A Geo-Archaeological Model of Holocene Landscape Development and its Implications for the Preservation of Archaeological Sites

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Abstract

This paper presents a geo-archaeological approach to estimating the potential state of preservation of archaeological sites in the Northern European Lowlands where the Holocene shaping of the landscape has been dominated by processes of soil erosion and deposition. Over time, as determined by topography and soil properties, protective soil layers are either removed (erosion), thereby exposing sites to an increased risk of being destroyed or built up (deposition), preserving the sites but making them hard to find. With the help of a geo-physical model and the integration of archaeological data, it is possible to locate and assess the potential locations of eroded and covered sites.

Assessing the Invisible

It has been understood for some time, that archaeological research on a landscape scale must pay close attention to the intimate relationships between cultural sites and landscape development (e.g. Davidson 1985, Holliday 1992). Besides conserving visible monuments of our past, we must also strive to preserve the true, unseen extent of our cultural heritage as it lies buried in the ground, hidden from the senses of the archaeological prospector[1].

Primarily, it is the strength of the geomorphological processes of erosion and deposition that determine the state of conservation of the embedded sites. If the protective soil cover has been reduced by erosion, the archaeological site's remains will be exposed to human activities (ploughing, construction work), and gradually destroyed. On the other hand, sites that have spent the last millennia under a thick, protective cover of deposited soil, can be expected to produce well-preserved features. Knowing where to expect the latter provides important hints for the allocation of resources. The planning and conduction of rescue excavations in particular could benefit immensely from the additional information offered by a robust model of erosion and deposition. These considerations led to the design of an erosion model for Holocene landscape development in the Northern European Lowlands. The geographical and archaeological data to support the research presented in this paper is taken from a study area west of the German capital city Berlin in North-eastern Germany ("Havelland" in Fig.1). With its extent of about 3 x 17.7 km, the region can be considered large enough to justify a landscape scale approach on a detail level of 10 x 10 m ground resolution.

Soil Erosion and Landscape Development

As far as the Northern European Lowlands are concerned, the most recent large scale shaping of the landscape by natural geological and geomorphological processes can be dated back to the final glacial phase of the last Ice Age ca. 12,000 years ago. The geological epoch that followed, the Holocene, has so far been one of stable geological conditions. The fact that archaeological stratigraphies in the area under discussion usually display a complex, heterogeneous depositional pattern can mostly be attributed to human impact. The European Plains as we perceive them today are much different in appearance from what they were like when the first farmers settled there in the 6th millennium BC. In fact, what we see is only a flattened, smoothed reminiscence of the natural Holocene landscape (Fig.2). Claiming one patch of land after another for millennia in succession, the farmers of the Northern European Lowlands have been stripping the landscape of its natural cover, hacking, burning down and up-rooting the vegetation and replacing dense forests with open, unprotected agricultu-

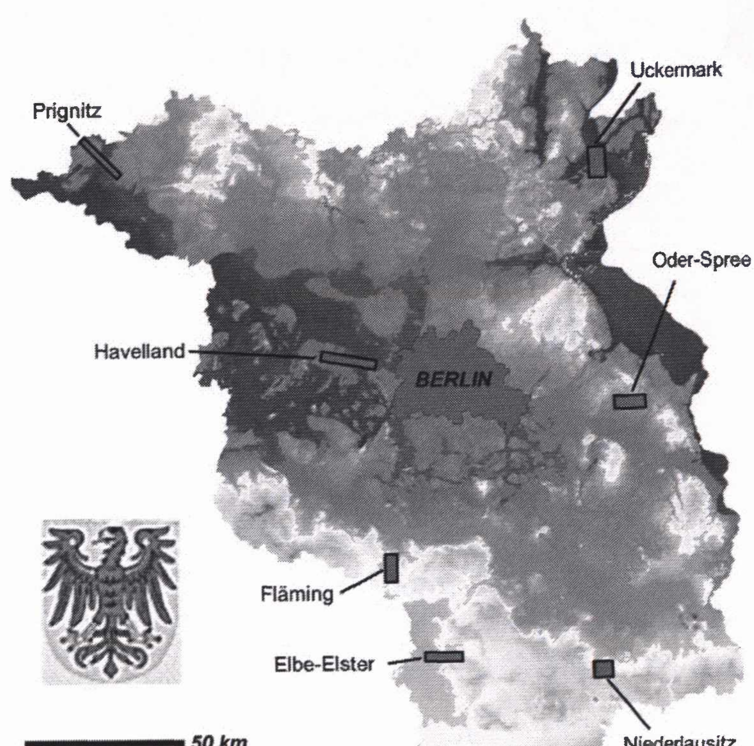

Figure 1 The state of Brandenburg in North-eastern Germany. The study area discussed in this paper is designated "Havelland"

ral fields. With the natural vegetation gone, there is nothing that could prevent the fertile, volatile cover of soil from being washed off and transported down the slopes by intense rain and from being blown away by the wind, whenever fields lie bare of crop. This process, called soil erosion, results in severe soil degradation and a flattening of the landscape. The archaeological literature abounds with stratigraphical and geomorphological observations that indicate events of disastrous erosion by water and wind. Some recent publications include examples from Central Europe as well as virtually all other parts of the world (e.g. Sandor 1992, Verhagen 1996, Zeidler and Isaacson 2001). However, precise quantifications of the soil volumes involved are hard to find. Fortunately, some recent publications with geo-archaeological study cases from North-eastern Germany (Bork et al. 1998) have considerably alleviated the stand-still situation. These recent studies have shown:

1. In the area under study, soil erosion has been and still is the dominant geomorphological process.

2. Soil erosion started as soon as agriculture was introduced in the area under study.

3. The intensity of soil erosion processes has seen several dramatic peaks; provably in the iron age (ca. 8th century AD to 4th century BC) and in the 14th century BC.

4. In the long term, soil erosion leads to a flattening of the landscape that makes geomorphological features harder to assess.

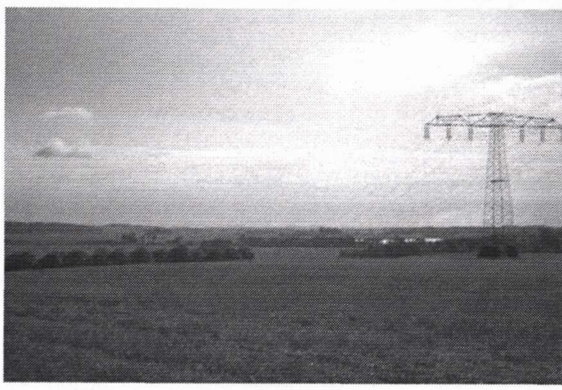

Figure 2 A typical landscape in North-eastern Germany

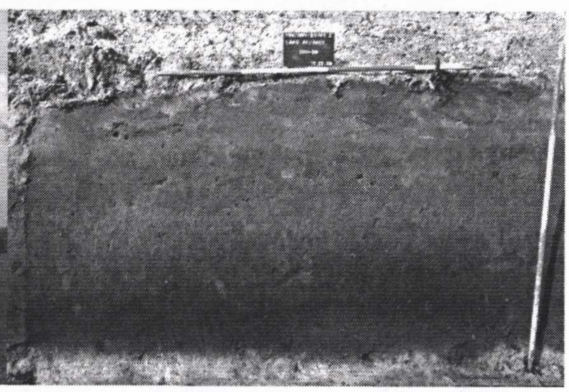

Figure 3 Stratigraphic cross-section of Dyrotz 37 (courtesy of L.A.N.D. ltd.)"

Modelling Soil Erosion

Although having been smoothed by soil erosion, the landscape's relief still retains its ancient topographical properties. It is possible, therefore, to model the movement of soil masses through the landscape in the past based on presently available data and from such a model learn about the locations of soil depositions that might still cover largely undisturbed archaeological sites in the landscape today. The last decade has seen the emergence of refined erosion models, many of which go far beyond the mere practical needs of calculating erosion risk. Process-based models such as the Water Erosion Prediction Project (WEPP, see WEPP 2001) or the European Soil Erosion Model (Eurosem, Morgan et al. 1998) allow for detailed studies of the processes involved in erosion to gain a better understanding of landscape development. While in theory being excellent research tools, the practical drawback of these models is that they require lots of difficult-to-obtain, precise quantifications for their numerous parameters.

An optimal model for archaeological erosion risk assessment would therefore combine easily accessible and robust parameters with the predictive capabilities of a more advanced model. Fortunately, just such a model exists. USPED (Universal Stream Power Erosion Deposition) calculates rates of erosion and deposition according to a simple geophysical model (based on original concepts by Moore and Burch 1986). It assumes a steady state overland water flow with uniform rainfall excess conditions. Steady state water flow can be expressed as a function of upslope contributing area per unit contour width which in turn can easily be calculated from a DEM. The net erosion/deposition rate is then estimated as divergence of sediment flow (Mitasova and Mitas 1999). Instructions for several popular GIS platforms and an in-depth explanation of the mathematical methods have been compiled by Mitasova and Mitas (1999). Armed with a high quality DEM and the USPED model, one only needs to supply a few parameters. All of them are stable enough in time to allow incorporation into a model for the entire Holocene and can be represented adequately on a landscape scale level.

1. Rainfall intensity can be approximated from histograms of local rainfall capacity.

2. Vegetation cover is a very complex parameter but can be roughly estimated using standard relations for vegetation classes (see Mitasova et al. 2001).

3. The erodibility of soil depends on many physical properties, such as particle size and cohesion, proportion of organic material, aggregate sizes and permeability. Fortunately, these micro-properties of soil can often be mapped to the most common classes of soil types (such as sandy, loamy etc.) via standard estimates.

4. A topographical parameter is derived from the DEM of the study area.

An Archaeological Study Case

The Havelland is a typical landscape in North-eastern Germany which is located west to the urban area of Berlin (Fig.1). Until modern times, the landscape's appearance was characterized by a dense network of streams that made the region a much-frequented passage way and established its status as an important centre of prehistoric settlement activity from the Neolithic to the Iron Age. The reorganisation of agriculture on an industrialised level after WWII brought the ruin of the historical landscape and subsequently gave way to the modern, minimised topography which is composed of broad and gentle slopes that are predominantly used for growing crops (Fig.2). As a case study for the local impact of the global erosion/deposition pattern, we will take a look at the prehistoric settlement site of Dyrotz 37. Artefacts indicate that several prehistoric settlements have been erected on the site over a period of approximately 4500 years: 1. Middle Neolithic (ca. 4600-4300 BC), 2. Late Neolithic (ca. 3500-3100 BC), 3. Late Bronze Age (ca. 1300-1100 BC), 4. Iron Age (ca. 550 BC-0 AD), 5. Germanic Age (ca. 0 AD-500 AD). Figure 3 shows the stratigraphic situation in those parts of the site that were covered under soil deposits: several colluvial layers can be distinguished by their darker shades. Undisturbed, natural soil layers of lighter shade in-between them are evidence of prolonged periods without settlement activity on the site and its immediate neighbourhood. The features in the western part of the excavated area lay buried under more than 2 metres of colluvial depositions and were accordingly well preserved. Roughly two thirds of the excavated area is situated up-hill where erosion has been pre-dominant and has essentially erased all of the prehistoric layers. The bottom parts of settlement pits were essentially the only surviving archaeological features in this area. In ignorance of the geomorphological situation, the site's importance was well underestimated and the resources allocated to its excavation were insufficient leading to a great loss of valuable archaeological information. It should be noted that the erosion/deposition model depicted in Figure 4 has been colour-coded for easy recognition of erosion/deposition patterns. In the natural landscape, the "steepness" of the slope on which the site is located is around 2 degrees and hardly recognizable at all. Even this small gradient, however, does make a decisive difference for the site's stratigraphic structure and the level of preservation of its archaeological features. The USPED-based model accurately predicts the depositional pattern of the site. In the case of Dyrotz 37, the individual depositional layers are up to 1.5 meters in height. The chronological determination of each erosion/deposition event and the accurate quantification of its strength requires geo-archaeological data of a quality that the entire study area presently lacks. For future work on the subject, many more site stratigraphies will have to be examined before a statistically valid relationship between USPED-calculated values and actual soil volumes can be established.

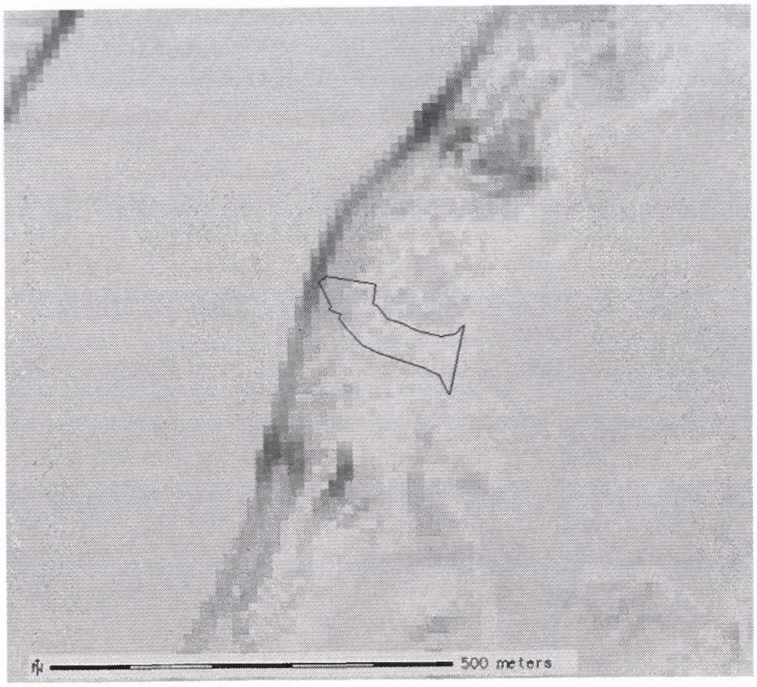

Figure 4 USPED-based erosion/deposition model of the archaeological excavation site "Dyrotz 37" (lower right, corner, red outline) and its surroundings. Orange to yellow colours (light) indicate erosion; greenish to blue colours (dark) indicate deposition

Results

Erosion and deposition are factors of primary importance when trying to predict the potential locations of well-preserved archaeological sites in the landscape. The method described in this document yields valid results only for a restricted class of landscape types where erosion and deposition caused by run-off are the dominant processes. The model can thus be applied to vast areas of the Central and Northern European Lowlands from the Netherlands to Poland. In other types of landscapes, Aeolian depositions, stream meandering, littoral processes etc. may be of importance.

1 The work presented in this paper is partly derived from the author's M.A. thesis (Ducke 2002, in German language, yet unpublished) and is also part of "Projekt Archäoprognose Brandenburg" , a research project aiming to provide a complete predictive map for archaeological sites in the state of Brandenburg, North-eastern Germany (Müller and Kunow 2002, http://www.uni-bamberg.de/~ba5vf99/index.html.

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