Archaeological Predictive Modelling: A proposal for the CRM of the Veneto region

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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 in order to **guide future developments** in the modern landscape → an archaeological heritage management application (Kamermans 2011; van Leusen, Kamermans (eds) 2005)
The (existing??) dycotomies: different theoretical approaches for the same problem

**Inductive approach**
...data-driven
...correlative
...bottom-up

**Deductive approach**
...theory-driven
...esplicative
...top-down

Kamermans, Wansleeben 1999
...others dycotomes

Possibilistic approach VS Probabilistic approach

Ecological determinism VS post-modernism approaches

Management- VS research-based models
Predictive models, acting between New Archaeology, Post-Processualism, emergent paradigms and epistemological issues: a possible match point

«...occorre rifiutare l’ assunto post-processualista che l’utilizzo di metodi predittivi conduca necessariamente allo scientismo, aderire alla sua richiesta di pluralismo, rifiutando il monolitismo processualista. L’indeterminatezza è parte integrante della predittività, ma questo non comporta necessariamente anarchia: Occorre stabilire dei gradi di confidenza di ciascuna teoria come facciamo quotidianamente redigendo la carta d’identità di uno strato o di un sito archeologico. È su questi giudizi e non sui dati grezzi che noi costruiamo i nostri modelli interpretativi» (Citter 2012: 3-4 )

It is necessary an **eclectic integration** of different approaches (Bintliff , Pearce 2011)

Inductive approach + deductive approach = **eclectic approach**

Archaeological predictive modelling is just one of the possible (integrable/interchangeable/negotiable) tool for the site pattern description and the consequent data mining, nevertheless it does not provide the solution of our problems!
1° Chi-square test

\[ \chi^2 = \sum \frac{(\text{observed sites} - \text{expected sites})^2}{\text{expected sites}} \]

\[ P(n) = \frac{1}{1 + e^{(Ln)}} \]

2° - Multivariate logistic regression \( Ln = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n \)

- Multicriteria Analysis \( P_i = \sum_{j=1}^{n} W_j X_{ij} \)
- Fuzzy Logic

3° Performance assessment:
- Accuracy and Precision
- Gain calculation \( \text{Gain} = 1 - \frac{Pa}{Ps} \)

Altschul J.H. 1988: 77
Attention at the drawbacks of modern development, and evaluation of the repercussions caused by environmental transformations and urban expansion as regard the landscape, is a particularly living matter as is the interest in devising means for protecting archaeological heritage as part of the normal spatial planning process. We need to predict the past in order to have a role in spatial planning (Kamermans 2011: 15)
We need to manage the transformations generated by the human physiological use of the landscape in order to protect it. In this respect, the role of archaeology is that of yielding archaeological potential assessment in order to address the territorial exploitation processes during the spatial planning policy actions.
Predictive Modelling for the CRM in the Netherlands

IKAW (Indicative Map of Archaeological Values of the Netherlands) produced by RCE (Cultural Heritage Agency)
Predictive Modelling for the CRM in the Netherlands

The project *Strategic research into, and development of the best practice for, predictive modelling on behalf of Dutch CRM* as part of the BBO programme (*Stimuleringsprogramma Bodemarchief in Behoud en Ontwikkeling, Protecting and Developing the Dutch Archaeological-Historical Landscape*) funded by:

![NWO](image)

*Netherlands Organisation for Scientific Research*

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-European Treaty Series - No. 143-

EUROPEAN CONVENTION ON THE PROTECTION OF THE ARCHAEOLOGICAL HERITAGE (REVISED)

Valletta, 16.I.1992

The Valletta agreement has let to the revision of the *Dutch Monuments and Historic Buildings Act*, and the activation of the BBO programme.
Predictive Modelling for the CRM in the Netherlands

**Team:** academic staff, officers of RCE (Cultural Heritage Agency *Rijksdienst voor het Cultureel Erfgoed*), archaeological companies.

**Goal:** to make a through analysis of the various predictive models and methods used in Dutch and international practice, to explore possibilities for methodological improvement and greater efficiency, and promote a second generation of predictive modelling more reliable for the archaeological resources management.

**Procedure:**

*I phase: baseline report*

*II phase: study of the most important issues (quality and quantity of archaeological input data, paleogeography & history and the relevance of the environmental input data, the socio-cultural landscape and the need to incorporate social and cultural input data, lack of spatial & chronological resolution, the use of spatial statistics, testing of predictive models)*

*III phase: final publication (Kamermans H., van Leusen M., Verhagen P. 2009) which includes a set of proposals for best practice in predictive modelling.*

van Leusen, Kamermans (eds) 2005
Some emblematic European case studies

Archaeprognose Brandenburg project

(MUNCH U. 2003; DUCKE B., MUNCH U. 2005)

Land evaluation analysis: a deductive predictive model for the Agro Pontino

(KAMERMANS H. 2000)

Archaeological Predictive Modelling of late Anglo-Saxon settlement in East Anglia

(WILCOX B. 2012)
Some emblematic Italian case studies

Il progetto MAPPA per l’area urbana di Pisa
(http://mappapproject.arch.unipi.it/)

Archeologia preventiva e predittiva nell’esperienza del cesenate (Gelichi S., Negrelli C. 2008; Gelichi S., Negrelli C. 2011)
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Predictive map obtained with the MCE operator of IDRISIGIS

Predictive map obtained with the FUZZY and the MCE operator of IDRISIGIS

Casarotto, De Guio, Ferrarese, Leonardi 2011
Archaeological predictive modelling: a proposal for the Veneto region

Casarotto, De Guio, Ferrarese, Leonardi 2011

Statistical analysis

Finding the significant correlations between settlement catchments and environmental/cultural variables.
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Reclassification of the variables with suitability values
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Assigning weights to each variable: Pairwise comparison technique

Longitude: 0.0135
Latitude: 0.0135
Altitude average: 0.2117
Water distance: 0.0949
Euclidean distance from the nearest neighbour settlement: 0.0461
Cost distance from the nearest neighbour settlement: 0.0449
Land use: 0.1107
Solar radiation: 0.0771
Intervisibility: 0.0199
Slope average: 0.1632
Morphology of the location: 0.2045
Archaeological predictive modelling: una proposta per la Regione Veneto

Multicriteria evaluation: a weighted linear combination

\[ P_i = \sum_{j=1}^{n} w_j x_{ij} \]
Archeological predictive modelling: una proposta per la Regione Veneto

Testing the reliability and functionality of the predictive model

The new independent sample of the “spread finds”:
the majority of the above mentioned site category overlap high probability values

Comparison between the outcomes obtained so far with the ones of a second researcher (Dr. Francesco Ferrarese) who used his own expertise to reclassify and weight the variables and then construct the likelihood map:
the results are absolutely comparable.

Recalculation of likelihood maps for each chronological phase by using a different method of reclassification (Fuzzy operator) and comparison with the previous maps:
the results are absolutely comparable.
Archaeological predictive modelling: una proposta per la Regione Veneto

High archaeological potential map for Middle Bronze Age 3 and Recent Bronze Age 1

Casarotto, De Guio, Ferrarese, Leonardi 2011

Such a likelihood map could be used by territorial authorities like a general guideline for orienting the spatial planning and assess the archaeological risk involved.
1) Archaeological predictive modelling for Preventive Archaeology

In the domain of Preventive Archaeology predictive modelling could become a **shared platform** for the standardized (objective) representation of archaeological potential, above all for the integrative phase of the preliminary planning. Indeed predictive modelling uses objective operators (mathematical algorithms and statistical methods) for producing archaeological risk maps.

To my mind it would be possible to make uniform the **editing criteria** for the construction of an archaeological risk map, and make as explicit as possible the **basic standards** to be followed for implementing such a map. A common language would make the predictive maps (attached to preliminary or definitive archaeological reports) tools which could be easily consulted, and the fact will appoint a certain grade of officiality that is typically requested by law.
2) Predictive modelling for landscape planning:

Predictive maps, as the archaeological maps, permit to gain further insights into the archaeological resources located within a territory, however the first ones give extra indications of the unknown archaeological potential. Therefore they result more informative for the land use planning of such a territory and that’s why they should be attached to territorial planning plans.

For the Veneto region, that has just published the new variation for the P.T.R.C. (Piano Territoriale Regionale di Coordinamento), this methodology may be helpful to improve the monitoring of the archaeological resources in the territory and to assess the archaeological risk involved.

In the Venetian webGIS it could be added a new layer regarding the archaeological predictivity described by different scales of spatial resolution. Moreover the model previously presented could be revised and improved and afterwards used as a test-area for the Veneto region-wide target.
But...
Personally, we believe that predictive modelling does perform at one’s best providing more reliable results and allowing the advancement of knowledge, when it is exploited for the purposes of scientific research.
Predictive modelling: limits

Environmental determinism

Landscape modifications and landscape development

Bias of the source dataset and proxy input data
Predictive modelling: limits

Discretization of the informative palimpsest

Uncertainty management

Test
Nevertheless…
Predictive modelling: future perspectives and improvements

Incorporation of cultural variables: attempt at introducing the cognitive components by making explicit the decisional making process that had led to a particular location choice (Space syntax analysis, Fuzzy logic, Distance zonation, Distance decay models, line-of sight analysis, Cost surface analysis).

Promising integrative methods:
• Survival analysis (De Guio A. 1985; De Guio A. 1986)
Predictive modelling: future perspectives and improvements

Uncertainty management:

• **Fuzzy Logic**: to model the nuance reasoning and to take over the subjectivity involved into the analysis.

• **Bayesian Statistic**: for the representation of the relationship between premises and conclusions. It allows for the incorporation of *a priori* knowledge and its updating in a continuous feedback.

• **DeMptster-Shafer theory**: it permits to formalize the lack of knowledge and put behind the decision about the presence or absent of a site.
Thank you for the attention

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DE GUIO A. 1985a, Archaeological applications of survival analysis, in VOORRIPS A., LOVING S.H. (eds), To pattern the past, P.A.C.T, 11, Souvain, pp.361-381.


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