Demography and Migration

Population trajectories from the Neolithic to the Iron Age

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edited by

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Session XXXII-2. Transitions démographiques. Mythes et réalités du Néolithique à l'âge du Bronze.

Session XXXIV-8. Peuples, migrations, colonisations : des approches historico-culturelles aux analyses génétiques en archéologie protohistorique, de la néolithisation à la fin de l'âge du Fer.

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FOREWORD TO THE XVIII UISPP CONGRESS PROCEEDINGS

UISPP has a long history, originating in 1865 in the International Congress of Prehistoric Anthropology and Archaeology (CIAAP). This organisation ran until 1931 when UISPP was founded in Bern. In 1955, UISPP became a member of the International Council of Philosophy and Human Sciences, a non-governmental organisation within UNESCO.

UISPP has a structure of more than thirty scientific commissions which form a very representative network of worldwide specialists in prehistory and protohistory. The commissions cover all archaeological specialisms: historiography; archaeological methods and theory; material culture by period (Palaeolithic, Neolithic, Bronze Age, Iron Age) and by continents (Europe, Asia, Africa, Pacific, America); palaeoenvironment and palaeoclimatology; archaeology in specific environments (mountain, desert, steppe, tropical); archaeometry; art and culture; technology and economy; biological anthropology; funerary archaeology; archaeology and society.

The UISPP XVIII World Congress of 2018 was hosted in Paris by the University Paris 1 Panthéon-Sorbonne with the strong support of all French institutions related to archaeology. It featured 122 sessions, and over 1800 papers were delivered by scientists from almost 60 countries and from all continents.

The proceedings published in this series, but also in issues of specialised scientific journals, will remain as the most important legacy of the congress.

L'UISPP a une longue histoire, à partir de 1865, avec le Congrès International d'Anthropologie et d'Archéologie Préhistorique (C.I.A.A.P.), jusqu'en 1931, date de la Fondation à Berne de l'UISPP. En 1955, l'UISPP est devenu membre du Conseil International de philosophie et de Sciences humaines, associée à l'UNESCO. L'UISPP repose sur plus de trente commissions scientifiques qui représentent un réseau représentatif des spécialistes mondiaux de la préhistoire et de la protohistoire, couvrant toutes les spécialités de l'archéologie : historiographie, théorie et méthodes de l'archéologie ; Culture matérielle par période (Paléolithique, néolithique, âge du bronze, âge du fer) et par continents (Europe, Asie, Afrique, Pacifique, Amérique), paléoenvironnement et paléoclimatologie ; Archéologie dans des environnements spécifiques (montagne, désert, steppes, zone tropicale), archéométrie ; Art et culture ; Technologie et économie ; anthropologie biologique ; archéologie funéraire ; archéologie et sociétés.

Le XVIII° Congrès mondial de l'UISPP en 2018, accueilli à Paris en France par l'université Paris 1 Panthéon-Sorbonne et avec le soutien de toutes les institutions françaises liées à l'archéologie, comportait 122 sessions, plus de 1800 communications de scientifiques venus de près de 60 pays et de tous les continents.

Les actes du congrès, édités par l'UISPP comme dans des numéros spéciaux de revues scientifiques spécialisées, constitueront un des résultats les plus importants du Congrès.

Marta Azarello

Secretary-General / Secrétaire général UISPP

Contents

Demographic Transitions – Cycles and Mobility in the Neolithic of Western Germany

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Abstract:

Estimates of population density for the Early Neolithic (Linearbandkeramik) of western Germany exhibit marked diachronic dynamics that may be described as demographic cycles. These patterns are validated by a source-critical approach on various scales that combines distribution maps and observation frequencies in time. As a second step, processes causing downswings are addressed. Did people become extinct or did they just move away? Furthermore, potential influencing factors are discussed. At a regional scale, a preliminary modelling of the LBK cycle in the lower Rhine basin based on a logistic equation is calculated and possible interpretations are discussed. For future analyses on supra-regional scales, a statistical analysis is proposed in which size and resilience of past societies are analyzed by internal dynamics as well as external factors.

Keywords:

DEMOGRAPHIC CYCLES, WESTERN GERMANY, LINEARBANDKERAMIK

Résumé :

Les estimations de la densité de population du néolithique ancien (Linearbandkeramik) de l'Allemagne de l'Ouest montrent une dynamique diachronique marquée qui peut être décrite comme un cycle démographique. Ces modèles sont validés par une approche critique à la source à différentes échelles combinant des cartes de distribution et des fréquences d'observation dans le temps. Dans un deuxième temps, les processus à l'origine des ralentissements sont traités. Les gens ont-ils disparu ou sont-ils partis ? En outre, les facteurs d'influence potentiels sont discutés. À l'échelle régionale, une modélisation préliminaire du cycle de LBK dans le bassin inférieur du Rhin basée sur une équation logistique est calculée et les interprétations possibles sont discutées. Pour les analyses futures à des échelles suprarégionales, il est proposé une analyse statistique dans laquelle la taille et la résilience des sociétés passées sont analysées à la fois par des dynamiques internes et par des facteurs externes.

Mots-clés :

CYCLES DÉMOGRAPHIQUES, ALLEMAGNE DE L'OUEST, CÉRAMIQUES À DÉCOR LINÉAIRE.

1. Introduction

For many reasons, estimations of prehistoric population density are of interest. They facilitate, for example, a deeper understanding of subsistence economy, social organization and human impact on environmental developments, to name but a few aspects. In the present paper, we focus on a long-term perspective. The Gordon Childe-Model with four long epochs each structured by demographic cycles and mobility is used as a point of departure. This is substantiated by the archaeological record from Neolithic sites in western Germany, which will serve as a case study.

1.1. Estimating population density – data and method

The underlying approach to estimating population densities combines different methods in a density-based upscaling approach (*fig. 1*) (for further details see also Zimmermann *et al.*, 2009: 358-360).

The lowest level comprises *individual sites*, like settlements or cemeteries, where contemporaneous houses and graves can be counted.

At the scale of key areas where all, or at least most, of the sites are known within a limited area, the average space available per household or per person may be estimated. This is possible, for example, in the lignite opencast mining area between Cologne and Aix la Chapelle in western Germany that has been archaeologically investigated for five decades. For the Linearbandkeramik (LBK) in this region, for example, we calculated that approximately one household per square kilometre existed in the middle of the 51st century BC. Since cemeteries from this period have also been documented, different spheres of living of the first farmers are known.

The next scale comprises *settlement areas*. They constitute areas of major settlement activities while in neighbouring areas settlements may be very sparse or even non-existent. For example, in the Lower Rhine Basin, LBK settlement areas exhibit a size of 1650 km^2. Using a combination of GIS methods, data on site distribution is transferred into site densities. The results allow for delimiting densely settled areas from areas with minor or no settlement activity. For this purpose, in a first step, Thiessen polygons are calculated for the site distribution in question. Their nodes are used as centres for the Largest Empty Circles (LEC). The radius between the centre and the three nearest sites constitutes a measure for site density. Proceeding from these observations, density is calculated by Kriging, as an interpolation tool. The calculated patterns are then converted into isolines reflecting areas of similar site density. In order to identify areas of major settlement activity ('settlement areas'), the optimal isoline is defined. The latter is constituted by a peak in the areal increase enclosed within consecutive isolines.

In a next step data from key areas is transferred into settlement areas by an upscaling procedure. The transfer function multiplies areas inside the Optimal Isoline by, for example, household density and then by number of inhabitants. In the case of LBK, the basis for the upscaling procedure is the number of contemporaneous households per square kilometer. The number of inhabitants and the duration of houses have to be considered, too. For a household during the Early Neolithic, for example, we use a duration of 25 years based on modelling ^{14}C and typological chronology (Stehli, 1989) together with figures of 7-10 inhabitants per household (or a mean of 8.5 persons). The latter is based on the excavation of two settlements and a cemetery from this period located in our working area where we assume that nearly all people were buried. For the first half of the 51st

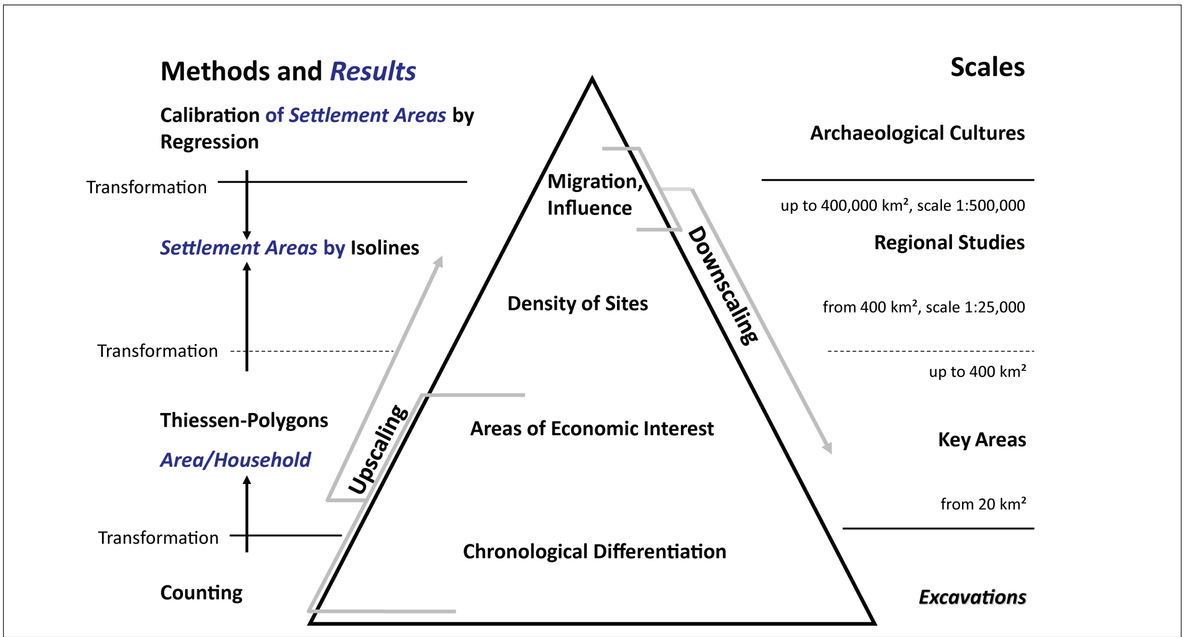

Fig. 1. Hierarchical model of scale levels, methods and results designed to achieve estimations of population density.

century BC the calculated maximum density is 0.6 person/km² ± 0.1 including also regions outside the settlement areas.

The largest scale, the *subcontinental* or even *continental scale*, involves distribution areas of archaeological cultures.

1.2. Source criticism

By producing maps through superimposition of isolines from different periods, it is possible to check the quality of the archaeological record (see also Zimmermann *et al.*, 2009: 360-362). As fig. 2 shows, LBK finds are missing in the Rothbach area, while finds from later periods are well known. We argue that it is highly unlikely that private collectors found archaeological remains of the Urnfield Culture and Roman times but missed the LBK, since we know that erosion affects these later periods as much as it does the LBK. Therefore, we interpret these gaps as unsettled areas that might be explained by the need of social groups to isolate themselves from other social groups. Obviously, the landscape was not used to its nutritional carrying capacity but to a kind of cultural carrying capacity. Considering empty areas constitutes a difference between our approach and those of others and affects the transfer of calculated densities from small, well-investigated areas to larger regions.

As already mentioned, for estimating the local population density, we reconstruct the number of contemporaneous houses and of burial grounds in a settlement area. In this regard western Germany is an optimal area of investigation since the lignite opencast mining area facilitates large scale excavations and surveys, producing a fairly detailed picture of contemporaneous settlements and households during various prehistoric periods.

1.3. From synchronic to diachronic perspective

Similar to the gaps that become visible in the synchronous perspective, we can also identify gaps in the diachronic development. LBK sites appear from 5300 BC onwards and the number of excavated

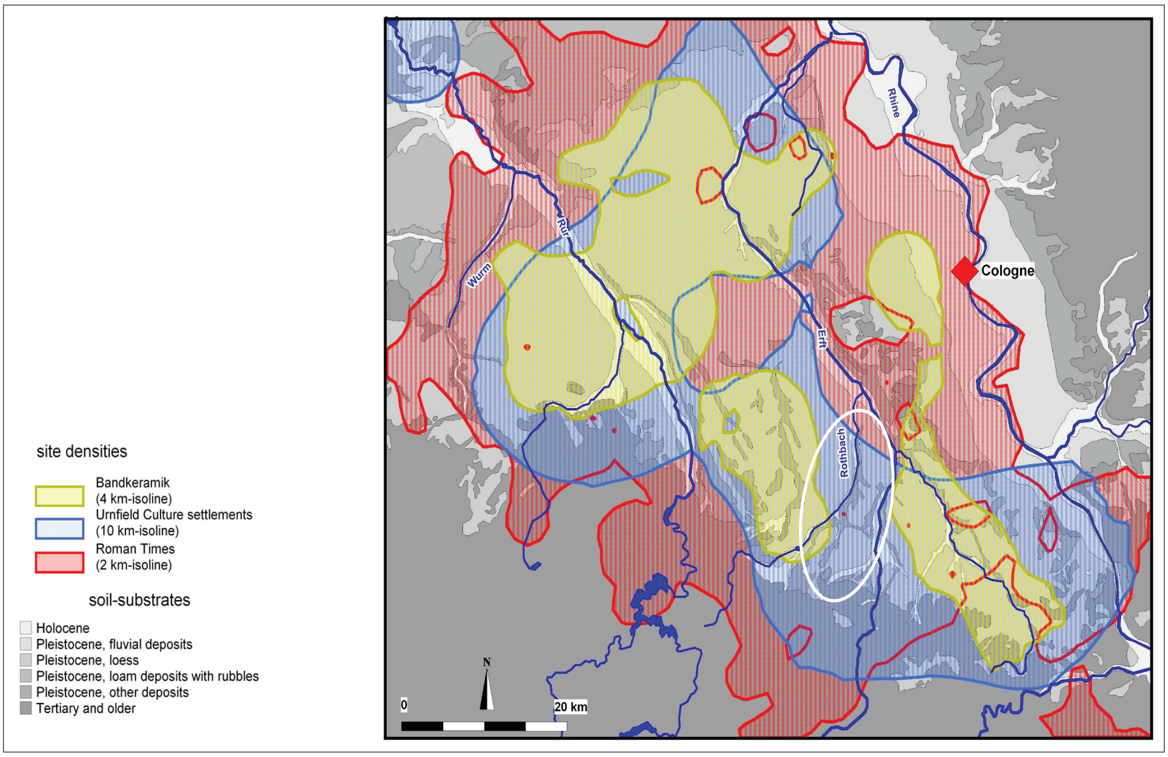

Fig. 2. Settlement areas for the Bandkeramik, Urnfield culture and Roman times for an area covered by the Geschichtlicher Atlas der Rheinlande (Cüppers and Rüger, 1985; Joachim, 1997; Richter, 1997).

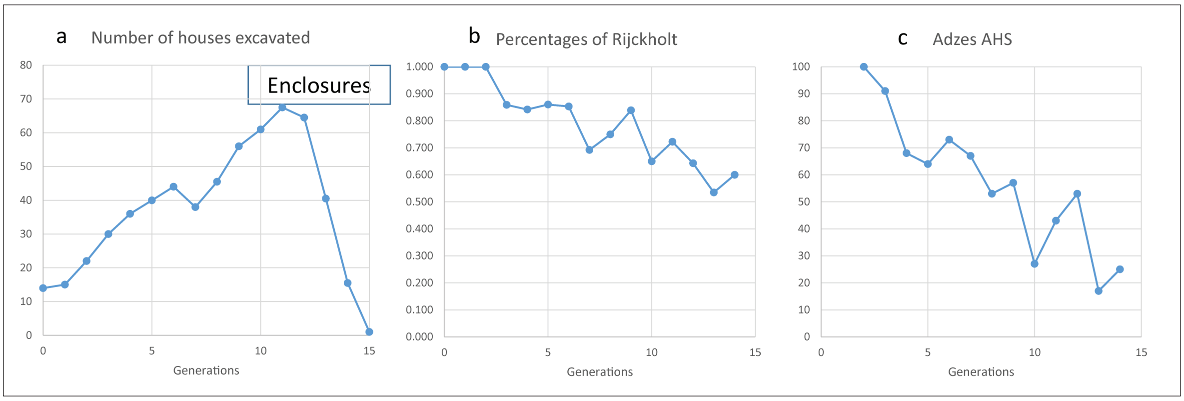

Fig. 3. a) Demography (number of houses); b) and c) connectivity (percentages of Rijckholt-Flint – Mischka, 2004, Abb. 31; and Actinolite-Hornblend-Schist (AHS) – Nowak, 2007) of the Linearbandkeramik in the Rhineland.

and dated longhouses gradually increases from about a dozen to nearly 70 in the last quarter of the 51st century BC (*fig. 3a*). Then, beginning at 5000 BC, a rapid decline can be observed within three generations. It has to be noted that the shape of the graph in fig. 3a has changed since it was first published in 1982 with a maximum of 17 contemporaneous houses (Lüning, 1982: fig. 23). The original structure of the curve with two peaks is still visible in the latest version presented here, however, the second peak is now much more pronounced. This difference between the peaks was still less developed in another version of the graph published in 2012 and based on a maximum of only 45 contemporary houses (Widlok *et al.*, 2012: fig. 7 a). One reason for this might be that our current knowledge is influenced more by small settlements from the younger LBK. These are nowadays more often excavated completely, while it is quite costly to excavate entirely those settlements founded very early on due to their size. Excavation of representative parts on the other hand, is a methodologically demanding task (Mischka, 2014: 295-322). However, reducing features where old house locations might be underrepresented reduces the difference between the peaks in the early and late LBK only very slightly. Nevertheless, this problem has to be discussed in the evaluation of the following analysis.

The early phases of the following Middle Neolithic Period show a depopulation of the Rhineland. It is not before the later stages of the Middle Neolithic that the number of households increases again. This reflects a regional population cycle. There are further well-described examples for population cycles, for example the demographic cycles from Czechoslovakia and Spain 1100-1800 AD calculated by McEvedy and Jones in 1978 and compiled by Turchin (2009: fig. 2), and the demographic cycle for the Lusatian Culture 1500-700 BC proposed by Buck (1985: fig. 1). Kristiansen's data collection shows an agricultural cycle accompanied by an increasing population in Denmark during the late Neolithic and the Bronze Age (Kristiansen, 1980: fig. 12).

2. Research question

If we accept that population increase and decrease are normal patterns of settlement dynamics, the question concerning possible causes arises. As already mentioned, the LBK population history of the Rhineland in western Germany will serve as a case study.

Until now, three types of causes for the population decline in this region have been discussed :

- Climate – Stimulated by findings of several wells from the late LBK, some authors discuss a period of decreased precipitation as the cause of an agricultural crisis which, in turn, led to a population decrease around 5000 BC. However, several arguments contradict this assumption. LBK farmers were depending on cereal species existing as wild forms in the Near East. Therefore, they should generally be robust in this respect. Additionally, synchronic and diachronic comparisons show that in other areas and periods Neolithic farmers were able to cope with more arid conditions than in the Rhineland (Zimmermann, 2016).

- Internal conflicts – One of the present authors has argued elsewhere that conflicts about rights and duties between persons involved in the procurement of flint and persons using flint, or conflicts concerning pasture could have been causes of disintegration of LBK society (Zimmermann *et al.*, 2005: 31-33). In this regard it is interesting to note that most enclosures in the Rhineland are dated to the end of LBK period. They are either interpreted as places of spiritual activities or as defensive structures – functions which do not exclude each other. In any case they are considered as collective work of many households and perhaps of all neighboring settlements. Therefore, even if we have to understand them as an indication of certain aggression potential, they rather point to conflicts with people from outside. Internal conflicts seem to be less probable.
- Disintegration of large-scale social networks – To this end, we have to think of the general cultural situation at 5000 BC. During the time of the last generations of LBK farmers in the Rhineland, 200 km to the south the Hinkelstein group is emerging in the northern Upper Rhine area. As long as the ancestors of these people were interested in Rijckholt flint it seems probable that marriage networks connected the Lower and Upper Rhine. At the beginning of the 5th millennium BC, however, a collapse of long-established kinship and marriage ties is a possible cause which could have influenced reproduction of LBK people in the area of interest here. This hypothesis is tested below through a modelling approach.

Therefore, connectedness to outside areas is of special importance for our argument. LBK settlements all share a very specific design of houses and a limited set of forms and decorations of ceramic vessels over their large distribution area. However, over time variability of pots increases considerably (RP and AZ in Widlok, 2012: fig. 7 b). A similar pattern has been observed concerning flint and adze raw materials (*fig. 3 b and c*). On the one hand, people in the Rhineland procured a specific flint in a region of what today is Dutch Limburg. We call this material, which probably came from a location near Banholt, 'Rijckholt-type' flint. The amount of production exceeded their own demand. Therefore, it was possible to pass this material on to neighboring areas. In the northern Upper Rhine area, at a distance of about 200 km from the source, frequencies of 50% are quite common. On the other hand, people in the Rhineland received raw material for adzes. Most spectacular is the exchange system for Actinolite-Hornblend-Schist from the area of Jistebsko in the Bohemian Basin. Similar to the increasing diversity of pottery, the percentages of these preferred raw materials decreased over time. The degeneration of this communication network is understood as a proxy for deteriorating conditions of marriage networks. This observation is directly related to the reproduction of a population.

2.1. Method

For modelling population development over time, a logistic equation may be used. The first part of this mathematical expression goes back to Thomas Robert Malthus (1798 and 1830).

''*I think I may fairly make two postulata.*
First, That food is necessary to the existence of man,
Secondly, That the passion between the sexes is necessary and will remain nearly in its present state.
These two laws, ever since we have had any knowledge of mankind, appear to have been fixed laws of our nature ...' (Malthus, 1798, cited in the edition of Flew, 1970a: 70).

Based on these postulates he derives the expectancy that 'population, when unchecked, increases in a geometrical ratio.' (Malthus, 1798 / 1970b: 71). The result is a geometric series (with r=growth factor per generation; N=Population, actual generation with an index $_t$, predecessor generation with $_{t-1}$).

$$\textit{Geometric Series: } N_t = r * N_{t-1}$$

In the text cited, Malthus expected that populations would double every generation. In this case r would equal 2. In a stationary population, when deaths and births match, it would be 1. In situations with known population size in different times it is possible to derive r empirically comparing situations before and after (indexing generations by $_n$).

$$\textit{GrowthFactor}_{\textit{per generation}}: (r)=(N_t/N_{t-n})^{(1/n)}$$

'Growth per year', or even a continuous exponential function, could be used but that is not considered in this contribution. In the LBK case study, growth of 1.29 is observed (r=1.29) between generation 0 and 3. Frequency of houses in generation 0 is not considered because this value was the result of an immigration and not of growth.

The concept of Malthus that population growth is limited by foodstuff was mathematically substantiated by Pierre-François Verhulst with the S-shaped '*Logistic Function*' (Verhulst, 1838 and 1845, 8). Verhulst complemented the Malthus Equation by a self-limiting factor. The larger a population already is - the smaller the growth because, for example, less space is available per person.

$$\textit{Self-Regulation term: } (1-N_{t-1})$$

The concept of limited productivity per unit of space is known, for example, from ecology with the key word '*carrying capacity*'. In human society food is not necessarily the only limiting factor. In economics the argument is known that considering limited resources (e. g. farm land) more and more areas are used that are less productive. It is possible to trace this way of reasoning back to David Ricardo (Ricardo, 1817 / 1821: 84 quoted according to Heinsohn et al., 1979: 111 f. with Graph E 3). The so-called term 'law of diminishing returns' goes back to John Stuart Mill (Mill, 1869: Bd. I, Capitel 13, 201; it may be possible to trace this concept back to the first edition from 1848).

When population size is normalized for the range between 0 and 1, the logistic equation may be expressed like this:

$$\textit{Logistic Equation: } N_t = r * N_{t-1} * (1 - N_{t-1})$$

Logistic growth is small at the beginning, but with increasing population it becomes faster and faster. Only when population exceeds half of its maximum does self-regulation begin to limit further growth more strongly (*fig. 4*).

Generations	Logistic Equation							
(t)	N_t	=	r	*	N_{t-1}	*	(1-	N_{t-1})
0			1.5		0.003			0.003
1	0.004				0.004			0.004
2	0.007				0.007			0.007
3	0.010				0.010			0.010
4	0.015				0.015			0.015
5	0.022				0.022			0.022
6	0.032				0.032			0.032
7	0.046				0.046			0.046
8	0.065				0.065			0.065
9	0.089				0.089			0.089
10	0.119				0.119			0.119
11	0.152				0.152			0.152
12	0.184				0.184			0.184
13	0.213				0.213			0.213
14	0.234				0.234			0.234
15	0.248				0.248			0.248
16	0.257				0.257			0.257
17	0.262				0.262			0.262
18	0.264				0.264			0.264
19	0.265				0.265			0.265
20	0.266				0.266			0.266

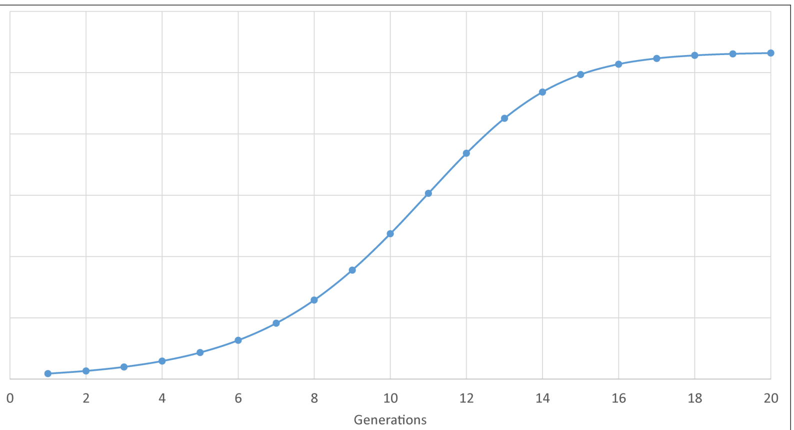

Fig. 4. Numerical example of logistic equation and logistic function.

2.2. Data

To test the hypothesis that disintegration of large scale social networks was a cause of decreasing LBK population we need to apply the logistic equation to the data available for the LBK case study. The number of excavated and dated houses may be used as a proxy for population size. It is also possible to derive the growth factor for LBK society from the growth period at the beginning of this time in the Rhineland. The central idea that a decrease in connectivity is the cause of the problem is, however, integrated into the analysis by replacing the self-limiting term with the decreasing frequency of exchanged stone materials. In the numerical example of table 1, percentage of Rijckholt-Flint from the settlement Kückhoven is chosen (Mischka 2004: fig. 31). This site is located about 50 km from the raw material source. Analysis of flint artefacts has shown that people living there had no direct contact with the extraction site but got their flint from people living closer to the source. Therefore, the development of this assemblage is a good proxy for connectivity.

2.3. Result and interpretations

The surprising result is that we are able to reproduce the observed number of houses in the respective phases of LBK with striking accuracy (figs 5 and fig. 6). Only with an empirically calculated growth factor and the respective percentages of exchanged products, population development may be 'hindcasted' in a quite valid way. Computing experiments with earlier versions of the house count in the Rhineland has shown that the result is very robust concerning the differences discussed in the section 'research questions'.

This analysis is not a falsifying procedure, but an explorative analysis. For us the result of this experiment is an argument in favor of the idea that deteriorating marriage networks could explain the observed population decline. Disintegration of social networks alone could be sufficient to understand the crisis at the end of the LBK in the Rhineland.

Network deterioration is, of course, only one possible reason why population might decrease in a specific case. For other historical configurations the causes might be different.

Demographic dynamics before the great transformation of the 19th century CE were triggered by the number of surviving children per household. Therefore, it was a decision of the family to raise more than one or two children. In our model the dependent variable is either demographic growth, stationarity or decrease. It is based on the latent variable 'expectations concerning the future'. These expectations were based on the family's experiences of the past as well as their perception of their present. Based on memory and perception people evaluated their expectations for the future. Since we are not able to directly control this latent variable, demography will serve as the evident dependent variable.

Based on a systematic survey of archaeological literature we suggest four very general independent factors. Actors were able to choose actively between alternatives concerning two factors: 1) How important are traditions and innovations for their way of life? And 2) how important are cooperation and competition for socio-economic organization. Concerning the two remaining factors, actors were less able to intervene: 3) Agency of neighbors and 4) environmental change, for example climate.

For the Lower Rhine Basin LBK we discussed three of these possibilities. In our view, climate change is falsified. For the remaining two aspects, one may choose between a regional perspective – neighbors decided to change the main direction of contacts – or a large-scale perspective – cooperation patterns changed within the LBK system of tradition and communication.

The question arising thereby is: What could people do in the Lower Rhine Basin at the end of the LBK when faced with deteriorating communication and marriage networks? Do we even expect

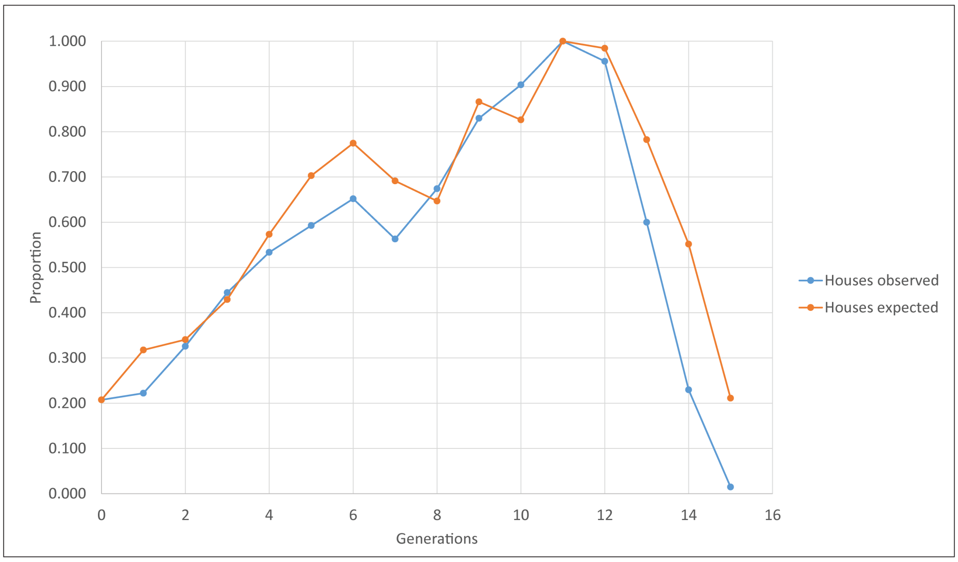

Fig. 5. Normalized proportions of all LBK houses excavated and dated in the lower Rhine basin updated until 2018 ordered in chronological sequence.

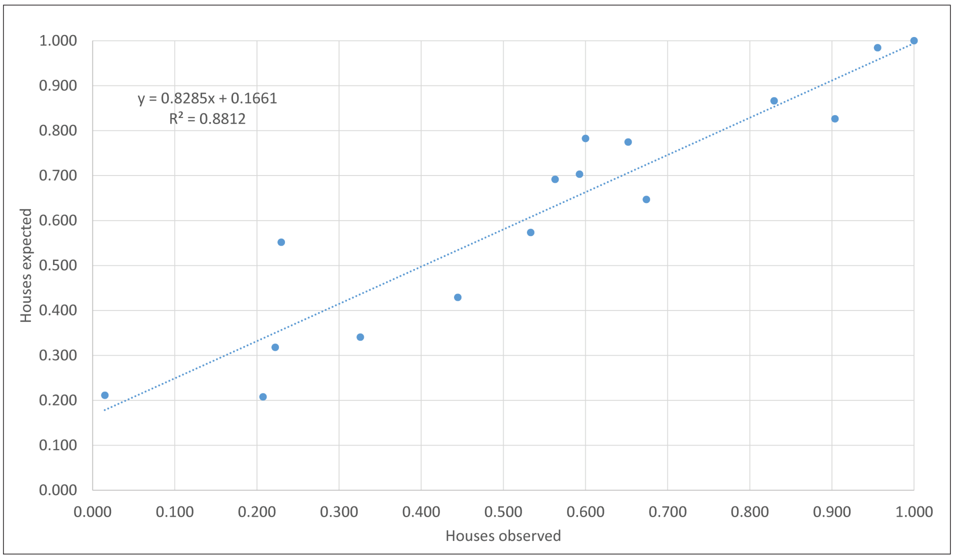

Fig. 6. Correlation of normalized proportions of all observed and expected LBK houses excavated and dated in the lower Rhine basin updated until 2018.

extinction? In our view, young people probably moved westwards to areas of modern Dutch Limburg and Belgium. Perhaps old people joined them – or stayed and died.

2.4 Large Scale

It is assumed that the analysis presented so far is representative for the LBK in the Rhineland with c. 1500 km^2 available farm land for the first farmers and a local population density of probably 8.5 Persons/km^2 inside settlement areas. Comparing this dynamic with other settlement areas it becomes evident that the beginning and the end of settlement activities are not synchronous in all regions. For example, in central Germany, in the so called '*Mittelelbe-Saale Gebiet*', the end of the Bandkeramik (including Stroke Ornamented Pottery) does not date to about 5000 BC but perhaps to about 4700 BC. Therefore, crisis in one area is sometimes contemporary with a time of maximum population density in another settlement area of the LBK. Adding all these cycles or oscillations for a large-scale perspective results in a bandwidth of a quite stable population density characteristic for agrarian non-state societies. These results underpin the importance of long-term and large-

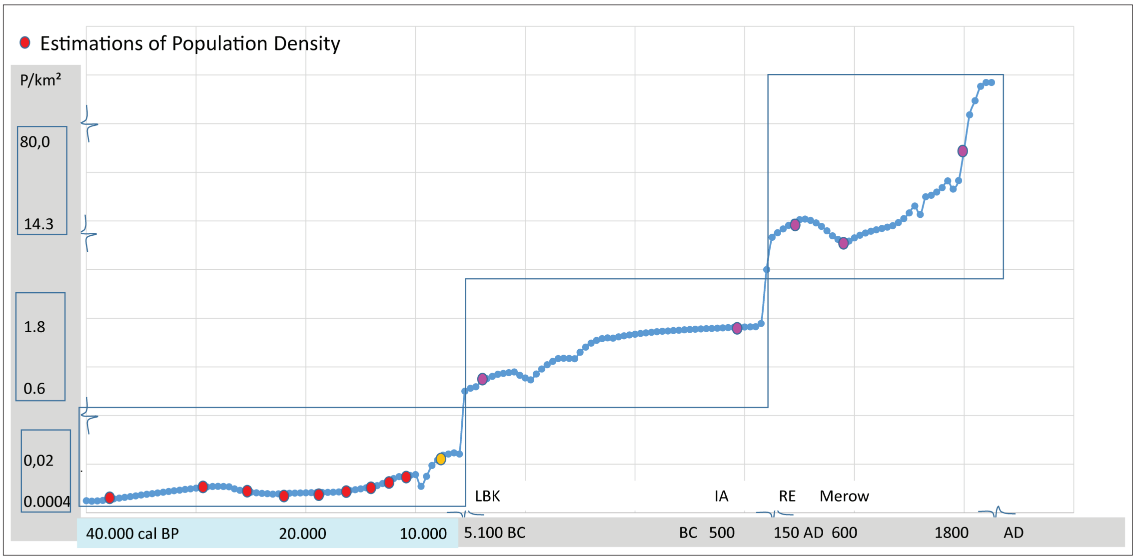

Fig. 7. Long-term-large-scale development of population density in Central Europe based on estimates derived through a unified methodology (LBK – Linearbandkeramik, IA – Iron Age, RE – Roman Empire, Merow – Merovingian time (estimations according to Zimmermann et al., 2009 and McEvedy and Jones, 1978 for CE).

scale perspectives in studies of population dynamics, accounting for the distinctive inherent principles to the *longue durée* perspective.

From a Central European long-term perspective, small oscillations as demonstrated for the LBK cycle in the Rhineland, are not visible. Interpolating between our estimations of population density by the Logistic Equation, carrying capacity (K) has to be integrated:

Logistic Equation extended by carrying capacity K: $N_t = r * N_{t-1} * (1 - N_{t-1} / (K_1 + K_2 + K_3)$

Based partly on regional observations as presented in the LBK case study, but also on superregional collections of relevant data in the last two decades, several estimations of population density were elaborated within the framework of two coordinated research projects (Hilpert *et al.*, 2018; Richter *et al.*, 2012; with regard to estimations of population density for hunter-gatherers Kretschmer, 2015; Maier *et al.*, 2016; Maier *et al.*, 2017; Schmidt and Zimmermann, 2019). In fact, the Gordon Childe-Model with its Neolithic, Urban and Industrial Revolution is validated at least for Central Europe. From epoch to epoch density increases by an order of magnitude.

In a next step it is of interest to interpolate between these estimations so as to arrive at a dynamic model of prehistoric population density. This is because valid estimations have not always been possible due to limitations based on archaeological evidence. For a long-term-large-scale interpolation, a logistic equation is also suitable. A first version of such a generalized visualization of population dynamics is presented in fig. 7. A time window is defined for each epoch with a coarse time resolution for Hunter-Gatherers and a fine time resolution for state societies. Furthermore, we need a minimal Carrying Capacity (K_1) which is different for hunter-gatherer, farmer, and state societies. For the Annales school of French historians this perspective would represent the *longue durée*. At a smaller time scale booms and busts may be recorded to integrate important cycles or oscillations – K_2 representing *conjonctures*. Events such as the Black Death or the Thirty Years' War, as well as the end of the Ice Age, interrupt continuous developments and are introduced in the calculation as K_3. The sum of K_1 to K_3 represents the specific cultural carrying capacity of different times.

For an improved version of this long-term-large-scale interpolation, several groups of data could be used:

			r	N_t		N_e	N_e
Generation (**t**)	N-House	Raw House %	Growth	House norm.	Rijckholt%	House raw	House norm.
0	14	0.024		0.207	1.0000		0.207
1	15	0.025	1.071	0.222	1.0000	0.267	0.318
2	22	0.037	1.254	0.326	1.0000	0.286	0.340
3	30	0.051	**1.289**	0.444	0.8592	0.361	0.429
4	36	0.061	1.266	0.533	0.8417	0.482	0.573
5	40	0.068	1.234	0.593	0.8602	0.591	0.703
6	44	0.075	1.210	0.652	0.8532	0.652	0.775
7	38	0.064	1.153	0.563	0.6923	0.582	0.691
8	45.5	0.077	1.159	0.674	0.7500	0.544	0.647
9	56	0.095	1.167	0.830	0.8387	0.729	0.866
10	61	0.103	1.159	0.904	0.6500	0.695	0.826
11	67.5	0.114	1.154	1.000	0.7222	0.841	1.000
12	64.5	0.109	1.136	0.956	0.6426	0.828	0.985
13	40.5	0.069	1.085	0.600	0.5345	0.658	0.783
14	15.5	0.026	1.007	0.230	0.6000	0.464	0.552
15	1	0.002	0.839	0.015	0.6000	0.178	0.211
Sum	590.5	1.000					
Max	67.5	0.114				0.841	

Table 1. Frequency of houses in the Linearbandkeramik of the Rhineland and percentages of Rijckholt-Flint per generation from Kückhoven (Mischka 2004: Fig. 31). Variables according to formulas above; r – maximum growth factor from generation 1 to generation 3 was chosen for all calculations; N_e – Number of houses expected. Normalized house percentages in Column N_t and N_e are calculated by dividing raw data by their maximum.

- Normalized archaeological distribution maps representing areas of intensive use
- Summed probability distributions of calibrated radiocarbon dates per settlement area
- Isotopic data related to plant-animal balance of human diet

Conclusion

Demographic booms and busts are no myth. Therefore, the question that arises is why are increases and decreases observed? A survey of published interpretations provides a ‘canon’ of factors proposed. On the one hand, external variables such as climate and neighbors are preferred as simple explanations. On the other hand, we propose two internal factors. People had to choose between cooperation and competition as well as between openness for innovations vs. insisting on traditional behavior. Trigger already stated that ‘*Anthropologists still do not know enough about reasons for widespread uniformities in human understandings. … [They] paid insufficient attention to the role of psychological and biological factors in shaping human behavior.*’ (Trigger 2003: 680). Additionally, it may be that behavior varies according to increases, phases of stability and decreases. However, it remains an open question whether booms and busts must be characterized as cycles in regular intervals or rather as irregular oscillations.

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