Virtual vs. Reality – Cyclicity in Modelled and Archaeological Data of Western Swiss Neolithic

Julian Laabs [1,a,b]

[1]Institute for Prehistoric and Protohistoric Archaeology, University of Kiel

[a]formerly at: Institute of Archaeological Sciences, University of Bern

[b]formerly at: Oeschger Centre for Climate Change Research, University of Bern

Introduction

Within the Western Swiss Neolithic (c. 4300-2200 BCE), lakeshore settlements constitute an important archaeological site category, which is above all characterized by quasi cyclic dynamics in space and time. These settlements offer high dating resolution and well preserved bioarchaeological remains, thereby constituting a promising ground for the application of a socioecological simulation modelling approach with LUTES (see Box). Two scenarios of crop cultivation regimes, permanent intensive and slash and burn, are simulated and the output modelled data will be compared with archaeological proxy data.

Archaeological data

The archaeological data indicating cyclicity is mainly provided by the dendrochronological and dendroarchaeological investigations into Neolithic lakeshore settlements. Those show, together with stratigraphic evidence, that settlement locations had been recurrent occupied for rather short time spans of about 5-15 years (Fig. 1). From those findings we know, among other things, about the high mobility of Neolithic communities in the Northern Alpine Foreland.

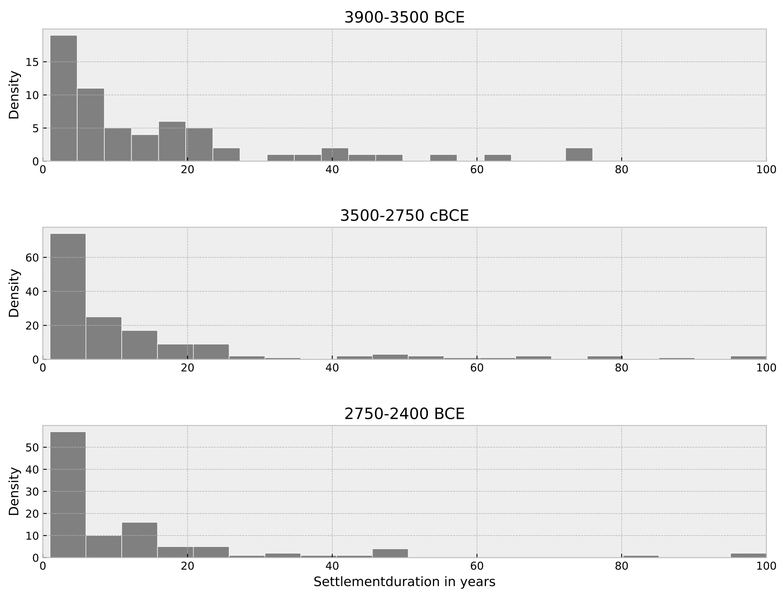

Figure 1: Histogram of occupation duration of dendro-dated settlements.

Based on the dendrochonological dated settlements around the three lakes of Neuchâtel, Morat and Biel at the Jura slopes a settlement sequence on annual resolution can be presented. Figure 2 shows a settlement dynamic that exhibits reoccurring increases, followed by decreases of settlement activities at the lakeshores of different length and intensity. Although a clear repetitive pattern is statistically not detectable, a quasi cyclic dynamic of settling the shores of the Jura lakes, however, can be assumed; distorted by taphonomic processes and past ecological and social circumstances.

Simulated data

The settlement durations in LUTES are mainly governed by resource availability, which is decreasing over time, when constantly used. As soon as the simulation landscape is settled, locations will be occupied more frequent and regeneration phases of resources tend to decrease. This is especially true for the permanent intensive cultivation scenario and well visible if the settlement duration of the both cultivation scenarios are compared over different phases of the simulation (Fig. 3).

The settlement dynamics in LUTES emerging from basic territorial behaviour (e.g. territories of communities do not intersect, former locations cannot be occupied immediately), mobility (e.g. when and how to leave the former location, distance to new location) rules and population development, leading to cyclic patterns of settlement activity at specific locations and population numbers in general. The population development for the whole simulation landscape (Fig. 4) is influenced by the variability of crop yield, where bad years can lead to population decline, but especially the out-migration of population causes the witnessed cyclic pattern. This is because at a given point of the simulation, the simulation diffuse into neighbouring communities. At specific points in the simulation many settlements reach a predefined population limit, thus leading to the complete settling of the landscape. However, the the population growth continues as long as crop yield is meeting the expectation and other food resources are available. Due to the implementation of a maximum settlement population between 250-350 people, based on archaeological settlement sizes (e.g. Hafner and Suter 2003) and cross-cultural observations (e.g. Coward and Dunbar 2014), settlements fission where parts of the

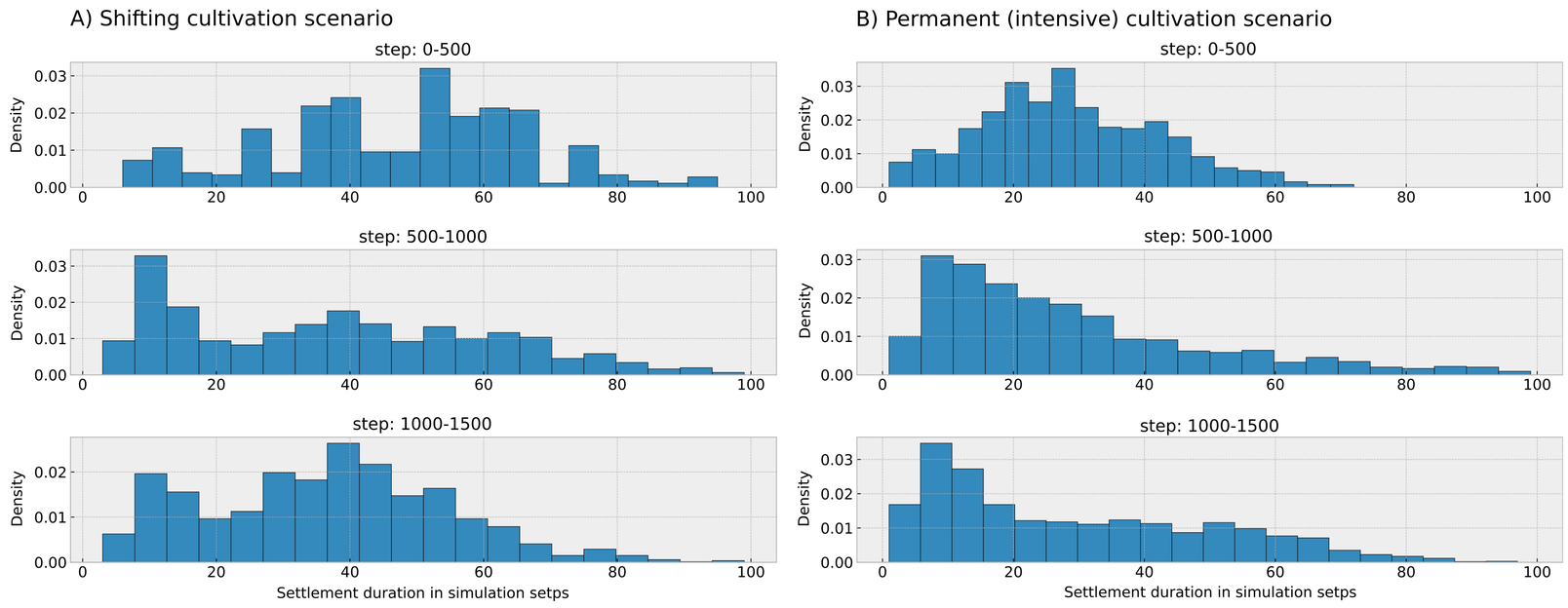

Figure 3: Histograms of simulated settlement durations, in 500 step time slices. 1 simulation step = 1 year.

communities try to establish new settlements. When no space for founding is left migration to neighbours happens and from here further settlements have the need to fission or fully abandon their location, as the population grew too much because of immigrated people. This dynamic is cascading into the settlement network and when too many settlement communities fission or abandon, out-migration (population leaving the simulation) is happening. A time of consolidation follows and the cycle begins again.

Discussion

When comparing archaeological and simulated settlement durations on a structural level, figure 1 and 3 indicate, that the short occupation time is more similar to the simulated durations of the permanent intensive cultivation scenario. Reasons for short settlement duration based on the simulation results seem to be coupled to environmental degradation and decreasing resource availability. In the “extreme” case of a total usage of a given landscape by settling communities this would not be sustainable.

A clear comparison of the settlement sequence (Fig. 2), as population proxy, to the overall simulated population development is not possible. The cascading settlement fission and out-migration visible in the amplitudes of the simulation are unrealistic and not witnessed in the archaeological record by any means of material evidence. But, when we keep in mind that in many cases of archaeological settlement and population studies consider only a restricted geographical area, often with artificially set boundaries, it is not much different than observing out-migration and consolidation in LUTES. A part of the population just left our scope. Settlement frequency series therefore might reflect patterns of activity of a given landscape but from here we cannot infer general assumptions about the local demography of whole networks of communities connected even beyond cultural boundaries.

Conclusion

The results from LUTES show that the assumptions implicit in land use strategies, together with easy spatio-temporal interactions between settlement communities and a dynamic landscape can lead to patterns of settlement activities that exhibit similarities to the archaeological record and might be thought of as its foundational setup. However, it seems that social mechanisms, such as property rights and regional kinship structures, played an important role in creating the visible settlement behaviour.

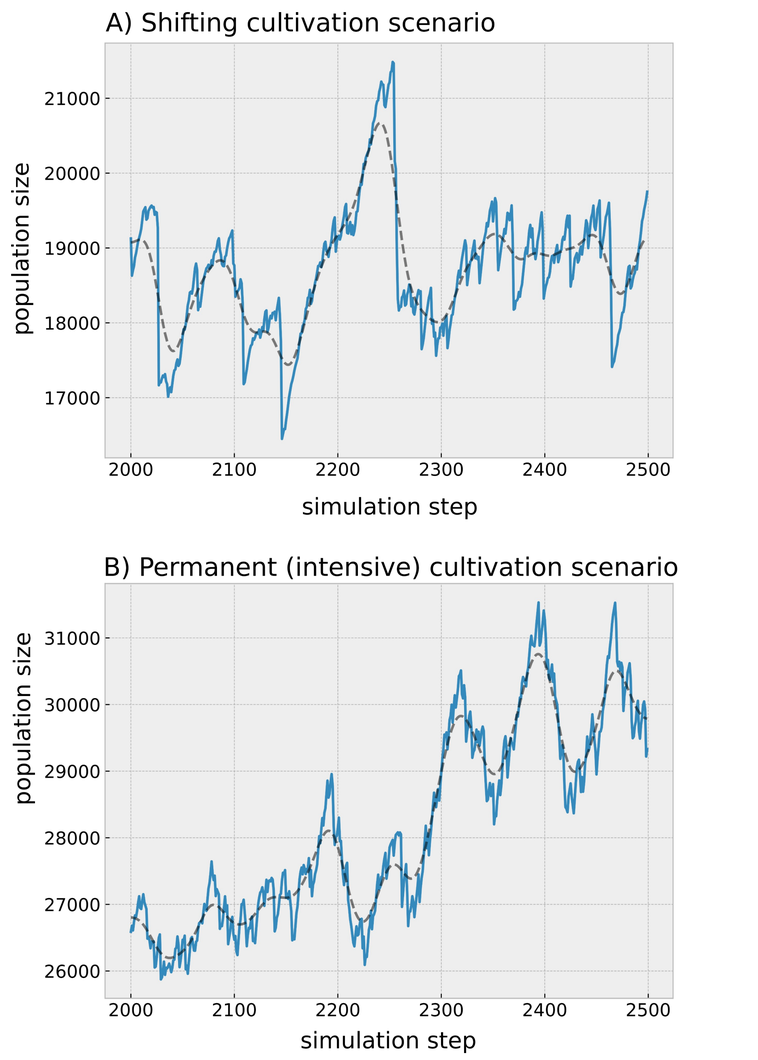

Figure 4: Simulated population development within the given simulation landscape.

LUTES – A simulation model

LUTES (Land Use and Technological Evolution Simulator; Laabs 2019) is a hybrid simulation model representing a socioecological system, combining the numeric model *GLUES* (Global Land Use and technological Evolution Simulator; e.g. Wirtz and Lemmen 2003) and the agent-based model *WELASSIMO* (WEtLAnd Settlement SIMulatOr; e.g. Baum et al. 2020). The population development in LUTES is driven by the gradient adaptive dynamic of GLUES. Land use implications are simulated by the concepts of WELASSIMO. To combine both simulation models they needed to be altered accordingly in order to feedback into each other. Modules that govern modes of territoriality and mobility are genuine to LUTES and enable simulation setups apart form land use.

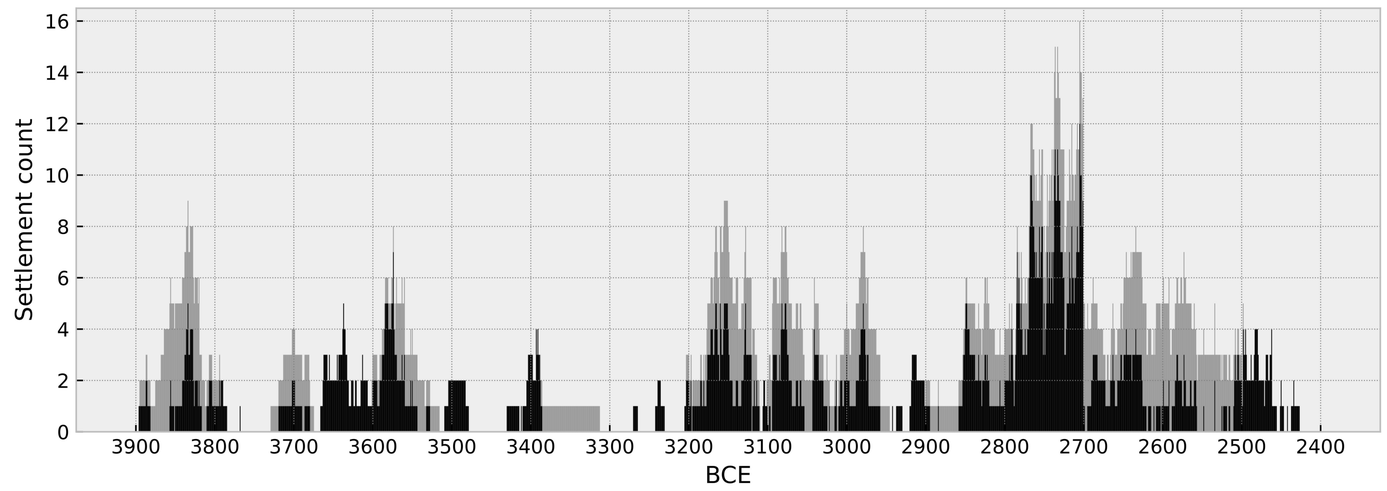

Figure 2: Neolithic settlement frequency at the Jura lakes, based on dendro-dated settlements. Black bars: settlements of expected duration; grey bars: settlements of unexpected long duration (> 35 years).

Selected references

Baum, T., Mainberger, M., Taylor, T., Tinner, W., Hafner, A., Ebersbach, R., 2020. How many, how far? Quantitative models of Neolithic land use for six wetland sites on the northern Alpine forelands between 4300 and 3700 bc. Veg. Hist. Archaeobotany 29, 621–639. https://doi.org/10.1007/s00334-019-00768-9

Coward, F., Dunbar, R.I.M., 2014. Communities on the Edge of Civilization, in: Dunbar, R.I.M., Gamble, C., Gowlett, J. (Eds.), Lucy to Language: The Benchmark Papers. Oxford University Press, Oxford, pp. 380–405.

Hafner, A., Suter, P.J., 2003. Das Neolithikum in der Schweiz. J. Neolit. Archaeol. 5, 1–75. https://doi.org/10.12766/jna.2003.4

Laabs, J., 2019. Populations- und Landnutzungsmodellierung der neolithischen und bronzezeitlichen Westschweiz (Dissertation). Universität Bern, Bern.

Wirtz, K.W., Lemmen, C., 2003. A Global Dynamic Model for the Neolithic Transition. Clim. Change 59, 333–367. https://doi.org/10.1023/A:1024858532005

UNIVERSITÄT BERN

UNIVERSITÄT BERN
OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

Beyond Lake Villages
universität wien
Baden-Württemberg Landesdenkmalpflege

CAU
Kiel University
Christian-Albrechts-Universität zu Kiel