Predictive Modeling: a View from the Ivory Tower

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The Netherlands
Predictive Modelling

Predictive Modelling is a technique to predict, at a minimum, the location of archaeological sites or materials in a region, based either on the observed pattern in a sample or on assumptions about human behaviour (Kohler & Parker 1986: 400).
Reasons to apply predictive modelling in archaeology

- To gain **insight into former human behaviour** in the landscape; an academic research application.

- To predict archaeological site location to **guide future developments** in the modern landscape; an archaeological heritage management application.
The inductive modelling cycle

- Known sites
- Correlation with environment
- Internal testing

- Predictive model

- Test data
- Expert judgment
- Independent testing

- New data

Kamermans & Wansleeben 1999
The deductive modelling cycle

- Known sites
- Predictive model
- Independent testing

- Hypotheses about site location
- Internal testing

Kamermans & Wansleeben 1999
Current Status of WHS Modeling in Alberta (Canada)

- Approximately 28 million ha of land has been modelled.

- Models are currently GIS-based using inductive approach.

- Models use extensive data sets that are limited by their sometimes coarse resolution.
  - DEM is 100 m, so smaller terrain features cannot be accounted for in the models.
  - Do not have soils data so this information has to be approximated through satellite imagery analysis.

- Models are 100% financed by private sector.
Research project:
Archäoprognose Brandenburg

Predictive models for the Land Brandenburg
(North-Eastern Germany)
A MISURA D’UOMO
Archeologia del territorio cesenate
e valutazione dei depositi

a cura di Sauro Gelichi e Claudio Negrelli
Problems  (Kohler & Parker 1986: 440)

- The use of inappropriate sampling techniques.
- Failure to differentiate significant temporal and functional subsets of sites.
- Failure to consider how proxy variables really contribute to locational decisions.
- Low spatial resolution.
- Inappropriate statistical tools.
- Little consideration for model validation.
QUANTIFYING THE PRESENT
AND
PREDICTING THE PAST

Theory, Method, and Application
of Archaeological Predictive Modeling

Judge & Sebastian 1988
Indicatieve Kaart van Archeologische Waarden (IKAW), schaal 1:50.000
Bron: ROB, 2000
Problem areas

- Quality and quantity of archaeological input data.
- Relevance of the environmental input data.
- Need to incorporate social and cultural input data.
- Lack of temporal resolution.
- Lack of spatial resolution.
- Use of spatial statistics.
- Testing of predictive models.
Problem areas

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Discover the world at Leiden University
Distribution maps for different plant species in the Netherlands
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Lothar (T+42 hours)

Ensemble forecast of the French / German storms (surface pressure)
Start date 24 December 1999: Forecast time T+42 hours

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Timothy A. Kohler (1988)

- “Why are the social, political, and even cognitive/religious factors that virtually all archaeologists recognize as factors affecting site location and function usually ignored in predictive modelling?”
- “Given the subtleties and especially the fluidity of the socio-political environment, is it any wonder that archaeologists have chosen to concentrate on those relatively stable, “distorting” factors of the natural environment for locational prediction?”
Four promising areas of research

- A systemic analysis of the archaeological records and their aggregation into culturally meaningful entities.
- Analysis of the logistic position of settlements.
- The continuity of the cultural landscape.
Four promising areas of research

- A systemic analysis of the archaeological records and their aggregation into culturally meaningful entities.
- Analysis of the logistic position of settlements.
- The continuity of the cultural landscape.
- Agent-based models.
Agent-based models (ABM)

- Multi-agent simulation
- Use of socio-cultural agents
- Agents interact in rule-based ways

2008
Agent-based models (ABM)

- Use Roman roads or wetlands offerings as “attractors”
- Agents interact in rule-based ways (looking for resources or suitable wetland spots for offerings, going down Roman roads, choosing strategic spots, etc)
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An experiment in archaeological site location: modeling in the Netherlands using GIS techniques

Roel Brandt, Bert J. Groenewoudt and Kenneth L. Kvamme

‘that each archaeological period will be analyzed separately in future efforts, and a distinct model will be generated for each period’

Introduction

Much of the archaeology in the Netherlands is hidden beneath the ground surface, making the process of archaeological discovery a labor-intensive and expensive activity. On-the-ground field inspection requires the examination by trained professionals of hectare after hectare of open fields, ditch-sides, molehills, and other exposed areas. The consequence is that choices must be made concerning the most suitable places to conduct the limited amount of survey it is possible to undertake given available resources.

It seems a logical step, then, to make use of the decades of archaeological work that has been performed in many regions of the Netherlands to aid in the survey planning process.
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Inductive predictive modelling

- Are we talking about an association or a correlation?
- Is there causality?
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Conclusion

The current forms of inductive predictive modelling are not suitable for archaeological heritage management in the Netherlands.
David Wheatley (2003)

“correlative predictive modelling does not actually work very well and, more significantly, will lead to an increasingly unrepresentative archaeological record”
“in many cases it is too costly or even impossible to do an correlative (inductive) predictive model and ultimately the resulting model does not provide better insight into site placement processes than intuition”
Deductive predictive modelling

Land Evaluation
- Land evaluation is a technique developed by soil scientists to generate different models for land use on the basis of ecological and social economic data. In archaeology, land evaluation can be used as a deductive form of predictive modelling.
Step 1
Basic survey's

Step 2
Models

Step 3
Qualitative Clas.

Step 4
Quantitative Clas.

Step 5
Land use

Kamermans et al. 1985
Papers in Italian Archaeology IV

The Cambridge Conference

Part I
The Human Landscape

edited by
Caroline Malone and Simon Stoddart

BAR International Series 243
1985
At this time the main research goal is to investigate changing patterns of prehistoric landuse in the Agro Pontino, from the middle Palaeolithic to the Bronze Age, using land evaluation techniques in conjunction with archaeological, ethnographic and historical data. In this way the potential of land evaluation for prehistoric research will be assessed.
ARCHEOLOGIE EN LANDEVALUATIE

in de Agro Pontino (Lazio, Italië)

Hans Kamermans

1993
Land Evaluation

- Helen Goodchild (2007)
- Antonio Rotolo (2012)
Archaeological land evaluation

A reconstruction of the suitability of ancient landscapes for various land uses in Italy focused on the first millennium BC

Ester van Joolen

2003
MODELLING ROMAN AGRICULTURAL PRODUCTION IN THE MIDDLE TIBER VALLEY, CENTRAL ITALY

By

HELEN GOODCHILD

A thesis submitted to
The University of Birmingham
For the degree of
DOCTOR OF PHILOSOPHY

Institute of Archaeology and Antiquity
School of Historical Studies
The University of Birmingham
April 2007
Determine size of the exploited area

Assess favoured resources

Ascertain nutritional requirements based on workload

Assess potential yields of the area

Calculate size of supported population

Goodchild 2007
La formazione sociale islamica in Sicilia
Popolamento e paesaggio medievale nell’area dei Monti di Trapani attraverso l’archeologia

Antonio Rotolo

Granada 2012
Fig. 13. Il flusso di lavoro dello studio della *land evaluation*. Rotolo 2012
Application of process models

- Ann Zwertvaegher (2012)  
  Integrated process models

- Rik Feiken (2013)  
  CALEROS
The use of integrated process models in a geoarchaeological context

A proof of concept

Ann Zwertvaegher

Proefschrift voorgedragen tot het behalen van de graad van Doctor in de Wetenschappen: Geologie

2012
No strong evidence for any occupational pattern

- (i) a non-systematic recording of presence/absence of finds;
- (ii) a biased sampling;
- (iii) the current landscape attributes do not explain past occupational patterns;

Zwertvaegher 2012
No strong evidence for any occupational pattern

- (iv) the landscape attributes used for predictive mapping do not give a physical explanation for occupational preferences;

- (v) a deterministic approach based on the physical landscape cannot explain occupational patterns completely.

Zwertvaegher 2012
Solutions

- Reason (iii) would motivate a palaeolandscape reconstruction;

- (iv) would motivate to search for biophysical factors that, with the land use at that time, give a physical –deterministic explanation for occupational patterns;

- (v) would motivate the inclusion of social, economic, cultural, ideological and ritual drivers that explain occupational patterns

Zwertvaegher 2012
Components of the model framework

- Elevation model
- Hydrological model
- Pedogenetic model
- Land evaluation model

Zwertvaegher 2012
Figure 3.4 Flowchart for the construction of a temporal DEM. Solid lines indicate data flows, dotted lines indicate information flows (for model calibration and verification).
Figure 3.9 Flowchart for the land evaluation model. For the legend, see Figure 3.4. Solid lines indicate data flows, dotted lines indicate information flows (for model calibration and verification).
Figure 3.11  Model framework incorporating the different model instruments (DEM, groundwater model, pedogenetic model and the land evaluation model). For the legend, see Figure 3.4.
Hidden Landscapes of Mediterranean Europe

Cultural and methodological biases in pre- and protohistoric landscape studies

Proceedings of the international meeting
Siena, Italy, May 25-27, 2007

Edited by
Martijn van Leusen
Giovanna Pizziolo
Lucia Sarti

BAR International Series 2320
2011
2 CALEROS: an erosion-deposition model for landscape archaeology

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² Department of Physical Geography, University of Utrecht, Heidelbergrlaan 2, 3584 CS Utrecht, The Netherlands – T.vanAsch@geog.uu.nl; R.vanBeek@geo.uu.nl

1. Introduction
Since 2000 the Groningen Institute of Archaeology (GIA) has conducted annual intensive and systematic archaeological field walking surveys in the Raganello catchment in northern Calabria (Italy). The primary result of these surveys is a series of high-resolution pottery density maps, known to be distorted by the action of natural and anthropogenic processes on the landscape. However, the effects of these processes on the recovery of archaeological evidence could never be modelled in detail.

In 2005 work began to remedy this and other methodological problems encountered by landscape archaeologists: the Hidden Landscapes project. In a collaboration with physical geographers from the University of Utrecht, the PC-Raster software is being used to construct the CALEROS dynamic erosion model. This poster presents our preliminary results in modelling the most important natural process: erosion. Future work will focus on refinement of the model, and on the inclusion of the major anthropogenic processes: agricultural terracing and plough erosion.

2. The pilot area
One of the areas studied by the Hidden Landscapes project is the Raganello river catchment in northern Calabria (fig. 1, inset map). A detailed archaeological field survey was conducted in three transects cross-cutting the catchment. One of these transects runs through the catchment of a tributary stream to the Raganello: the Maddalena. Figure 1 shows the landscape in the Maddalena catchment, which we selected for the CALEROS pilot model because of the presence of interesting archaeological phenomena. The Maddalena area is made up mainly out of easily weathering schists (foreground) and hard limestones (background). A detailed geomorphological mapping was carried out in order to define landscape units in which geomorphological processes occur more or less homogeneously (Van Leusen & Feiken 2007).
Van Beek & Feiken 2013
CALEROS: a meso-scale landscape dynamics model

- Soil production and development;
- Soil hydrology;
- Sediment transport due to water induced erosion and diffuse transport (creep, tillage, landslides);
- Dynamic vegetation growth for plant-functional types (incl. cereal);
- Regional population growth;
- Field and resource allocation to meet demands of produce (crops and livestock) and wood.

Van Beek & Feiken 2013
Land evaluation as archaeological predictive modelling

- Techniques are used out of context.
- The problem of optimisation.
- Environmental determinism.
Conclusions

- If we want to predict archaeological site location we need insight in the variables that influence human settlement decisions in the past.
Expectations

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).
Conclusions

- For subsistence we are doing alright.
- But for cultural, social and psychological factors a lot of work has to be done.

- I believe that the modelling of societies in the past and using these models in a form of deductive predictive modelling is the way to proceed.
References

References


References

References

More information:

- http://archaeology.leiden.edu/organisation/staff/kamermans.html

- http://archaeology.leiden.edu/research/computerapplications/bbopredmod.html

- Email: h.kamermans@arch.leidenuniv.nl