Archaeological Predictive Modelling Used For Cultural Heritage Management

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Abstract:
This paper considers the possible use of archaeological predictive modelling for cultural heritage management in the UK by comparing the technique with the current system of cultural heritage management. The paper examines aspects such as data interrogation, limitations of the technique, the testing of models, criticisms against the use of the technique and costs. It is concluded that the technique would be viable in the UK in certain circumstances, such as for large projects and if paid for by developer. It would not be viable for the majority of cases of cultural heritage management within urban areas, as defined by local development plans. The success of the technique appears to be dependent upon the terrain being modelled and the archaeological data available.

Key Words: *Archaeological Predictive Modelling, Cultural Heritage Management*

Introduction

Part of cultural heritage management is the official governing and protection of archaeological remains (buildings, features and artefacts) in a region, which includes any undiscovered archaeological remains that are likely to be destroyed by development. Currently, the decision of when and where to demand an archaeological investigation, paid for by the developer, is carried out on an individual basis by the county archaeological department. However, in some cases there is little archaeological data with which to base such decisions on. As archaeological predictive modelling determines the probability of discovering archaeological remains within unexplored areas, it could be used to assist with these decisions and it has the potential to save the developer paying for unnecessary archaeological excavation.

Archaeological predictive modelling is normally carried out by assigning numeric values to various categories within digital environmental layers (such as soil type, ground slope, etc.) and then adding the layers together to produce a layer of prediction. The process is normally carried out in a GIS using raster squares. Assessing what numeric values to assign to environmental categories is complex. One method, termed deductive modelling, is to use expert opinion. One or more experts estimate initial values and a predictive model is produced, which is then tested by evaluating how well it predicts new archaeological data and the expert's initial values are adjusted to increase the prediction of the model. However, normally no two experts agree and without this feedback correction system, the predictive model becomes just one expert's opinion which could be biased. The advantage of this method is that it does not rely upon known archaeological data, it is not affected by administrative boundaries (see below) and it involves relatively simple mathematical procedures. Another method, termed inductive modelling, uses statistics. Statistics are obtained from known archaeological data (such as the percentage of known archaeological remains on clay, chalk, loam, etc.). These statistics are then used to determine what numeric values to apply to the

Figure 1. Map of the UK, showing the four counties of East Anglia.

environmental categories and how different environmental factors relate to each other. For example, is soil type more or less important than say the distance to a river when choosing a suitable site to locate an arable farm? The main advantage of this method is that there are mathematical techniques available to test the model before its application (for example, split sampling).

Most archaeological predictive models tend to relate to a specific historic period as settlement patterns vary between cultures using different subsistence strategies. For example, settlement patterns of hunter-gathering societies will be very different to settlement patterns of early farmers. For my studies I have concentrated on producing archaeological predictive models for the Late Anglo-Saxon period (850 – 1066 AD) within East Anglia (four counties forming a group in the east of the UK) (Fig. 1).

Archaeological Data

Modern planning laws in the UK, restricts new development to well-defined areas called local development plans. Thus, development-led archaeology is normally confined to these areas whilst other sources of archaeological data, such as field walking and metal detecting tend to come from outside these areas. In some East Anglian counties, archaeological data mainly comes from development-led archaeology and in other counties it mainly comes from other sources. Thus, the archaeological record is more concentrated (within local development plans) in some counties (like Cambridgeshire) compared to other counties (like Norfolk). Further, some counties (like Norfolk) have a longer tradition of collecting and recording archaeological data than other counties. Both these significant biases make archaeological predictive modelling across modern county boundaries problematical.

Development-led archaeology is providing us with ever more archaeological data within urban areas. However, surely it is more important (and interesting) to obtain archaeological data in unexplored areas, between local development plans. Whilst archaeological research agendas exist for East Anglia (Brown and Medlycott 2008), there appears to be little co-ordination to data collection by the individual county archaeology departments. They appear to just collect archaeological data, and probably due to the current recession, they do not have the resources to fully consider what that data could, or would, be used for.

Environmental Data

Most archaeological predictive models use modern environmental datasets, which are readily available. However, do these datasets reflect the past environment? For example, has annual rainfall and temperature changed over time and if so, how has that affected foraging for food or farming? Have the positions of rivers changed and are modern soils the same as historic soils? Modern UK digital soil maps show *basic* soil properties that are not influenced by fertilisers or drainage (www.LandIS.org.uk/soilscapes). Hence, their properties should be very similar to historic soils. For my study area, landscape archaeologists suggest that the river system has only been altered by man by a few percent (Williamson 1997) and experts suggest that the overall environment was only a few percent different from today's environment (Lamb 1997). However, would small differences in annual rainfall and tempreature affect agriculture during the Late Anglo-Saxon period, compared to modern agriculture? Agricultural experts in East Anglia report that hexaplodal bread wheat (introduced by the Romans) is similar to today's varieties with the exception that they would have been taller and hence more susceptable to heavy rain (refer to Crop Genetics Department, John Innes Centre, Norfolk). However, it is considered that Anglo-Saxon farmers would change crops and farming techniques to suit changees in the climate (Fowler 2002). Hence, it appears likley that two or three consecutive bad growing seasons would have had more of an inpact on Anglo-Saxon farming societies than a gradual small change in the climate.

Modelling Limitations

Some landscapes funnel human settlement or restrict the exploitation of the landscape. For example, in the study by Duncan and Beckman in SW Pennsylvania in 2000, the general region has an average ground slope of around 16% but on average archaeological sites occur on a ground slope of around 6% (Duncan and Beckman 2000). Powerful commercial archaeological predictive models are being produced for the Muskeg region in Canada in advance of oil exploitation, as the wetland nature of the region heavily restricted the location of past settlement (refer to Millennia Research Ltd, BC, Canada). One way to overcome the problems of different archaeological densities, archaeological concentrations and differing terrains is to produce an archaeological predictive model for each different region. The national archaeological predictive model for the Netherlands (the IKAW) is split into various 'archaeo-regions' that are modelled separately. Unfortunately, this technique can cause problems where one model abuts another as each model would be based on different data and modelling techniques.

Model Testing

It is widely agreed that archaeological predictive models should be tested against an independent dataset. Determining how well a model predicts its own input data is a circular (and dangerous) argument as archaeological data or expert opinion can be severely biased. However, is the current system of cultural heritage management in the UK ever tested? In the UK each development application is assessed by the county archaeological department on an individual basis. Research has revealed that on average in East Anglia, this system only discovers archaeological remains in approximately two thirds of all development archaeological investigations. It is appreciated that some archaeological investigation is designed to define the extent of archaeological deposits and so it may not expect to find any archaeological remains. However, if the retrieval of archaeological data is used to judge cultural heritage management, this success rate is not very impressive. Research also suggests that this unproductive archaeological investigation costs the tax payer and developers in each county in excess of £1 million per year.

Criticisms Against Archaeological Predictive Modelling

Critics argue that the use of archaeological predictive modelling would likely result in self-fulfilling models as county archaeological departments would only demand archaeological investigation in the high probability areas, which in turn would strengthen the prediction of that area (Wheatly 2004). However, decisions by UK county archaeological departments about where to demand archaeological investigations are predominantly based upon the proximity of known archaeological data. If you only investigate areas near to known archaeological data, you can never find archaeological data away from those areas. Both these situations are self-fulfilling!

Critics also argue that archaeological predictive models must predict all archaeological remains else important archaeological data would be lost. Research suggests that within East Anglia, approximately 2% of all development (that involves disturbance to the ground) has some form of archaeological investigation. Hence, the current system of cultural heritage management in the UK is not protecting *all* archaeological remains! This issue raises the question of how much money do you wish to spend on protecting your cultural heritage.

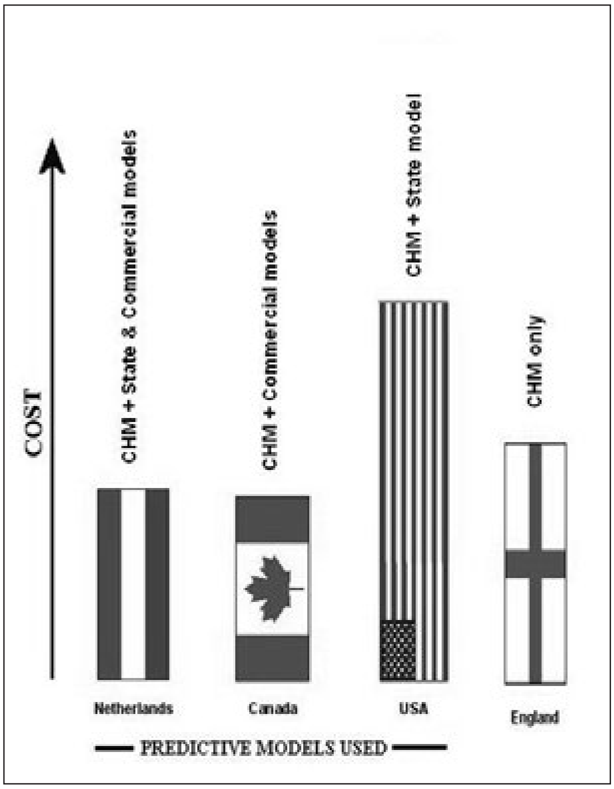

Figure 2. Relative costs of cultural heritage management in four countries. Please note that this figure has been made using different calculations (to determine this basic cost) and in some cases it is based on data which is an educated guess, by others.

Costs

The major consideration for using archaeological predictive modelling for cultural heritage management is cost. Would using the technique save money or could more archaeological remains be saved for the same amount of money by using archaeological predictive models? To investigate this, the average cost to the tax payer for a single archaeological investigation (paid for by a developer) but managed by four different authorities in 2008 was calculated (Fig. 2).

It appears that if the UK wishes to use archaeological predictive modelling for cultural heritage management, and the authorities produce and maintain that model (as in the USA), the cost to the tax payer is likely to increase. However, if archaeological predictive models were produced by private companies (as in Holland and Canada), submitted for approval by the authorities and paid for by developers, there could be a saving for the UK tax payer. However, the technique is costly and would not be financially viable for every small development. Research suggests (based on Dutch data) that the technique would only be financially viable in the UK on developments in excess of £3 million.

Conclusions

Cultural heritage management appears to be about balancing risk against cost. If a county archaeological department allows development on a site, what is the probability of that work destroying important archaeological remains? Also, exactly what constitutes important archaeological remains? Do we have to save every shard of ancient pottery? The problem

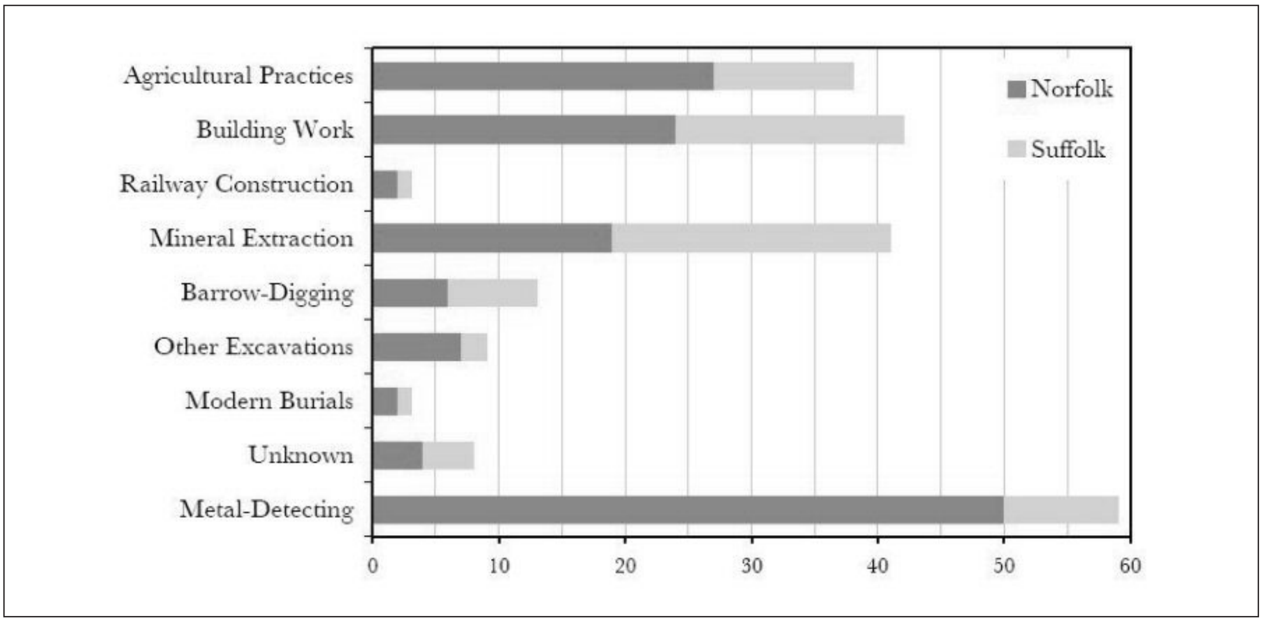

Figure 3. The discovery of Anglo-Saxon cemeteries by different means (Hogget 2007).

is that unless an archaeologist excavates the site, nobody can be *exactly* sure of the risk involved or if a particular pottery shard is worth saving. However, is it fair to demand that every development site has some form of archaeological investigation? If so, the cost of an archaeological investigation could stop some sites being developed and new housing, infrastructure, offices, factories and shops would not be built. Our heritage defines our culture and who we are. However, what is more important, our heritage or the quality of our lives? Surely we have to balance the two. As a consequence, cultural heritage management should be about maximising the protection of archaeological remains for the minimum cost.

Accurately assessing the potential for discovering important archaeological remains within a development site is the key to this. For example, deductive archaeological predictive modelling appears to work well in Canada. However, given the small amount of known archaeological data and large areas of land involved, this technique is probably the only one available to the Canadians. In contrast, in the UK new development is mainly confined within small areas, which are normally rich in known archaeological data. Often a visual inspection of that data is sufficient to base a judgement of whether to archaeologically investigate it or not. However, there are large areas in the UK (outside local development plans) where this is not the case such as areas of mineral extraction, new roads, pipelines, etc. The archaeological importance of these areas has recently been highlighted by a survey of how Anglo-Saxon cemeteries have been discovered in the past within the counties of Norfolk and Suffolk. The combination of agricultural practices, mineral extraction and metal detecting account for about 65% of discoveries compared to building work within urban areas that account for about 20% (Fig. 3).

Archaeological predictive modelling can never be 100% perfect but it appears that the UK system of cultural heritage management can also never be 100% perfect! Therefore, the question is; '*Which method works best in the area you are interested in*'?

As terrain appears to affect both inductive and deductive settlement modelling, some

UK counties will produce stronger predictive models than others. Modelling across modern administration boundaries or environmental boundaries can be a problem for inductive techniques, but not for deductive ones. Ideally any archaeological predictive model should be within a single administrative area and have only one type of terrain.

To be a viable option for cultural heritage management in the UK, it appears that the technique would work best on large projects, between local development plans, where the archaeological record is sparse. Further, it appears that developers would need to pay for the actual modelling for it to be a financially viable alternative to the current system of cultural heritage management. However, archaeological predictive models could be used to focus physical archaeological investigation, and hence save the developers money in the long term. For the UK, the above conclusions suggest that the technique would only be most suitable for new pipelines, roads and rail schemes, mineral extraction and in particular farming practices, which account for 75% of the UK (Trow 2010, 12). Archaeological predictive modelling would not be that suitable within local development plans, unless there is a significant lack of basic archaeological data.

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