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ARCHAEOLOGICAL LANDSCAPES AND GIS APPLICATIONS

QUANTITATIVE METHODS

Predictive Modelling

The Application of Predictive Modelling in Archaeology: Problems and Possibilities

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Abstract. Predictive modelling is a technique used to predict archaeological site locations in a region on the basis of observed patterns or on assumptions about human behaviour. The application of predictive modelling has given rise to considerable academic debate. This paper identifies some problems with predictive modelling and mentions possible solutions.
Keywords: Predictive modelling; Archaeological heritage management; GIS

1. Introduction

The analysis of human site location in the past has always been an important topic in archaeology. Over the years the application of predictive modelling has made major contributions to this study. One of the first definitions of predictive modelling is by Kohler and Parker (1986: 400): "Predictive locational models attempt to predict, at a minimum, the location of archaeological sites or materials in a region, based either on a sample of that region or on fundamental notions concerning human behavior".
Nowadays the two main reasons for applying predictive modelling in archaeology are:
To predict archaeological site locations to guide future developments in the modern landscape; an archaeological heritage management application.
To gain insight into former human behaviour in the landscape; an academic research application.

2. History

Predictive modelling was initially developed in the USA in the late 1970s and early 1980s, where it evolved from governmental land management projects (Kohler 1988). Today it is widely used in the USA (various examples in Wescott and Brandon 2000), Canada (Dalla Bona 2000) and many countries in Europe (e.g. Deeben *et al*. 2002; Münch 2003).
From the start the application of predictive modelling gave rise to considerable academic debate. The material deposits of this debate can be found in articles in conference proceedings and scientific journals (see e.g. Carr 1985; Church *et al*. 2000; Ebert 2000; Harris and Lock 1995; Kamermans and Wansleeben 1999; Kamermans *et al*. 2004; Van Leusen 1995, 1996; Lock and Harris 2000; Savage 1990; Verhagen *et al.* 2000; Wheatley 2004) but also in conference proceedings devoted entirely to the subject (Judge and Sebastian 1988; Wescott and Brandon 2000; Van Leusen and Kamermans in press; Kunow and Müller in press; Mehrer and Wescott in press).

3. Problems and Solutions

In this debate six major problem areas can be identified that need to be better understood in order to guide the future development of predictive modelling (Kamermans *et al*. 2004). These problems all have implications for the quality, applicability and reliability of the current predictive maps:
- Quality and quantity of archaeological input data
- Relevance of the environmental input data
- Lack of temporal and/or spatial resolution
- Use of spatial statistics
- Testing of predictive models
- Need to incorporate social and cultural input data

Many of these problems were discussion points immediately from the introduction of predictive modelling in archaeology. Sebastian and Judge wrote in 1988 on the first page of the first chapter of their book *Quantifying the Present and Predicting the Past* (Judge and Sebastian 1988): "One of the more interesting developments in the field of archaeology in the recent past is the emergence of predictive modeling as an integral component of the discipline. Within any developing and expanding field, one may expect some initial controversy that will, presumably, diminish as the techniques are tested, refined, and finally accepted. We are still very much in the initial stages of learning how to go about using predictive modeling in archaeology,…." (Sebastian and Judge 1988: 1). More than 15 years later it looks as if this quote still describes the present situation. The controversy continues and we are still refining and testing the technique. Predictive modelling is far from universally accepted. But are we making progress in the problem areas mentioned above? Some recent attempts are worth mentioning here.
The first ones are on the topics quality and quantity of archaeological input data and the relevance of environmental input data (covering the first two problem areas). In many countries archaeologists are working hard to improve the quality and quantity of archaeological and environmental input data and to make these data available in a digital format. Examples are ARCHIS, the national archaeological GIS of the Netherlands (e.g. Deeben *et al*. 2002), VIVRE, a similar project in Luxembourg, and various initiatives in Germany

(e.g. Ducke and Münch in press; Münch 2003, this volume). An example of more fundamental research into the quality of input data is by Philip Verhagen (Verhagen in press b; Verhagen and Tol 2004) who discusses the role of augering in archaeological prospection.

Almost all archaeologists employing predictive modelling are convinced of the importance of introducing a temporal and spatial resolution in predictive models (e.g. Peeters in press, this volume; Verhagen and McGlade 1997). The problem with this approach in heritage management are the greater costs of this type of approach.

The use of spatial statistics and the testing of predictive models has been discussed for more than 20 years (e.g. Kvamme 1988, 1990; Parker 1985; Woodman and Woodward 2002). However we can still expect progress in this field. Some researchers think that the use of a Bayesian approach in spatial statistics looks very promising (Van Dalen 1999; Millard in press; Verhagen in press a), others believe that using the Dempster-Shafer theory will solve at least some of the problems that we have in predictive modelling with uncertainties (Ducke this volume; Ejstrud in press a, in press b).

The last topic, the need to incorporate social and cultural input data, is a difficult one. Predictive modelling, especially when performed with the aid of a GIS, has been accused of environmental determinism (Gaffney and Van Leusen 1995; Kvamme 1997; Wheatley 1999, 2004). For years almost all archaeologists have been agreeing that you cannot study past human behaviour in purely ecological/economical terms and that social and cognitive factors determine this behaviour to a large extent (e.g. Binford 1983; Carlstein 1982; Ellen 1982; Jochim 1976). These factors should therefore be additional predictors in the process of predictive modelling (Verhagen *et al*. this volume). Modern landscape archaeology gives us much insight into human social and cultural behaviour in the landscape (Bender 1993; Tilley 1994), but to incorporate these variables into models is a different question. Examples are given by Ridges (in press), Stančič and Kvamme (1999) and Van Hove (this volume). Most promising is the work by Thomas Whitley, who recently published a number of papers addressing the more fundamental aspects of 'cognitive' predictive modelling (Whitley 2000, 2002 a, 2002 b, 2003, 2004, in press a, in press b, this volume). One problem is that most examples of the incorporation of social and cognitive variables have an ethno-historical and not an archaeological origin.

Recently two articles have been published that argue that the correlative method of predictive modelling should not be used in archaeological resource management. In January 2004 *Internet Archaeology* published an article by David Wheatley (2004) called *Making Space for an Archaeology of Place*. Part of this article deals with the inductive, correlative form of predictive modelling that is used for resource management and the author is very critical.

His main points of critique are:

it doesn't actually work very well

According to Wheatley most practitioners of predictive modelling make no attempt to find out how well their models perform (generally very badly). The way to do that is to collect more archaeological data to test the model but that is in most cases the activity people are trying to avoid. The reason for building the model is that it is a cheap and easy way to say something about the distribution of archaeology in a region, while surveying is expensive and time consuming.

it isn't used

Wheatley states that there is often a legal requirement to look for archaeology on the ground whether the model predicts archaeology or not. Here Wheatley is wrong. In many countries the models play an important role in the planning process.

it shouldn't be used

Wheatley has a point here. If a predictive model is generated on the basis of known sites and then used to influence where we look for undiscovered archaeology, we will have created a self-fulfilling sampling strategy.

Wheatley's final conclusion is that correlative predictive modelling will never work because archaeological landscapes are too complex. The reason why it is used anyway is that there are insufficient financial resources to conduct archaeological work everywhere, so the solution would be to focus on well-designed and properly implemented sampling strategies.

Thomas Whitley's (2004) article *Causality and Cross-Purposes in Archaeological Predictive Modelling* explains the nature of the conflict between some of the basic underlying assumptions of certain kinds of predictive models and the purposes for which they were originally intended. His conclusion is that in many cases it is too costly or even impossible to do a correlative predictive model and that ultimately the resulting model does not provide better insight into site placement processes than intuition.

4. Conclusion

The first researchers to apply predictive modelling in archaeology were very much aware of at least some of the problems mentioned above (e.g. Parker 1985). It was originally expected that predictive modelling would allow "a broad range of potential constraints on human settlement decisions to be evaluated for their importance: subsistence, constructional, psychological, social and other factors" (Carr 1985: 117). This was seen as a step forward from previous decision-making analyses of prehistoric settlement choice (e.g. Binford 1980; Jochim 1976; Keene 1981) since they have been limited to "the investigation of potential causal factors in the subsistence domain" (Carr 1985: 117). Sebastian and Judge (1988: 4) thought that the "emphasis on descriptive models will and should eventually be replaced by an emphasis on models that are derived from our understanding of human behavior and cultural systems, models with *explanatory* content".

It looks as if in the last twenty years progress has been made on details but that we have not been able to solve the major problems. In my mind there is no doubt that predictive modelling is a valuable tool for academic archaeological research. It can give insight into human behaviour in the past

in general and in past land use in particular. But we should be more critical about the use in current archaeological heritage management. Certainly in Europe with its complex archaeological record, predictive modelling is not a good tool for identifying areas with a high archaeological 'value'. The current models are neither methodologically nor theoretically sound, their performance is poor and to improve them (if at all possible) would make them too costly for archaeological heritage management purposes. Predictive models should not reach land managing officials and certainly not the planners. Their only role should be in an initial phase, to aid archaeologists to stratify an area in order to plan various forms of archaeological prospection on the basis of a good sampling design.

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