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The Event Horizon in Landscape Development: When Economy Makes the Landscape Cultural

Abstract: Agricultural activity is economic activity and the development of the cultural landscape can be understood as the accumulation of economic processes. A macroeconomic index derived from pollen-analytical data is presented here. The scores on the first axis of a canonical correspondence analysis are used to show the intensity of land use through time. These scores correlate with the cultural indicator curves when the vegetational development is dominated by agriculture involving grassland, arable fields and ruderal patches. In the Lake Constance area and the Rhineland, this point is first reached in the Bronze Age, when there is no primordial forest left. The cultural landscape can be seen as a capital resource and the development of the cultural landscape as capital formation. This development is an irreversible and directed process. Further research will show whether the human impact curve can serve as a long-term economic index analogous to cereal prices.

Introduction

The development of the cultural landscape began with the first farmer cutting the first tree to gain arable land. From that point in time onwards farmers have converted the landscape. The cultural landscape may be seen as the natural landscape plus the work of generations. In that sense, it is really economy that shapes the cultural landscape.

Economy is the entity of production, exchange and consumption. In early economies, these three sectors lie mostly together. The farmer produces goods for his own consumption and exchange takes place only on a minor scale. This changes throughout prehistory: as specialisation becomes increasingly important, more and more people depend on exchange. This development proceeds from a single Neolithic farm to specialized settlements such as Dürnberg near Hallstatt, which were partly dependent on their hinterland, and ultimately to the *urbs* which covered the enormous cereal demand with imports from the whole empire.

Agricultural activity, such as arable farming, grazing or wood gathering, affects vegetation and through it the pollen production and record. Thus the palynological record contains information about the changes in landscape development and the intensity of land use. I am introducing a long-term index for the intensity of economic activity, extracted from the pollen record by canonical correspondence analysis. It will be demonstrated as to how this index shifts through time and how it can be interpreted in terms of economic changes (for the method and references see also Lechterbeck 2008).

Methods

The nature of pollen-analytical data is punctual in the sense that samples are taken from a locality, which represents only a point in the landscape. A single pollen dataset contains a great deal of information, but this information has only a limited range – normally a circle just a few hundred meters to a few kilometres in diameter around the sampling locality (Kerig / Lechterbeck 2004; Lechterbeck 2004). To make more regional statements, several independently dated and high-resolution pollen profiles from a region are needed. The Rhenish Loessboerde and the western Lake Constance region are both pollen-analytically well analysed. They also belong to those long-settled landscapes which have been more or less continuously settled since early Neolithic times.

Pollen contains the male germ cells of flowering plants. They are emitted and transported in great numbers and at last deposited in natural archives, such as lakes and mires, from which they may be retrieved, determined, and counted. Normally, pollen data are presented as a pollen diagram, where every species is plotted as a percentage curve. Palynological data are vast and high-dimensional, so multivariate statistical methods suggest themselves in their analysis.

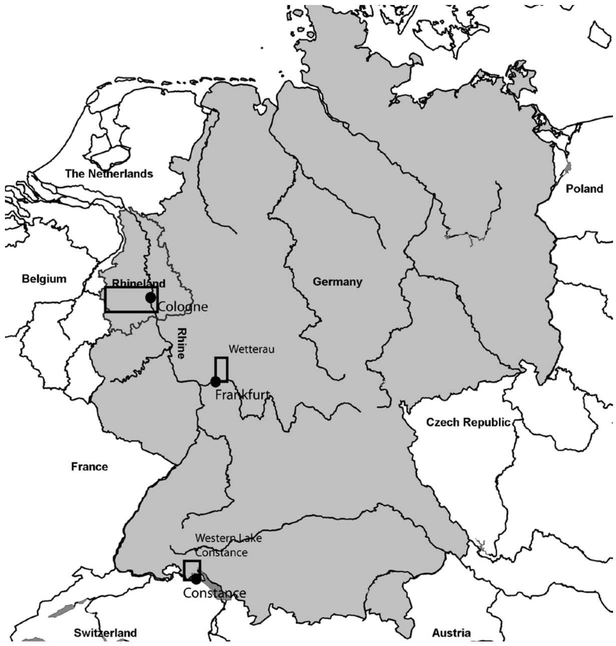

Fig. 1. Localisation of core regions.

Here canonical correspondence analysis (CCA) is used to extract a main dimension of explanation from the pollen data of one region. A case study involving the analysis of only one profile by correspondence analysis (CA) showed that this mathematical main dimension of explanation can be used as a proxy for human impact (Kerig / Lechterbeck 2000; idem 2004; Lechterbeck 2004; idem 2008). This was concluded from the fact that the scores on the first axis of the CA from Lake Steisslingen data correlate with high significance to the sum percentage curve of the cultural indicators from the Bronze Age onwards.

The pollen distribution follows a gradient, which describes the development from dense forests in the Neolithic to the open cultural landscape of the Middle Ages. In other words, this gradient indicates increasing economic activity.

To obtain a spatial response, it is necessary to analyse several profiles of a region at the same time. The suitable method is canonical correspondence analysis, as it allows us to analyse several datasets for structures they have in common. For canonical correspondence analysis, a canonical dimension is set and the analysis is optimised on those structures which correlate with this dimension. A CCA was carried out for datasets from the western Lake Constance region and from the Rhenish Loessboerde *(Fig. 1)* and the age was set as canonical axis. The scores on the first eigenvector were plotted against time. To see whether human impact is also the main dimension of explanation in other profiles and landscapes, the cultural indicator curves are displayed and their correlations with the sample scores on the first axis of the CCA are calculated.

Human Impact Curves

Fig. 2 shows three curves for the western Lake Constance region and also the sum percentage curves for the cultural indicators. Lower scores on the first axis of the CCA mean higher human impact, therefore a strong negative correlation with the cultural indicators is expected. This is just the opposite of ordinary correspondence analysis. The reason this occurs is due to the setting of a canonical axis: the shift is an effect of the ordination procedure. For the interpretation it is of no significance whether positive or negative values indicate human impact, because the taxa scores also shifted from positive to negative and vice versa.

The human impact curves show strong similarities, although the western Lake Constance region is a quite variable landscape and the three archives are of different type and size. During the Neolithic the curves descend significantly, which is due to the replacement of the oak mixed forest by beech forest. The spreading of the beech might also be triggered through human activities, as the beech profits from clearing activities in the dense lime forests (see discussion in Gardner / Willis 1999; Haas / Hadorn 1998; Küster 1999).

The cultural indicator curves correlate significantly with the human impact curves over some stretches. In these sections the vegetational development can be sufficiently explained by the cultural indicators alone. Only from the Bronze Age on are there any significant correlations between the human impact curve and the cultural indicators. From this point in time the vegetational development, indeed the whole landscape development, is dominated by a single factor only, human impact or economic activities. That is the "event horizon in landscape development", almost a point of no return, because the forest ceased to be the major vegetational feature.

If the vegetational development is dominated by human impact, then all the suitable habitats for cultural indicators like grassland, fields, pathways, pastures, must constitute the major features of the landscape. Of course, even in the Neolithic there are

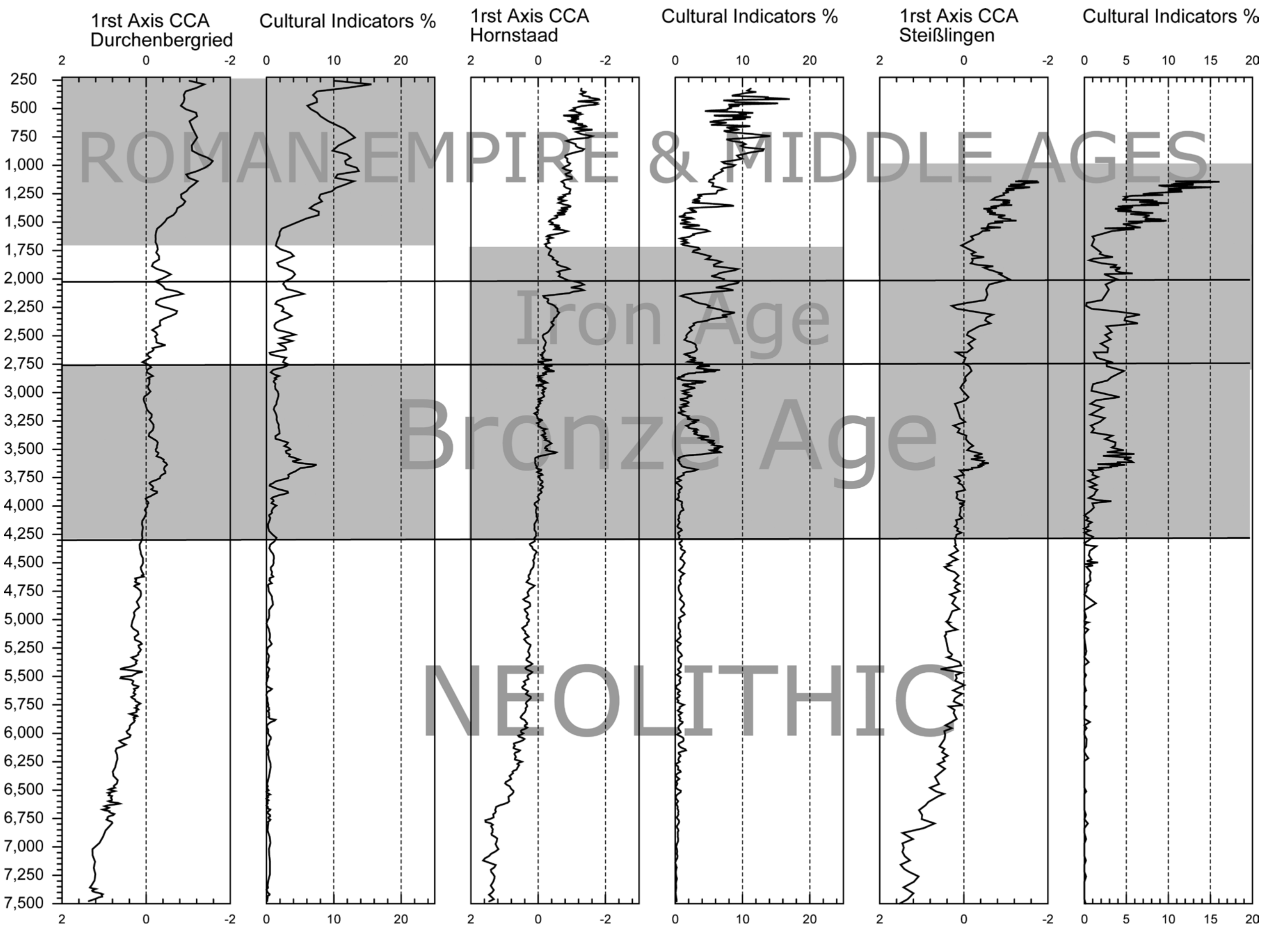

Fig. 2. Human impact curves from the Lake Constance region and sum percentage curves for the cultural indicators. Stretches of the curves with a highly significant correlation are marked by light grey background.

fields, pathways and cattle drifts, though grassland is not yet developed. The Neolithic is dominated by forests, and all economy and agriculture had to deal with a forested landscape. Grassland is a vegetation form which may have started to develop during the Neolithic. It is certainly there in the Bronze Age.

For the Lake Constance region the forest ceases to be the dominant vegetational feature in the early Bronze Age. There are local reforestations afterwards, but on the whole an open vegetation characterized by fields, paths, pastures and managed forests prevails.

The conditions in the Rhineland differ from those in the Lake Constance region. Here a much larger area and more profiles were integrated in the analysis (*Fig. 3*, Bunnik 1995; Janssen 1960; Kalis 1983; idem 1988; Kalis / Meurers-Balke 2003; idem 2005; Knörzer / Meurers-Balke 2002; Lechterbeck / Kalis / Meurers-Balke in press; unpublished data). The profiles are roughly ordered along a west-east transect *(Fig. 3)* and they cover the time span between the early Neolithic and the late Middle Ages in different resolutions. The pollen profiles are not as uninterrupted as in the Lake Constance region. Though the Rhenish Loessboerde is a quite unvarying landscape, the vegetational development is not as uniform as at Lake Constance. This might be because the distances between the profiles are much larger. Also in the Rhineland the scores on the first axis of the CCA could be interpreted in terms of human impact, and again the first significant correlations between the human impact curve and the cultural indicators occur in the Bronze Age *(Tab. 1)*. From then on suitable habitats for cultural indicators are sufficiently widespread to ensure not only their precipitation but also their dominance in the pollen record. However, unlike in the Lake Constance region, the kind of land use changed in the Iron Age and apparently these areas became strongly used as pastures, while usage also changed in the forests. These forests are no longer dominated by lime, elm, oak, acer and ash but instead by hazel,

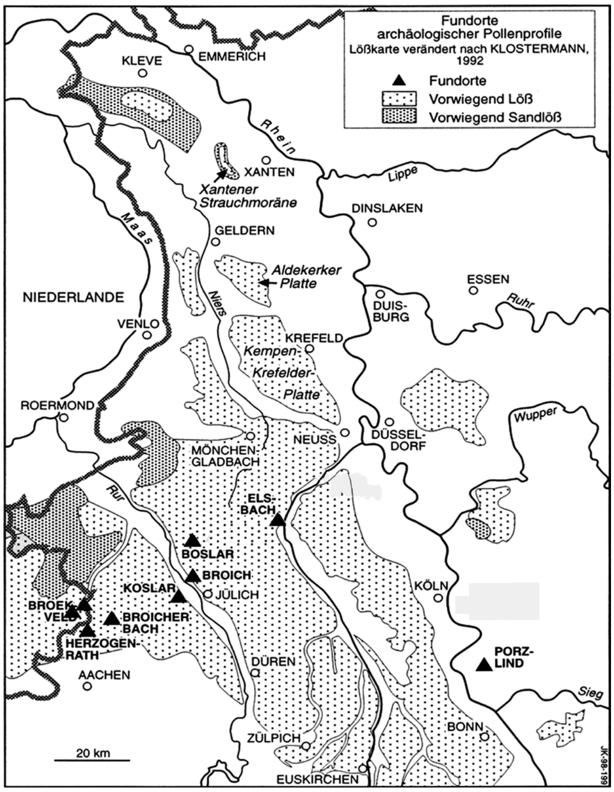

Fig. 3. Localisation of pollen profiles in the Rhineland.

	Neol.	Bz	Ha/Lt	Ro&MID
TEZ	-0.48	-0.93	-0.54	-0.85
RUR	-0.38	-0.33		
BRO	-0.37	-0.21		-0.77
HRZ	-0.19	-0.52	-0.17	-0.90
FRZ		-0.88	-0.70	-0.90
RIM		-0.83	-0.31	-0.42
LIN		-0.82	-0.36	-0.08
BRB				-0.80
KOS				-0.93

Tab. 1. Correlations between human impact curves and cultural indicators in the Rhineland for different archaeological periods. Boslar (TEZ), Broich (RUR), Broekveld (BRO), Herzogenrath (HRZ), Elsbach/Frimmersdorf (FRZ), Rimburg (RIM), Porz-Lind (LIN), Broicher Bach (BRB), Koslar (KOS).

birch, beech, oak and sometimes even pine. They are secondary forests, which were used for cattle browsing and were managed by humans. These were not the dense forests met by the first farmers in Europe.

The Human Impact Curve as an Economical Index

Agricultural activity is economic activity. The human impact curve is a long-term index to depict this activity regionally. Aspects of the cultural landscape can be explained in economic terms, whose definitions are taken from a common economic text book for the purpose of this publication (Samuelson / Nordhaus 1998), because the author of this paper is not an economist. The alterations of the landscape by human impact are not necessarily destructive and not necessarily lost from generation to generation – on the contrary, they add up. A secondary forest will always be easier to clear than a primordial forest, and existing pathways and cleared spaces can be used further and expanded. The classics identified work, land and capital as the three principal factors of production. Modern theory has adopted the "socialistic" statement that there is only work as a factor of production while land and capital are a means of production. In this sense environment is non-monetary capital. There is also real capital loss – for example when the human impact lessens; once abandoned, open space like meadows and fields are reforested, first by bushes and later by trees. These areas are more difficult to convert back to arable land than areas continually kept open. The introduction of new technologies like the plough, draught or fertilizers leads to an increase in non-monetary capital of an economy. From Roman Times at the latest, the rural population had to produce a surplus for the urban population and the emperor's army. That is only possible in a cultural landscape sufficiently developed to allow the production of a surplus.

The economic historian Henning correlated long-term indices of economic development and he displayed the population density of western Germany with the number of cities and the rye prices for the period from 800 to 1750 AD (Henning 1979). The human impact curves covers this time span in a similar resolution and also reaches back to the Bronze Age. *Fig. 4* shows Henning's diagram and the human impact curve from Hornstaad. While this curve is only a local one, it does depict the development of the population density and the number of cities in Germany. The higher the population density, the higher the human impact. This connection is quite obvious, as more people need more arable land which is also more intensely used. The human impact curve also correlates strongly with the curve of the rye prices

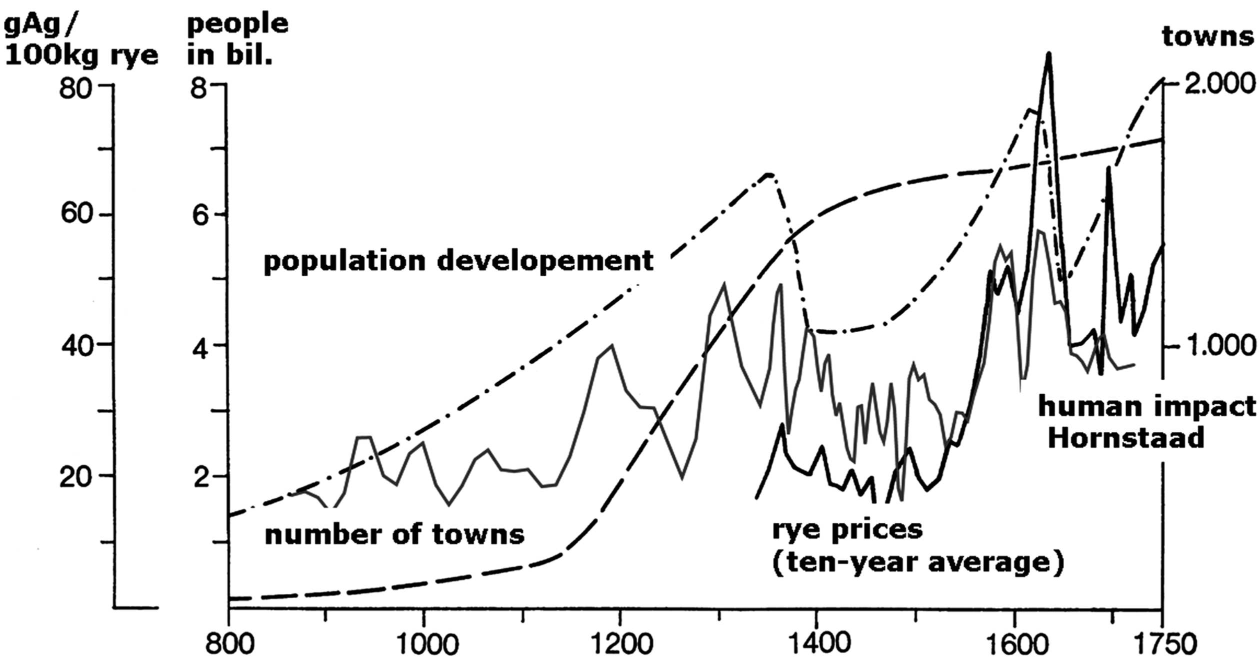

Fig. 4. Diagram depicting the development of population, number of towns and rye prices between 800 and 1750 AD in Germany (modified after Henning 1979). The light grey curve is the human impact curve from Hornstaad, which runs closely parallel with the population development and with the rye prices.

and it even seems able to depict small details. This is a first hint that the human impact curve could be used as an economical index analogous to the cereal price curves. The advantage of this is that the human impact curves reach back to the Bronze Age which is several thousand years before the notation of prices. The Hornstaad curve is strongly related with economical development. Further research is needed to show whether the human impact curves can be used as macroeconomic indices in other landscapes as well.

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