

Conceptual Aspects of the „Archaeoprognose Brandenburg“ Project, Archaeological Site Predictions for Various Test Areas in Brandenburg

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Abstract. The objective of the research project “Archäoprognose Brandenburg” is to develop and compare methods of prediction for the mapping of potential archaeological sites for all prehistoric cultures in the state of Brandenburg. In archaeological heritage management it often turns out that only a fraction of archaeological sites is known to date. Different methods for drawing up predictive maps are evaluated, and as expected, the pattern of settlement structures and density of archaeological sites will change considerably. In addition to the cultural-historical relevance of this diachronic comparison, the heritage management potential will be useful for predicting archaeological sites and for the actual landscape-planning proceedings. This paper gives an overview of the nature of the problems encountered during the use of Geographical Information Systems for digitisation, analysis and visualisation and ways to overcome them, discussing both conceptual and practical aspects.

Keywords. Predictive maps, GIS, data modelling, landscape archaeology, spatial analysis

1 Introduction

In order to be able to protect prehistoric monuments we need to be aware of their existence. This premise, trivial though it may seem, it is only met for a small fraction of our archaeological heritage. Quality and efficiency of heritage management and monument preservation would benefit greatly if the degree of precision in predicting the locations of undiscovered sites could be improved (Deeben et al 1997).

Therefore, the aim of the research project “Archäoprognose Brandenburg” is to develop improved methods for producing archaeological predictive maps as a tool for heritage management in the state of Brandenburg.

The sheer volume and heterogeneity of the data sets involved require computer-based storage and analysis. One of the most appropriate tools available for this purpose are Geographical Information Systems (GIS), which our project employs for the digitisation, analysis and visualisation of archaeological and geographical data.

This article attempts to give an overview of the nature of the problems encountered and ways to overcome them, discussing both conceptual and practical aspects.

This research project is a joint endeavour of Professor Dr. Jürgen Kunow of the Brandenburg State Authority for Heritage Management and the State’s Archaeological Museum at Wünsdorf and Professor Dr. Johannes Müller of the Department of Prehistory of the University of Bamberg, and is sponsored by the Fritz Thyssen Foundation in Cologne.

2 Conceptual Aspects

2.1 Objectives

Archaeological heritage management in practice reveals again and again that only a small fraction of archaeological sites are known.

The objective of this research project is to develop and compare methods of prediction for the mapping of areas

suspected of containing undiscovered archaeological sites in the state of Brandenburg.

This article attempts to evaluate various approaches to producing predictive maps.

Apart from reconstructing the cultural landscape, this process also allows us to gain new insights into the settlement patterns during various epochs of prehistory and early history.

2.2 Definition of Task

In order to record and interpret settlement structures of prehistoric communities, it is necessary to know something about their preferred habitats. The spatial distribution and with it the targeted choice of specific areas for different types of activity, e.g. the location of residential, agricultural and funerary areas and their relative positioning is largely determined by two main factors:

- 1) Natural landscape characteristics; and
- 2) Social developments in the course of prehistory and early history.

The positioning of archaeological sites, both relative to each other as well as with regard to the ecological parameters of an area, shows certain regularities. These could be said to describe the potential behaviour of those communities with regard to the environment, i.e. they reveal different perceptions of the attractiveness of certain landscape characteristics. And it is these factors on which the production of predictive maps is based (Kamermans 2000).

2.3 The Area of Work

The area of work is the state of Brandenburg, and the mapping of suspected archaeological sites is based on seven test areas situated in different types of natural landscape (Fig. 1).

They each comprise an area of between 30 and 50 square kilometres, and have been designated according to a number of different criteria.

The test areas designated had to contain a sufficiently large number of known archaeological sites and be classifiable as belonging to different categories of landscape (Marcinek and Zaumseil 1993).

They will provide the basis for the reconstruction of potential sites in areas of similar landscape categories or formations in which no archaeological finds have been discovered to date.

In addition, the areas designated are characterised by different intensities of activity in terms of heritage management. Therefore they can be expected to show differences in the quality of existing archaeological sources, and could thus serve for the verification of potential site maps. Examples are an area of open-cast lignite mining which is continuously monitored and archaeologically documented, or an area with volunteer ground heritage management, or an area fully covered by student prospecting.

3 Methodical Procedure

3.1 Setting Up Regional Geographical Information Systems

To begin with, Geographical Information Systems had to be set up for the test areas (Bonham-Carter 1994). The software employed for this task included MapInfo, Arcview, GrassGis, Mapscan, Photopaint and AirPhoto.

The database consists of topographic, geological, hydrological and soil maps from different periods. In order to ensure that statements about the landscape-relatedness of archaeological sites are of the highest possible degree of precision, a map scale of 1:10.000 was chosen (Fig. 2).

The work is based on the topographic map system of the state of Brandenburg which includes the information layers of relief, surface waters, forest, and ground plan.

The quality of data in the available maps varied greatly, and environmental data from various sources was only partly supplied in digital format. Incorporating these data into the Geographical Information System required a large degree of adaptation work. Printed maps were scanned and referenced in MapInfo. In addition, orthophotos of the corresponding scale were purchased in digital format.

For the calculation of an elevation model, the scanned contour line maps needed to be vectorised. This was done by means of the Mapscan software. Although this US- designed software includes a referencing feature, it does not correspond to the reference system of Gauß Krüger. Therefore, an affine transformation of data was required to allow for the vectored representation to be incorporated into the Geographical Information System (Schödlbauer 1982). This involved the manual entry of elevation values for the contour lines.

Soil maps were available in varying quality and in smaller scales than 1:10.000. The information contained in the various sources needed to be digitised, interpreted and summarised manually for incorporation into the GIS. The genesis of soils is difficult to reconstruct, therefore the mapping is based on substrates (Fig. 3).

3.2 Reconstructing the Ancient Landscape

Since maps available today reflect the present-day condition of the landscape, past conditions had to be reconstructed by means of historic maps and aerial photographs. This involved

adapting present-day map layers as much as possible to the historic conditions of a landscape.

However, the numerous historic maps available for the state of Brandenburg could not be incorporated into the Geographical Information System, as they showed considerable distortion due to generalization and surveying errors. But they give a good impression of the condition of the landscape before the substantial changes that were brought about by the reallocation of land and settlement activity in modern times.

So far, the surface water features have been reconstructed (Fig. 4). Particularly useful for this purpose were the vertical aerial photographs taken in 1953, seen together with the historic maps.

After rectification by means of reference points and taking elevation data into account, these photographs provide a very accurate, true-to-coordinates photomap, which allows for precise super-positioning with the other GIS layers.

Erosion and accumulation models are to be evaluated in a further work phase.

In addition, maps of different dates have been combined in order to reconstruct surface areas which have been lost, e.g. through open-cast lignite mining. Figure 5 reflects the situation in 1993-95. We have no topographical data for the surface areas consumed by the open-cast mine. Figure 6 shows complementary topographical data which were extracted from topographic maps dating back to 1976. The incorporation of these data was effected by means of affine transformation of coordinates into the current reference system.

Setting Up the Archaeological Database. The next step was to set up a specific database incorporating archaeological site data for the test areas from the archives of the Brandenburg State Authority for Heritage Management, and to process these data (Fig. 4).

An essential task was the verification of site coordinates, since they form the basis for all further evaluation. This task required comprehensive work on the archives, because not all information was available in digital format.

Archaeologically relevant results from aerial photographs also form part of the GIS. To visualise them, the photographs were rectified by means of the AirPhoto software programme, and then linked to a database. In some cases it was difficult to date these results, but in others it was possible. Results from aerial photographs complement the information about the distribution of archaeological sites, since some sites are located in areas which were not covered by field walking or for which no surface sites are known.

3.3 GIS Modelling (Data Merging)

The second phase of work is the 'GIS modelling'. On the basis of the data recorded, various models were calculated.

After the earlier-mentioned adaptation of contour line maps, which included vectorisation and attribution of altitude values, an elevation model with a resolution of 10 meters was calculated by means of the GrassGis programme (Mitasova 1992, Fig. 4).

For the purpose of statistical evaluation in the context of the Archaeoprognosis project it is necessary to have an altitude value for each and every point of the map sector – therefore,

contour line maps, which only contain this information in the form of lines, are not adequate for this purpose.

From the digital elevation model the gradient and aspect of slopes can be determined. This calculation is also done on a resolution of 10m.

An important factor for the calculation of suspected site areas is the distance from water, which is also calculated on the basis of a resolution of 10m.

Digital Landscape Model. The calculation of suspected site areas is done on the basis of the various landscape data mentioned. In order to combine these, a grid with squares of 50m has been used, with each cell containing the characteristic features. This digital landscape model is structured to form a georeferenced database. For prediction purposes, five factors, namely distance from water, altitude, slope gradient, aspect and combination of substrate, have been taken into account (Fig. 7).

3.4 Development of Different Predictive Models (Data Analysis)

The third work phase comprised the development of various predictive models for the mapping of suspected archaeological site areas.

Method of Brandenburg State Authority for Heritage Management. The Heritage Management Authority's planning is currently based on the following criteria: Areas of up to 200 m distance from surface water and areas with a radius of 80 m around any known site are considered to be suspected site areas. However, in practice, the actual location of sites often differs greatly from this assumption. Therefore, the Authority needs to develop a method which delivers better results.

This work is based on the landscape features which characterise known sites, the so-called practice areas. To date, we have results based on the entirety of known archaeological sites, without differentiation of historic periods.

Minimum-Maximum-Method. One calculation of suspected site areas was done according to the so-called minimum-maximum method. Under this method, the areas between the minimal and the maximal values for each factor form the basis for prediction (Fig. 8).

For local planning purposes this method is not very useful, as it classifies approximately 82% of the total area as suspect. While this would clearly be in the interest of archaeologists, it would hardly be justifiable in the eyes of those responsible for construction or building projects.

Method of Identical Factors. Another option is the method of identical factors. Under this method, all factors from the practice areas will have to be met within the suspected site area, and the combination of individual factors will also have to be exactly identical (Fig. 9).

Using this method, only very few areas will be identified, apart from the already known sites. Therefore, it does not constitute an adequate planning instrument for heritage management. Experience from larger construction projects has shown that, normally, a much larger number of sites than predicted by this method have been discovered.

Probability Method. A third option is the probability method. Under this method, a probability value is assigned to every grid cell of the test area. It is based on the frequency of occurrence of each factor. Adding these, each grid cell is given

a valuation which takes into account all factors in their respective valuation (Fig. 10). For the purpose of interpreting the results thus received, they are divided into three categories: of high, medium and low probability. The areas of high probability account for 12% of the total area, and 60% of sites are located within these areas.

3.5 Verification of the Results

Verification of these results can be achieved in various ways. A theoretical test of the predictive models can be carried out by means of a time-related splitting of find data according to discovery dates. In this process, the more recently discovered finds are tested against the older ones: If the model delivers correct predictions, the more recent finds should be located within the suspected site areas calculated on the basis of the older find data. In a way, this procedure simulates the data available to archaeological heritage managers at the splitting date. The test then consists in comparing whether the newly mapped suspected site areas actually contain the more recently discovered finds.

Testing the "Minimum-Maximum Method".

The result produced by testing the "Minimum-Maximum Method" in this way differs only marginally from the total result. The suspected site area is only 0.5% smaller. All more recent sites are located within the suspected site areas, thus the validity of this model has been confirmed.

Testing the "Method of Identical Factors".

The suspected site area at which we arrive when the "Method of Identical Factors" is tested in this way, only comprises around 30% of the area identified when using the entire data set. 16 out of 53 sites, i.e. about 30% of sites, are not recognised.

This means that the suspected site area changes rather substantially when additional data are taken into account. Therefore, this method is not suitable for predicting site locations.

Testing the "Probability Method".

The calculation based on the "Probability Method" using only half of the data set arrives at a slightly larger area of high probability than when the full data set is used (Fig. 11). The area identified as highly probable is 22% of the total area. All more recent finds are located in areas of high or medium probability. Only 13% of the more recent finds are located in areas of medium probability, and none in areas of low probability.

Another way of verifying the prediction results consists in the mapping and integration of new finds. They should be located within the suspected site area; alternatively, the factors which characterise sites located outside the suspected area will have to be incorporated, and the suspected site area will have to be recalculated or updated accordingly.

Apart from the theoretical verification, there will also be a practical one. It will be carried out in the course of this year through a survey of suspected site areas and negative areas presumed to be void of sites.

Parallel to this, the probability method will be further developed through the use of various statistical procedures. B. Dücke presented an application of „artificial neural networks“ with data based on test area 4 in this publication.

4 Conclusions

The various methods deliver differing results, in line with their definition. The choice of method will depend on the type and quality of the available data and on the specific task. The verification of results by means of the above-described test has shown that the method of identical factors and the minimum-maximum method are not suitable for the prediction of archaeological sites. Up to now we have come to the conclusion that the probability method delivers the best results for the practice of archaeological heritage management.

On a more general note, this type of mapping of suspected site areas should be seen as an open system, which will continue to improve with time, and with the increasing scope of the data basis.

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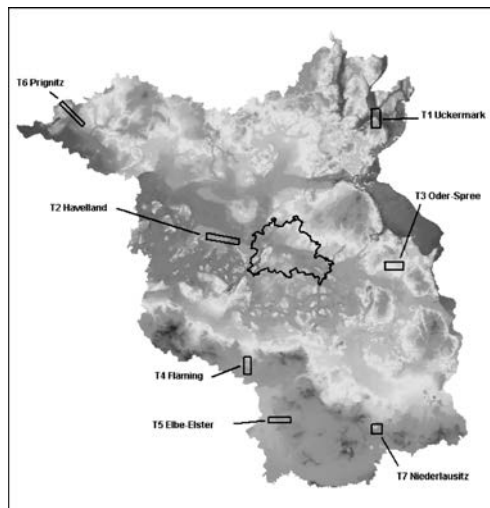


Fig. 1. A topographic view of Brandenburg including the test areas.

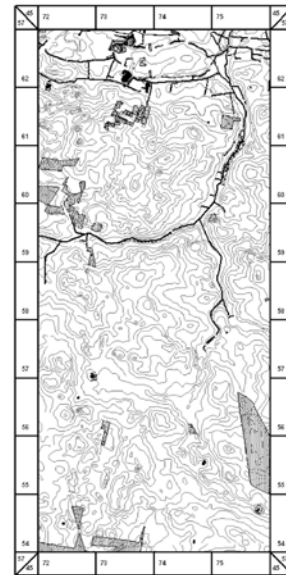


Fig. 2. Test area „Fläming“ with information based on the topographic map system of the state of Brandenburg (forest = grey, surface water = black).

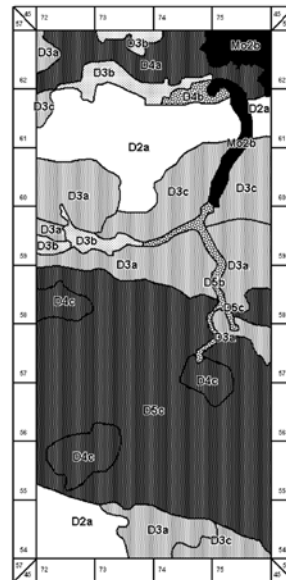


Fig. 3. Test area „Fläming“, mapping of Substrates.

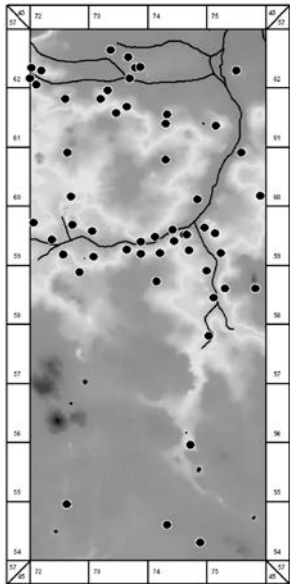


Fig. 4. Test area „Fläming“, archaeological sites, digital elevation model and reconstructed surface water.

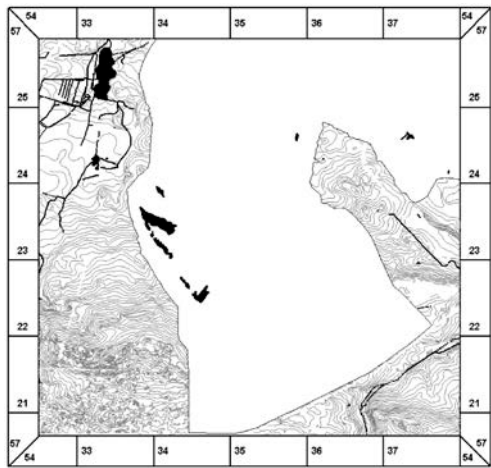


Fig. 5. Test area „Niederlausitz“, the situation in 1993-95.

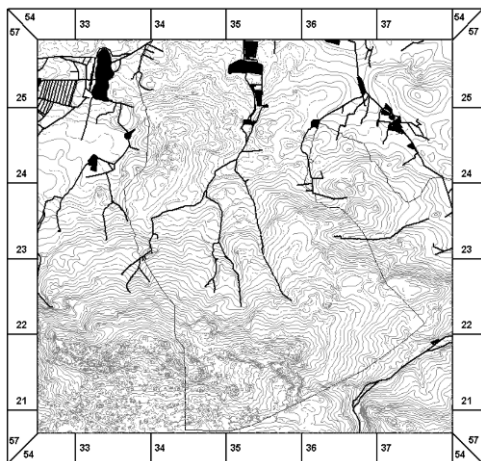


Fig. 6. Test area „Niederlausitz“, the situation in 1976.

ID	w_distance	hight_hn	slope	aspect	substrat_k
13317	200,000000000	75,166257040	0,025278840	0,000000000	100
13476	254,000000000	75,223008160	0,040237160	0,000000000	100
13398	251,000000000	75,127422760	0,048301400	3,860241600	100
13397	250,000000000	75,167933960	0,044740400	14,396500240	100
8864	277,000000000	81,513309320	0,095435480	24,013566800	1000000000
9216	202,000000000	84,498288480	3,031450960	25,542739480	1000000
13399	259,000000000	75,097222920	0,059815520	27,794570760	100
12749	149,000000000	74,945538280	1,639837720	29,061591200	1000000000
8198	230,000000000	86,035408040	2,528565120	34,226655800	1000000000
13478	260,000000000	75,077316320	0,232826440	34,483325440	100
12108	540,000000000	84,996455640	1,240858960	37,599480880	1000000000
13558	210,000000000	74,780794000	0,990513880	38,580833120	100

Fig. 7. Test area No. 4, digital landscape model.

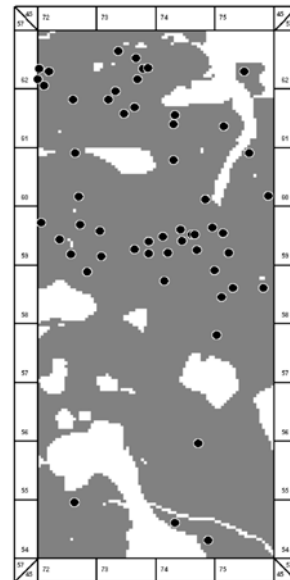


Fig. 8. Test area No. 4, „Minimum-Maximum-Method“, (suspected site area = grey).

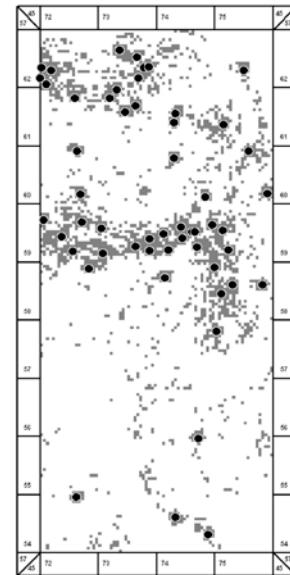


Fig. 9. Test area „Fläming“, „Method of Identical Factors“, (suspected site area = grey).

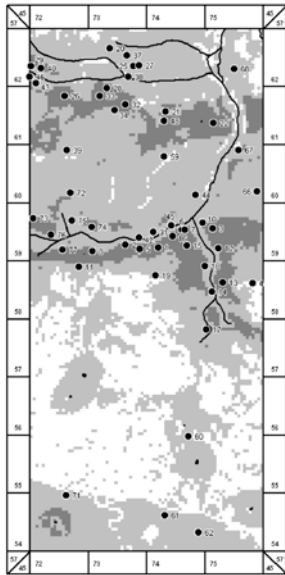


Fig. 10. Test area „Fläming“, „Probability-Method“, (high probability = dark grey, middle probability = light grey, low probability = white).

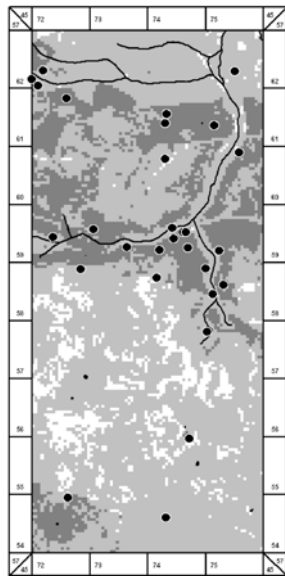


Fig. 11. Test area „Fläming“, Testing the „Probability-Method“, (high probability = dark grey, middle probability = light grey, low probability = white).