit. Local scholars interpret this as the possible presence of members from different communities at these sites.

9.4.3.3 (Critical) Resources: Access and Distribution

In this case study, resource access and distribution concern (1) resources related to subsistence economy, (2) raw materials for technical items and prestige goods, and (3) man power/labour.

(1) Subsistence: Western Siberia is an outstandingly rich ecosystem from a hunter-gatherer-fisher perspective. Fish, aquatic birds, forest fowl and large game such as elk and reindeer have predictable seasonal occurrences. Ethnographic information from sub-recent and contemporary hunter-fisher-herder communities in this region highlights the role of seasonal resources such as water and forest fowl that is often underestimated in archaeological studies, and of active resource management and niche construction strategies (e.g. Groß et al., 2019; Piezonka et al., 2020b). Seasonal mass harvesting, e.g. of fish at favourable sites, is seen as a precondition for the accumulation of storable surpluses. In the past, natural environments containing such reliable, seasonal resources 'invulnerable to excessive exploitation' (Hayden, 1996, p. 238), could have stimulated competition among hunter-gatherer groups over good sites. This wealth might have contributed to a rise in population and socio-political complexity once mass harvesting strategies of such 'naturally stored' and storable resources took hold (Adaev, 2007; Golovnev, 1995). Storage in turn can lead to increased territorial behaviour (e.g. Morgan, 2012; Testart, 1982). This is a possible explanation for the intensification and innovation phase around 6000 cal. BCE, which might have involved restructuring of intra-group social relations through accumulation of wealth, communal stores etc., and also the rise of inter-group conflicts and warfare over good sites, as physically manifested through the construction of fortifications.
(2) Raw materials for technologies, prestige materials: In the study region, essential raw materials (clay, bone, wood, bark etc.) are widely available locally and therefore do not show any specific, significant patterns. An exception is good lithic raw materials, as these are rare across much of the region. While the lithic inventory of many sites is dominated by a few ground stone tools, the unique early Neolithic settlement of Et-to in the northern taiga seems to represent a location for open-cast mining of better, rare lithic materials (Kosinskaya, 2006). The very specific comb ware pottery points to a particular group that undertook the raw material extraction here, but information on distribution patterns is currently still lacking. Further research is needed before this aspect can be addressed in more detail. In the early Bronze Age, an archaeologically well-visible type of trans-regional prestige good makes its appearance in the region: hundreds of bronze artefacts of the wide-spread Sejma-Turbino type, including e.g. ornamented axes and daggers, came to light mainly as hoards and single finds, even in remote parts of the taiga (Korochkova et al., 2020).
(3) Man power/labour: Given the substantial pit houses which can be up to 2 meters deep, and the banks, ditches and palisades constructed at the fortified sites, man power and labour must have been important resources for the respective com-

munities in prehistoric West Siberia. Resource abundance and the need to protect surpluses are regarded as often interconnected with labour exploitation for the construction of fortifications (Hayden, 1996). Furthermore, labour for the construction of monumental architecture, like large dwellings and fortification systems, can play a key role in wealth agglomeration, thus potentially linking such structures with social and economic inequality (e.g. Coupland & Banning, 1996; Hayden, 1996). However, increasing political complexity must not necessarily be accompanied by higher levels of wealth inequality (Moreau, 2020), and labour-intensive defensive architecture can also be coordinated without centralised authorities, based on communal decision and collective action (Feinman, 2017; Grier et al., 2017).

9.4.3.4 Network Configurations

Configurations of networks in the West Siberian case study involve different scales, from the local community level, to regional connectivities, to trans-regional networks.

At the community level in Neolithic/Eneolithic and Bronze West Siberia, the seasonal rounds of the hunter-gatherer-fishers formed the basis of the geographical range of the core groups. Seasonal mobility most likely went hand in hand with group size fluctuations that involved larger gatherings at certain times of the year, and more dispersed groupings at others. Based on ethnographic evidence from the region, but also from communities in the boreal zone of North America, it can be presumed that river catchments formed an important basis for kinship clans and totemic units, and also would have played a role in the division of hunting and fishing grounds.

On a regional scale, rivers were the basic communication routes, and between the catchments passways would connect the upper courses of tributaries. Along such routes, relations with other neighbouring groups would have been maintained and developed. Archaeologically, such regional connections and communication networks are reflected by, for example, the stylistic and technological similarities of pottery types across wider areas, which can often be traced along the major river systems.

For the constitution of transregional communication systems and related wider socio-economic dynamics, the role of boats and other long-distance transport is a key aspect in such forested environments (cf. Rowley-Conwy & Piper, 2017). Especially in a landscape like the West Siberian taiga – where long-distance movement is almost exclusively concentrated on (open or frozen) bodies of water across all seasons – boats, sledges, and skis would be essential both for building and keeping up relations within and between dispersed communities; but also for fission dynamics leading to ‘voting with your feet’, for the colonisation of other territories, and for raiding and war, an aspect likely reflected in the early forts and later fortified homesteads.

9.4.3.5 Organisation of Decision-Making

Aspects of decision-making in the discussed Siberian societies of the Neolithic to Bronze Age period can only be indirectly inferred from settlement characteristics and patterns, as well as material culture, in combination with more general anthropological reasoning.

Based on this evidence, it is possible that the constitution and organisation of decision-making power differed between the Neolithic/Eneolithic period and the Bronze Age. In statistical approaches using the Gini index, house size differences have been taken as a proxy to measure wealth inequalities and power imbalance in stratified hunter-gatherer societies (Ames & Grier, 2020; Schreiber et al., 2022). Judging from the hierarchical layouts of the Neolithic/Eneolithic fortified settlements, and from the high Gini scores that were pronounced in these early enclosed sites – as opposed to both contemporary open settlements and the subsequent Bronze Age homesteads – the presence of powerful individuals or subgroups centred at the forts can be suspected for this period. It is possible that such individuals/groups would have held hierarchically elevated positions that would have come with the ability to make authoritarian, centralised decisions on certain aspects of the social and economic spheres, e.g. concerning building activities, action in conflict and defence, or concerted (seasonal) food procurement activities. However, as mentioned before, alternative scenarios of collective action, and heterarchical or anarchical decision organisation, would also be suitable to explain the archaeological evidence in question.

In the Bronze Age, decision-making on community aspects probably became less centralised and would have taken place within the small group units that were more or less self-sufficient in erecting the fortified single homesteads and the small open settlements.

9.4.3.6 Property Rights

As territorial markers on river banks and lake shores, the early fortified sites in West Siberia would have ensured access to economically important places with reliable seasonal abundance of aquatic resources. The autochthonous emergence of monumental constructions, such as ritual mounds and fortifications around 6000 cal. BCE may thus mark a rearrangement of the social order towards ownership and territoriality, centring on ecological hotspots. By securing access to these sites with their (seasonally) abundant resources, enhancing social memories and histories, as well as creating social relationships, monumental constructions would have embodied both individual and collective agendas (Grier & Schwadron, 2017). While not exactly property, family hunting grounds are a type of restricted access that is widely known ethnographically from the northern forests both in America and across North Eurasia. It is likely that such socio-economic arrangements also played a role in prehistoric West Siberia.

Aspects connected to emerging power imbalances and hierarchies, such as aspiration to power by leaders and the installation of property rights in order to control productive resources, can also be understood with respect to possible bottom-up counteraction, e.g. through the cooperation of groups with shared interests, through resistance against authority, and also through the fission mechanism of 'voting with your feet' as an alternative to (violent) conflict. Levelling mechanisms such as feasting can also help re-balance emerging wealth inequalities and the accumulation of property by a few (e.g. Boyd et al., 2019; Hayden, 2019; Taché & Craig, 2015). Within such a political economy framework, the interrelation between emerging social inequalities, resource ownership, territoriality and (inter-group) conflict is seen as embedded in 'historically specific webs of political and economic interactions [that] structure social relationships and create cultural meaning' (Furholt et al., 2020b, p. 163).

9.4.3.7 (Violent) Conflict and Conciliation

In order to understand the role of conflicts and conciliation in the prehistoric societies of the West Siberian taiga, various sources can be taken into account: fortified and open settlements, weapon finds, and ethnohistorical evidence on violent conflict, its reasons and dynamics. Due to the general sparsity of prehistoric burial sites in the study region and the unfavourable conditions for bone preservation, burial evidence cannot be added to the picture in this case.

Concerning the Neolithic/Eneolithic period in the West Siberian taiga, currently no more than approximately ten early fortified settlements are known in the region (Borzunov, 2020). As described above, common traits include their location on high river terraces and promontories, their hierarchical layout with a 'citadel' and a 'bailey'-like outer settlement, the presence of one larger house often at the most prominent site, e.g. the tip of the promontory, and defensive lines consisting of banks, ditches and palisades. In the case of the early fortified settlement complex of Amnya, the defensive nature is underpinned by the exceptionally high proportion of slate arrowheads found in and between the house pits, compared to other open contemporary settlements. In the Bronze Age, complex fortified settlements ceased to exist, and instead single large pit houses became common, surrounded by elaborate, often multiple, defence lines of banks and ditches.

In West Siberia, we have the favourable situation that the study of historically documented socio-economic strategies in connection with Indigenous fortifying behaviour can yield a framework for archaeologists to widen the scope of strategies and practices across the social, economic and ritual spheres pursued by hunter-gatherers in these specific environments that would otherwise not be taken into account for archaeological interpretations. Ethnohistorical information provides rich accounts of sub-recent warfare in the taiga from the sixteenth/seventeenth century onwards, including data on migrations and evictions of local populations, on combat norms and tactics, and on the fortifications themselves, their construction and maintenance, and their defence during conflict (Golovnev, 2000; Perevalova, 2002). According to these sources, the building of fortification systems was closely connected to the display of status and wealth, so that some researchers see the phenomenon of fortification construction in the taiga as closely interwoven with the rise of social inequalities (Chindina, 2000). Fortification building was also used as a strategy to react to either uneven power relations or unpredictable attacker behaviour such as raiding, the latter commonly aiming at the theft of women and/or domestic reindeer (Golovnev & Osherenko, 1999). Based on more general insights from anthropology, especially within highly mobile societies, costly defence constructions may also have served to prevent violent behaviour and to both attract but also repel people (Feinman, 2017). Fortifications can thus be seen as a representation of both conflict and conciliation.

Turning back to the prehistoric situation, based on the current state-of-the-art, an economic intensification model – possibly in combination with the influx of newcomers from other regions – appears to be best suited to explain the concurrent appearance of a population rise, the emergence of fortified sites, an increase in pithouse settlements, the rise of ritual monumentality, and the adoption of pottery in Western Siberia c. 8000 years ago. Three scenarios concerning the potential role of environmental change in these developments, perhaps connected to the 8.2 ka global climatic cooling event, seem possible: Scenario (1) assumes that the innovation package reflects the human response to economic stress induced by climatic fluctuation, triggering the adjustment of economic and social systems, e.g. by technical innovation. Scenario (2), holds that environmental changes in the wake of the 8.2 ka event led to increased abundance and/or accessibility of certain seasonal resources, triggering new mass harvesting strategies and improved storage practices that would in turn have enabled the accumulation of surplus and resulting socio-political developments. Scenario (3) rejects a deeper connection of the socio-economic innovation package to environmental change. In this scenario, the forts might have been built either by immigrants to the area in order to secure appropriation of the region, or by local populations defending themselves against such incoming new groups, which are generally thought to have originated further south (Borzunov, 2020; see also Chairkina & Kosinskaya, 2009; Kosinskaya, 2002). The disappearance of fortified complex settlements in the Eneolithic, and their replacement by enclosed fortified single houses in the Bronze Age, indicates substantial shifts in the socio-economic system, with a trend towards more social homogeneity, as indicated by the wealth inequality measurements mentioned above, and possible more self-sufficient, small social units that had to care for their own defence and safety.

9.4.3.8 Knowledge

Various facets of knowledge can be related to power disparities. If the knowledge of seasonal and spatial resource distribution and hotspots is restricted, power disparities might result. Technical innovation and its role in socio-economic intensification is also regarded as a crucial factor in emerging wealth inequality (e.g. Angelbeck &

Cameron, 2014; Jordan, 2015). In non-agricultural societies this concerns, for example, capture techniques, processing, preservation and storage methods, and prestige technologies. Seasonal mass harvesting, in particular, is seen as a precondition for the accumulation of storable surpluses through preservation techniques (Craig, 2021). Stationary fishing devices represent a potentially very important technological feat in this regard. It is unclear when they took hold in this region, and how they might have been connected to the development of territoriality at favourable sites in the river and lake systems (cf. Koivisto & Nurminen, 2015; see also Ritchie & Angelbeck, 2020). Pottery also constitutes an important technical achievement in this respect, enabling new strategies in resource exploitation and long-term storage through the production of high-calorie, preservable products such as fish oil (Craig, 2021; Piezonka, n.d.). However, while all these technologies might have substantially contributed to the described socio-economic and political developments in the taiga, they most likely did not represent specialist or restricted knowledge.

This might have been different when it comes to ritual knowledge which, judging from more recent, ethnographic evidence from this region, could have been restricted to ritual specialists (such as shamans) who would likely have played important roles in many aspects of life, from hunting and fishing, to health issues and death, to settlement choices and spatial taboos.

9.4.4 Case Study 4: Politics in Neolithic Trypillia Mega Sites

At the end of the fifth millennium BCE, a network of human agrarian communities developed in the forest-steppe between the Carpathian foothills and the Dnieper River, of which the predominant group belong to the largest and most populous prehistoric settlements in Europe and are labelled under the term Trypillia. In cultural terms, these communities had close ties to Neolithic-Copper Age societies of Southeast Europe, and within them several innovations were made, among other things with regard to settlement layout, animal husbandry, animal-drawn sledges and ceramic technology.

Building on a long research history of Russian, Soviet, Ukrainian and Moldovan scientists, several major research projects on Trypillia have been carried out in the last two decades with international participation (e.g. Chapman et al., 2014; Gaydarska, 2019; Menotti & Korvin-Piotrovskiy, 2012; Müller et al., 2016). The research teams obtained high-resolution settlement plans via geomagnetic surveys, which provide a quasi-complete insight into the structures of these communities with thousands of houses, pits, integrative assembly buildings, streets and squares, as well as ceramic production facilities, due to excellent contrast (Hale, 2020; Rassmann et al., 2014).

In terms of chronology, Trypillia aggregated settlements begin between 4300 and 4100 BCE, and developed into larger and larger settlements until about 3700 BCE. The main group of these communities in terms of size was concentrated in the catchments of the Southern Bug and Sinyukha Rivers, where they – thanks to the extremely fertile loess soils – reached sizes between 100 and 320 ha. These settlements are composed of thousands of burnt houses arranged in concentric rings along a circumferential ring corridor, which formed the main road for these settlements, and a central unbuilt open space. The houses contain the remains of rich inventories of numerous painted vessels, tools, and miniature objects such as sledge models, house models and anthropomorphic and zoomorphic figurines.

Due to the sheer size of the populations of these communities, we can necessarily assume the existence of political institutions. In addition, thanks to the excellent quality of the evidence, these settlements represent an extraordinary source for the archaeological reconstruction of political processes.

9.4.4.1 Community Size

Reconstructions of the size of local communities with Trypillia pottery styles are based on the number of houses and their floor areas. This is possible thanks to the prehistoric burning of practically all houses and their resulting excellent visibility in archaeo-magnetic plans. The space requirement for one person is assumed to be 7 m^2, derived from cross-cultural ethnological research (e.g. Porčić, 2011).

The most problematic variables in population estimates are the site duration and the number of simultaneously used houses within settlements. For a long time, very short occupation spans were assumed for large Trypillia settlements, in the range of 50 years, with a correspondingly high number of contemporaneous houses (e.g. Diachenko, 2016). In contrast, new ^{14}C dating indicates Trypillia megasites had considerably longer durations of 150+ years and a correspondingly reduced proportion of houses in use simultaneously (Millard, 2020; Ohlrau, 2020; Rud et al., 2019; Shatilo, 2021). At the mega-site Maidanetske, which had a duration of approximately 300 years, 1550 out of 3000 houses are considered to belong to the main occupation phase of the settlement between 3800 and 3700 BCE. Assuming an average lifespan of 50 years for a house and the average floor size of 72 m^2 (Ohlrau, 2015, p. 51, Table 3), this would imply a population at the settlement Maidanetske of about 8000 people (1550 houses * 72 m^2 = 111,600 m^2/7 m^2 = 15,943 People/2 (fifty-year-steps) = 7971 people). Assuming a lifespan of 50 years for a house, however, we would have to take into account that this significantly exceeds the average life expectancy of prehistoric people, which was more likely between 20 and 30 years (Acsádi & Nemeskéri, 1970). This would imply the use of the houses by more than one generation. As modelling of ^{14}C-dates from south-eastern European tells shows, the actual periods of use of houses are probably much more variable and, in some cases, amount to only a few years (Draşovean et al., 2017; Tasić et al., 2015). Therefore, much shorter average occupancy periods of 25 years should also be considered, which would reduce the number of simultaneous inhabitants. Even though the general data situation in Trypillia settlements is excellent, the estimates of the population numbers have a relatively high degree of uncertainty.

The number and size of houses per settlement vary considerably in space and time, ranging from 7–130 houses in small settlements (<10 ha) to several thousand houses in mega-sites such as Nebelivka (c. 1400), Maidanetske (c. 3000) and Talianki (c. 2500). Depending on the average house occupation duration, the estimated number of inhabitants in small settlements (0.3–10 ha) varies between 50 and 500 inhabitants, if the total house area is used to calculate the total number of inhabitants over the entire occupation time of the settlement. The populations of large settlements with areas between 95–320 ha would vary between 2500 (Volodymyrovka) and 11,000 (Dobrovody), based on a 50-year average period of use for the houses. The assumption of a median house lifespan of 25 years would reduce the estimated population to 25–200 for small settlements and 1300–5550 for large communities.

9.4.4.2 Conformity/Diversity

In many cases, a pronounced uniformity of the structural elements of Trypillia settlements has been highlighted and used as an argument against increased social complexity within Trypillia communities (e.g. Graeber & Wengrow, 2022). Such standardisations concern, among other things, the architecture and construction of dwellings: the majority of dwellings were constructed raised off the ground (often interpreted in terms of two storeys). There was usually an anteroom and a main room on a massive platform, with specifically arranged interior elements: a stove at the side of the entrance in the main room, a podium on the opposite long side, a fireplace (often misleadingly called an ‘altar’) and a grinding facility near the entrance. The houses had round roofs. Only occasionally could certain deviations from this pattern be observed, e.g. houses with a third room and isolated ground-level buildings, which could also represent chronological patterns.

Decreasing variability of house sizes indicates decreasing social inequality in the phase after the foundation of the earliest Trypillia mega-settlements (Hofmann et al., n.d.). This trend towards greater conformity runs counter to the theoretic assumption that vertical differentiation and social inequality must increase with the size of local communities. We interpret this pattern as an expression of an egalitarian ideology and the establishment of effective mechanisms for social levelling. A reversal of the trend towards slightly higher floor size variability emerged after 3800 BCE, probably when these mechanisms began to fail. In the disintegration phase of large settlements, the variability of house sizes then increases again significantly.

A high degree of standardisation also concerns pottery technology and styles. Within large Trypillia settlements, we see uniform fabrics, as well as sets of ceramic shapes and decoration schemes, that are extremely difficult to differentiate at the household level (Ohlrau, 2020, pp. 192–202; Shatilo, 2021, pp. 110–126). However, this high degree of intra-settlement conformity is probably not exclusively the result of central specifications, but rather of specific production and distribution conditions with specialised pottery workshops. This corresponds to the fact that ceramic stylistic differences have so far been found primarily across settlements. These were primarily interpreted exclusively chronologically (e.g. Harper et al., 2021).

According to the aforementioned theoretical framework of this study, the observed standardisations would have to be interpreted in the sense of a centrally regulated, communally established conformity and equal treatment of citizens.

9.4.4.3 (Critical) Resources: Access and Distribution

Several arguments point to an egalitarian ideology in Trypillia communities and unrestricted access to the perhaps communally managed resources of the settlement environment. This is indicated, among other things, by the spatial layout of the settlements, whose configuration along a circumferential ring-corridor ensured equal access to the communal infrastructure (e.g. the unbuilt central square). This settlement layout has analogies with plans of egalitarian organised communities from cross-cultural ethnographic contexts (Wagner, 2019). In addition, the aforementioned development of house sizes is an indirect indication of effective mechanisms for redistribution of achieved surpluses.

That the egalitarian ideology was, in reality, in tension with diverging interests, and that certain wealth disparities actually existed with Trypillia communities is indicated, among other things, by differences in house sizes in different parts of the settlement. The largest houses were located along the ring corridor and the main plaza (beside the central mega-structure) while in the zones inside and outside the ring corridor, smaller houses predominated. The ring corridors represent the basic component of the settlements, planned and realised at the time of settlement foundation. In contrast, the zones inside and outside the ring corridor tend to represent secondarily developed areas. According to the primary and secondary character of the different zones, the social differentiation which is manifested in different house sizes, might refer to a vertical differentiation of founder families on the one hand, and families that joined later on the other.

However, it is unclear what the basis was for this possible social advantage of the founder families, and what consequences it had. It is possible that these families had exclusive rights to use high-quality land, e.g. located within or near the settlements. They could have used the surplus obtained through this economic advantage to gain higher prestige and more rights in decision-making processes. In addition to arable and grazing land, control over other critical resources such as the supply of flint, salt and metal, or over transport capacities with cattle-drawn sledges, are possible sources of differences in household wealth and political power.

We take the fact that the Gini index of house sizes increased from about 3800 BCE onwards as a possible indication that the mechanisms of social balance began to fail at this time.

9.4.4.4 Network Configurations

Insights into the configuration of networks are based, on the one hand, on regional and interregional comparisons of settlement data. On the other hand, the origins and spatial connections of 'imported' goods and certain ideas show the range of external relations. In the catchment area of the Sinyukha River, the distribution of settlements indicates a high degree of mobility between Trypillia communities, which led to an increasing concentration of people in larger and larger settlements until at least 3800 BCE (R. Hofmann & Shatilo, 2022). After 3800 BCE, the disintegration of large settlements began and numerous smaller communities were founded. The high residential mobility potentially led to dispersed distributions of families and lineages in different settlements.

The integration of Trypillia communities into long-distance networks can be seen, for example, in causewayed enclosures, which form a quasi-pan-European network (Hofmann, 2022). Indirectly, we can assume an enormous demand for, for example, salt, pigments (magan) for painting pottery, copper and also flint (Chapman et al., 2019). In the case of flint, the raw materials have proven origins; from regional sources and the resource-rich Prut-Dniester area, where households specialised in extracting flint material and processing it into semi-finished products.

The directly proven quantities of imported goods in Trypillia megasites are relatively small. By comparing 48 house inventories from the Maidanetske megasite, it was possible to distinguish 'rich' households with signs of trade (tokens, hoards) from households associated with imported ceramic vessels in addition to a specialisation in textile production (Ohlrau, 2020, pp. 35–58). Presumably, households' access to external resources could be crucial in gaining additional influence in political processes.

9.4.4.5 Organisation of Decision-Making

The reconstruction of decision-making processes in Trypillia communities is based on a category of integrative building structures, so-called megastructures, which we can identify in archaeomagnetic plans and excavations (Hofmann et al., 2019). The criteria for distinguishing these integrative structures from residential buildings are, in order of importance: (1) their highly visible position in undeveloped public space, especially within the ring corridor and a special so-called 'main plaza', (2) a specific ground-level architecture (in contrast to the elevated construction of residential buildings), and (3) their often extraordinary dimension. Exemplary excavations show that megastructures were multifunctional facilities in which other integrative activities were carried out and surplus was consumed jointly in addition to decision-making.

Megastructures existed since at least the first half of the fifth millennium BCE and thus long before agglomerated Trypillia settlements. They are suitable for the reconstruction of decision-making processes because they occur multiple times in large Trypillia settlements. Due to their wide distribution within settlements, we can assign them to different ‘use groups’, either for parts of the community or its entirety. Their multiple occurrence within the same settlement is probably due to the unification of several smaller communities into large megasites that each retained their integrative decision-making structures. Accordingly, we assume sequential, bottom-up decision-making processes that were decentralised and organised from the level of neighbourhoods or quarters.

The size and architectural development of megastructures indicate increasing centralisation of decision-making processes in Trypillia communities after 3800 BCE, in line with the findings of an increase in social inequality, reconstructed based on house sizes. On the one hand, we observe a process of increasing enlargement of the ‘use groups’ of decentral megastructures. On the other hand, decentral megastructures, e.g. distributed in the ring corridor of many settlements, become increasingly smaller and finally disappear, while the size and architectural prominence of central megasites increased. Architecturally, central megastructures developed from relatively light buildings with open areas to buildings that are more massive. Some of them show monumental characteristics.

9.4.4.6 Property Rights

Indirect indications of ownership in Trypillia communities are the ring-shaped layout and the low variability of house sizes, both of which tend to not to support the idea of pronounced differences in property, instead favouring the interpretation of a tendency towards equal distribution of resources. On the other hand, the differences in house sizes in the ring corridor and other parts of the settlement show that certain parts of the population seem to have possessed advantages over others, which might have been indicative of exclusive rights of use (ownership?) of critical resources. The existence of property rights over building plots within the settlement is indicated by the fact that larger empty spaces were initially left within the rows of houses, which were only filled successively by new buildings over several generations. This resulted in spatially separated clusters of houses that perhaps reflected several generations of the same family.

9.4.4.7 (Violent) Conflicts and Reconciliation

There is very little clear evidence of violent conflict within and between Trypillia communities, although the fusion of large numbers of people into megasites and also the burning down of practically all houses have been interpreted in this direction by some authors (e.g. Anthony, 2007; Kruts, 1989). The same applies to human skeletons associated with burnt houses in Kosenovka (Kruts et al., 2005) Direct evidence of intergroup conflict is provided, for example, by traumata on a large number of skeletons from the Verteba cave, one of the few burial records (Madden et al., 2018).

The situation with fortification ditches is more differentiated: fortification ditches of settlements of the period before (prior to 4300/4100 BCE) and after (subsequent to 3650 BCE) the phase of aggregated Cucuteni-Trypillia settlements and megasites, were frequently constructed on naturally protected promontories and thus clearly show a fortified character (Hofmann et al., n.d.). In contrast, the discovery of causewayed enclosures in the Middle Trypillia megasites Nebelivka (Videiko & Chapman, 2020) and Maidanetske (Ohlrau, 2020, pp. 114–116) clearly does not support a fortified character for ditches just of the largest communities.

The evidence for weapons is similarly ambiguous (Klochko, 2001): before and during the phase of population aggregation in megasites the number of possible weapons is limited and, in the case of arrowheads or flat axes, not clearly distinguishable from tools for hunting or for wood processing. In the post-megasite period, we observe a quantitative explosion of possible weapons, the majority of which, however, now originate from graves, which therefore cannot be compared with the earlier evidence from settlements.

9.4.4.8 Knowledge

We assume highly specialised knowledge existed, e.g. for pottery production and the processing of metals (copper, gold). This is evident in, among other things, the development of advanced pottery kilns, whose operation and maintenance certainly required special knowledge. The animal bone spectrum of a pottery workshop in Maidanteske, which deviates from domestic contexts, might indicate a special economic and social role of potters in the community (Benecke et al., in press). Since we see the emergence of professional specialisations as a strategy to compensate for deficits in household income, it seems unlikely to us that this specialised knowledge was a source of social power. This is especially true for potters, who tend to have a low social status in many societies (Rice, 1987).

9.4.4.9 Conclusion

Trypillia communities were established as part of the colonisation of the forest-steppe zone on the northern border of the Northwest Pontic steppe zone. Their outstanding demographic success is probably due to a progressive and reform-oriented political organisation that enabled broad political participation in sequential bottom-up decision-making chains and effective (redistributive) mechanisms to avoid or reduce social inequality. This progressive constitution increasingly came into conflict with the vertical social differentiation processes that developed, perhaps along the sociological and economic break in the line of founder families and families that joined the settlement later. These processes led to increasing centralisation of decision-making and political power and were the starting point for increasing dissatisfaction and the resulting gradual disintegration of aggregated Trypillia communities from 3800 BCE at the latest.

9.4.5 *Case Study 5: Iron Age Greece – Facets of Political Practice and Patterns of Power Relations*

The centuries of the Greek Iron Age that followed the Palatial civilisations of the Aegean Bronze Age and the so-called post-palatial period up to the seventh century BCE are characterised by socio-political dynamics such as, among others, the transition from a region of village communities to a world of city-states/citizen-states (*poleis*) with complex institutionalisation. Research on this period involves methods from archaeology and history, since from the eighth century BCE on, contemporary written texts are also available. Therefore, a subdivision of the period into the tenth/ninth century BCE and then the eighth/seventh century BCE is often applied, with the latter no longer being prehistory, but rather 'protohistory' (on this term Knodell, 2021, p. 193, and p. 252: a 'period in which written texts of historical interest are present but there is no formal conception of writing history as a genre').

Yet epics, poems and, in the seventh century BCE, also inscriptions, each constitute different text genres with their own specific challenges, and they offer different insights into contemporary experiences and world views. For example. The Homeric epics of the Iliad and Odyssey, both based on oral tradition, do not describe the reality of their time (the late eighth and early seventh century BCE), yet presuppose knowledge of it in order to be understood, since the socio-political constellations described (the so-called 'Homeric society') had to make sense to the audience (Crielaard, 1995; Raaflaub, 1989, pp. 10–11; Raaflaub, 1998; Seelentag, 2015, pp. 76–77; Ulf, 1990, 2011, p. 276). Hesiod, on the other hand, addresses more immediate aspects of everyday economic as well as socio-political life, while early poets such as Tyrtaios or Archilochos offer insights into the local value systems of their time. Remarkably enough, these early (and earliest) texts already prominently address aspects of social organisation of communities and their political dimension, e.g. elite leadership or ideals of community (Raaflaub, 1989, p. 2; on discourses on leadership and power in Homer and Hesiod: Ulf, 2017). Finally, from the second half of the seventh century BCE onward, a few early inscriptions specifying forms of local self-organisation and the regulation of power are an invaluable source for our knowledge of the development of the Political. However, for the same period in different places, we encounter quite different and locally bound processes and trajectories. They argue against a 'Greek' kind of social organisation of communities, or a linear, evolutionary development towards a specific form of (city-)statehood. But above all, all these texts indicate facets of socio-political complexity of communities of their time, which cannot be ascertained from the archaeological record alone, and which stands in remarkable contrast to the rather modest material culture of contemporary settlements.

9.4.5.1 Community Size

Compared to the Greek Bronze Age, the Early Iron Age was characterised by a marked decline in settlement and modest settlement sizes, indicating low population density and considerable decentralisation. Nevertheless, differences do emerge from region to region, and even within some regions (Knodell, 2021, p. 43; for a demographic-economic approach: Murray, 2017, pp. 210–246).

Typical for the tenth/ninth century BCE are small village communities in dispersed, sometimes only short-lived settlements of modest houses. The scattered houses of perhaps 40 family units of Peloponnesian Nichoria (McDonald et al., 1983) are regarded as typical for such settlements, whose face-to-face communities consisted of several households or kin groups (Knodell, 2021, p. 165) and usually show no signs of greater social inequality. Only some settlements that became larger over time, such as Athens, reveal local social hierarchies (Knodell, 2021, p. 28), and the famous Homeric Catalogue of Ships (Iliad 2, 484–760), with its long list of in some cases only small regions with their (main?) settlements, suggests supra-regional geographic awareness. In the epics, these communities are self-contained, autonomous entities (Ulf, 2011, p. 275), yet without state-like organisation.

For the eighth and seventh centuries BCE, changes in settlement patterns become apparent, yet again with regional variability. Although villages remained the dominant form of settlement, now a clear increase in the number of settlements, as well as a growth of existing ones, is apparent (Morris, 2005, pp. 8–12). By 700 BCE, several dozen of them must have had over 1000 inhabitants (Knodell, 2021, p. 28). It is also the period of the establishment of settlements overseas referred to often as Great Colonisation, which led to new, independent polities (Knodell, 2021, p. 233, referring to Osborne, 2009, pp. 110–121: about 30 in the eighth century BCE, about 60 in the seventh century BCE). Discernible is also the emergence of regional centres, whose relationship to surrounding village communities must have resulted in new challenges which were met with political integration, among other things (Knodell, 2021, p. 195, referring to Bintliff, 1999, pp. 24–25). It is the early phase of city-states/citizen-states (polis) as the focal place of socio-political dynamics. Their settlement centres became the site of public spaces and venues, as well as the first efforts towards (public) architecture and forms of monumentality, all the result of communal decisions (Kõiv, 2013). And whereas for the tenth/ninth century BCE only little overlap of community territories can be assumed (Knodell, 2021, p. 197), now the emergence of a specific territoriality of these poleis becomes apparent, manifest in efforts to extend territorial control (as in the case of Sparta's Messenian wars), and in manifestations of a 'political geography' of states (as in the case of the poleis of the so-called Lelantine War between Chalcis and Eretria).

9.4.5.2 Conformity/Diversity

(In-)equality and social difference as markers for power relations are indicated by burial inventories and other contexts and forms of display. The archaeological record for the tenth/ninth centuries BCE suggests only minor signs of social differentiation within the village societies. Local social inequality and personalised leadership are indicated by some elite burials such as, for example, the singular burial of Toumba at Lefkandi that demonstrates an impressive mobilisation of local resources for one individual (Popham et al., 1993). However, elite burials and burial customs in Iron Age Greece were remarkably varied. Comparison of the Toumba necropolis at Lefkandi with elite burials in Athens, for example, suggests that the political character of both communities must have differed significantly (Ulf, 2007, p. 320). Additionally, in Athens the sharp increase in 'formal burial' for only a short period during the eighth century BCE suggests that burial forms exclusive to the local elite during the tenth/ninth century BCE were now used by larger groups of the community, indicating their new self-awareness as part of the polity (Morris, 1987). The vast majority of settlements, however, show no signs of complex social hierarchies. Only the occasional larger, but short-lived houses indicate personalised, non-institutionalised leadership (Knodell, 2021, p. 165), yet they follow common house types and are by no means palatial in character.

Facets of social inequality and power hierarchies are much more concrete in the epics. The most prominent form of leadership are the *basileis*, as individual leaders or members of local elites. Their position is based primarily on prestige, which in turn is acquired in central spheres of elite action (*Prominenzrollen*: Seelentag, 2015, p. 77). These include, among others, military bravery, agricultural competence, or prowess in the resolution of disputes (Ulf, 2011, pp. 259–261). Thus, reputation is founded primarily on achievements and qualities to be proven again and again. The Homeric ideal 'always to be first and to excel among all' (Iliad 6, 208; Iliad 11, 784) outlines the ethos of an elite whose members were constantly competing with each other. Thus, the Homeric elite was not, despite all references to lineage, a dynastically legitimised aristocracy, as those emerging during the Archaic period (seventh and sixth century BCE) (Raaflaub, 1989, p. 29). However, other early texts reflect contemporary discourses on appropriate behaviour and qualities of leadership. As a shared system of values, this elite ethos and its logic must have also contributed to conformity and thus cohesion of local elites. Another, more inclusive, dimension of conformity is finally indicated in the seventh century BCE by early steps towards what later became the formalised citizenship of a polis (Seelentag, 2015, p. 155; see also Zurbach, 2013); a specific form of belonging and partaking, emerging in the communities through the involvement of the individual in local socio-political '*Integrationskreise*' denied to others (Seelentag, 2015, p. 276).

9.4.5.3 (Critical) Resources: Access and Distribution

Land (and cattle) was the most important resource of local elites. In the epics, the number of cattle owned indicates wealth and status (Ulf, 2011, p. 269). However, also important for status and prestige was participation in supra-regional networks and the distinctive prestige goods culture embedded in them. Such participation remained centralised (or reserved?) for certain members of the communities – and was used locally to negotiate power relationships and to establish and maintain inequality (Knodell, 2021, p. 190). The prominent role of prestige goods in the epics, in various contexts of negotiating status and prestige among peers, is also evident in the archaeological record, e.g. in objects of Levantine origin found in elite burials. However, the emergence of supra-regional trade activity can already be traced in the Iron Age. Although the epics are ambivalent about mercantile activity for one's own advantage (Ulf, 2011, p. 268), the omnipresence of fine wares, for example of Corinthian manufacture, all over the Greek world from the eighth century BCE onward indicates forms of 'globalised', albeit still pre-monetary, mercantile exchange.

9.4.5.4 Property Rights

Individual property rights can be taken as a given for the Iron Age. Land and cattle ownership, the accumulation of prestige goods, but also discussions about the appropriateness of gifts or portions of booty in the early texts, indicate the importance of property for members of the elites. But Homer's and especially Hesiod's agricultural village societies are also characterised by individual ownership of land, livestock, and tools. Arable land is owned by households (Ulf, 2011, p. 266). Large and sometimes prominently placed storage vessels in houses, e.g. in Lefkandi, Oropos or Zagora, but also round installations in settlement contexts interpreted as granaries (in Lefkandi or Old-Smyrna), indicate individual or at least decentralised storage in these communities. Compound-like arrangements or courtyard walls in settlements, and also cities such as in seventh century BCE Old Smyrna (trench H: Akurgal, 1983, pp. 27–34, Fig. 98), likewise suggest demarcation and ownership. Hesiod even emphasises, despite all forms of 'village reciprocity' mentioned in his Works and Days, an ideal of individual self-sufficiency to be striven for: oxen, plough, wagon, and tools were individual property (Barry, 2016). Individual land ownership (and the collective initiative for its distribution) is also suggested by the land division of the colonial settlements overseas. Status and political power were also based on land ownership in later times, and there are indications for regulating the ownership of property from the seventh century BCE onwards (Zurbach, 2013, pp. 648–649). The Solonian reforms for Athens (c. 600 BCE) set land ownership as a criterion for participation in the institutions of the Polis. Land ownership could even occasion rights over other individuals, since early texts already recognise various forms of dependency (cf. Zurbach, 2013). The leasing of land was common by the seventh century BCE at the latest and could, as in Athens, lead to forms of debt bondage that threatened the polity's internal peace (and were therefore abolished by Solon). Individual property, after all, could also be people: slaves. Already Hesiod gives advice on the treatment of slaves, and the father of Odysseus reclaims land with his slave (Ulf, 2011, p. 266; on slavery in Homer and Hesiod: Harris, 2012; on early slavery also Zurbach, 2013).

9.4.5.5 Network Configurations

For Iron Age elites, the establishment, cultivation, and expansion of networks was of great importance. Imported objects from burials, and later sanctuaries, attest to contacts with the outside world and the relevance of displaying them. In general, however, the settlement communities of the Early Iron Age were isolated. The vast majority of tenth/ninth century BCE settlements show no evidence of supra-regional exchange or overseas contacts (Knodell, 2021, p. 190). Imports from the Near East, e.g. made of bronze, are rare (Braun-Holzinger & Rehm, 2005; Dirlmeier-Kilian, 2000). A few places (or their elites), however, show early contact with the eastern Mediterranean. Crete, Lefkandi and Athens, for example, were well connected, as imported objects from local elite burials show (e.g. Bourogiannis, 2018). The demonstrated participation in networks was also used to consolidate status. This demonstration, however, took place above all in locally specific constellations, as different strategies of display from place to place show (Knodell, 2021, p. 159). Supra-regional networking is also characteristic of the Homeric elites. The campaign to Troy appears as an almost panhellenic undertaking of peers, as do their cross-generational and cross-regional (guest-)friendships, demonstrated by accumulated gifts of often exotic origin, old age or from prominent previous owners (cf. e.g. Wagner-Hasel, 2000 or Kienlin & Kreuz, 2015 with an object-biographical approach). During the eighth/seventh century BCE, however, shifts are discernible. Although elite networks still played an important role, the now significantly larger number of imports, for example, indicates an intensification (and also depersonalisation) of long-distance contact beyond peer interaction. Now we also find Greek objects in foreign contexts and, for example, some local products all over the Greek world, like the already mentioned Corinthian fine wares, whose omnipresence can only be explained by trade.

An important role for regional and supra-regional networks was increasingly played by sanctuaries during this period. The numerous, often costly, votive offerings found in them show that now sanctuaries, and no longer only burials (as before in the tenth/ninth century), also became sought-after places for elite self-representation (Knodell, 2021, p. 214). Especially the previously regional, now increasingly panhellenic, sanctuaries of Olympia and Delphi became prominent sites of elite interaction. They developed into major hubs of Greek 'network architecture' and an 'interregional political consciousness' (Knodell, 2021, pp. 29, 212).

Such a network architecture and political consciousness is also apparent in the already mentioned Lelantine War (late eighth, early seventh century BCE) between the neighbouring Euboean poleis Chalcis and Eretria. Here, for the first time in our record, we encounter trans-regional alliances with other poleis and, even if these may still have been based on personal elite networks, a degree of relationship between communities through which a local conflict acquired trans-regional impact.

9.4.5.6 Organisation of Decision-Making

The development of village-based communities into larger, and towards the end of the Iron Age even city-like, settlements also had consequences for their socio-political organisation. For the small communities of the tenth/ninth century BCE, localised leadership can be assumed, whether by a leader or the leaders of local kin groups, with power being exercised in a vertical hierarchy (Knodell, 2021, p. 27; on archaeological evidence for political organisation during this period: Kõiv, 2016). In the epics, too, power is exercised directly, not through specialised institutions (Seelentag, 2015, p. 82). Yet we also encounter a wide range of forms of decision-making (Ulf, 2011, p. 270). Personal leadership and commensality are central political practices of the *basileis* (Seelentag, 2015, p. 378; on the specific role of commensality in differing local Iron Age societies: Kistler & Ulf, 2005), but also councils (of peers and/or elders) and assemblies of the people (*demos*) – i.e. a public – convening on occasion are frequently mentioned. The actual decision-makers, however, were always the *basileis*, even if a decision consensus was expected (Ulf, 2011, p. 270). Opposition was possible, but considered harmful to the community, especially opposition among the *basileis* (Ulf, 2011, p. 271; cf. e.g. Iliad 2, 225–259). The *demos* attending assemblies, in turn, had no political initiative, although it was a point of reference for the arguments brought forward in councils and assemblies (Ulf, 2011, p. 270). It is in this sense that we encounter the beginnings of the institutionalisation of the *basileis'* leadership, in that common welfare was linked to the elite's entitlement and claim to leadership (Ulf, 2011, p. 274).

However, these communities were still pre-state entities. It was not until the seventh century BCE that the forms of political organisation emerged that were to become a characteristic of the Greek city states (Knodell, 2021, p. 29). A major feature of these forms of organisation was a set of institutions, as codified laws known since the middle of the seventh century BCE from several communities reveal, with the oldest one known from Cretan Dreros. Despite their variation, these local laws already share a degree of institutionalisation with officials, smaller bodies, councils and assemblies (Hölkeskamp, 1999; Seelentag, 2015, p. 60). Yet offices and bodies always remained reserved for members of the local elites: in pre-Solonian Athens, for example, the council of the Areopagus consisted of former holders of the archonship, which in turn was reserved for leading families, and still in Solonian Athens access to offices was regulated according to – property-based – status. Nonetheless, the important role of public assemblies and the public negotiation of communal matters can also be seen in the institutionalisation of their location. Not only is the meeting place of Homer's (utopian) city of Scheria paved and equipped with smoothed stones for sitting (Odyssey 8, 3–7), such local institutionalisations of public assembly and decision-making are also archaeologically attested, most conspicuously by a square of approximately 40 x 20 m lined with stone seating steps – the local Agora – in Cretan Dreros (Drerup, 1969, pp. 59–60; Seelentag, 2015, p. 206 with further references). Datable to as early as the eighth century BCE, this public infrastructure in the centre of the polis is several generations older than the local inscriptions mentioning Dreran institutions (themselves the oldest known legal inscriptions). The institutionalisation of the assembly found its materialisation long before the written law (Seelentag, 2015, p. 206).

9.4.5.7 (Violent) Conflict and Reconciliation

The world of the Greek Iron Age was full of conflict, both within the communities and in their relations with one another. Conflict, but also conflict resolution, play prominent roles in the early texts. Military skills and aptitude as leaders were important qualities of Iron Age elites. The Homeric epics, for example, repeatedly mention these aspects of the elite ethos, and in some regions the frequency of weapons in elite burials confirms the importance of this competence for status and identity (cf. the burials with weapons in Athens: D'Onofrio, 2011). But the Iliad also shows efforts to settle the conflict through negotiations by representatives of both parties (Ulf, 2011, p. 276).

The usual form of conflict *between communities*, especially in view of the increasing number of settlements and settlement growth, must have been neighbourhood conflicts, e.g. over land (but see, in contrast, the cause of the Trojan war). Compared to the only little overlap of community territories assumable for the tenth/ninth century BCE, the increasing proximity of settlements since then must also have had an impact on the understanding of one's own territoriality (Knodell, 2021, p. 197). And with the long-lasting (territorial) conflict of the Lelantine War over the homonymous plain, we encounter not only trans-regional alliances, but also agreements on conditions under which the battle was to be fought (e.g. the discussed prohibition of weapons hitting from a distance: Parker, 1997, pp. 95–105 with antique sources), as well as ways to settle this conflict (truces, single duel, treaties). Surprisingly, for most of the Iron Age, unfortified open settlements were the norm. Only from the eighth century BCE onwards, and mostly on the islands, is there evidence for simple fortifications, sectional walls or fortified refuges (Drerup, 1969, pp. 100–103). The city walls of Old Smyrna, built already in the ninth century BCE, stand out as an impressive collective effort, while even larger poleis such as Corinth or Eretria did not build city walls before the seventh century BCE. The simple, tower-less walls, however, fulfilled only basic defensive needs; time-intensive and resource-intensive sieges or the destruction of poleis were – despite the Troy narration – not the focus of inner Greek conflicts. On the contrary, sources reveal open battle as the dominant and ideologically affirmed way of warfare: the heroic duel under the eyes of the involved parties, the open battle of elites of opposing polities with their followings, and, in the seventh century BCE, the emergence of hoplite warfare, which involved more members of the poleis and, in turn, reinforced their self-confidence and claim to participation in the political process of their polity (on hoplite warfare: cf. the contributions in Kagan & Viggiano, 2013). The ideological shift from the individual (elite) warrior to the community in arms (Knodell, 2021, p. 214) can also be linked to changes in the pattern of displaying weapons. In Athens, for example, elite male burials of the first quarter of the first millennium BCE still are characterised by weapons, but they are hardly present any more from the middle of the eighth century BCE onwards (D'Onofrio, 2011; Ruppenstein, 2015, p. 495 with references). In comparison, from the late eighth century BCE onwards, weapons become prominent as votives in the supra-regional, panhellenic sanctuary of Olympia, offered by individuals and now also communities, and often as parts of booty from conflicts between poleis (Eder, 2015, 523).

There is no unambiguous evidence for conflicts *within communities* from the tenth/ninth century BCE. In the early texts, however, they are already a prominent topic. The elites of the epics share an understanding of what behaviour was detrimental to the community and that inner conflicts endangered the group's claim to leadership (Seelentag, 2015, p. 91), and there are already the first signs that rules of proper conduct can be considered as 'law' (*dike:* Ulf, 2011, p. 271). These shared values and norms also affected the resolution of inner conflicts and thus presuppose political, albeit pre-state, communities (Seelentag, 2015, p. 87). Arbitration was a central form of conflict resolution; for Hesiod, aptitude for arbitration is an important quality of a good *basileus* (Theogony, 81–92; cf. Raaflaub, 1989, pp. 19–21; Seelentag, 2015, pp. 145–147), and Homer's famous description of the depictions on the shield of Achilles comprises a publicly negotiated, institutionalised arbitration (Iliad 18, 503–6; Ulf, 2011, p. 270). The necessity of good/lawful order (*eunomia*) for a functioning community, but also the responsibility of local elites for it, is still emphasised in the seventh century BCE, in Athens for instance by the lawgivers Draco and Solon, both members of the local elite themselves. They emphasise the balancing of (elite) interests, as well as community-oriented conduct, and warn against internal tensions up to civil war-like conditions (*stasis:* Raaflaub, 1989, pp. 24–25; Seelentag, 2015, p. 525). Such tensions could sometimes only be resolved radically, for example by eliminating a faction (cf. the recently excavated mass grave in Athens and its discussed connection with the failed coup of Cylon and his followers around 630 BCE: Ingvarsson & Bäckström, 2019) or by 'community fissioning', i.e. the secession of elite factions or kin groups to establish settlements overseas (i.e. 'colonies': Knodell, 2021, pp. 204–205). Against this background, the known early laws and local institutionalisations have to be also understood as attempts by local elites to defuse internal power struggles and conflicts among competitive peers, since instead of defining the powers of institutions they rather regulate and curtail them, e.g. by limited terms of office and restricted iteration (Seelentag, 2015, pp. 135–138; cf. also the contributions in Meister & Seelentag, 2020). The concern was thus, clearly, to prevent a concentration of power and, in consequence, a permanently leading position of one person over his peers (Seelentag, 2015, p. 74). And already the oldest laws do not establish but presuppose the institutions mentioned, i.e. they are to be understood as reactions to conflicts and power struggles within their communities (Seelentag, 2015, p. 140). This is also indicated by their character as ‘constitution’. The laws of Dreros, for example, were no systematic body of laws written down at one time, but individual regulations from different years that must have been decided and published on occasion (Seelentag, 2015, pp. 139–140).

9.4.5.8 Knowledge

For the tenth/ninth century BCE, we can assume highly personalised knowledge in the communities and mostly traditional knowledge. The heroes of the epics, too, boast their competencies in many fields to underline their authority, even if we also meet specialists such as physicians, bards, seers, or carpenters in the epics (Ulf, 2011, p. 267). Wandering bards with a shared repertoire of themes and narrations, but also elite mobility and their participation in peer-polity interaction, e.g. in panhellenic sanctuaries, must have contributed early on to a well-established trans-regional exchange of knowledge. During the eighth century BCE, however, the emergence of specialised sacred architecture indicates a decoupling of (religious) specialised knowledge important for the communities from an outstanding local individual, and its functional institutionalisation (priests: Mazarakis-Ainian, 1997). Above all, however, the adaptation of the Phoenician alphabet to the Greek language and its rapid dissemination during the eighth century BCE marked an important turning point for the hitherto oral Iron Age culture, offering also new possibilities for the preservation, distribution and use of knowledge (Whitley, 2017 with an archaeological approach to early writing and its materiality, esp. pp. 90–94 on early Cretan inscriptions). The earliest written texts already reflect and document extensive shared bodies of knowledge. Hesiod’s Theogony, for example, outlines religious knowledge and, embedded in it, an idea of the past, while his Works and Days incorporates comprehensive agricultural knowledge. And from the seventh century BCE onwards, we come across writing with explicitly political function in the form of laws (Knodell, 2021, p. 234). Their monumental form and presentation as permanent inscriptions show that they were meant to address the local public (Seelentag, 2015, p. 231) and to be referred to in case of dissent or conflict. Political knowledge in the communities became institutionalised – and transparent.’

9.4.5.9 Conclusion

The Greek Iron Age offers remarkable insights into socio-political developments and potentially diverse trajectories of processes that led from communities in small scattered settlements, with only modest material culture and low organisational complexity, to the formation of the polis, the city-state/citizen state with its increasingly complex political institutionalisation and public conduct. The perspectives offered already by the earliest written testimonies from the eighth and seventh centuries BCE, in particular, are unique. They attest to a complexity and diversity of forms of concrete social organisation, as well as to discourses on power, leadership, community, and reactions to crisis beyond simple top-down models and their often-assumed implications. It is this complexity and diversity in its specific depth that cannot be extrapolated from the archaeological record alone. And these texts also show us the limits of categorising societies according to only a few criteria in the sense of anthropological archetypes and models. We have to assume regional variety, different forms of society, and socio-political complexity all at the same time (and thus also different forms of elites: Kistler & Ulf, 2005; Kõiv, 2016; Ulf, 2007, p. 321). But above all, these developments and processes did not take place everywhere, in the same way, or have comparable outcomes, even if they were always influenced by strategies of local elites to gain and maintain power and by their attempts to defuse resulting crises among peers and within their communities. A participatory bottom-up governing polity of institutional complexity, however, as was the (extreme) outcome of democratic Athens from the late sixth century BCE onwards, was never envisaged.

9.5 Discussion

Having brought our data to a baseline by describing all case studies along the defined parameters, it is now possible to compare them and tease out political systems and practices, as well as their dynamics, pattern, developments, changes and transformations that the case studies (CS) share, by using statistical exploration.

We consider here the patterns highlighted by the cluster analysis.

The analysis includes all CS in terms of the defined parameters with all available attributes. The results (Fig. 9.6) indicate that certain parameters are crucial for the formation of clusters. Particularly clear is the relevance of community size, network configuration (especially concerning mobility aspects), resource distribution or accessibility, conformity/non-conformity, and aspects of settlement organisation, as they seem to structure certain cluster developments. These parameters almost always form close links with different attributes, which in turn give rise to overlapping, less interconnected links. In the following, we would like to discuss these influencing factors against the background of their connections with other attributes. In particular, we want to look at the different scales of community sizes, breaks with political traditions, decision-making processes, social differentiation and settlement policies.

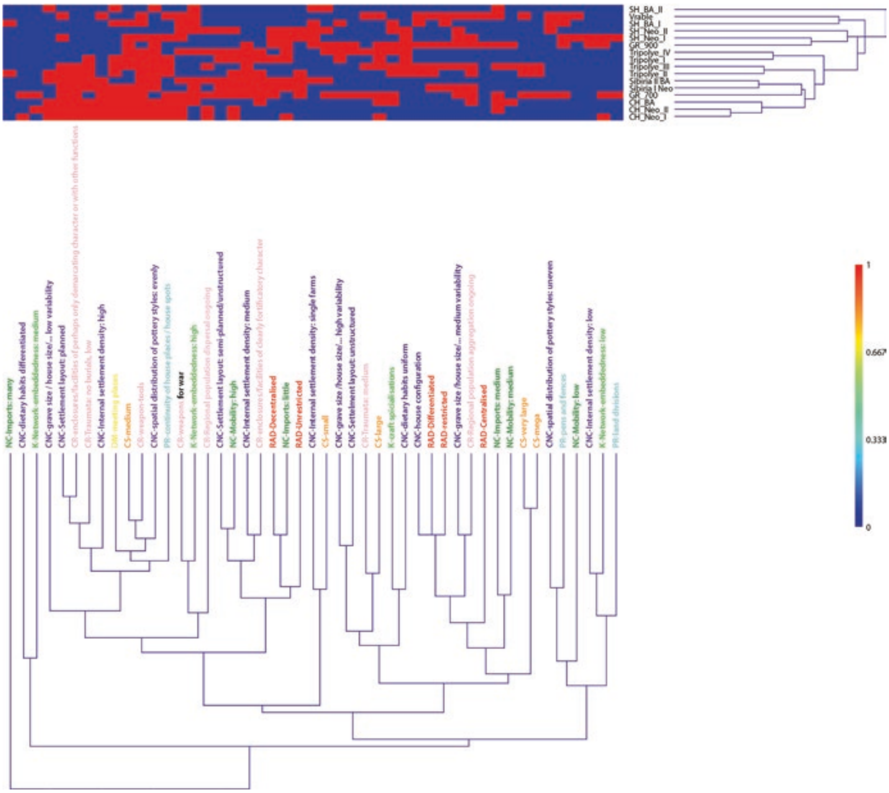

Fig. 9.6 Dendrogram of a hierarchical cluster analysis (using PAST, version 4.03) concerning the five case studies: Neolithic and Bronze Age Schleswig-Holstein (SH Neo I-II, SH BA I-II), Neolithic and Bronze Age in the Northern Alpine Foreland (CH Neo I-II, CH BA), Neolithic and Bronze Age West Siberia (Siberia I Neo, Siberia II BA), Neolithic Trypillia (Trypillia I-IV), Iron Age Greece (GR 700, GR 900). In addition, the site of Vráble is used for comparison

9.5.1 Scales of Communities

In our data, we can distinguish single farmsteads (CS: older and younger Bronze Age Schleswig-Holstein), small (CS: Neolithic Schleswig-Holstein), medium-sized (CS: lakeshore settlements of Switzerland), and large or mega (CS: Trypillia; Greece) communities, that reveal different concepts in socio-political order. There are, of course, more parameters which we deem influential in the configuration of political systems, and these will be described later.

Starting with the particularly small and scattered settlement structures that we can record, for example, in Nordic Middle Neolithic to Late Neolithic Schleswig-Holstein, we can see that they are often related to the decentralisation of resources, while in the Older Bronze Age they seem more restricted or required, e.g. by using high amounts of resources mainly for barrows (Falkenstein, 2017; Schaefer-Di

Maida, 2023), and exhibit lower degrees of mobility than, for example, the lake shore settlements in the Alpine regions. While the settlement system itself was characterised by a low density of inhabitants and rather scattered location of the settlements themselves, wider networks and communication are visible, for example in the presence of similar forms, decoration patterns and usage of pottery during the MN phase in Northern Europe (Furholt, 2012; Müller & Peterson, 2015). We can assume that many of the daily affairs were handled with social roles which were represented in these, presumably, tightly organised and small communities. Although, therefore, some important part of daily socio-political affairs was handled within small groups, which might have been mostly defined by kin-based relations, there is also a wider political structure detectable. The small size of the settlements, and therefore the number of people inhabiting them, might lead towards a great dependency on the wider network connected to the single farmsteads. Security and help, for example, in the case of sickness or bad harvests, could be provided by communities which exceeded the small social groups living together permanently. Social security and cooperation are crucial in any form of residence system and can only be provided, at least in some cases, by a larger but usually scattered collective. The wider political structures are reflected in monumental architecture, although the outline and purpose of these seem to be very different when speaking about the phases of the Bronze Age. In the Nordic Middle Neolithic, monumental architecture is represented by megaliths which are, in their majority, clearly designed to represent collectives with little or no emphasis on individuality. The clusters of these graves have been repeatedly altered and revisited (e.g. Gebauer, 2014; Mischka, 2022). The effort of their construction and maintenance by far exceeds the capabilities of the small contemporaneous settlements based on single farmsteads (e.g. Brozio, 2016; Wunderlich, 2019), and should represent collective decision-making and an important space for gatherings and the organisation of the wider political system. As clear markers of social inequality and differentiation of wealth, not only is consumption missing during this phase, but we might also assume a rather flexible socio-political system, which might have been based on a mechanism such as feasting and merit-based status – derived and earned by, for example, the participation in collective action such as the construction of megalithic graves. During the Bronze Age, monumentality maintained its importance, but was directed in a very different way. The focus on the individual, reflected especially in monumental buildings for highlighted personalities, seems connected to not only the settlement or household system, but also to the transformations connected to the rise of metallurgy and the ever-growing importance of the exchange networks connected to it. In this, pronounced social differentiation is a representation to the outside world of the head of the household, as a ‘chosen individual’ representing the household and its connections, economic strength, and wealth, as is evident from grave mounds built on top of former houses (e.g. Handewitt, Trappendal, Hyllerup, Tranarp: cf. Bokelmann, 1977, pp. 82ff.; Svanberg, 2005, p. 79). Such direct connections between houses and megalithic tombs, on the other hand, did not exist during the Neolithic period. The role system addressed was thereby probably strongly fixed and left little room for negotiation. These tight political structures, possibly enforced and controlled by a representative person of the household, who was the only one to receive a grave mound, may have served the productivity of the household, and were thus strongly associated with resource control but also spendthrift expenses on certain aspects such as barrow construction. As a consequence of this narrow system, there was little room for innovation, as can be seen in the Bronze Age, for example, in the simple production of settlement pottery, which is monotonous throughout southern Jutland. This changes only with the younger Bronze Age, when settlements emerge that go beyond single farmsteads. The houses do not increase in size, but the single households seem more connected to each other, so that we could call them small- to medium-sized settlements. They show new socio-political developments, which appear more equal, and without focus on one representative person but on the collective (especially in the graves and networks, see CSs), so that a completely different socio-political system can be assumed, which was shaped by new worldviews and ideas (see below). This younger phase of the Bronze Age in Schleswig-Holstein is separated from the other CS in the cluster analysis and it no longer follows any former system known in that region. While it still includes small communities, it breaks with the previously strong social differentiation; networks break down and with that seems to come to a focus on risk management (rise in hoards). The highlighting of single individuals loses importance and political entities focusing on the collective seem to transform the previous structures (see CS: Neolithic and Bronze Age Schleswig- Holstein). In summary, the first socio-political system that we can derive from the data analysed here is characterised by small and loosely organised settlements, the presence of wider networks, presumably lower degrees of mobility and social structures that might span from more egalitarian to hierarchical systems. In both cases, monumentality as central locations for spatially separated clusters of people is a key feature for communities to express and renew their political structures.

According to our cluster analysis, the factor of mobility seems to be of great influence within this system, as another part of the case studies included here shows. Small to medium-sized settlements, however, can also offer a more flexible and mobile way of life, promoted by equally flexible socio-political concepts. Such communities are evident in the lakeshore settlements in Switzerland, as well as seasonally in the hunter-gatherer communities in Siberia. In the cluster analysis they show a common tendency to high residential mobility. The roles of individuals were probably less fixed and more negotiable, but had to be fulfilled when it mattered in order to remain part of the community. The high importance of residential mobility raises a central question concerning political structures: to what degree did high mobility prevent the formation of stricter systems of socio-political structures within groups that maintained close connections (such as settlement communities)? Rule systems seem less strict in this regard and aspects of mobility would also not allow strict rules at all. A non-correspondence approach, as Ebersbach (2010a) suggests for the Swiss lakeshore settlement, does explain a lot of the variation that we see in our dataset: a community is made up of different groups linked by different aspects such as kinship, religion, economic factors and so on. Despite belonging to such a social group, their members live scattered, and together with members of other groups, and thus form diverse residential communities. Since both the subunits of residential communities (such as households), as well as the communities themselves (e.g. short-lived settlements) are highly mobile, the social networks connecting them existing and are meaningful, yet they are flexible and presumably resilient, and might also have been dependent on specific moments such as gatherings. Depending on the season, event, etc., group members come together to serve certain activities and thus fulfil a specific role that may be required at that time. Thus, they reflect political units that are scattered and can come together when necessary (seasonally, in certain situations). In doing so, they focus on collective representations (CS: Siberia re. fortifications, social signals – kinship, religion, etc.) and pursue an outward representation. The necessity of collective and highly representative structures, which by no means have to be permanent or archaeologically visible, is a crucial characteristic in our case studies. Even more than the previously described socio-political system, being based on small but comparatively stable settlements, communities with high residential mobility might have had the need for regular or special gatherings and clear symbolism representing the broader and maybe temporary political units connecting them.

Turning to the large settlements (CS: Trypillia; Greece), we see more spatially fixed and permanent political units. At the same time, such a large community offers more possibilities in composition and order, as well as change and innovation. They provide evidence of communal houses that may have been used collectively, but the question arises as to who actually had access to such a house, as we also learned from the CS from Greece that such communal houses, communal events, committees and certain positions in the process of decision-making were again reserved for certain groups (CS: Greece – elite groups, who have gained access to knowledge and are involved in politics) and thus not necessarily for everyone – whoever belonged (and did not belong) to the general community in the respective society. A system of political representation, as indicated by communal houses, might have mirrored influential subgroups within the larger context of a settlement (such as tribes, neighbourhoods etc.). Which mechanisms were used to choose the persons representing these subunits cannot easily be reconstructed based on archaeological evidence alone, yet some exclusive mechanism may be assumed here (e.g. merit, age, or gender-based systems). Nevertheless, the representation of such institutions, which possibly served political decision-making, is to be seen in the collective. Due to the size and longevity of the settlements, it can be assumed that the materialisation of important political institutions was symbolised primarily inwardly. A clear representation within the larger community, in the form of communal houses, might have been an important stabilising factor within the wider political system of the settlements. Such large settlements also allowed for more intense resource and risk management, which must have been geared toward stability, that maintained a focus on the collective. Apart from the community sizes prescribing different political structures, we recognise the different applications of cooperation in different societies. As mentioned above, cooperative activities occur in different CS, while their societies are subject to completely different political structures. The building of the house, in particular, required the involvement of the community. This can be seen in the houses of the Schleswig-Holstein Neolithic and Early Bronze Age, in the Swiss lakeside settlements, and also in the houses and especially the communal houses of Trypillia. Another cooperation was required in the construction of monuments such as the megalithic tombs and burial mounds in Schleswig-Holstein, but also the menhir alignments for the Swiss lakeshore settlements. They are usually located outside settlements, thus occupying their very own ritual landscape or shaping it in a sustainable way in terms of visibility. In this way, they may not only mark territories, but also nodes in networks, security areas and larger entities – but always with an externally directed political impact. This external representation contrasts with the internal representation we see for the community houses in Trypillia. It can be assumed that a large or mega community size (as in Trypillia) forms a high political entity, which is only bound to the settlement structure and thereby also focuses more on the settlement itself as an area, while a lower density (as in Schleswig-Holstein and Switzerland) binds a political entity to certain areas that go beyond the actual settlement area, so that the settlement is only part of a political entity, which, however, extends over a socio-political – but also ritual – landscape around it.

9.5.2 Political Traditions

A central clue to changing policies that seem pervasive is the break with political traditions or practices that played a central role and are no longer carried out after a certain point within a transformation process, often accompanied by other fundamental changes. Such traditions of politics can be, for example, the construction of megalithic tombs or burial mounds, which extended over long periods of time, involved a lot of effort, and influenced the image of landscapes and in that way the culture of memory (Horn & Wollentz, 2018; Müller, 2018). The break with this monumentality around 1300 BCE (CS: Schleswig-Holstein), combined with the burial change and the introduction of cremation urn burials with equal treatment, which opened access to a grave to the whole population (all gender and ages, including newborns and children, cf. Schaefer-Di Maida, 2023), shows a clear break not only in the tradition of monumentality, but also of certain political entities, as it was also connected to a breakdown of networks, and the introduction of new symbols, materials and new activities. Cooperative necessities enacted at the monumental building thus fell away completely. The representative highlighting of individuals became unimportant; instead, all were treated in the same way during cremation until the individual was unrecognisable. The elimination of cooperation also eliminated the roles that everyone had in such a process. Instead, new symbols were used to communicate, and new activities, such as at the cooking stone pits, indicate gatherings of whole communities and community groups (Kruse & Matthes, 2019; Schaefer-Di Maida, 2022). Decision-making processes thus might be transferred from single individuals to the group structure at such meeting places.

9.5.3 Decision-Making Processes

At the beginning of this chapter, we asked who decided what, and who was involved in decision-making. With this question, we come to another central driver of political processes: the involvement of individuals in decision-making processes. Based on our CS, we found that decision-making positions were strongly associated with knowledge. The CS on Greece, in particular, shows us how decision-making processes were carried out. For periods that have left us no written sources, this information serves all the more as a basis for interpretation – albeit one that must be applied critical.

A grammar of ornaments and vessel forms was widespread in the Nordic Middle Neolithic as an indication of widespread and widely perceived social interactions. Based on find distributions (mainly rich barrows), it can be assumed for the older Bronze Age in Schleswig-Holstein that knowledge was tied to specific individuals when symbolism appeared mainly on prestige objects that were only given to monumental graves, which means single and selected individuals, which in turn could have represented the collective. With the socio-political changes in the younger Bronze Age (see above), on the other hand, the dissemination of knowledge becomes visible through new symbols on objects known to the general population, as we can see on everyday objects (e.g. razors) in various graves, while symbolic prestige objects no longer appear (and are sometimes taken from burial mounds and intentionally rendered unusable: cf. Randsborg, 1998, pp. 115ff., 121ff.). In the CS of Trypillia, the communal houses show us that not only one individual but several could interact, but perhaps not all. As we know from the Greek CS, certain requirements – such as reading – could be a skill that only certain people were interested in acquiring, while those who did not possess these skills could not participate in meetings or decision-making. For the Trypillia CS, a similar group dynamic tied to knowledge and symbolic language cannot be ruled out.

9.5.4 Social Differentiation

Another aspect shaping politics is varying degrees of social differentiation, which could be crucially expressed in terms of unequal or equal political rights for individual members of a community. In our cluster analysis, these are particularly evident in the parameter of conformity or nonconformity. In particular, settlement layout, house division and variability in house and grave sizes are crucial indicators for such unequal rights, as they show us differences in the treatment of individuals.

A connection between house configuration and restricted access to resources can be seen, for example, during the Early Bronze Age in Schleswig-Holstein, in the Trypillia Phases II and III, in Vráble, and around 900 BCE in Greece. For

Vráble, Schleswig Holstein (BA I) and Greece (900 BCE) we have much evidence pointing to social differentiation on different levels in features and finds (cf. CSs). The Trypillia phases II and III, on the other hand, show a clear decrease in social differentiation in the interpretations of features and finds (cf. CS: Trypillia), so that divergent assumptions concerning the attribute distributions can be seen here. A major difference between Trypillia Phases II and III and the other case studies mentioned, is that the size of the settlement is increasing considerably with Phases II and III and varying between medium and mega community sizes, and aspects such as the division of houses and resources probably required special organisation as the population increased, which does not necessarily represent social differentiation. Unrestricted access to resources, on the other hand, is often accompanied by decentralisation, which in turn is often accompanied by few imports. This combination occurs especially in the Neolithic phase in Schleswig-Holstein and in Siberia (Neolithic and Bronze Age). Furthermore, only decentralisation and few imports are shown in the case studies Greece (900 BCE) and Trypillia (I).

A planned settlement layout also often entails enclosures or facilities with perhaps only demarcating character or with other functions, as well as a limited (medium) number of inhabitants and weapons in tool form. This combination of attributes is almost always accompanied by an even spatial distribution of pottery styles. This is especially the case for the Swiss lakeshore settlements, Greece (700 BCE), Trypillia (III), Neolithic Siberia and partly also for Bronze Age Siberia, Trypillia Phase II and the Neolithic Phase I of Schleswig-Holstein. In contrast, a semi-planned or even unstructured settlement layout is also often accompanied by high mobility. The internal settlement density is in the moderate (medium) range. Enclosures, or facilities which have a clear defensive character, are also often linked to these attributes. This combination of attributes occurs particularly in the following case studies: Greece (700 BCE), Trypillia (I and IV), and Siberia (Neolithic and Bronze Age). This attribute combination does not seem to be tied to a specific settlement size. However, it is noticeable that smaller to medium-sized communities predominate in the case studies mentioned. A completely unstructured settlement pattern also goes with high variability in house and grave sizes. Traumata in this combination are mostly in the medium range and community sizes are large. Often this attribute combination is associated with craft specialisations and uniform dietary habits, and occurs especially in the case studies Trypillia (IV) and Greece (700 BCE and 900 BCE). A low internal settlement density, on the other hand, occurs especially in the first Neolithic phase of Schleswig-Holstein, together with low network-embeddedness and land divisions. Comparable results can only be found for Greece, but here the combination of a low internal settlement density and a low network embedding around 900 BCE differs from the combination of a low network embedding and land divisions around 700 BCE. Since weapons in tool form were mentioned above, it should be mentioned here that, on the other hand, weapons that were also intended for warlike purposes are associated with a high embedding in networks. This is especially the case for Siberia (Neolithic and Bronze Age), the Bronze Age in the Swiss lakeshore settlements, Greece (700 BCE), Trypillia (IV) and Vráble. For the site of Vráble (Furholt et al., 2020a), which can be used for comparison, we note an attribute combination of an uneven spatial distribution of pottery styles, the occurrence of pens and fences, and low mobility. For the First Neolithic phase of Schleswig-Holstein, pens and fences can also be associated with low mobility, while in the Older Bronze Age of Schleswig-Holstein and in Greece (700 BCE), pens and fences occur mainly together with uneven spatial distributions of pottery styles.

It is noticeable that the case study on the Younger Bronze Age of Schleswig-Holstein is often isolated and has few comparisons to the other case studies. This can be explained by the fact that only a few attributes are applicable to the Younger Bronze Age, since we mainly have information from graves and hardly any settlement data.

9.6 Conclusion

We are aware of the limitations of our study: our selection of case studies reflects current research activities and our own research interests, and it is not representative of prehistoric non-state societies worldwide, not even across Europe. We are also aware of the historical specificity of each individual CS. Yet since the political dimension of prehistoric societies is such an underdeveloped research topic, we do think our first tentative approach to the social patterns and structures underlying and shaping the negotiation of collective decision-making processes has been able to point to the importance of specific factors, such as settlement size, regional networks, conformity of architecture and settlement layout. Beyond these factors, and the configurations described, the politics of each single case study was probably, to a large degree, shaped by unique historical situations, which should also be appreciated. Nevertheless, we hope to have demonstrated that a comparative perspective on the social factors underlying certain forms of politics is a topic that archaeology is able to further explore for prehistoric communities far beyond the number of CS discussed here. For archaeology, we can state that we can model past polity and politics on the basis of material legacies together with anthropological insights, and make them available for comparative approaches. Finally, our discussed examples demonstrate patterns of political activities and transformations. They also go together with transformations in non-political spheres of life and show, on the one hand, the complexity of political processes and, on the other, the interconnectedness of the individual spheres of life with political dynamics, the navigation of which possibly correlates with the relationship between people and the environment.

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Part IV
Conclusions: Ancient Change in Europe

Chapter 10
Overarching Patterns of Ancient Transformation in Europe

Johannes Müller, Wiebke Kirleis, Jutta Kneisel, and Wolfgang Rabbel

10.1 Introduction

Can similar patterns or even simultaneous socio-environmental transformations be identified in different European regions? In order to answer such a question, the forms of analysis and interpretation described in Chap. 2 can be brought together, at least to some extent. We discuss some results from the CRC 1266's regional transformation studies together with historically supra-regional transformation phases so far identified. As a reminder: we define transformation as processes leading to a substantial and enduring re-organisation of socio-environmental interaction patterns that occur on different temporal, spatial and social scales (Müller & Kirleis, 2019; see also Chap. 1). The aim is to identify an imprint of the important transformation phases in European prehistory in the period 10,000–1 BCE. With this concluding chapter we shall bring together threads from the previous chapters and begin to weave them together into such an imprint.

Structural comparisons have already been made by comparing different parameters in relation to the political economy of some case studies from different periods and different areas (Chap. 9). "The results (Fig. 9.6) indicate that certain parameters are crucial for the formation of clusters. Particularly clear is the relevance of community size, network configuration (especially concerning mobility aspects), resource distribution or accessibility, conformity/non-conformity and aspects of

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settlement organisation, as they seem to structure certain cluster developments. These mentioned parameters almost always form close links with different attributes, which in turn give rise to overlapping, less interconnected links" (Chap. 9).

While the role of community size, network configuration and access to resources in particular emerged in the regional studies as decisive fields for transformative changes, the question of the spatial dimension and the possible simultaneity or non-simultaneity of transformations has not yet been answered.

In the current state of research, specific periods of change can be identified (see below), which constitute different effects in different regions, but take place more or less simultaneously. Without wanting to conduct a detailed analysis here, certain time horizons of supra-regional transformation processes emerge. In contrast to transformation processes that cover a spatially limited area, at the European level we are dealing with different periods of accelerated change that can be recorded in several sub-regions of Europe. Before we analyse at these in more detail, however, we would like to discuss transformation phases that were already considered in the CRC 1266 in 2020.

10.2 Regional Transformation Phases in Comparison

As part of an expert survey across various subprojects of the CRC 1266, information on different aspects of transformations was collected in 2019 (see supplementary material). Due to the different proxies from which they were derived, these data are quite variable with regard to the fineness or coarseness of quantification, as well as their temporal and spatial depth and resolution. However, we consider them as a useful approach for comparing the quite heterogeneous source situation in different European landscapes.[1]

The data requested come from southern Scandinavia/northern Germany for the periods 9600–6400 BCE, 3300–1700 BCE and 1800–500 BCE, from southern Central Europe for the periods 5300–4900 BCE and 3900–2400 BCE, from south-western Eastern Europe for the period 4800–3300 BCE and the Aegean for the period 1200–700 BCE.[2] The semi-quantitative data (see below) on an equivalent scale made it possible to make comparisons that could serve to build hypotheses[3] (Fig. 10.1).

[1] The overall alignment of the data obtained in the CRC 1266 is planned for a third phase of research(2024–2028).

[2] CRC 1266 subprojects B2 (9600–6400 BCE), C1 (3300–1700 BCE), D3 (1800–500 BCE), C2 (5300–4900 BCE), D2 (3900–2400 BCE), D1 (4800–3300 BCE), E1 (1200–700 BCE), with the integration of aspects from the component projects (F1-F5).

[3] It is clear that the observations before c. 6400 BCE refer only to north-central Europe and southern Scandinavia, those from 5300–4900 BCE only to southern central Europe, those from 4800–3900 BCE only to south-western eastern Europe, those from 3900–3300 BCE only to southern Central Europe, those from 3300–2400 BCE only to Central Europe and southern Scandinavia, those 2400–1200 BCE only to northern Central Europe and southern Scandinavia, and those after 1200 BCE to northern Central Europe/southern Scandinavia and the Aegean.

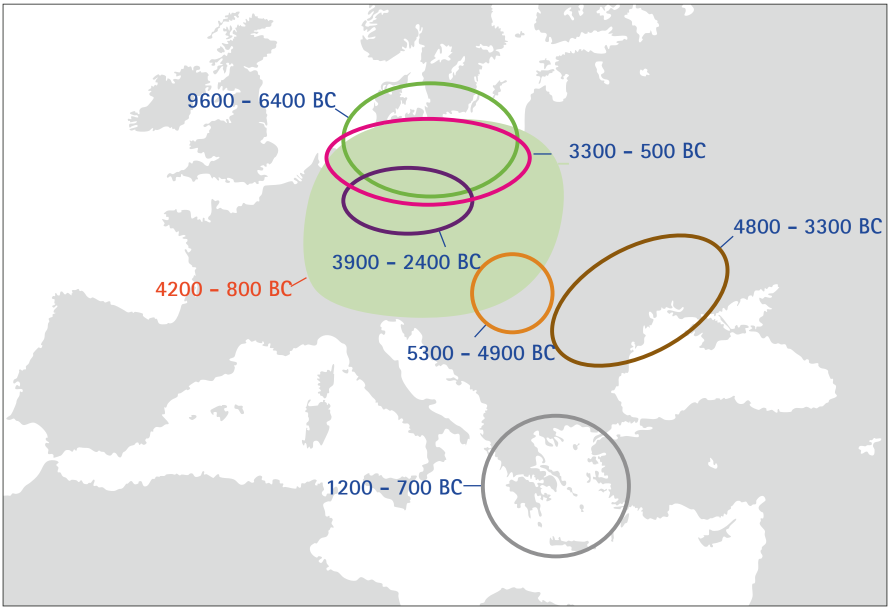

Fig. 10.1 Regions and CRC 1266 subprojects whose data were integrated into the comparison of regional transformations

A comparison of these different regions from Scandinavia and Central Europe to the Aegean and the North Pontic area presupposes a detailed examination of the sources. For a multidisciplinary approach, it was necessary to generate a common level of comparability. This means converting information from material culture, socio-cultural changes, scientific data and written sources into time functions of numerical indices that enable a diachronic comparison.

This time function of change (TFoC) was computed in the following steps:

1. Based on 18 selected parameters (Fig. 10.2) – cosmology/ideology, networks, power, conflict, institutions, inequality, specialisation, production, technology, mobility, organisation of space, demography, nutrition, seasonality, religion/ritual, health, extreme climate events, and soil quality[4] (Müller & Kirleis, 2019, p. 1520, Fig. 3) –, data from different regions were compiled and observed changes were rated on a scale from −1 (decrease) to 1 (increase). This indexing corresponds to a differential calculation, which describes changes to the previous value. In this case, the value 0 means no change.

[4] Health and extreme climate events are only available for a short period of time and were not considered for the time being. The soil quality only changed as a result of cultural processes during the Bronze Age (1900–500 BCE), leading to fuzziness in the graph, due to which it was omitted here. The marked transformation processes, however, remain unchanged.

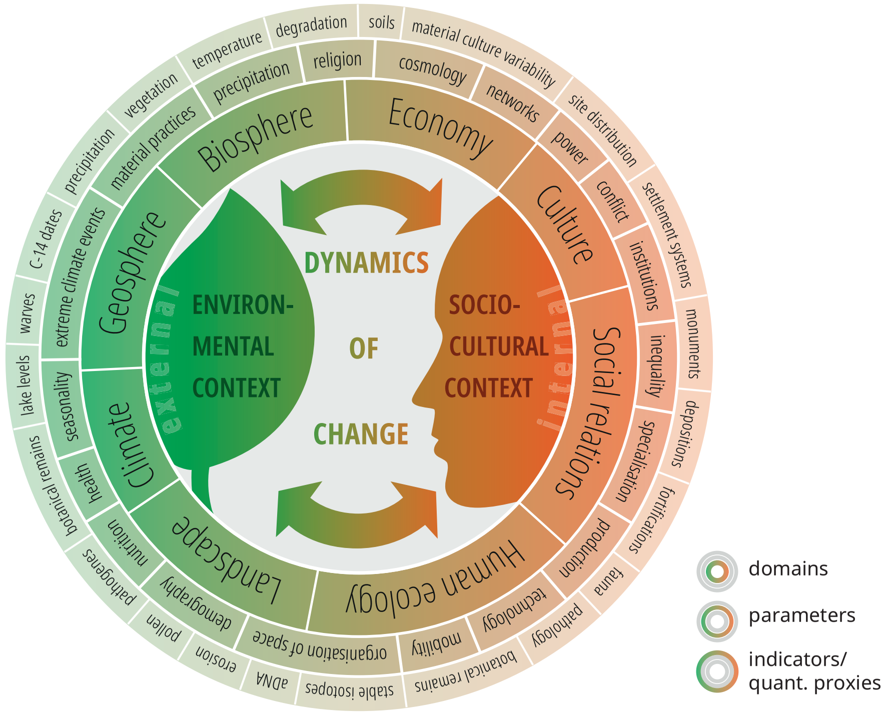

Fig. 10.2 The CRC 1266 approach to studying transformation: Exemplified indicators/quantitative proxies reveal parameters connected to the domains of socio-environmental contexts. Both the identification of categories of archaeological and palaeo-environmental archives that can be used for the reconstruction of transformations, and the assignment of these categories into domains and processes, are indicated

2. For each kind of parameter and each region, the index values were ordered in 100-year intervals along the time axis, thus forming one time function per parameter and region.
3. For each parameter, the time functions of all regions were ordered along the common time axis. Segments of time functions that overlapped in time were averaged. The result is 18 supra-regional diachronic time functions of change, one for each parameter (Fig. 10.3).

   Since the 18 time functions of the parameters resulting from step 3 are very difficult to read as a line graph, we displayed the discretized values as coloured bands extending in both positive and negative value ranges. Independently of the absolute magnitude of the value, each positive value of the time function is marked with a stripe in the positive direction, each negative value with a stripe in the negative direction. The more parameters point to the same direction of change, the darker the stripe pattern gets (Fig. 10.4).
4. Finally, these parameter-specific time functions were averaged for each time point.[5] The result is the supra-regional diachronic time function of change, shown in Fig. 10.5. The curve agrees with the transformation pattern from step 3, which may be regarded as an indicator of the "intensity" of the transformation.
5. Red bars in Fig. 10.5 indicate times of clear changes in the curves, interpreted as strong transformation phases.

The overlapping of the bands (step 3) marks increased change and transformations in both the negative and positive ranges. Thirteen clear transformations can be marked on the graph (red lines), six of which take place only in the positive area, three only in the negative area. Of these, two are close to each other (c. 4200–400 BCE and 1800–1600 BCE), which can be considered together with the four other continuous transformation phases – those ranging from the negative to the positive range. They mark a significant change in the parameters. In the following, the continuous transformation phases are referred to as high transformations, the others as low transformations.

The transformation phases are mainly characterised by socio-cultural and environmental changes, each with a different intensity. The beginning of our time scale is around 9600 BCE, the post-glacial colonisation of northern Germany, the end is the Roman occupation of parts of Central Europe (c. 50 BCE). Thirteen transformations have been identified, which can be described as follows.

Transformation 9300 BCE (South Scandinavia/Northern Germany) A weak transformation is present after the preboreal oscillation around 9300 BCE with the first Bond Event (Terberger, 2014; Terberger et al., 2009). The Palaeolithic Ahrensburgian groups are no longer detectable; instead we find a Mesolithic way of life influenced by the spread of woodlands. Stationary game hunting replaces the tracking of herds. Seasonally sedentary hunter-gatherer groups emerge in the phase between 9200–8700 BCE.

[5] Time points void of data were excluded from the averaging.

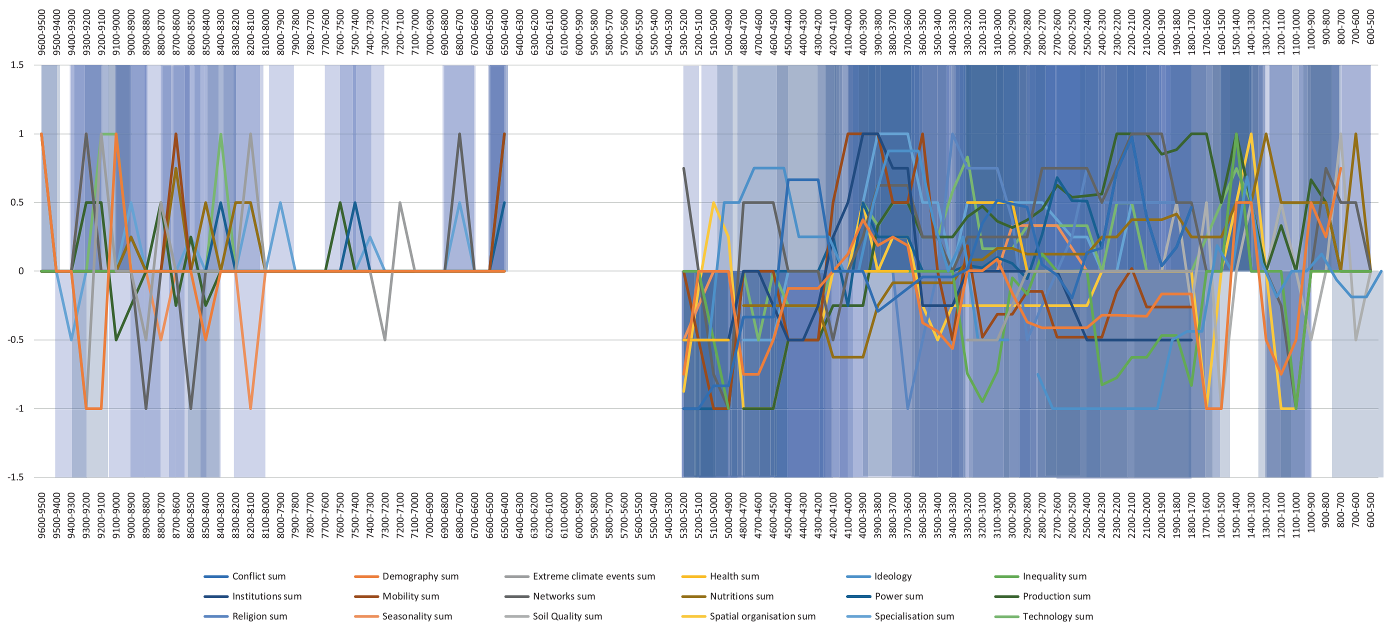

Fig. 10.3 Visualisation of the transformation phases according to the differential calculus of 15 parameters from the CRC 1266 subprojects

Fig. 10.4 Visualisation of the differential calculus of 15 parameters, combined, from the CRC 1266 subproject D2

Transformation 8800 BCE (South Scandinavia/Northern Germany) The second weak transformation phase is around 8800 BCE, when the spread of hazel leads to a renewed change in the Mesolithic way of life. It is the second phase of land occupation by Mesolithic hunter-gatherer groups. Subsequently, we see repeated changes on a smaller scale.

Transformation 6500 BCE (South Scandinavia/Northern Germany) It is only from c. 6500 BCE onwards that we see another transformation phase as a result of the rapid rise in sea level, which leads to a migration of coastal dwellers from the North Sea basin to inland areas. Technologically, flint technology changes from the triangular microliths of the older Maglemose group to the Late Mesolithic trapezoidal microliths. The new inland networks are more Central European in their orientation, though along the southwestern Baltic Sea the Kongemose group sets itself apart from this as a coastal culture. The connections to the north-western techno-complex of the British Isles break off, and a largely independent flint technology emerges there.

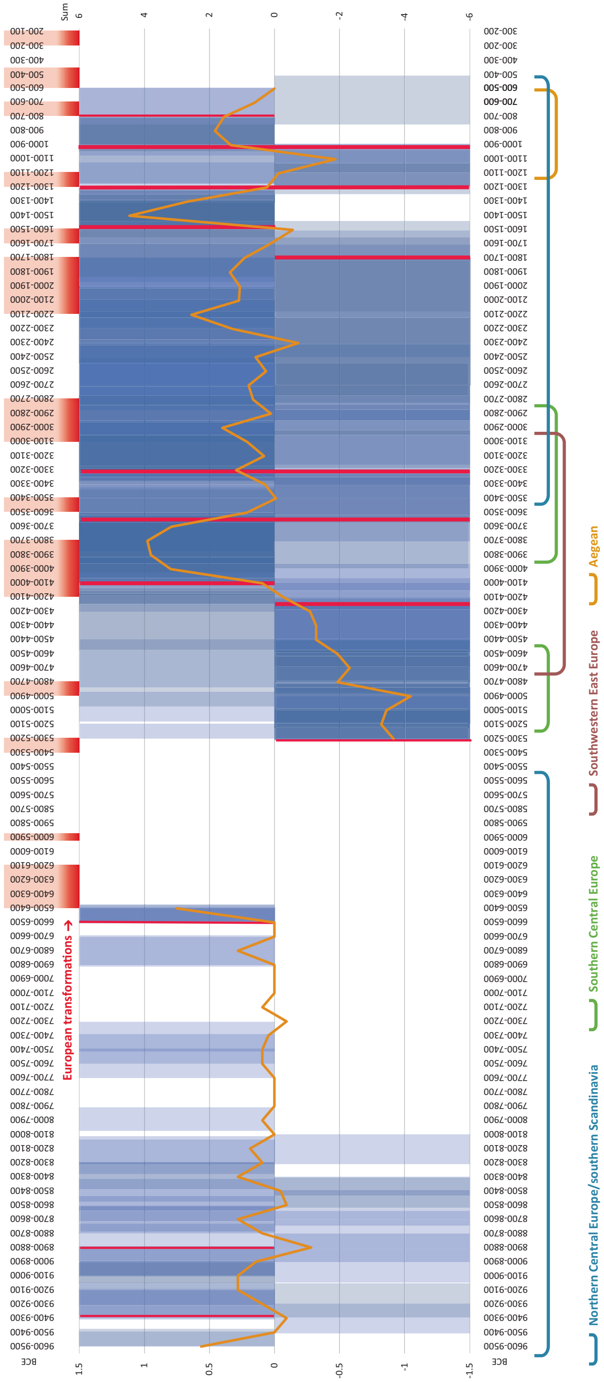

Fig. 10.5 Visualisation of the transformation phases according to the differential calculus of 15 parameters, combined, from the CRC 1266 subprojects and the sum curve of all parameters (average value). Both the regions that were covered, and the European transformations (cf. Figure 10.7), are displayed

Transformation 5300 BCE (South Central Europe) Linear Pottery settlements in south-eastern Central Europe begin around 5500/5300 BCE, with a low transformation due to the lack of data from previous archaeological periods (Furholt et al., 2020). Population agglomeration decreases around 5000 BCE, and strong changes in settlement structures occur once more from 4800 BCE onwards with smaller-scale agglomeration, but the structures are different. Additionally, further changes can be observed; in the treatment of the dead from c. 5000 BCE and the construction of the rondels from c. 4800 BCE. The parameters of this change lie in the ritual and ideological spheres and are an expression of communal actions. However, this transformation does not stand out very clearly, but is recognisable in the peak of the cumulative curve of the parameters.

Transformation 4300 BCE (Central Europe/Southwest East Europe) In southern Central Europe from c. 4300/4200 BCE onwards, we detect the emergence of causewayed enclosures and the establishment of Michelsberg societies with new agro-technical innovations, a changing burial practice and an intensification of raw material quarrying (Fuchs et al., 2019). Imported copper objects increase and lead to the establishment of copper metallurgy in some regions around 3800 BCE. In southwest Eastern Europe, the development towards larger sites – the mega-sites – begins.

Transformation 3600/3500 BCE (Central Europe/Southwest East Europe) From 3600 BCE onwards, the transformation from Michelsberg to Wartberg and other more regionally oriented societies (Drummer, 2022; Rinne, 2022) indicates a change which might have been triggered by the introduction of the ard. In southwest Eastern Europe, a transformation takes place between 3600 and 3500 BCE with the end of the East European mega-sites (Müller et al., 2016). In the subsistence economy, we record the beginning of agriculture and the emergence of the ard around 3600 BCE. An extensification of cereal cultivation by use of draught animals and manuring of fields is observed from 3300/3200 BCE (Kirleis, 2019; Filipović et al., 2019; Kirleis, 2022). At the same time, we also see a change in the range of cultivated plants. Barley, which is more flexible in cultivation, becomes more important in this region. These phases also stand out as significant transformations.

Transformation 3200/3100 BCE (Central Europe/Southern Scandinavia) Around 3100 BCE there is also a significant transformation: the end of the collective burial custom in Northern Germany and Scandinavia (Brozio et al., 2019; Müller, 2019). The following period up to 2700 BCE is characterised by numerous major and minor changes in Northern Germany, which in themselves, however, do not form a transformation phase of their own (Chap. 5). The establishment of the Corded Ware Societies between 2800 and 2500 BCE can be identified as transformations in the region (Fig. 5.2). Other transformations are detected in the beginning of cyclic reburial in megalithic graves, on a local level, from c. 2600 BCE, or the changes in parameters such as ideology or networks. Similar to the Central German Loess areas, we do not perceive the subsequent changes, such as the transformation from

Funnel Beaker Societies to the Globular Amphorae or Single Grave phenomenon (3100–2600 BCE), the beginning of the dominance of the single grave custom (2800–2300 BCE) or the Bell Beaker phase (2400–2000 BCE) in northern Europe. Obviously, these changes are imbedded in "Late Neolithic *habitus*" without huge supra-regional changes in the realm of socio-cultural spheres.

Transformation 1700 BCE/1500 BCE (Southern Scandinavia/Central Europe) In contrast, the transition from Late Neolithic to the Older Bronze Age around 1700 BCE, the end of the Dagger Period and the beginning of massive burial mound development can be seen as a significant transformation, comparable to the first megalithic boom in the North (Chap. 5).[6] The beginning of Period II around 1500 BCE marks a massive increase in material culture in the burial mounds (Kneisel et al., 2019). From 1500 BCE onwards, a clear diversification of cultivated plants, and altered cultivation strategies with winter and summer cereals, set in. The stepwise introduction of common millet (*Panicum miliaceum*) in Europe occurs in each case during high transformation phases: 1700 BCE in south-eastern Europe, 1500 BCE in central Europe, 1200 BCE in northern Europe (Filipović et al., 2020, 2022).

Transformation 1300 BCE (Southern Scandinavia/Central Europe and Aegean) The transition from inhumation to cremation around 1300 BCE and urn burials mark the second high intensity transformation (Iacono et al., 2022; Kneisel et al., 2022; Schaefer-Di Maida, 2023).

Transformation 900 BCE (Southern Scandinavia/Central Europe and Aegean) From c. 900 BCE onwards, the number of settlements increases, centers of wealth such as in Albersdorf and Seddin (May, 2018) emerge, and supra-regional networks are also intensified again after a phase of decline. The increase in graves indicates a rise in population during this period (Kneisel et al., 2019). In the Corinthian Gulf, based on pottery styles, we detect a change from a homogeneous social structure to a stronger stratification of society at the transition from Protogeometric to Geometric around 900 BCE (Keßler, 2023).

Transformation 700 BCE (Southern Scandinavia/Central Europe and Aegean) A low transformation appears after 700 BCE with the beginning of Period VI in the north, where there is a change in networks and a complete exchange of material culture in the graves (Kneisel, 2021). In the Corinthian Gulf, we observe a significant change in ceramic styles from c. 750 BCE with the beginning of the Late Geometric phase, which indicates an intensification of networks in this region (Keßler, 2023).

[6] In contrast, the changes heralding the Dagger Period in northern Germany, with a diversification of cereal types starting around 2200 BCE, are not quite as obvious. This may be due to the different developments in the rest of the research area; in Denmark, for example, this diversification declines from 2200 BCE onwards.

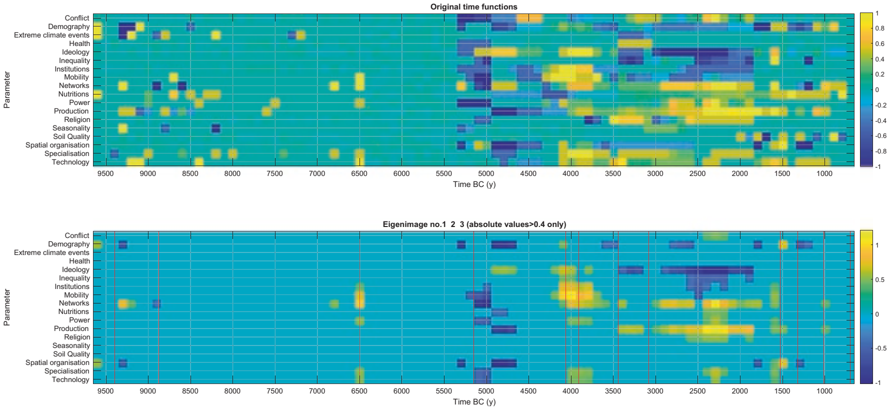

Fig. 10.6 PCA of the parameters according to time. (a) with the first three eigenimages; (b) the transformation phases marked red according Fig. 10.5. Between 6400–5400 BCE is a data gap

But which parameters are characteristic for the high intensity transformation phases within the surely diverse and only partly covered regions between Scandinavia and the Aegean? A principal component analysis (PCA) of the time functions of change ("parameters") shows that the first three eigenimages enable us to identify long-term active parameters. Figure 10.6 illustrates the correlation between parameters and transformation phases and the long-term consistency of parameter patterns correlating with major transformations since the Palaeolithic within the space-time frame of the CRC 1266. Fundamentally, there are three parameters that repeatedly determine changes over time. These are demography, networks and spatial organisation. From the Neolithic onwards, two further important parameters are added: production and ideology. In contrast, inequality, institutions and mobility play a less consistent long-term role in the transformation processes in the Neolithic of the three regions analysed. A change in the parameters around 5000 BCE is clearly visible in the PCA, which is reflected as a sharp increase in the overall curve of the TFoC. The phase of "Late Neolithic *habitus*", which is characterised by constant changes between around 3000 BCE and 1800 BCE, particularly in the parameters of networks, mobility and ideology, is equally clear. The thirteen transformation phases identified above can be associated with changes in these parameters. Two additional transformations, which are only visible through peaks in the TFoC, can be identified using the PCA: 5000 BCE and 2300 BCE are important phases of change at the European level. The European transformation around 5000 BCE can be identified with the end of the Linear Pottery and the beginning of tell settlements in the Carpathian Basin. From 2300 BCE, the introduction of bronze begins and the first urban complexes and state societies emerge in the south.

In summary, it can be stated that in a supra-regional comparison the six high transformation phases can be identified, which were detected in the mathematical derivation of quantitative and qualitative data of different CRC 1266 subprojects. These high transformations go hand in hand with, respectively, the secondary colonisations around 4100–3700 BCE, the introduction of new technologies around 3500 BCE and the change to more global communication structures around 3200 BCE. Until 1700 BCE in the Northern Middle to Late Neolithic, numerous transformations can be observed on a regional and local level. Thus, supra-regional changes do not principally dominate the importance of local and regional developments.

A similar situation can be grasped in the Mesolithic, where many individual events reflect change, but taken together no clear transformation phases become visible, according to our definition. Only the climatic and vegetation changes, such as the sea-level rise of the North Sea or the preboreal oscillation, which are accompanied by a change in living habits, are recognisable as transformation. The environmental changes act as triggers here. Changes in demography, networks and spatial organisation are an essential factor for transformations in all periods. From the third millennium onwards, production and ideology gain more importance. Inequality, technology, specialisation and power structures take on a significant role in the transformation processes at specific times. Conflicts, religion/ritual and subsistence also play a certain role in these transformations, as they can also be recorded more widely in the archaeological material of Northern Europe in these time periods (Chap. 5).

10.3 Supra-Regional European Transformation Phases

In principle, the transformations identified in the sub-areas point to transformations that can also be identified at the European level, i.e. in at least two geographical supra-regional European units.[7] In the following, individual time horizons are therefore considered that represent periods of accelerated transformations on a corresponding spatial dimension (Fig. 10.7) at the European level (cf. Bintliff, 2012; Broodbank, 2013; Fokkens & Harding, 2013; Fowler et al., 2015; Guilaine, 1998; Hodos, 2017; Schnurbein, 2014; Whittle, 2018).

European Transformation 9600 BCE Under changing environmental conditions, different economic and social changes can be identified that led to significant changes throughout Europe and the Near East over the course of several centuries. These include the domestication processes associated with the PPNA in the Near East, as well as the transition from "Late Palaeolithic" reindeer hunter groups to "Early Mesolithic" local game hunters in large parts of Europe, where fishing also played a more dominant role (Terberger, 2014).

[7] Here we consider the following areas as supra-regional geographical units: Scandinavia, north-western Europe (British Isles), central Europe, south-eastern Europe, south-western Eastern Europe, northern Eastern Europe, central southern Europe (Italy), western Europe (France) and south-western Europe (Iberian Peninsula).

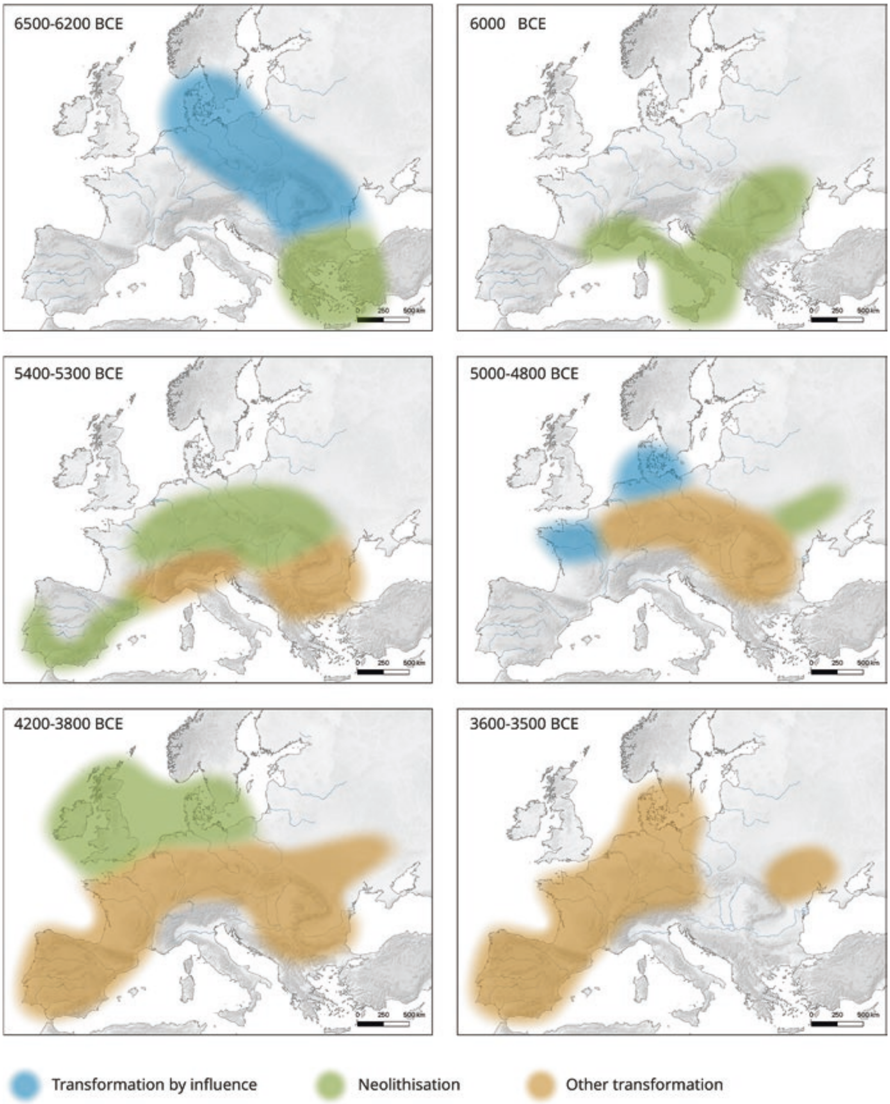

Fig. 10.7 European transformation phases. Main areas of change are indicated. Both regions with primary transformations (e.g. Neolithisation) as well as regions with secondary influences that lead to transformations are indicated. Selected are transformation phases starting c. 6500 (Fig. 10.7a) to those until c. 400 BCE (Fig. 10.7b). See the text for further explanation

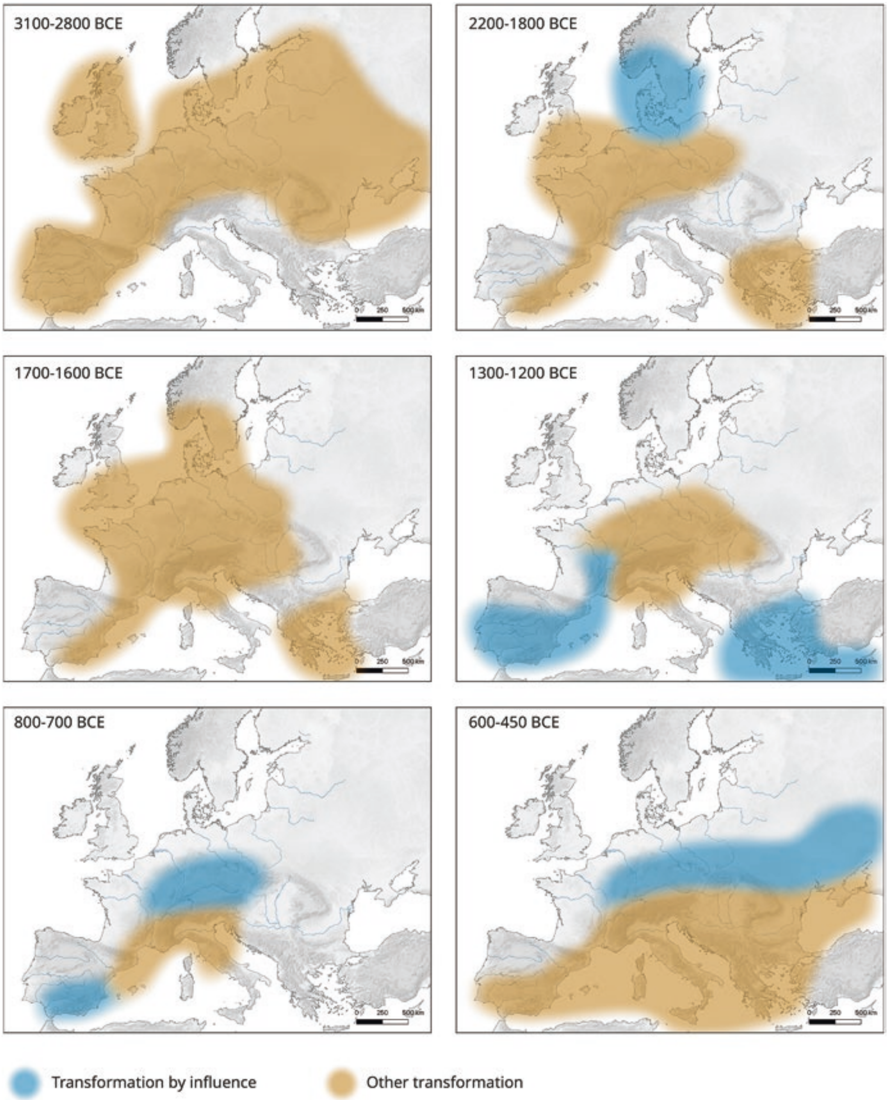

Fig. 10.7 (continued)

European Transformation 6500/6200 BCE At the end of the seventh millennium, the spread of agricultural production in Europe began (Furholt, 2017; Guilaine, 2007). The oldest European evidence for Neolithisation comes from the Aegean and Thrace, where Neolithisation first took place from 6400 BCE and increased from 6200 BCE. Although this process represents a drastic change, its effect on other areas of Europe is unclear. In fact, we can also observe the settling of Mesolithic groups in the Iron Gates region and the aforementioned changes in Mesolithic groups in Northern Europe. To what extent such supra-regional changes are causally connected to each other, however, must remain open at present. In the north, too, considerable changes can be observed around 6500 BCE due to biotope change in the Baltic and North Sea regions, which is connected, among other things, with the introduction of microlithic trapezoids.

European Transformation 6000 BCE The 8.2 ka event is sometimes named as the cause of the later Neolithisation of the southern Carpathian region and other areas of south-eastern Europe (among other things, in connection with alleged land losses due to the hydrological changes at the Black Sea), which then took place mainly around 6000 BCE. If we follow the "arrhythmic" model of the European Neolithisation process (Guilaine, 2007), then around 6000 BCE both the central Mediterranean region, with Italy and northern south-eastern Europe, are neolithised. This fundamental transformation of the way of life is to be understood as an abrupt process with a clear northern border to "temperate" Central Europe.

European Transformation 5400/5300 BCE The Neolithisation of the loess areas of Central Europe, and thus the expansion of the agrarian mode of production, take place only about 500–700 years later. At the same time, the establishment of early copper production in Southeast Europe begins, which is connected with a considerable spatial expansion of the phenomenon of settlement mounds (cf. Whittle, 2018). Culturally, we recognise this in the Linear Pottery, as well as Vinča and Karanovo VI/Gumelniţa, societies in Central and South eastern Europe. Iberian Neolithisation also falls primarily within this time horizon (Sanjuan et al., 2022). The early exchange of jadeite axes in the northern Italian/south eastern French area also begins in this period. A processual transformation thus covers several supra-regional areas of Europe, including south-western Eastern Europe, south-eastern Europe, Central Europe and Western Europe.

It remains unclear at present what drove these changes. We know that, on the one hand, considerable immigration and, on the other hand, admixtures between natives and immigrants both played a role, for example in the western distribution area of the Linear Pottery. However, we do not know the reasons for these migrations. It is also unclear why the intensification of copper mining in Southeast Europe began at this time and led to considerable innovation processes.

European Transformation 5000/4800 BCE The end of Linear Pottery occupation in Central Europe can be linked to the emergence of the phenomenon of rondels and the oldest tell settlements in the Carpathian region. Furthermore, the formation of the first Trypillia settlements east of the Carpathians now takes place and with it the Neolithisation of wide areas of the forest steppe (Müller et al., 2016). Furthermore, tell settlements and Neolithic cultures spread to the northern edge of the Carpathian Basin. In the west, the first megalithic sites are apparently found in north-western France (Cassen et al., 2009). In Scandinavia, imports from Neolithic areas are increasingly detectable in the forager societies there, leading to changes in the sedentary settlements. On the Iberian Peninsula, a crisis within the Early Neolithic can be observed (Lilios, 2019).

European Transformation 4200/3800 BCE The spread of the Neolithic mode of production to Scandinavia and the north-western European British Isles, the emergence of Michelsberg, and the establishment and internal colonisation with causewayed enclosures are accompanied by the establishment of non-megalithic and megalithic monuments (Fowler et al., 2015; Klassen, 2014; Müller, 2019; Whittle et al., 2011). These processes in northern and central Europe, which include the first pile-dwelling (*Pfahlbau*) settlements on the pre-Alpine lakes, are accompanied by the end of Chalcolithic settlements on the Lower Danube and in the Black Sea area, but the emergence of mega-sites in Ukraine (Casa & Trachsel, 2005; Kirleis et al., 2023; Link, 2006; Müller et al., 2016). Far-reaching processes of change are thus detectable between north-western Europe and the Black Sea. On the Iberian Peninsula we also recognise the beginning of causewayed enclosures and megalithic graves (Sanjuan et al., 2022).

European Transformation 3600/3500 BCE In this period, the mega-sites in south-eastern Eastern Europe are abandoned, in northern Central Europe and southern Scandinavia there is a boom in the construction of monuments and opening of the landscape, and in southern Central Europe and Western Europe we see the end of Chasseen or Michelsberg (Brozio et al., 2019; Drummer, 2022; Hofmann & Shatilo, 2022; Immel et al., 2021; Lilios, 2019; Müller, 2019). Obviously, these changes can be seen in the context of various technological innovations, such as the introduction of the animal-drawn ard and wheel and cart. A megalithic boom also began on the Iberian Peninsula.

European Transformation 3100/2800 BCE The end of the construction of megalithic tombs in northern Europe is accompanied by the greater spread of single graves under burial mounds by Yamanya society and the developing Early Corded Ware Pottery (Heyd et al., 2021). Globular amphora distribution also plays a major role here (Müller, 2023; Szmyt, 2017). In the northwest, the first henge monuments (e.g. the non-megalithic Stonehenge) emerge (Darvill, 2010). On the Iberian Peninsula and in the central Mediterranean, Chalcolithic societies are now flourishing (Veracia, Los Millares, V.N.S.P.). In western France, the Artenacian emerges with large houses (Burmeister et al., 2013; Laporte, 2009).

European Transformation 2200/1800 BCE On a transect between Scandinavia and the Aegean, we recognise the establishment of Late Neolithic dagger societies with a changed economy (extensive agriculture), the emergence of Central European, Northwest French and West Iberian Early Bronze Age societies, and in the Aegean the emergence of early urban complexes and state societies, e.g. on Crete (Apel, 2004; Fowler et al., 2015; Kirleis, 2022; Meller et al., 2014). The introduction of tin bronzes, requiring a stable, trans-regional network, is likely to play a role (Vandkilde, 2017). Apart from political changes in the eastern Mediterranean urban/palatial areas, the emergence of Minoan palace societies and the transition from the old to the new Egyptian empire are particularly noteworthy (Bintliff, 2012).

European Transformation 1700/1600 BCE While in southern Scandinavia and northern Central Europe there is a considerable consolidation of activities with the Nordic Bronze Age, in other parts of Central and Southern Europe Early Bronze Age societies collapse (Únětice, Polada, El Argar: cf. Kneisel, 2012; see also Delgado-Raack & Risch, 2015; Earle & Kristiansen, 2011; Lull et al., 2011; Maran, 2018; Meller et al., 2014). The "Argaric crisis" is also taking place on the Iberian Peninsula, with the end of the Argaric settlements. New social contexts are emerging, be it the tumulus societies of Central Europe, the beginning of Terramare in the Po Valley or the beginning of the Mycenaean Late Helladic pre-palatial period in the Aegean region.

European Transformation 1300/1200 BCE Considerable changes in the Eastern Mediterranean region (including the decline of the first state societies, the end of the palace period) are mirrored in the Central Mediterranean region by the decline of Terramare, and in Central and Western Europe by the beginning of the Urnfield societies (Falkenstein, 2017). While in the Aegean region the collapse of Cretan-Mycenaean rule is associated with the decline of the palaces in the south, in the North the first regional centres developed, like Frattesina (Cavazzuti et al., 2019). On the Iberian Peninsula, a recovery from the preceding crises, an increased metal exchange, and the start of the southwest Iberian warrior stelae are reflections of new developments (Broodbank, 2013; Lilios, 2019). This is the period in which the custom of cremation can be traced in most areas of the Mediterranean, northern and central Europe (Cavazzuti et al., 2022; Falkenstein, 2017; Iacono et al., 2022). The process ended around 1100 BCE at the latest with the establishment of urnfields, and was accompanied by considerable changes in the world view and ritual sphere.

European Transformation 800/700 BCE In Central Europe, significant changes in settlement systems and the construction of burial mounds, e.g. with sword grave goods of the new material iron, are recorded around 750 BCE (Fernandez-Götz, 2017; Krausse et al., 2016; Nakoinz, 2013; Stoddart, 2017). Considerable changes can also be observed in Etrurian northern Italy, where the emergence of the first urban complexes leads to not only pre-state, but even city-state societies (753 BCE foundation of Rome). Greek colonisation of the central and western Mediterranean begins around 750 BCE. The Phoenician colonisation in southern Iberia already began in 850 BCE (cf. 814 BCE foundation of Carthage). The transformations lead to processes that take the form of different developments in the individual regions.

European Transformation 600/450 BCE The emergence of Late Hallstatt fortified settlements with richly furnished graves under large burial mounds marks social changes that are accompanied by Scythian warrior societies in Southeast and Eastern Europe (Fernandez-Götz, 2017; Krausse et al., 2016; Nakoinz, 2013; Stoddart, 2017). Thus, the founding of the Greek colony of Massilia causes a considerable push for changes in southern Central Europe, with the emergence of so-called large burial mounds and princely seats. While city-state societies were politically active in the eastern and central Mediterranean region, Iberian societies became visible in the Iberian region as a result of the founding of colonies from around 550 BCE.

European Transformation 300/200 BCE Great open settlement agglomerations and oppida of the La Tène period emerged between the French Atlantic coast and Bohemia at the end of the third century BCE (Fernandez-Götz, 2017; Fernandez-Götz & Krausse, 2016). The large state structures of the Aegean (Macedonian Empire; Hellenism) are accompanied in the Mediterranean region by the first independent state developments such as the Carthaginian Empire. The Carthaginian conquests on the Iberian Peninsula around c. 220 BCE put an end to the Iberian societies there (Broodbank, 2013).

With these 14 spatially more widespread transformations, we cover, due to the average duration of the transformation process of 100 ± 50 years, at least 1200–2400 years of the 9600-year long period under consideration (i.e. 12.5 ± 6.75% of the total time). We think we have captured decisive turning points in prehistoric European history (after 10,000 BCE). Compared to the preceding, regionally oriented study, three transformation phases could be recorded, which obviously do not occur in the regionally considered areas. This points to the different intensity of the "European transformations", which of course cannot be recorded everywhere.

10.4 Conclusion

In this volume we have presented theories, approaches, data and models on past transformations under consideration of system-centred approaches like the concept of Driving forces, Pressures, States, Impacts and Responses (DPSIR), next to agent centred approaches like Bourdieus concept of capitals, theories on (social) behavior, including perspectives from semiotics, emergence and political practices, as well as more practical concerns with the modelling of archaeological material. To some extent, this may be perceived as a means of methodological fragmentation. However, we believe that there is not one single methodology or theoretical approach to explain the (pre-)history of humankind. To take up an important message from Chap. 5: The understanding of past and present transformations cannot be subject to the unity of method, but it can be subject to a unity of purpose.

This final chapter has brought together elements from the research and data of all the preceeding chapters to provide initial insights into the general phenomenon of transformation in prehistoric and archaic Europe. It has become clear that the 14 European transformation phases identified on a supra-regional scale (Figs. 10.7 and 10.8) are each acting regionally and locally in a specific manner. Empirical continuities and discontinuities were reconstructed for each transformation phase.

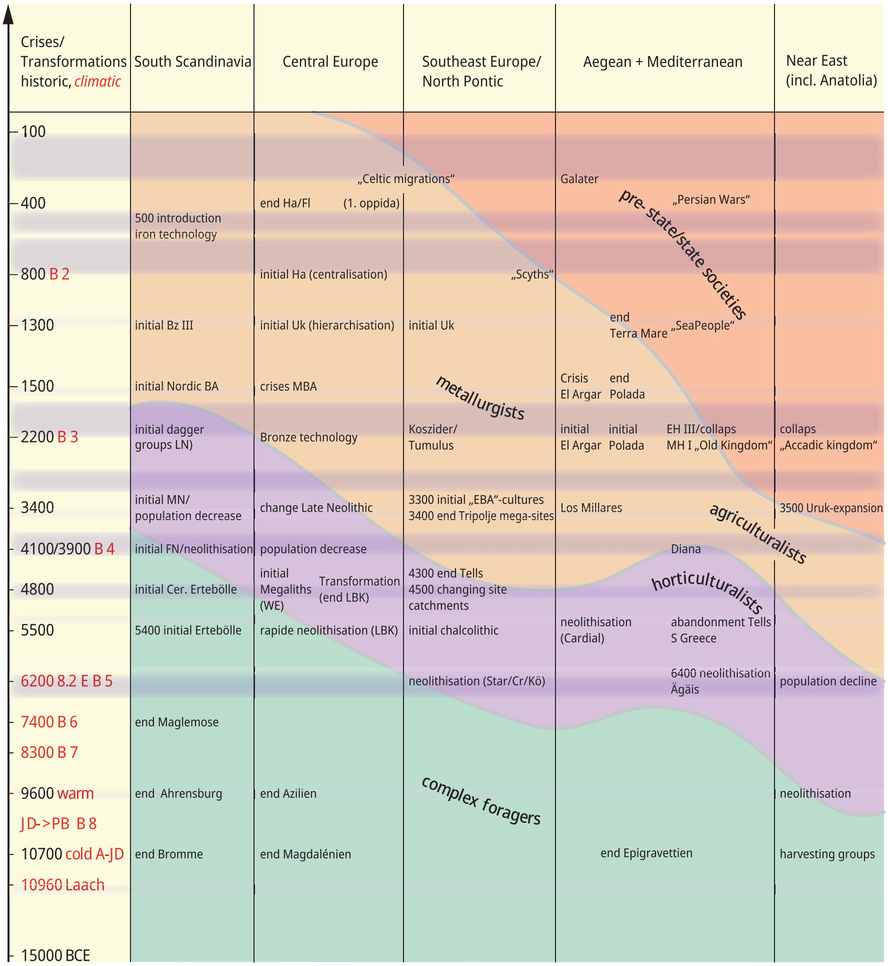

Fig. 10.8 European transformation phases. Different socio-environmental transformation horizons are identified and marked with horizontal bands

Nevertheless, it becomes clear that the 14 European transformation phases that have been worked out are independent of the rather technically determined traditional divisions of European prehistory into Stone, Bronze and Iron Ages. This traditional approach of dividing up human history based on technological changes in material culture or their related effects on lifeways does not take into account the breadth and diversity of changes taking place synchronously across the whole of Europe at certain times, within different societal forms living in a multitude of different environment. As this volume's contributions have shown, transformations must include multiple domains of human-environmental interactions (see Chaps. 1, 4, 5, 6, 7, and 9). Due to the nature of archaeological evidence, there can be a bias towards giving greater explanatory power to the changes most visible in material culture, as has so often been critiqued when it comes to cultural historical approaches. Here we have tried to avoid such pitfalls by basing our interpretations on multi-proxy, interdisciplinary research. While in some cases the European transformations phases presented appear at first sight to align with traditional periodisation systems, the approach behind this high-level abstraction of our data is a complete antithesis to cultural history. It may be that, despite the differences in approach and theoretical leaning, researchers from different traditions may identify some of the same key transformations; this could potentially support the relevance of these few cases, rather than a weakness of our approach (Chaps. 2 and 3). This will require further analysis to properly disentangle. We still believe that the assumption that only single factors (e.g. technological changes) are sufficient to identify, describe or explain profound changes in human societies does not do justice to the complexity of human existence. It may be the case, however, that for some transformations highly-visible individual factors tend to overshadow other, equally if not more important, ones (see Chaps. 4 and 8).

Qualitative studies on the causes of transformation in individual regions have also shown that the aforementioned division by no means covers similar societies (see Chap. 9). Consequently, we should start working on a general periodisation system that no longer uses technical boundaries but rather transformation phases as a basic criterion for identifying period boundaries in European prehistory. As such, our hope is to provide a starting point which will encourage others — through integration of different structural and post-structural explanatory patterns and by consideration of the high data density of interdisciplinary research — to further develop an integrative archaeology and contribute to the archaeological understanding of transformations, as we also continue to refine our interpretations and improve our models. Independent of the model presented here on transformations on a European, supra-regional scale, an overall evaluation of the data on a comprehensive European level, that considers the distinct and sometimes contradicting expressions of change, is still pending. Only if the multiple social, environmental, temporal and spatial scales are taken into consideration, can the triggers of transformation phenomena be captured in such a way that the reconstruction of an anatomy of transformations is possible.

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