A GIS Driven Regional Database of Archaeological Resources for Research and CRM in Casco Bay, Maine

Matthew Bampton and Rosemary Mosher

Geography-Anthropology, University of Southern Maine

Gorham, ME, USA

e-mail: bampton@usm.maine.edu

Abstract

The needs of research and cultural resource management (CRM) are frequently at odds with one another. In the first case maximum accuracy of all records and open access to complete data sets is essential. In the second case differential access to data for the general public and resource managers is a regrettable necessity for protecting archaeological resources. The potential offered to researchers and resource managers by the availability of cheap, powerful, and portable computers and GPS units is offset by the potential for abuses of these same tools to exploit archaeological sites for personal gain. The legal and moral issues raised for a free society by this dilemma are not amenable to a technical fix. However, careful design of a GIS database offers an interim solution to the problem by simultaneously providing accurate information to the research and management community, while rendering sensitive information in a protected form for the broader audience.

Key words: GPS, GIS, database, accuracy, security

1. Introduction

For the past six years the GIS Laboratory at the University of Southern Maine has been exploring the potential of GIS as a tool for archaeological research and cultural resource management (CRM) by developing a case-study data base of the Casco Bay area on the coast of Maine, USA. In previous work some of the parameters within which this work has been done, and some of the difficulties faced, have been outlined (Bampton and Hamilton 1996, 1997). Rapid developments in the technology, an exponential increase in the amount of data available, and a significant increase in the number of actual and potential users have all contributed to a significant development in the approach used in the Casco Bay GIS.

Further developments have been prompted by the growing number of models for multi-purpose GIS data sets presented by workers in other areas of the world. Of particular note is the model of integrated archaeological and geographical data linking field and archival materials currently used in Sweden by the State Archaeology Group (Riksantikvarieämbetet Avd för Arkeologiska Underskökningar). In the USA discussion of the problems and potentials of archaeological GIS is now becoming more common (e.g. Allen et al. 1990, Harris and Lock 1995, Esser and Shaw 1997). In this paper we discuss some the evolving needs of the constituencies using the Casco Bay GIS and some of ways in which we have tried to address these needs.

2. Problem statement

To be useful an archaeological data set must meet two necessarily contradictory conditions: It must precisely record the location, extent, and contents of sites for a professional audience, and; simultaneously preserve the integrity of sites by concealing their location, extent, and contents from a broader public audience. Astride this contradiction sit cultural resource managers, charged with serving both the scientific community and the public (for examples see Lynott and Wylie 1995, Speiss 1978, 1994).

The increasing use of GIS, GPS and total stations by archaeologists in the past ten years has brought this problem to the fore. What was previously a pipe dream is now becoming a reality: Sub-meter accuracy GIS data-bases incorporating all available digital environmental data, and all archaeological field data within a single data structure. Websites such as that at the University of Rhode Island now offer many of these data as downloadable GIS coverages — though with some restrictions placed on archaeological site location data (URI 2000). As these technologies become more widely applied there is growing discussion of the role of GIS in both research and CRM (e.g. Hurlbert 2000).

From the perspective of scientific analysis this means that scholars can now combine the results of field work with a broad range of environmental data sets generated by workers in other fields. Regional scale analyses of patterns in space and time can be developed, as can speculative models of past habitats, combining such factors as sea level change, soils, vegetation coverage, aerial photography, remotely sensed imagery, and cartographic records.

From the perspective of cultural resource management (CRM) an accurate accounting of archaeological resources can be combined with a cartographic representation of threats to the record in the form of environmental changes such as erosion, and human social changes, such as development. When combined, the scientific and the CRM GIS data sets can be used strategically, to identify resources that are of particular value or are unusually vulnerable, and can provide supporting information to decision-makers, who must decide what and when to preserve, excavate, or even sacrifice.

There are two groups of challenges confronting anyone attempting to produce a GIS data base that serves both research and CRM functions. The first group of challenges are technical, centring on the unique data demands placed on a GIS by both research and CRM users. The second group of challenges are operational and centre on the precision and accessibility of the GIS.

3. Technical challenges

Archaeologists - and most other field scientists - have long recognized the importance of gathering spatial data sets, and have proven themselves capable surveyors using standard tools such as optical instruments and topographic maps. And like most field scientists they allow a fairly generous error factor in their surveys, historically tending to ignore such arcane issues as projections, reference surfaces, datums and changing magnetic declinations.

In respect to this tendency GIS has proven to be rather unforgiving. If the GIS is simply used as a cartographic device slight failures of registration, location, orientation, or projection can be “fudged” by juggling colours, line widths, symbols, and as a last resort, by using correction fluid or a pair of scissors and a bottle of glue. However, when the data are intended for use in any analytical application minor survey issues can have disastrous consequences. Incorrectly specified projections and datums do not simply create skewed images, in some of the most widely employed GIS packages they can quite literally collapse the data structure.

Imported database files used to generate point coverages can also create problems. A convention used by some researchers to enter latitude and longitude values of 0°0’0" by 0°0’0" for site locations they have not yet calculated resulted in the sudden appearance of several dozen prehistoric Native American middens 425 km due south of Accra, Ghana. Accidental transposition of values for Casco Bay — actually about 43°40' by 70°10' - placed a cluster of sites in central Greenland, 500 km northwest of Godhaven (we have assumed that these database entries were errors, though it is possible that some particularly diligent field crews have discovered hitherto undreamed of cultural links).

While the spectacular anomalies are fairly easy to spot, the more subtle ones present greater problems. In Maine all nautical charts are referenced to North American Datum 83 (NAD83), all topographic sheets are registered to NAD 27, most hand-held GPS units default to World GPS Datum 1984. The three datums produce results that have, on average, a difference of between 200 and 2000 m in our study area.

Serious analytical problems can result from these types of survey or mapping errors. A simple procedure such as generating a point in polygon overlay - a response to a query such as “how many archaeological sites are located on sandy soils”- can be rendered meaningless by any of the issues outlined above, or by the locational inaccuracies resulting from the size of the dots drawn with a .05 mm mechanical pencil on a 1:25,000 map (the standard 7.5" USGS topographic sheet).

When a diversity of other data sets are combined with the archaeological field data the problem of deficient survey work is exacerbated by errors and inconsistencies in these source materials, whether digital or in some other form.

Data cleaning, and the resolution of issues of projection, registration, and scale have all proven to be as important as data gathering in constructing the GIS. Once the archaeological data are cleaned the question of registration with other data sets must be addressed. Much of the time sacrifices of precision and accuracy are made in order to preserve compatibility with the growing number of publically available environmental data sets. Finally, even when data are cleaned and corrected they can frequently prove problematic, as both graphical and database conventions that appear correct to field workers not familiar with GIS can be unsuitable for application in many standard GIS packages. Spreadsheet fields with long narrative entries are essentially unsearchable in many applications.

4. Operational challenges

The Casco Bay GIS is designed to serve two constituencies. On one level it functions as a secure repository of technical information, and on another level it serves as an open-access public resource. Presenting the professional community with accurate site maps, and precise site locations has become fairly straightforward if survey-quality GPS and total station equipment is used. Once the data are acquired, it is simply a question of presenting them in a PhD-proof software package, such as ArcView. Security can be ensured by combining good data management practices with fairly exclusive system password privileges, the internal data hiding capabilities of the software, and the storage of data on a removable medium, such as a CDROM.

The public access component of the system presents greater problems. Although at some future date some information concerning selected sites may be made available to the general public as an educational service, at present both legal and practical concerns prevent this application from being explored in any detail (Arthur Speiss, pers. comm. 1992-2000).

At present the primary public access application is site preservation, and is designed to serve the planning community. To preserve sites from vandalism and looting, and in some cases to preserve human remains, precise locations must be kept secret — this is becoming increasingly important as the advent of cheap hand-held GPS units has made it very easy for the curious or malicious person to get to within 30 m of any point for which latitude and longitude values are available. However to preserve sites from destruction during construction activities it is necessary to make property owners, town planners, and building inspectors aware of site locations. This becomes particularly important in such as Casco Bay where sites can, at times, occur every 300 m along a shoreline.

It is fairly easy to use a graphical device such as a disproportionately large symbol to conceal site locations. However all point data are still stored in the accompanying data base by their exact latitude and longitude location. Rudimentary system skills will enable an unauthorized user to find the location of any point. It is possible to automatically generate buffer zones around known sites and so conceal precise locations within a large polygon, and then remove the point data from the public access component of the data set. However the system centres buffers on point locations, so if you find the middle of the circle, you can find the point location of the site.

To present planners, and the general public with a data set that will alert them to the proximity of a site if, and only if, they are working in its immediate neighbourhood, it is necessary to map all known sites but to present them nested inside randomly shaped buffer zones. These zones must be small enough to prevent extended areas from being unnecessarily blanketed with historical preservation orders, and yet large enough to encapsulate sensitive places. They must be discernable only when the user requests information on a single location. And they must be physically separated from the original point data from which they were generated.

The site locations were randomised by imposing a regular grid over the entire region. Cell size was half of the desired protection radius. That is, a 50 m cell size was used if a 100 m protection radius was required. The grid was then reclassified as a binary coverage site/no site. All cells not containing sites were discarded, and all of the original point locations were discarded. The cells were then buffered to the desired protection radius, and the cells discarded. Finally all parts of the buffer falling on ocean were discarded. Thus the final polygons were irregularly- shaped, and surrounded a point falling somewhere unspecified no less than the desired protection radius from the boundary but no more than 1″ times the desired protection radius from the boundary.

In Casco Bay it was decided to identify two classes of sites, “small” and “large” — more complex archaeological classification schemas proved to be beyond the powers of the GIS lab team. Small sites were protected with a 200 m buffer, large sites were protected with a 500m buffer. Sites having particular archaeological value, as defined by the Maine Historical Preservation Office (MHPC), were identified as “Protected”, sites with either unknown value, or limited value were defined as “Maybe Protected”, all other areas were defined as “Unprotected”.

The whole coverage was coloured in a single shade, with no visible differentiation between these three classes of protection. A coverage depicting roads was added to allow users to orient themselves. The whole project was presented in a heavily customized ArcView desktop. Users were not granted access to database files, printing capabilities, customizing tools, and zoom capabilities were severely limited.

A user activates the cursor, and defines an area of interest - perhaps drawing in the four corners of a lot that he or she wishes to build on. An information screen appears stating that the area falls into one of the three classes defined: “Protected”, “Maybe Protected” or “Unprotected”. In either of the first two cases the user is alerted to the fact that they must contact an MHPC officer before proceeding with any development activities.

5. Conclusions

Creating secure data structures for archaeological data sets is a necessary evil. The increasing sophistication and the decreasing cost of powerful computing and navigational tools mean that the general public are more likely than ever to be able to find, record, and return to sensitive archaeological sites. As the pressures of development remain as strong as ever, the net result is an increasing pressure on a diminishing resource. We believe that appropriate use of GIS technology can, in some measure, mitigate the negative effects of these trends by providing a powerful tool for planners that may help to preserve archaeological resources by aiding planners and preservation officers to co-ordinate their efforts to protect archaeological sites. And while the diminishing costs and increasing power of computers and GPS units may pose a threat, they also present an opportunity. Well-designed databases can serve to provide researchers with a new set of analytical tools. The research potential of such complex multi-dimensional data is only now starting to be explored.

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