Modelling the Intensity of Linear Pottery Land Use – An Example from the Mörlener Bucht in the Wetterau Basin, Hesse, Germany[1]

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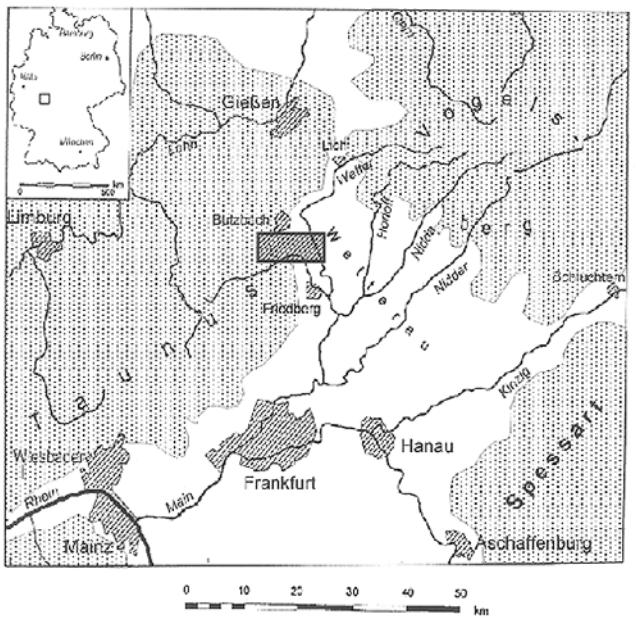
Introduction

How intense was the impact of early farmers on their environment? This is neither a new question, nor do we have any sensational, revolutionary new answers. In fact, in this article, we want to turn again to previously made suggestions concerning this issue, which can be summarized as follows:

The intensity of the impact may have been a) low: there was barely any measurable impact. The Linear Pottery farmers cleared only islands in the primeval forest; b) medium: permanent clearings led to the first formation of a cultural landscape; c) high: overexploitation and mismanagement of the local resources caused a man-made environmental crisis at the end of the Linear Pottery period.

What is now new when reconsidering these three possibilities, is the archaeological data and the methods employed: GIS is a powerful tool which can be used to translate figures into areas, territories, and onto maps. Using new settlement archaeological data and archaeobiological parameters we have been able to calculate the demand for arable and pasture land for a given Linear Pottery population in the study area. With the help of GIS, we have, on the one hand, placed the figures onto maps, and looked at the relationship between the demand of the first farmers and their animals and, on the other hand, at supply, that is to say the potential resources available in the natural landscape. The resulting maps we have labelled „land use models".

Fig. 1: The study area „Mörlener Bucht" (Schade 2003a:36ff, Abb. 1).



Data Base

The study area, the so called „Mörlener Bucht", is part of the favourable basin landscape in Hesse known as the „Wetterau" (fig. 1). It extends over 72 sq km and is characterized by loess soils. Small rivers drain the homogenous, undulating land from the west to the east. The main river valley runs from the north to the south. In the west the land rises up to

more than 400 m asl, forming the highlands of the „Hintertaunus“. Today, the whole area is under intense cultivation .

Results from the project „Settlement History of the Linear Pottery Period in the Mörlener Bucht“ [2], realized by Christoph Schade at the University of Frankfurt between 1998 and 2001, have shown that the settlement history of the Linear Pottery period in this area (about 400 years) can be divided into short intervals lasting one generation. Over 700 plots of land, altogether 18 sq km, were surveyed exhaustively, and the surface finds analysed in detail. The research was complemented by geomagnetic investigations. At the same time S. Schade-Lindig of the Cultural Heritage Management of Hesse excavated the largeLinear Pottery settlement Bad Nauheim – Nieder-Mörlen “Auf dem Hempler“, also located within the study area (Schade-Lindig and Schwitalla 1999, Schade-Lindig 2000, 2002a, 2002b, 2003, Schade-Lindig and Schmitt 2003, Schade-Lindig and Schwitalla 2003). The results achieved from the research methods listed above, make the study area one of the best known Linear Pottery settlement units in Germany to date. We know how the sites were distributed, their size, their duration, the number of houses, and the position each settlement had within the hierarchical settlement systems at the time of the first farmers. This information forms the data base of our land use models (fig. 2). During the first four phases the number of settlements, and the estimated population density, increased slowly but steadily. At the end of the period the settlement density then decreased remarkably, a development that continued into the first half of the following Middle Neolithic period.

phase	contemporaneous settlements (n)	contemporaneous houses (n)	estimated number of people	estimated population density (n/sq km)
earliest LBK	14	53	318	4.4
earlier LBK	33	79	474	6.6
middle LBK	35	110	660	9.2
later LBK	47	122	732	10.2
latest LBK	19	53	318	4.4

Fig. 2: Linear Pottery sites within the study area: maximum number of contemporaneous settlements per generation (Schade 2003a:215ff., Abb. 122) and estimated population densities calculated as 6 inhabitants per farmstead.

Method

Our models consider just two variables: fields and cattle, which means that they only provide information regarding the minimal size area needed to supply people with cereals, and cattle with pasture. The map is based upon a simplified soil map. It shows the distribution of three differing types of land: „potentially arable land“ (loess soil), „meadows in the flood plain“only suitable for grazing, and so called „steep slopes“ suitable neither for fields nor for grazing. 59 sq km, or 82% of the study area, are suitable for fields, 8 sq km, or

11%, can be used as grazing land (water meadows), only 7 % are steep slopes.
The maps differ considerably depending on the economic parameters chosen, e.g. field size, herd size and pasture demand. We decided to use the same parameters used previously by other archaologists when considering Linear Pottery subsistence economy (Bakels 1982, Bogucki 1982, Gregg 1988, Lüning 1988, 2000).
- settlement and farm size: German speaking archaeologists more or less agree with the idea that a Linear Pottery household consisted of an enlarged family comprising between 5 to 7 people. Excavation results also show that every house was surrounded by a yard. According to calculations, the total demand of space per house is equivalent to 0.5 ha, this we populated with an average of 6 people.
- field size: most of the authors are of the opinion that field sizes of between 0.3 and 0.5 ha per person and year were necessary to meet calorie demands, given that cereals were the most dominant crop. The slight variation is due to a differing calculation of various factors e.g. how high was the yield of the fields? Was there any fallow land or not? We calculated our land use models using the higher value of 0.5 ha per person or 3 ha per farmstead.
- herd size: how many head of cattle were kept per person or per household? This parameter is based on pure guess work, as up to present there is neither any archaeozoological nor any useful empirical data available. Remarkably, only very few authors that have worked towards reconstructing the prehistoric landscape in general, also looked at cattle husbandry and its demands on pasture. Bakels and Gregg used the high values of 1.2 or even 2 head of cattle per person. We decided to model the land use maps with a slightly lower value of one head of cattle per person. A discussion of the importance of this parameter follows below.
- size of pasture: there is some empirical data for this parameter, but it differs extremely, depending on the natural resources of a landscape and also on the respective form of cattle husbandry.
Today's most common system in Central Europe is that of an intensive hay economy with manured and irrigated rich grassland. Employing such a system means that a minimal size of about 1 ha or even less is sufficient to feed one head of cattle the whole year round (Bakels 1982:10, Ebersbach 2002:156ff.). On the other hand, cattle grazing on meagre highland pastures or – even worse – climax deciduous woodland with barely any undergrowth, requires up to 12 and even 15 ha per head to survive (Adams 1975, Ebersbach 2002:156ff., Grossmann 1927, Schibler et al. 1997:348, Schott 1936). Our land use models were calculated with the relatively high value of 10 ha per head of cattle. This value corresponds with the available palynological evidence, which states that no grassland existed during this period, and that the forests provided very little undergrowth (Schweizer 2001, Stobbe 1996).

Results

We have generated one map for each phase of the Linear Pottery period. Each of the maps is based on the maximal number of contemporaneous houses within one generation in each phase.[3] Every map has to be understood as a model that gives an idea of the intensity and quantity of minimal territory size - that is to say, of cultivated or grazed land.

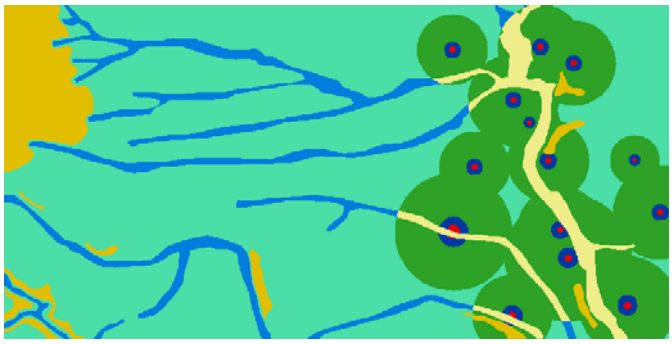
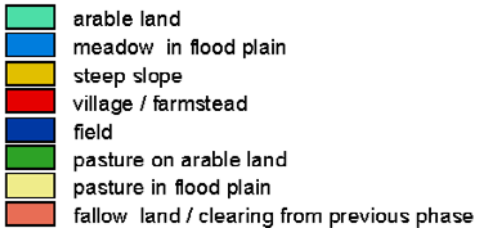


Fig. 3: Linear Pottery earliest phase: land use model. Total territories used / cultivated: 20 sq km (27,8 % of study area).



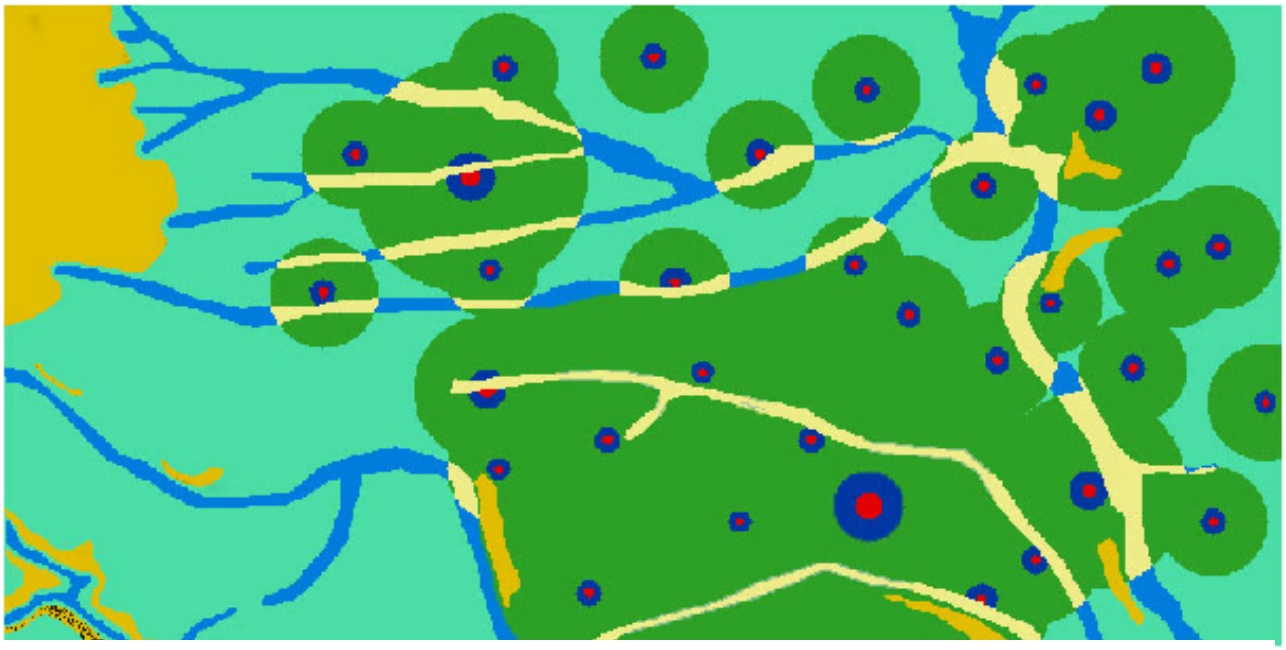


Fig. 4: Linear Pottery early phase: land use model. Total territories used / cultivated: 35 sq km (48.6 % of study area).

During the earliest Linear Pottery phase (fig. 3) around 14 settlements were clustered mainly in the east of the study area, near to the main drainage system. There are hamlets and single farmsteads with overlapping grazing territories, but there are still patches of forest between settlements that were neither under cultivation nor being grazed. In total 20 sq km are used for fields and grazing, that is nearly 30 % of the study area. Palynological research undertaken in the flood plains of this river has shown that the water meadows were more or less free of trees at the beginning of the Linear Pottery settlement (Schweizer 2001). Shrubs and grasses may have been good grazing areas for the cattle of the pioneer settlers. During the following earlier Linear Pottery phase 33 sites existed in the study area (fig. 4). In the vicinity of the

main settlement of that period the entire land was used mainly for grazing purposes. However, aside from this territory the interference of the landscape is much lower, and areas with natural woodland may still have existed between the villages. The average agricultural and pastoral territory demand is 35 sq km in total, which is about half of the study area. In the middle Linear Pottery phase former single farms developed into hamlets (fig. 5). Therefore, despite an increase of only two sites, to a total 35, much more land is used in this period. For the first time we find settlements near to the highland, in areas up to 300 m asl, with a hinterland less favourable for agriculture. 86 % of the study area is exploited by the farmers and their animals. The population and settlement density increased clearly again in the later phase (fig. 6). Now, several hundred people and their livestock inhabited 47 sites. The whole study area is no longer sufficient to meet the required demands.

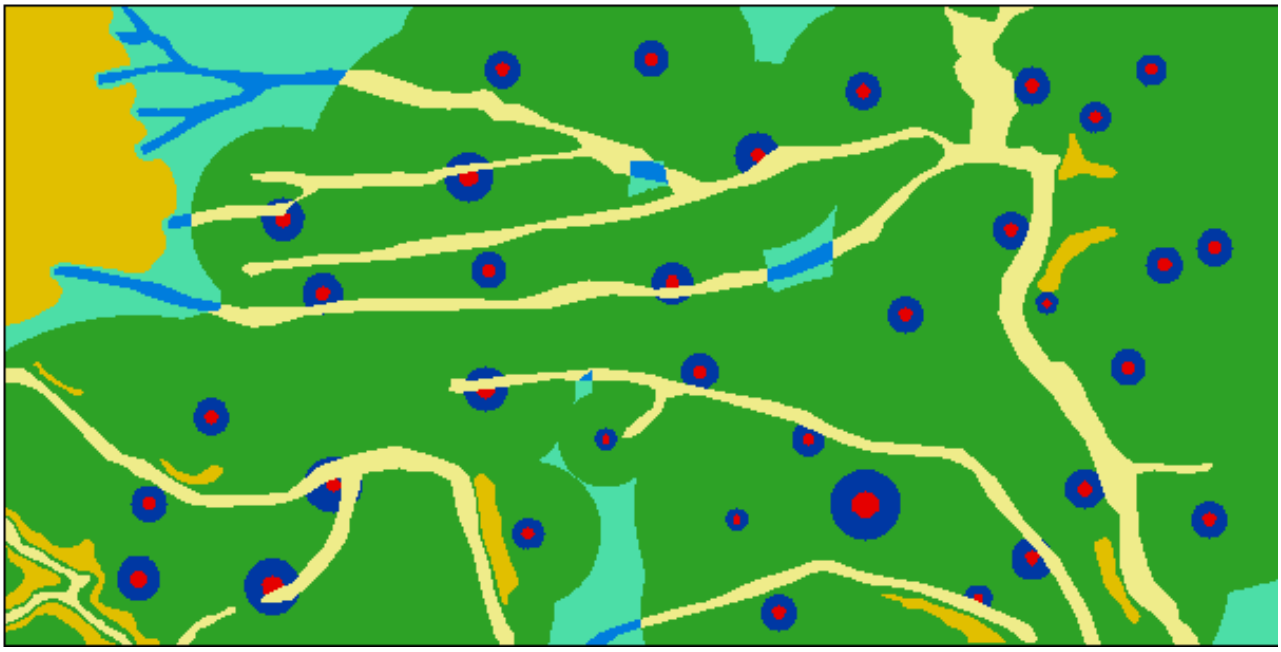


Fig. 5: Linear Pottery middle phase: land use model. Total territories used / cultivated: 62 sq km (86 % of study area).

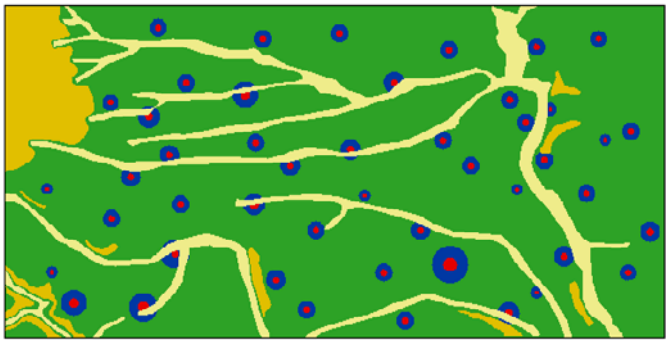


Fig. 6: Linear Pottery later phase: land use model. Total territories used / cultivated: 74 sq km (103 % of study area).

If the chosen parameters are realistic, then it is to be expected that the people now faced some problems. These did not concern field size, but grazing land. Scientists interested in social and political archaeology would predict conflicts and stress - which seem to be good

assumptions if one considers the last map (fig. 7) showing the latest phase of the Linear Pottery culture in this landscape (Schade 2003a:215ff., Schade 2002b:325ff.). Only 19 sites survived into this phase, the settlement density is less than half that of the previous phase. The territories of the existing villages occupy only 47 % of the whole area.

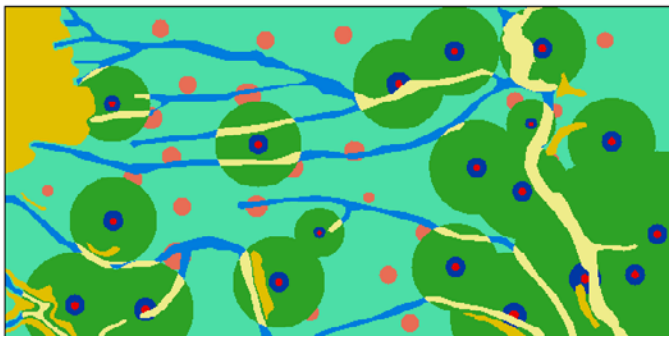


Fig. 7: Linear Pottery latest phase: land use model. Total territories used / cultivated: 34 sq km (47 % of study area).

Discussion

We wanted to know if the intensity of land use in the Linear Pottery period was only low and barely measurable, or if these first farmers were able to create their own cultural landscape, which eventually may even have led to a self-made environmental disaster bringing about their own downfall. Looking at the maps (fig. 3 – 7) this last idea appears probable: the demands of the population seem to have increased steadily until they went beyond the resources available in the landscape. It has to be pronounced again that the model used only two variables, that is fields and cattle. It is no problem to calculate even bigger territories if further demands such as timber, fire wood, hunting grounds and so on are taken into consideration (Schade 2003a:223ff.). The maps visualize impressively that the one and only important parameter that can be considered a limiting factor of the whole system, is that of keeping livestock.[4] Neither field size, firewood nor timber ever seem to have been a limiting factor in the Linear Pottery subsistence system.

Is this a reasonable result? What do we really know about this most crucial of parameters: the prehistoric techniques of keeping livestock? We have to admit that our knowledge of Linear Pottery animal husbandry in general, and information regarding the numbers of cattle kept in these early farming communities, employing whatever methods of management, is very unsatisfactory. This may be the reason why most of the authors who have written about the subsistence system deal only with the fields, and perhaps timber, but have disregarded animal husbandry. This is however a grave mistake, especially if we want a realistic idea regarding the amount of land required by the first farmers. If authors give figures or estimates with regard to the size of herds and pasture land, they are not – this has to be stressed – based upon archaeozoological data, not even upon empirical data from historic or ethnographic records, but they are theoretical constructions. Calculations of herd size argue either with calories (e.g. Bakels 1982, Gregg 1988), or with the minimal number of animals that are necessary to keep a herd alive and healthy. In 1982 Bogucki concluded that a herd of at least 30 to 50 animals

was necessary to be, on the one hand, demographically stable, and on the other hand, to produce enough „output“ to make them worth keeping . Other authors, e.g. Gregg 1988, applied these figures uncritically to their village or hamlet and arrived at very high values of cattle per person.

Both ethnographic and historical records have also proved that a herd of 30 to 50 animals is necessary to be demographically stable (Dahl and Hjort 1976, Ebersbach 2002). Here, the main question is, which social, political or religious unit[s] kept the herd? In Linear Pottery times, possible units are the single farmstead, the hamlet, the secondary or the main village or the settlement group (Schade 2003a:20ff., 219ff.). Exchange systems used in the distribution of silex and pottery have often been proven at the level of the settlement group. Different patterns of dependency and exchange existed between the main village of such a group and its associated hamlets and single farms[5]. Therefore, we also consider this unit to be the most probable one for herd management. In the following, two examples of a herd management system at the level of a settlement group are given:

The settlement group „Niedermörlen“ consists of one main village with at least 15 contemporary houses and other hamlets and single farms. During the middle phase of the Linear Pottery a total of 25 houses belonged to the group (Schade 2003a:228ff.). If we divide 50 head of cattle amongst them, each household will have kept 2 animals, every person 0.3 animals. The group „mittleres Merzbachtal“ on the Aldenhoven Plateau consists of the main village „Langweiler 8“ and some hamlets and single farms, altogether 16 contemporaneous houses in generation 12 (later phase; Lüning and Stehli 1994). If the 50 animals are then divided by the 16 houses, one arrives at a total of 3 animals per household, or 0.5 animals per head.

Conclusion: if the unit managing the herds was indeed the settlement group, the number of animals per head or per household would only be half that, or even less, of the estimates made by Bakels and Gregg and other authors.

There is also new empirical data that supports such lower numbers of livestock per household. Subsistence systems and diet of more than 70 small scale farming communities were analysed with an ecosystem approach (Ebersbach 2002). All villages are situated in temperate landscapes and their economy is based upon cereals and cattle. How many animals can be kept in such subsistence systems? The average value for 73 villages is 0.48 head of cattle per person (fig. 8). In some systems even less animals are cared for: The median value for the classical „three field systems“ which were widespread all over Europe in historical times is only just under 0.3 animals per person. It is remarkable that no system with a self-sufficient economy manages an average value of one animal per person, only few villages come near to this value. Obviously it is not possible to combine the production of a steady and sufficient supply with cereals and the management and care of greater herds of cattle. The limiting factor is usually the given manpower and its seasonal distribution. The above mentioned

average value of about 0.5 cattle per person not only seems to be a good estimate, but also can be confirmed as a realistic value by empirical data from ethnographic and historical sources.

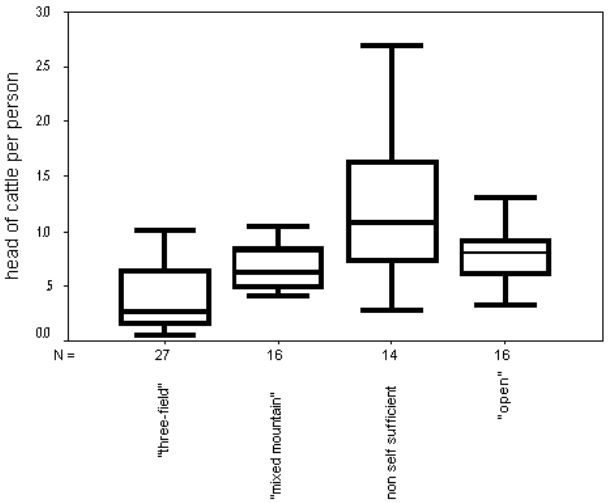


Fig. 8: Cattle density: average numbers of cattle held per person within small scale farming communities of different economical types (Ebersbach 2002:fig. 140, supplemented, see Ebersbach 2002:167-175 for details).

If we want to discuss whether the linear pottery people suffered from a man-made crisis at the end of the period, it is crucial that new parameters are considered . Therefore, we created another land use model for the most densely populated later phase of the Linear Pottery period, now calculating only 0.5 head of cattle per person or 3 per household (fig. 9): Now only 40 out of 72 sq km of the research area are required, that is 56 %. There appear to be no signs of a man-made crisis or abuse of the landscape when looking at this map.

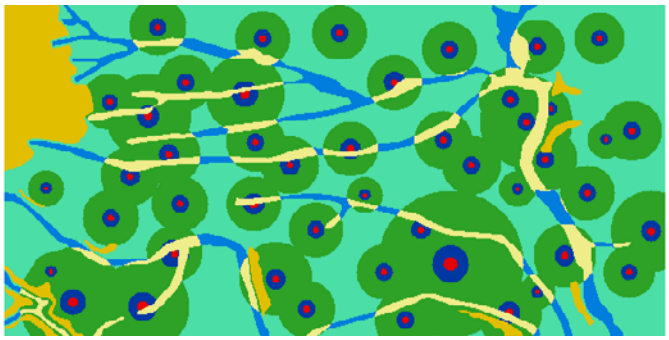


Fig. 9: Linear Pottery later phase: land use model with only 0.5 head of cattle per person instead of 1 cattle per person. Total territories used 41 sq km (57 % of study area).

Theses:

a) In order to better understand the intensity of land use at the time of the first farmers, and hence their potential of having a lasting effect on the natural landscape, results from different branches of science e.g. settlement archaeology, archaeozoology, archaeobotany and soil geology must be integrated in the study of individual settlement groups or natural landscape chambers (Schade 2000a:9ff.).

b) Land use models created with the help of GIS are a good instrument to visualize ideas about the intensity of prehistoric human impact on the environment and human-nature interaction.
c) Within the study area the land demand of the first farmers was measurable and enduring, but probably cannot be regarded as an „over-exploitation".
d) The most important limiting factor in this type of landscape was most probably pasture ground.
e) The cow is an underestimated species! It may have been the most important tool for creating a cultural landscape, and is therefore worth much more attention and research work.

Acknowledgements

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References

ADAMS, S.N., 1975. Sheep and Cattle Grazing in the Forests: A Review. *Journal of Applied Ecology* 12:143-152.
BAKELS, C.C., 1982. Zum wirtschaftlichen Nutzungsraum einer bandkeramischen Siedlung. *Kolloquium Nové Vozokany 1981. Siedlungen der Kultur mit Linearbandkeramik in Europa. Nitra*:9-16.
BOGUCKI, P., 1982. Early Neolithic Subsistence and Settlement in the Polish Lowlands. B.A.R. Int. Series 150, Oxford.
DAHL, G. and HJORT, A., 1976. Having Herds. Pastoral Herd Growth and Household Economy. *Stockholm Studies in Social Anthropology* 2, Stockholm.
EBERSBACH, R., 2002. Von Bauern und Rindern. Eine Ökosystemanalyse zur Bedeutung der Rinderhaltung in bäuerlichen Gesellschaften als Grundlage zur Modellbildung im Neolithikum. *Basler Beiträge zur Ur- und Frühgeschichte* 15, Basel.
FENGLER, A., 2002, unpubl. Flächen- und standortbezogene geomorphologische und bodenkundliche Untersuchungen zur neolithischen Siedlungsstruktur in der Mörlener Bucht. Dissertation, Frankfurt.
GREGG, S., 1988. Foragers and Farmers. Chicago.
GROSSMANN, H., 1927. Die Waldweide in der Schweiz. Zürich.
LÜNING, J., 1988. Frühe Bauern in Mitteleuropa im 6. und 5. Jahrtausend v. Chr. Jahrb. *RGZM* 35, 1:27-93.
LÜNING, J., 2000. Steinzeitliche Bauern in Deutschland. Die Landwirtschaft im Neolithikum. *Universitätsforschungen zur Prähistorischen Archäologie* 58, Bonn.
LÜNING, J. and STEHLI, P., 1994. Die Bandkeramik im Merzbachtal auf der Aldenhovener Platte. *Rheinische Ausgrabungen* 36, Bonn.
MEIER-ARENDT, W., 1966. Die bandkeramische Kultur im Untermaingebiet. *Veröffentlichungen des Amtes für Bodendenkmalpflege im Regierungsbezirk Darmstadt* 3, Bonn.
PFNORR, S. and SCHADE, C., 2002. Geomagnetik, Ausgrabung und Phosphatbeprobung eines bandkeramischen Hauses in Butzbach-Fauerbach v.d.H. „Dicknett". *Berichte der Kommission für Archäologische Landesforschung in Hessen e.V.* 6, 2000/2001:31-39.

SCHADE, C. and POSSELT, M., 2000. Die bandkeramische Fundstelle Butzbach Hoch-Weisel: Ergebnisse einer interdisziplinären Intensiv-Prospektion im Rahmen des Projektes "Besiedlungsgeschichte der Bandkeramik in der Mörlener Bucht (BBM)". *Berichte der Kommission für Archäologische Landesforschung in Hessen* 5:17-26.
SCHADE, C., 2000a. Landschaftsarchäologie – eine inhaltliche Begriffsbestimmung. Studien zur Siedlungsarchäologie II. *Universitätsforschungen zur Prähistorischen Archäologie* 60, Bonn:135-225.
SCHADE, C., 2000b. Roden, Siedeln und Bewirtschaften, Bandkeramik in der Mörlener Bucht. In: *Einblicke. Kommission für Archäologische Landesforschung in Hessen e. V.*, Wiesbaden:10-11.
SCHADE, C., 2002a. Landschaftsarchäologie in der Mörlener Bucht: Zentralität und Rohstoffvorkommen - ein bandkeramischer Zentralort mit Nebensiedlungen in der Gemarkung von Butzbach-Fauerbach v. d. H. *Berichte der Kommission für Archäologische Landesforschung in Hessen e. V.* 6, 2000/2001:9-30.
SCHADE, C., 2002b. Besiedlungsgeschichte der Bandkeramik in der Mörlener Bucht/Wetterau (BBM). Zentralität und Peripherie, Haupt- und Nebenorte, Siedlungsverbände. *Archäologisches Nachrichtenblatt* 7:325-329.
SCHADE, C., 2003a. Besiedlungsgeschichte der Bandkeramik in der Mörlener Bucht / Wetterau (BBM). Zentralität und Peripherie, Haupt- und Nebenorte, Siedlungsverbände. *Universitätsforschungen zur Prähistorischen Archäologie,* Bonn.
SCHADE, C., 2003b. Flurbegehung, Einzelfundeinmessung und geomagnetische Prospektion im Verbund an der bandkeramischen Fundstelle „Ottert“ in Butzbach, Hoch-Weisel. In Eckert, J., Eisenhauer, U. and Zimmermann, A. (eds.), *Archäologische Perspektiven. Analysen und Interpretationen im Wandel, Festschrift für Jens Lüning zum 65. Geburtstag,* Rahden/Westfalen:315-321.
SCHADE-LINDIG, S. and SCHWITALLA, G., 1999. Das Steinzeitdorf vom Hempler. *Denkmalpflege und Kulturgeschichte* 1:26-32.
SCHADE-LINDIG, S., 2000. Neolithische Kreisgrabenanlage? *Archäologie in Deutschland* 2000, 4:44.
SCHADE-LINDIG, S., 2002a. Idole und sonderbar verfüllte Gruben aus der bandkeramischen Siedlung „Hempler“ in Bad Nauheim – Nieder-Mörlen. *Varia Neolithica* II, Weissbach:99-115.
SCHADE-LINDIG, S., 2002b. Idol- und Sonderfunde der bandkeramischen Siedlung von Bad Nauheim – Nieder-Mörlen, „Auf dem Hempler“ (Wetteraukreis). *Germania* 80:47-114.
SCHADE-LINDIG, S., 2003. Die bandkeramische Siedlung von Bad Nauheim – Nieder-Mörlen, Wetteraukreis. Sonderfunde und Idole. *Starinar* 2002:117-137.
SCHADE-LINDIG, S. and SCHMITT, A., 2003. Aussergewöhnliche Funde aus der bandkeramischen Siedlung Bad Nauheim – Nieder-Mörlen, „Auf dem Hempler“ (Wetteraukreis): Spinnwirtel und Webgewichte. *Germania* 81:1-24.
SCHADE-LINDIG, S. and SCHWITALLA, G., 2003. Die Kreispalisadenanlage aus der bandkeramischen Siedlung Bad Nauheim – Nieder-Mörlen, „Auf dem Hempler“. In: Eckert, J., Eisenhauer, U. and Zimmermann, A. (eds.), *Archäologische Perspektiven. Analysen und Interpretationen im Wandel, Festschrift für Jens Lüning zum 65. Geburtstag,* Rahden/Westfalen:351-358.
SCHIBLER, J. et al., 1997. Ökonomie und Ökologie neolithischer und bronzezeitlicher Seeufersiedlungen am Zürichsee. *Monografien der Kantonsarchäologie Zürich* 20, Zürich und Egg.
SCHOTT, C., 1936. Landnahme und Kolonisation in Canada am Beispiel Südontarios. *Schriften des Geographischen Instituts der Universität Kiel* 6, Kiel.
SCHWEIZER, A., 2001. Archäopalynologische Untersuchungen zur Neolithisierung der nördlichen Wetterau / Hessen. Mit einem methodischen Beitrag zur Pollenanalyse in Lössgebieten. *Dissertationes Botanicae* 350, Stuttgart.
STOBBE, A., 1996. Die holozäne Vegetationsgeschichte der nördlichen Wetterau. Paläoökologische Untersuchungen unter besonderer Berücksichtigung anthropogener Einflüsse. *Dissertationes Botanicae* 260. Berlin.
ZIMMERMANN, A., 1995. Austauschsysteme von Silexartefakten in der Bandkeramik Mitteleuropas. *Universitätsforschungen zur Prähistorischen Archäologie* 26, Bonn.

Notes

[1] This paper is the slightly extended version of a lecture given at the CAA 2003 Conference „Enter the Past – The E-way into the four Dimensions of Cultural Heritage“ in Vienna.
[2] German title: „Besiedlungsgeschichte der Bandkeramik in der Mörlener Bucht BBM“. See also: http://www.uni-frankfurt.de/fb09/grk/. Publications regarding this project: Schade and Posselt 2000, Schade 2000b, 2002a, 2002b, 2003a, 2003b, Pfnorr and Schade 2002.
[3] The phases correspond to the chronological system of Meier-Arendt 1966. Further discussions of chronology see Schade 2003a.
[4] Gregg 1988:fig. 5 and Bakels 1982:14f. both came to the same results for the Linear Pottery Period.
[5] for further reading: Zimmermann 1995; Schade 2003a:219ff., Schade-Lindig 2002b:47ff., 2003:117ff..