SYMPOSIUM 2 / COLLOQUE 2

NEW TECHNOLOGIES IN CULTURAL RESOURCE MANAGEMENT
AND ARCHAEOLOGICAL PRESENTATION:
G.I.S., VIRTUAL REALITY, INTERNET, MULTIMEDIA

NOUVELLES TECHNOLOGIES DANS LA GESTION DU PATRIMOINE
CULTUREL ET DANS LA PRÉSENTATION ARCHÉOLOGIQUE:
S.I.G., RÉALITÉ VIRTUELLE, INTERNET, MULTIMEDIA

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INTRODUCTION

The XIV Congress of the *Union Internationale des Sciences Pré- et Protohistoriques* (UISPP) held in September 2001 in Liège (Belgium) was a traditional occasion for its Commission IV to organise a series of workshops and colloquia about archaeological theory and computer applications in archaeology. In the footsteps of the successful GIS-colloquium held during the former edition of the Congress (Forlì 1996) it was decided to tackle a somewhat wider theme. I was charged, together with Zoran Stanèiè, to organise "Colloquium 2" under the heading *New Technologies in Cultural Resource Management and Archaeological Presentation: G.I.S., Virtual Reality, Internet, Multimedia*.

When the program of the 2001 UISPP is compared to the proceedings of the 1996 UISPP meeting we can clearly distinguish a surge in adoption and innovation in GIS by archaeologists. Five years ago GIS was still a novel technology, and archaeologists were just starting to explore its potential. It is now a well-established tool for data management and analysis and is rapidly changing approaches to Cultural Resource Management (CRM) and archaeological presentation. Most of the contributions assembled here focus on GIS as an essential tool, and although they display a much wider field of new technology, GIS remains clearly the motor of the machine for the efficient study, rational management and attractive disclosure of the archaeological data and results.

In his paper Mark Mehrer presents some very practical advice for the elaboration of GIS in predictive modelling. This technique, with already many archaeological applications in the United States, has great potential for CRM work. As recently vast amounts of data were produced that are now being assembled in large databases, the potential has grown for useful site location models in support of heritage conservation. Although decision-support modelling seems to have a great near-term potential as a useful modelling tool, there are also significant methodological and theoretical issues yet to be resolved before a wider use of such tools can be envisaged. With his pilot study of Du Page County (Illinois) Mehrer illustrates the potential of decision-support modelling. Some of the problems inherent in site survey and the analysis of ancient behaviour can be avoided in models designed as decision-support tools. This kind of modelling can never be a substitute for fieldwork as a way to discount some areas as unworthy of further work, but it is an efficient way to plan for the deployment of limited time and resources in a reasonably well-informed way on behalf of heritage conservation.

Three papers illustrate well some of the computer-based projects which characterise new and fascinating developments in European archaeology. Paola Moscati explains the philosophy and strategy underlying the so-called 'Caere

Project' in and around Etruscan Cerveteri. The 'Caere Project' involves the employment of an information system to the study of a town and its territory. It concentrates on the combination of archaeological data with methods developed over many years of experimentation in computer applications in archaeology, including the use of a GIS and other related technologies as well as multimedia applications for the purpose of data diffusion and conservation.

A Belgian team, under the direction of Jean Bourgeois, demonstrates that computerisation of archaeological archives offers interesting perspectives for heritage management and scientific research. An extraordinary GIS-based archive of oblique aerial photographs assembled at Ghent University is the core for the design of a systematic inventory for Flanders. This database will not only make possible an effective management and protection of the archaeological heritage of Northern Belgium, but it goes without saying that such an archive – once more spatial analyses will be included – is also of great scientific value for the charting of "evaluation maps", for the conduct of regional studies, and for the design of distribution patterns and models.

In a Belgo-Cretan research project, presented in Liège by A. Sarris, a whole range of typical GIS-applications in spatial analysis are displayed. This wide area study in full progress centres on the landscape impact of Minoan peak sanctuaries on Crete. It aims to redefine the peak sanctuary, clarify its function, and examine the relation between the cultural and natural variables, which characterize the distribution of these sites in the Cretan landscape. To accomplish these goals advanced mapping techniques (e.g. GPS), satellite remote sensing (based on SPOT), statistical analysis and regular GIS-analyses (e.g. viewsheds) were applied. As a first outcome a chronological evolution of the peak sanctuary landscape is proposed, explaining the location of the sanctuaries, in relation to each other and other site types.

Matthew Bampton focuses in his contribution on the significant problems that may occur for field mapping in archaeology, still one of the most important data gathering techniques in archaeology. He observes that over the last years global positioning systems (GPS) and electronic total stations (ETS) have become viable tools for use in archaeological field mapping. When used in conjunction GPS and ETS can generate precise, accurate, and georeferenced three-dimensional digital data sets in real time. As survey work proceeds associated attribute tables, incorporating field measurements and commentary can also be created, and the entire data set can be imported directly into GIS. That this technique of precision digital mapping can produce accurate, high density data sets of unprecedented richness, will no doubt be of immense value to the quality of future archaeological analysis.

An application of novel technologies of a very different kind is finally presented by Jeffrey Altschul, who represents one of the very productive CRM firms that typify the archaeological field in the United States. In his paper he draws on case studies from the American Southwest to show how archaeologists have used the Internet and CD-ROM technology to address the typical challenges of modern CRM work. Two major innovative approaches are discussed here. First there is the elaboration of a web-based system developed for a large excavation project designed to keep all concerned abreast of the status of fieldwork and analyses. Secondly, the use of CD-ROM technology (including video) to disseminate project materials and reports in a cost-effective manner and partly for a non professional audience, is evaluated.

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A GIS-BASED ARCHAEOLOGICAL DECISION-SUPPORT MODEL FOR CULTURAL RESOURCE MANAGEMENT

1. Introduction

The goal of this project is to develop a set of simple processes that can be widely used to build basic models of site location using data-types that are becoming more widely available. There are two main issues in this paper: technical aspects related to data, GIS, and analysis; and theoretical issues related to model application.

This modeling exercise is a pilot study to establish a set of basic methods for acquiring, processing, analyzing, and modeling archaeological and earth science data using readily available sources of information and popular computer software. The exercise was designed specifically to use data available for Illinois, but perhaps there will be some information useful to other modeling efforts. There are many cautions to observe throughout the process and most of the problems have not been solved. The basic processes, however, have been established and might prove useful or encouraging to others.

The basic modeling notion used here is the one of time-honored simplicity relating archaeological site locations to topography and proximity to water. There are many more sophisticated concerns widely recognized today about modeling parameters (e.g., Ebert 2000; Gaffney, van Leusen 1995; Harris, Lock 1995; Verhagen *et al.* 1995), but this simple modeling expedient proves useful for developing the methods and techniques needed to assemble and process data. GIS applications and predictive modeling are no longer rare; various methods and theories have been evaluated and used with some success (e.g., Kamermans, Wansleeben 1999; Stanèiè, Kvamme 1999; Stanèiè *et al.* 2001; Wescott, Brandon 2000; Verhagen, Berger 2001; Vermeulen *et al.* 2001) and need not be elaborated here. Theoretical and data-centric issues relevant to the present model can be addressed in the future, during the process of refining the model.

Du Page County, in northeastern Illinois, was selected for its suitability in this pilot study. The natural setting is relatively uniform across the county and it has had many modern archaeological surveys done within its boundaries. The county falls entirely within a single biotic region called the Morainal Section of the Northeastern Morainal division (Schwegman 1973), meaning that the environmental background is relatively consistent throughout its area. This region is covered with deep glacial drift from the Wisconsinan glacial stage. The topography is hilly rolling terrain dominated by moraines and morainic systems. Prehistoric plant communities included oak forests and prairies with some fens, marshes, sedge meadows, and bogs (Schwegman 1973, 11-13).

The following presents first the technical aspects related to data, GIS, analysis, and modeling and second visits some of the problems that remain to be worked out and some consideration of relevant theoretical issues.

2. Technical overview

There were five basic steps in handling the data: 1) assembling the data; 2) processing it; 3) analyzing it; 4) extracting the results; and 5) modeling it. The present project is still a work in progress at the fourth step. The following outlines these processes.

2.1 *The data*

There are readily available GIS data sets for Illinois that are useful for archaeological modeling. For this basic model, the useful data sets are watercourses, archaeological sites, archaeological survey areas, and digital elevation models (DEMs).

The watercourse data were downloaded from the Illinois State Geological Survey (ISGS) web site maintained in Champaign, Illinois. The water features are modern rather than ancient, a fact that must be considered before interpreting the locations of sites in relation to the recorded water bodies. Also available from the ISGS are political boundaries for Du Page County.

The archaeological data were made available through the Illinois State Museum. Spatially, they represent archaeological sites and areas of archaeological survey. The sites are recorded as polygons, not just centroids, so site size and shape are represented. Also recorded for sites are the archaeological time period(s), the date the site was first recorded, subsequent revisits, the nature of disturbances to the site area, how the site area was being used when surveyed, the land owner, and other information. The archaeological survey areas are also recorded as polygons, but have little other data associated with them in the GIS data. The individual surveys are on record with the Illinois Historic Preservation Agency and formal reports are available that detail all the pertinent information about the survey and the findings.

The DEMs were downloaded from a web site maintained by The GeoCommunity. Individual DEM files represent topographic elevation points in a 30 m grid extending across the area of a 7.5’ USGS quadrangle map. Such maps cover about 55 square miles (ca. 140 km^2). The 30 m grid of elevations is fine enough to be well-suited to modeling the terrain of archaeological site, each of which is usually large enough to include at least one or two elevation points within its boundaries.

2.2 *Assembling the data*

Even though the data are available in GIS format, there were various processes necessary to make them compatible with one another and to make them accessible to ArcView, the GIS application used. The archaeological data are maintained in dBase III format designed for GIS use. They can be loaded into ArcView without preprocessing. The hydrological and political data are maintained and offered in standard ArcINFO (.e00) format, so they must be processed using ArcView's Import71 facility before being loaded. The SDTSEDEM program available from United States Geological Survey was used to convert the elevation data set from SDTS (Spatial Data Transfer Standard) to DEM format. Upon loading, the DEMs are automatically converted into ArcView Grids, the proprietary ESRI format. Because there were 12 individual 7.5' DEM Grids in the study area, they had to be combined with one another to form a single seamless topographic surface. A script for use within ArcView (Grid Mosaic by Yuan Ming Hsu) was used to join the twelve 7.5' quad DEM Grids. The DEMs are projected in UTM-1927, Zone 16.

The archaeological, hydrological, and political data are all projected in a custom Lambert Conformal Conic projection using the Clarke 1866 spheroid, designed specifically for use by the State of Illinois. This shared projection is convenient for displaying them together, but it does not facilitate overlaying them onto a UTM-projected DEM surface. The archaeological, political, and hydrological data were reprojected into UTM to match the DEMs.

After assembling and processing the data, there is a seamless topographic surface overlain with watercourses, archaeological sites, archaeological surveys, and political boundaries. The next step is to divide the countywide research universe into three sections (northern, central, southern) so that models defined on the basis of the results from one section can be tested against comparable data in other sections.

3. Site analysis

For analytical purposes, each site is characterized by its topography (elevation, slope, and aspect), distance to water, and whether it was inside or outside a surveyed area. These few simple variables are useful in this pilot study. More refined future analyses could take into account soils and ancient vegetation, but in this exercise, these site variables are at least minimally adequate.

3.1 *Site topography*

The sites are represented in the GIS as polygons, not points, so any site larger than about 90 square meters will have more than one elevation point to represent its topography. Each DEM grid point (spaced every 30 m) within a site's area contributes a single elevation value to the overall description of the site's topography. These elevation values are used to report a site's elevation, and also to derive their slopes and aspects. The procedures used to create slope and aspect surfaces are available as ArcView menu facilities. The values for each site's elevation, slope, and aspect can be derived statistically and summarized by the GIS in a table that includes their minimum, maximum, mean, standard deviation, and so forth.

Using elevation, for example, if one site's area is nearly level, it will have a relatively narrow range of elevations; if another site is on relatively uneven ground, then it will have a greater range of elevations values. Likewise, the variability of each site's slope and aspect can be reported in comparable statistics. A summary of each site's elevation, slope, and aspect can be saved for export to a database management system or statistical packages.

3.2 *Sites and surveyed areas*

Sites are also characterized by their location either within or outside of a surveyed area. Surveyed areas are especially important because, within their limits, they let us know not only where sites are but also where sites are not. Surveyed areas will eventually be subjected to special spatial analyses to examine not only the characteristics of site locations but also the characteristics of non-site locations. Theoretically and statistically, such negative information is useful for modeling where sites are likely to be found (Warren 1990a, 1990b; Warren, Asch 2000). Sites within surveyed areas were separated from sites outside surveyed areas and each set was saved in its own GIS layer.

3.3 *Distance to water*

Two sets of sites went into this analysis: one set of sites within surveyed areas and another outside surveyed areas. Each set was treated to the same measuring procedures. Basically, sites were categorized according to their distance to water. This was done by creating ten 200 m buffers around the water courses represented in the hydrology layer. Sites that fell within each buffer were grouped together.

There were two obvious choices for how to measure a site's proximity to water: the distance from water to the nearest edge of the site or the distance from water to the center of the site. Neither is a perfect measure of proximity. To illustrate, the nearest edge of a large site may be closer to water than the nearest edge of a small site even though most of the large site is much farther from water than any part of the small site. Also, some sites were large enough or situated so that they fell partly in two 200 m buffers, although most sites fell comfortably within a single buffer. Which point to measure from? To simplify these issues, each site was assigned to the buffer that contained the site's centroid. In this way, the site polygons were not used in measuring their distance to water.

There are alternatives for handling these issues. In some future analysis, the actual distance from each site centroid to the nearest stream could be measured, rather than assigning sites to buffers. Likewise, in a future analysis, the total areas of sites could be factored into the measure of proximity. For example, the range of distances could be used to represent a site's proximity to water. However, in this analysis, the assignment of sites to categories based on 200 m buffers is sufficient. For each of the three county sections (north, central, south), the result of these analyses consisted of two export files for each buffer; one file for sites within surveyed areas and one file for sites outside surveyed areas.

4. Export to database

All the various tables and site summaries were then exported to a database management system for compilation. This is the present stage of progress in the modeling procedure. In this context, the data produced by the GIS will be augmented by data from the statewide archaeological site file, such as archaeological periods, the name of the surveyor, and the dates of survey. Additional variables, such as soil types, could be added to the database if useful.

The database application is used to relate all the collected values and to assemble one or more datasets for mathematical modeling in a statistical package. The goal is to produce data sets suited to focused analyses. One approach might be to extract sites of one time period for modeling. The model of Archaic hunter-gatherer land use should be somewhat different than that of Late Prehistoric agriculturists. The difference between these models should be instructive. Another approach might be to extract all the sites to simply model where sites have been discovered, the assumption being that in the future sites will be discovered in similar situations. Different modeling goals require different theoretical assumptions and different data sets to be extracted from the database.

5. Modeling

No modeling has yet been done. There are issues to be resolved before the data will merit an effort to model mathematically. However, the plan is to use SAS or a comparable statistical package to apply logistic regression analysis to the site variables (DeMaris 1992; Stokes *et al*. 1995; Warren, Asch 2000, 8-9). The ability to incorporate ratio, interval, and categorical data into a single model is especially useful considering the different types of variables discussed above.

Using the Du Page County data, a preliminary model could be generated using one section, for example the Central Section, of the county. This model could then be tested on the data from the other two sections to examine its predictive strength. This procedure could be replicated using one of the other sections first and testing with the remaining two sections. In this way the characteristics of the modeling process and the quality of the data could be examined in a sampling universe that holds the natural setting as constant as possible using real world data.

The single-county example outlined above was designed to hold the natural setting constant to highlight patterns among the other variables, but in a larger context, such as a whole river drainage, there may be several types of natural setting included. Different natural regions may require separate models depending on the goals of the modeling effort.

6. Unresolved issues

There are several issues that will require more attention as work on the model proceeds. Each of the data sets – archaeological, hydrological, and topographical – will require scrutiny. Much of this effort will be in the form of applying our theoretical and substantive knowledge of the archaeology of Illinois to use the data in ways that minimize its misuse in analysis or its misinterpretation in results.

There must be some attempt to control several dimensions in the archaeological data. For example, many of the sites recorded are the legacy of several decades of archaeological work in Illinois. Site survey and reporting standards have changed during that time, so the year or decade that the site was reported may have a bearing on the completeness of its data. Another example, the criteria for the assignment of archaeological period(s) to sites is not always clear, especially for sites reported long ago. Again, the method for estimating site size or the locations of site boundaries is not explicit for most sites. However, the surveyors names are recorded for the sites and some way may be found to account for different methods of boundary estimation. Nevertheless, in recent decades, there has been much archaeological investigation done, and many sites reported, by professionals. This information will form the core of interpretive data. Moreover, most of these sites were found within surveyed areas so their interpretive power is especially robust.

The reconstruction of the ancient hydrology must be attempted in order to represent the ancient landscape more authentically. Historical maps of watercourses should be incorporated into the GIS layers before measuring, or categorizing, site distances to water. There are many waterways in the hydrology GIS layers that are the result of the modern canalizing of natural streams. These need to be replaced in their ancient locations to adequately represent their relationships to ancient sites. In a similar vein, pre-Euro-American settlement vegetation may be a useful variable to add to the GIS in layers derived from historical maps.

Ground truthing the digital elevation data is advisable. This may include using a portable GPS unit to check relative and absolute elevations within site boundaries for a selected set of sites. This form of back-checking will help to clarify the accuracy of the DEMs and the interpretive power they have in the modeling process. In a similar vein, some modern landscapes are dramatically different than their ancient counterparts. It will be important not to include modern quarries or landfills in the topographic algorithms that will characterize site localities.

The edge-effect must also be dealt with in some way. This problem will arise for sites near the county border that are near water courses outside the county limits. Likewise for sites that span the county border. This issue should be relatively straight forward to deal with in a GIS environment with abundant data. The likely solution is that the hydrology and DEM layers can be enlarged beyond the county's political borders.

7. The goals of site location models

This progress report on a set of relatively simple modeling procedures is offered as an example of how simple steps can be used to address modeling needs and to point out some obviously problematic issues that must be addressed. In addition to the issues specified above, the matter of goals is especially important theoretically. There are at least three basic goals for modeling site location: 1) site-prospection; 2) anthropological understanding of ancient lifeways; or 3) decision-support for cultural resource managers. Site prospection is simply the goal of predicting where the next important site will be found. An anthropological understanding of ancient lifeways is a laudable goal but one that is troubled with the uncertainty of cultural misunderstanding and the lack of many types of information in the archaeological record. The goal of decision-support, however, seems to be at least modestly attainable. Decision-support modeling is not totally independent of the other two types of goals, but it is narrowly focused and can be usefully applied even in situations where the other two goals are not attainable.

The goal of decision-support modeling is to help planners incorporate archaeology into their schedule and budget in ways that are reasonable considering the probable amount of archaeology that can be expected in a specific project area. While it is necessary to clean the archaeological data and to reconstruct the ancient landscape as well as possible, it is not necessary to thoroughly model ancient cultural lifeways in order to make a reasonable prediction of how much archaeology (rather than what kind of archaeology) can be expected in a specific region. In this way, the data that we do have, which is the admittedly-limited result of archaeological discovery, is appropriate to use to make probabilistic estimates of how much archaeology remains to be discovered in well-known landscape situations.

Some critics might say that predictive modeling is not a legitimate research avenue because models could be misused to limit field research. It is important to emphasize in this discussion of modeling goals, that archaeological site location modeling should never be used to define areas where further archaeological work need not be done. The way to find those places is to do appropriate field and lab work. In short, decision-support modeling is not a substitute for field work as a way to discount some areas as unworthy of further work. It is a way to plan for the deployment of limited time and resources in a reasonably well-informed way in service to heritage conservation.

It seems unlikely that in the near future computer models will be able to more accurately predict the location of the next important site or to substantially improve our anthropological understanding of past lifeways. But they might be able to help us make important decisions about how to plan for the management of our cultural resources.

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ABSTRACT

Cultural resource management (CRM) work in the United States has recently produced vast amounts of data that are now being assembled in large databases. Thus, the potential has grown for useful site location models in support of heritage conservation. As geographic information systems (GIS) have become more powerful, they have become more useful to archaeologists. The realm of archaeological predictive modeling has grown to include at least three types of models that focus either on site-prospection, on understanding ancient lifeways, or on decision-support for cultural resource managers. Decision-support modeling seems to have the greatest near-term potential as a useful modeling tool. However, there are also significant methodological and theoretical issues yet to be resolved before such tools can be widely used. An example of an archaeological site location model currently in development illustrates the potential of decision-support modeling. Some of the problems inherent in site-prospection and ancient-behavior analysis can be avoided in models designed as decision-support tools.