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The Application of Predictive Modelling in Archaeology: Problems and Possibilities

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Beyond the Artifact

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Content

Foreword	
<i>Franco Niccolucci and Sorin Hermon</i>	9
The Etruscan Town on the Bisenzio – Geophysical Research and Applications	
<i>Gabriella Poggesi, Pasquino Pallecchi and Paolo Machetti</i>	11
ARCHAEOLOGICAL THEORY	
Archaeological Theory, Techniques and Technologies: Beyond Quantification and Visualization Methods	
<i>J. A. Barceló</i>	19
New Technologies Applied to Artefacts: Seeking the Representation of a Column's Capital	
<i>Mercedes Farjas, Nieves Quesada, Miguel Alonso, Andrés Diez and CARPA</i>	21
A Fuzzy Logic Approach to Reliability in Archaeological Virtual Reconstruction	
<i>Franco Niccolucci and Sorin Hermon</i>	28
Chaos and Complexity Tools for Archaeology: State of the Art and Perspectives	
<i>Carlos Reynoso and Damian Castro</i>	36
On the Frontier: Looking at Boundaries, Territoriality and Social Distance with GIS	
<i>Thomas G. Whitley</i>	41
THE ARCHAEOLOGICAL RECORD	
Holy Grail or Poison Chalice? Challenges in Implementing Digital Excavation Recording	
<i>Sarah Cross May and Vicky Crosby</i>	49
The EKFRASYS: a New Proposal of an Archaeological Information System	
<i>Alfonso Santoriello and Francesco Scelza</i>	55
To OO or not to OO? Revelations from Ontological Modelling of an Archaeological Information System	
<i>Paul Cripps and Keith May</i>	59
Integration of Complementary Archaeological Sources	
<i>Martin Doerr, Kurt Schaller and Maria Theodoridou</i>	64
Which Period is it? A Methodology to Create Thesauri of Historical Periods	
<i>Martin Doerr, Athina Kritsotaki and Stephen Stead</i>	70
A Computer-Aided System for Dynamic Pottery Classification Using XML	
<i>Maria Bonghi Jovino, Giovanna Bagnasco Gianni, Lucio G. Perego, Elisa Bertino, Pietro Mazzoleni and Stefano Valtolina</i>	76
From XML-tagged Acquisition Catalogues to an Event-based Relational Database	
<i>Ellen Jordal, Jon Holmen, Stein A. Olsen and Christian-Emil Ore</i>	81
ArchaeoCAD, ArchaeoMAP, ArchaeoDATA – An Integrated Archaeological Information System	
<i>Andreas Brunn and Martin Schaich</i>	86
SIGGI-AACS, a Prototype for Archaeological Artifact Classification Using Computerized Agents	
<i>Robert Schlader, Skip E. Lohse, Corey Schou and Al Strickland A.</i>	90
Breaking Down National Barriers: ARENA – A Portal to European Heritage Information	
<i>Claus Dam, Tony Austin and Jonathan Kenny</i>	94
FCS_WORD: Conceptual and Technical Framework for the Collaborative Documentation, Management and Presentation of Cultural Statistics, Activities and Research on the Web	
<i>Nicolas Vernicos, Gerasimos Pavlogeorgatos, Evangelia Kavakli, Dimitris C. Papadopoulos, Efthimios C. Mavrikas and Sophia Bakogianni</i>	99
Artefacts: Starters for Standards	
<i>Adolph Guus Lange</i>	103
From a Relational Database to an Integrated System: a Milan University Project	
<i>Glauco Mantegari and Tommaso Quirino</i>	107
Between the Book and the Exhibition. Creating Archaeological Presentations Based on Database Information	
<i>Øyvind Eide, Jon Holmen, Anne Birgitte Høy-Petersen</i>	111
Uroi Hill (Magura Uroiului) – The Beginning of an Interdisciplinary Research	
<i>Angelica Balos, Adriana Ardeu, Roxana Stancescu and Cristina Mitar</i>	113
Data Management of Preservation Activities on Archaeological Sites	
<i>Chiara Bergamaschi and Annamaria Rossi</i>	116

ARCHAEOLOGICAL LANDSCAPES AND GIS APPLICATIONS

New Approaches to the Study of Archaeological Landscapes – Session Introduction

<i>Martijn van Leusen</i>	121
Detection Functions in the Design and Evaluation of Pedestrian Surveys	
<i>E. B. Banning, A. Hawkins and S. T. Stewart</i>	123
Fuzzy Logic Application to Artifact Surface Survey Data	
<i>Emeri Farinetti, Sorin Hermon and Franco Niccolucci</i>	125
Scaling and Timing the Past for the Reconstruction of Ancient Landscape	
<i>Maurizio Cattani, Andrea Fiorini and Bernardo Rondelli</i>	130
Human Space and Disadvantage in Settlement Distribution	
A GIS Analysis on the Case of “ronchi” and Some New Considerations about the Approach	
<i>Alberto Monti</i>	135
From Archaeological Sherds to Qualitative Information for Settlement Pattern Studies	
<i>Frédérique Bertoncello and Laure Nuninger</i>	140
Calculating the Inherent Visual Structure of a Landscape (‘Total Viewshed’) Using High-Throughput Computing	
<i>Marcos Llobera, David Wheatley, James Steele, Simon Cox and Oz Parchment</i>	146
Mobility, Visibility and the Distribution of Schematic Rock Art in Central-Mediterranean Iberia	
<i>Sara Fairén</i>	152
The Geographic Information System of Pescara Valley and the Settlement Patterns in the II Millenium BC.	
<i>Viviana Ardesia</i>	156
Lands of the Middle Fiora Valley in Prehistory and Late Prehistory – from Survey to GIS	
<i>Albero Tagliabue, Nuccia Negroni Catacchio and Massimo Cardoso</i>	162
Landscapes of the Past: The Maremma Regional Park and the Grosseto Coastal Belt –	
Methodology and Technical Procedures	
<i>Michele De Silva</i>	166
From Iberian Oppidum to Roman Municipium – GIS Study of Ancient Landscape in Eastern Spain	
<i>Ignacio Grau Mira</i>	171
Surveying Ashmounds	
Integrated Data Collection for the Establishment of Site Life Cycles in Southern Deccan (India)	
<i>Ulla Rajala, Marco Madella and Ravi Korisettar</i>	175
Understanding Interpretations of Landscape Research	
<i>Marina Gkiasta</i>	179
Mapping the Domestic Landscape: GIS, Visibility and the Pompeian House	
<i>Michael Anderson</i>	183
Counting the Stones: GIS as an Indispensable Tool for Intrasite Analysis	
at the Ancient Maya City of Chunchucmil (Yucatan, Mexico)	
<i>Aline Magnoni</i>	190
Lithics and Landscape: GIS Approaches to the Analysis of Lithic Artefact Scatters	
<i>John Pouncett</i>	195
Intra-Site Analysis of the Palaeolithic Site of Isernia La Pineta (Molise, Italy)	
<i>Carlo Peretto, Marta Arzarello, Rosalia Gallotti,</i>	
<i>Giuseppe Lembo, Antonella Minelli and Ursula Thun Hohenstein</i>	201
An Innovative Tool for Web-GIS Applications SVG and the Open Source Format	
<i>Laura Saffiotti, Francesco Iacotucci and Andrea D’Andrea</i>	207
Monitoring Archaeological Sites along the New Via Egnatia	
<i>Dora Constantinidis</i>	212
An User-Friendly Approach to GIS-Application:	
an Utility for the Study of Etruscan Cemetery of Pontecagnano (Italy)	
<i>Francesco Iacotucci and Carmine Pellegrino</i>	217
Forestry GIS Applications – Protecting Archaeological Sites in Forested Areas	
<i>Pirjo Hamari</i>	220
Intelligent Models and Ideal Cities:	
a Data Model for a Sustainable Urban Planning and Cultural Heritage Safeguard	
<i>Massimo Massussi, Paolo Massussi, Raffaele Piatti and Sonia Tucci</i>	224

The Settlement Pattern of Ancient Icaria through a GIS Approach – A PhD Project (preliminary report)	
<i>Sophia Topouzi</i>	228
Topoclimatic Models and Viewshed in Archaeological Visibility Studies	
<i>Mar Zamora</i>	232
Global Access to Mediterranean Archaeology	
<i>Dora Constantinidis</i>	237
UNDERWATER ARCHAEOLOGY	
Constructing Real-Time Immersive Marine Environments for the Visualization of Underwater Archaeological Sites	
<i>Paul Chapman, Warren Viant and Mitchell Munoko</i>	245
Orthophoto Imaging and GIS for Seabed Visualization and Underwater Archaeology	
<i>Julien Seinturier, Pierre Drap, Anne Durand, Franca Cibecchini, Nicolas Vincent, Odile Papini and Pierre Grussenmeyer</i>	251
Innovative Technologies for the Investigation of Deep Water Archaeological Sites	
<i>Pamela Gambogi, Andrea Caiti, Giuseppe Casalino, Alberto Rizzerio and Giancarlo Vettori</i>	257
Underwater Archaeology: Available Techniques and Open Problems in Fully Automated Search and Inspection	
<i>Andrea Caiti, Giuseppe Casalino, Giuseppe Conte and Silvia Maria Zanolì</i>	261
Putting Predictive Models Underwater, Challenges New Perspectives and Potential of GIS Based Predictive Models in Submerged Areas	
<i>Penny Spikins and Morten Engen</i>	266
PREDICTIVE MODELLING	
The Application of Predictive Modelling in Archaeology: Problems and Possibilities	
<i>Hans Kamermans</i>	273
An Application of Predictive Modelling in the Tiber Valley	
<i>R.E. Witcher and S.J. Kay</i>	278
Imagining Calabria – A GIS Approach to Neolithic Landscapes Some Critical Thoughts on Modelling the Effects of Agency and Qualifying Landscapes in Terms of Human Activity	
<i>Doortje Van Hove</i>	284
Modelling Mesolithic-Neolithic Land-Use Dynamics and Archaeological Heritage Management: An Example from the Flevoland Polders (The Netherlands)	
<i>Hans Peeters</i>	291
Regional Scale Predictive Modelling in North-Eastern Germany	
<i>Benjamin Ducke</i>	296
Are Current Predictive Maps Adequate for Cultural Heritage Management? The Integration of Different Models for Archaeological Risk Assessment in the State of Brandenburg (Germany)	
<i>Ulla Münch</i>	302
First Thoughts on the Incorporation of Cultural Variables into Predictive Modelling	
<i>Philip Verhagen, Hans Kamermans, Martijn van Leusen, Jos Deeben, Daan Hallewas and Paul Zoetbrood</i>	307
Re-Thinking Accuracy and Precision in Predictive Modeling	
<i>Thomas G. Whitley</i>	312
VISUALIZATION, 3D AND VIRTUAL RECONSTRUCTIONS	
Virtual Archaeology: Yesterday, Today, and Tomorrow	
<i>Donald H. Sanders</i>	319
An Integrated Approach to Archaeology: From the Fieldwork to Virtual Reality Systems	
<i>Maurizio Forte, Sofia Pescarin, Eva Pietroni and Nicolò Dell'Unto</i>	325
House of the Skeletons - A Virtual Way	
<i>Fernando Silva, Dino Rodrigues and Alexandrino Gonçalves</i>	335
Computer Graphics and Virtual Reality: two Different Contributions in Archaeological Research	
<i>Sabina Viti</i>	341

The Role of Scientific Reconstruction in Virtual Archaeology. Education, Communication and Valorization. The “Pompei - Insula del Centenario (IX 8) Project” <i>Daniela Scagliarini Corlàita, Antonella Coralini and Erika Vecchietti</i>	347
The Virtual Trip Through The Medieval Torun – Possibilities of Using Open Source and Shareware Software in Multimedia Projects and Archaeological Interactive, Virtual Reconstructions of Medieval Architecture <i>Lukasz Andrzej Czyzewski</i>	351
A Multimedia 3D Game for Museums <i>R. Montes and F.J. Melero</i>	355
Progressive Transmission of Large Archaeological Models <i>F.J. Melero, P. Cano and J.C. Torres</i>	359
Archaeology – A Virtual Adventure <i>Juliane Lippok</i>	363
Analysing Images of Archaeology in Entertainment Media as a Means to Understanding and Meeting Public Expectations <i>Kathrin Felder</i>	367
Virtual Reality at York: Vr and the Management Of Historic Sites <i>Stephen Dobson</i>	372
3D Temporal Landscape: A New Medium to Access and Communicate Archaeological and Historical Contents <i>Tiziano Diamanti, Mauro Felicori, Antonella Guidazzoli, Maria Chiara Liguori and Sofia Pescarin</i>	376
Photogrammetric Recording, Modeling, and Visualization of the Nasca Lines at Palpa, Peru: An Overview <i>Karsten Lambers, Martin Sauerbier and Armin Gruen</i>	381
A Novel System for the 3D Reconstruction of Small Objects <i>Vassilios Tsioukas, Petros Patias and Paul Jacobs</i>	388
Shortcomings of Current 3D Data Acquisition Technologies for Graphical Recording of Archaeological Excavations <i>Geoff Avern</i>	392
3D Scanning Technologies and Data Evaluation in an Archaeological Information System <i>Martin Schaich</i>	396
QUANTITATIVE METHODS	
Statistical and 3D Artifact Analysis – Session Overview <i>Uzy Smilansky</i>	403
‘To Err is Human’, but to Really Foul Things up You Need a Computer <i>Clive Orton</i>	404
Quantitative Measures of the Uniformity of Ceramics <i>Avshalom Karasik, Liora Bitton, Ayelet Gilboa, Ilan Sharon and Uzy Smilansky</i>	407
Optimal Choice of Prototypes for Ceramic Typology <i>Uzy Smilansky, Itzhak Beit-Arieh, Avshalom Karasik, Ilan Sharon and Ayelet Gilboa</i>	411
Computerised Geometric Analysis of a Spire Coming from a Gothic Tabernacle <i>Cédric Laugerotte and Nadine Warzée</i>	415
Detection of Matching Fragments of Pottery <i>Martin Kampel and Robert Sablatnig</i>	419
Breaking Down an Early Neolithic Palimpsest Site – Some Notes on the Concept of Percolation Theory and the Understanding of Spatial Pattern Formation <i>Hans Peeters</i>	423
Modelling the Archaeologist’s Thinking for the Automatic Classification of Uruk Jamdat Nasr Seals Images <i>Sergio Camiz, Elena Rova and Vanda Tulli</i>	429
Unsupervised and Supervised Classifications of Egyptian Scarabs Based on the Qualitative Characters of Typology <i>Sergio Camiz and Sara Venditti</i>	433
Everyday Life in Mediaeval Uthina <i>Maria Carmen Locci and Mariano Porcu</i>	438
Kohonen Networks Applied to Rincón del Toro Rock Art Site Analysis <i>Damian Castro and Diego Diaz</i>	444

Artificial Neural Networks Used in Forms Recognition of the Properties of Ancient Copper Based Alloys <i>Manuella Kadar, Ioan Ileana and Remus Joldes</i>	448
Frequency Seriation and Temporal order – A Zooarchaeological Study <i>Juan A. Barceló and Laura Mameli</i>	451
DAMAXIS - Danish Mesolithic Axes Information System <i>Vincent Mom and Jens Andresen</i>	457
A 3-Dimensional Reconstruction of a Hellenistic Terracotta Plaque <i>Sam C. Carrier, Masana Amamiya and Susan Kane</i>	463
GEOPHYSICS AND SURVEY	
Investigation of Hungarian Early Copper Age Settlements through Magnetic Prospection and Soil Phosphate Techniques <i>Apostolos Sarris, Michael L. Galaty, Richard W. Yerkes, William A. Parkinson, Attila Gyucha, Doc M. Billingsley and Robert Tate</i>	469
“Personal” Multistage Remote Sensing and Traditional Field Work to the Archaeological Analysis of Complex Landscapes: Relationships, Benefits and Actual Limitations <i>Stefano Campana</i>	473
Landscape Archaeology in the Sesto Fiorentino Area: the Contribution of Aerial Photographs to the Study of Archaeological Contexts as Part of an Integrated Approach <i>Giovanna Pizziolo</i>	479
Egialea Survey Project: Method and Strategies <i>Alfonso Santoriello, Francesco Scelza and Roberto Bove</i>	484
CULTURAL HERITAGE – COMMUNICATION	
Heritage Communication through New Media in a Museum Context <i>Diane Leboeuf</i>	491
Digital Paths to Medieval Naantali From Mobile Information Technology to Mobile Archaeological Information <i>Isto Vatanen, Hannele Lehtonen and Kari Uotila</i>	495
Virtual Reality as a Learning Tool for Archaeological Museums <i>Laia Pujol</i>	501
The Jerusalem Archaeological Park Website Project <i>Y. Baruch, R. Kudish-Vashdi and L. Ayzencot</i>	507
PRAGRIS - Praetorium Agrippinae Roman Information System <i>Vincent Mom</i>	511
Projects for the Presentation of the Natural and Cultural Heritage in Hungary <i>Elisabeth Jerem, Zsolt Mester and Zsolt Vasáros</i>	517
Communication in Archaeology The use of Multimedia Devices in Communicating Ancient Past <i>Cinzia Perlingieri and Nicola Lanieri</i>	523
Communicating Archaeology via Multimedia Multimedia Archaeology in Goseck, Germany <i>Peter F. Biehl</i>	527

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 Wansleben 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. Duce 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 (Duce 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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