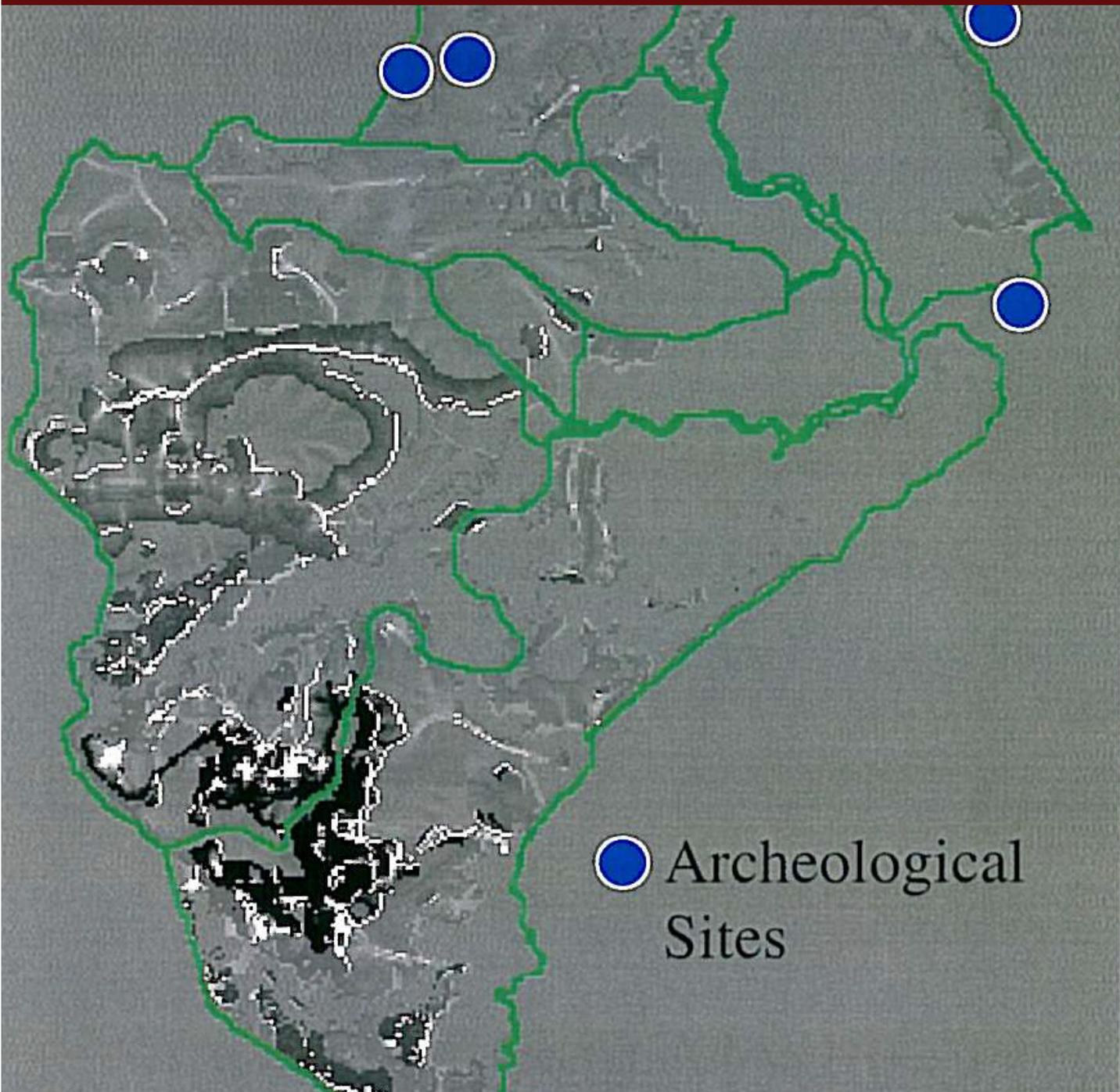




A Review of Recent Advances in GIS Applications for Archaeology | 1998-38

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Executive Summary

Over 400 sources of information on GIS applications in archaeology have either been published or have been presented at conferences. The objective of "A Review of Recent Advances in GIS Applications for Archaeology" is to provide a comprehensive overview of these data sources and review the current status of the use of GIS technology to preserve and protect archaeological resources.

The article provides some basic introductory material on GIS and the role of spatial analysis in archaeology. A chronological overview of publications on the use of GIS in archaeology indicates some progress in expanding the GIS user community among archaeologists; there are fewer broad overviews and an increase in the consideration of method and theory. Typical GIS applications in archaeology are presented along with a subset of references providing examples of these applications. The data are also broken down by publication trends to show how and where they are being disseminated. Most of the data, slightly more than 50%, is available in books, CDs, or proceedings from conferences on GIS and archaeology/anthropology or computers/quantitative methods and archaeology. The article closes with examples and suggestions for how GIS technology is being and can be used for historic preservation purposes.

A REVIEW OF RECENT ADVANCES IN GIS APPLICATIONS FOR ARCHAEOLOGY

by
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The objective of this article is to provide a comprehensive overview of existing literature on geographic information system (GIS) applications in archaeology and review the current status of the use of GIS technology to preserve and protect archaeological resources.

General Introduction to GIS and Archaeology

GIS

A GIS is a sophisticated computer-based tool that can be used to store, manipulate, analyze, and display spatially referenced data. A GIS is primarily a data management system that brings together a relational database and mapping capabilities. It allows the user to manipulate a large amount of locational data and determine relationships from that data. Typical data sources include maps, remotely sensed imagery, and aerial photography.

The spatial data are stored as a series of layers in the GIS in vector or raster format. Vector data consist of points, lines, and areas and are most applicable to cartographic projects. Examples of vector data include locations of monitoring wells (points), roads (lines), and water bodies (polygons). Raster data are in the form of a grid in which the smallest unit represented is a cell. These data tend to be most applicable to projects concerned with continuous surfaces and fuzzy boundaries (e.g., soil types).

Each data layer in the GIS represents a specific category of spatial information. Specific items within each layer are connected to a database containing attribute information that describes pertinent data about each item. At a minimum, the attributes include an item identifier and a location, but they can also include any other tabular information. For example, attributes of a road might include a unique identifier, name, type, length, width, number of lanes, and number of interchanges. If large amounts of data are associated with a particular item or if real-time data are needed, external databases may also be linked to the internal GIS database through the unique item identifier.

The data within the GIS can be manipulated to change the display scale, remove distortion, rotate the image, generate new data layers, and create composite maps. For example, elevation data typically available as digital elevation model (DEM) data can be used to generate GIS data layers for slope and aspect. Analytical capabilities typically include the ability to look at routing alternatives, create buffer areas for a user-defined distance, and link data to external models. Some statistical analyses can also be completed. Ultimately, the GIS allows the display of original and derived spatial data and can produce hard copy maps, database query tables, and statistical summaries.

Spatial Aspects of Archaeology

Archaeologists rely heavily on spatial data because of the nature of their discipline, which, when put in the simplest of terms, is to **locate** the material remains of past human activities. Once archaeological resources are located, they can be studied from different theoretical perspectives and analyzed by using various research methods to elucidate an understanding of past human behavior. The following examples represent only a few of the various levels and complexities with which archaeological research can be approached from a spatial perspective. The resources might be analyzed at the site level (intrasite analysis) to discover as much as possible about a particular location, or at a broader (local, regional, or global) level to look at how a number of sites are distributed (intersite analysis). Resources might be analyzed as part of a larger system that includes not only their specific locations but also the natural features that surround them, as well as the cultural landscape, which may link a number of archaeological resources together. A particular resource may be the focus. For example, the presence of exotic chert at a site might indicate long-distance travel or trade, the route of which could be speculated on by identifying possible locations of the chert source. All of these research activities have a fundamental spatial component, and a GIS could be used to help with the analyses.

Concomitant with providing these research opportunities, archaeological resources, once identified, can be used for educational purposes, to teach the public about the past. They also can be evaluated for significance and preserved and protected for future generations. GIS has the potential to permeate many of these aspects of archaeology as well, especially within a cultural resources management context.

Overview of Existing Literature

Published literature on the use of GIS for archaeological applications has been growing steadily since the 1980s. Most information is provided in books, conference proceedings, newsletters, government reports, or a mixture of archaeological and nonarchaeological journals. The material is widely scattered, most likely because of the wide applicability of GIS to archaeological research. Recently (since 1995), several books on the topic have been released. These are predominantly edited volumes that compile the papers presented at a variety of conferences (Lock and Stancic 1995; Aldenderfer and Maschner 1996; Maschner 1996; Wescott and Brandon, in press). An edited compilation of conference papers was also released in 1997 on a compact disk (CD) (Johnson and North 1997). An annotated bibliography pertaining to GIS and archaeology was published in 1995 (Petrie et al. 1995).

Articles on the subject first began to appear regularly in the late 1980s when GIS started taking hold as more than just computer-aided mapping. Kenneth Kvamme seemed to dominate the publication list for this time period, especially with regard to one of the more popular GIS applications in archaeology -- the predictive modeling of archaeological site distributions (Kvamme 1983, 1986a, 1986b, 1988, 1989; Kvamme and Kohler 1988). Precursors would include articles on computer simulation studies in the late 1970s (e.g., Hodder 1978).

Government publications were fairly prevalent during the late 1980s as well. In 1986, the U.S. Bureau of Land Management (BLM) produced a report on the potential for using GIS for cultural resource management (Calamia 1986). Another government report released in 1986 on the use of GIS for general government applications (Opitz 1986) included several articles pertaining to archaeology (Kvamme 1986b; Overstreet et al. 1986; Parker 1986). A report on GIS and predictive modeling was also published by the U.S. Forest Service in the same year (Parker et al. 1986).

During these early years and into the 1990s, publications resulting from the Computer Applications in Archaeology (CAA) Conferences in Europe provided some of the best international sources of information on the latest in computer technology and archaeology, including GIS and related topics such as remote sensing applications and database design (Lafin 1986; Ruggles and Rahtz 1988; Rahtz 1988; Rahtz and Richards 1989; Lockyear and Rahtz 1991; Lock and Moffett 1992; Andresen et al. 1993; Huggett and Ryan 1995; Wilcock and Lockyear 1995).

In 1990, the first book dedicated to the subject was published: *Interpreting Space: GIS and Archaeology*, edited by Allen, Green, and Zubrow. The book was intended to be a "basic sourcebook of GIS for archaeologists, and social scientists in related disciplines" (Allen et al. 1990:ix). It appears to serve that function well when one considers the frequency with which it is cited by authors who also have found an interest in integrating GIS technology and archaeology.

The following year, the only book published to date on GIS and archaeology that is not an edited volume was released: *GIS Approaches to Regional Analysis: A Case Study from the Island of Hvar*, by Gaffney and Stancic (1991). It provides an excellent overview of GIS concepts and focuses on using GIS for a series of specific regional analyses conducted on the Island of Hvar off the Dalmatian Coast of Croatia.

Publications during the early 1990s placed considerable attention on general overviews of GIS technology, including potential applications (see next section for examples), hardware and software (Zubrow and Green 1990; Madry 1990; Roorda and Wiemer 1992), and a variety of technical issues concerning data management (Arroyo-Bishop 1991; Lock and Harris 1992), graphical display (Fletcher and Spicer 1992), and statistical algorithms (Kvamme 1993). Much of the literature on cultural resources management and environmental planning using GIS was published in the early 1990s as well (see next section).

The latter half of the 1990s has focused more on specific GIS applications than on the broader overviews. Overviews on GIS and archaeology during this time period have been geared more toward theoretical or methodological considerations (e.g., Church et al., in press; Gaffney et al. 1996). The trends in applications mirror those discussed in the early 1990s (no new categories of GIS analysis have emerged that had not already been identified).

Typical GIS Applications in Archaeology

The importance of the spatial dimension in archaeology should be indicative of the potential importance of GIS technology in archaeology. However, the use of GIS has not become commonplace for a variety of reasons -- cost, commitment, and digital data

availability, to name a few. Regardless, significant strides in archaeological research, cultural resource management, and general environmental planning have been accomplished as a result of using this spatial analysis tool. The following discussion summarizes some of the ways in which GIS can and does contribute to the field of archaeology.

Modeling

The use of GIS for modeling purposes is one of the most popular applications in archaeological research. (The use of GIS for data management and display is also popular.) In general, two types of modeling prevail in archaeology: predictive modeling of archaeological sites and terrain modeling of various environmental features for landscape-scale analyses.

The archaeological literature on predictive modeling has advanced more or less in parallel with that on GIS. Much of the literature focusing on quantitative predictive models for archaeology was published in the mid- to late-1980s (Kohler and Parker 1986; Kvamme 1983; see also Carr 1985; Judge and Sebastian 1988). As GIS technology began to take hold, many of the researchers interested in predictive modeling began to investigate the potential of GIS for their applications (Carmichael 1990; Dalla Bona 1991, 1993, 1994; Kvamme 1989, 1990a, 1992; Kvamme and Kohler 1988; Warren 1990a, b). In 1996, a symposium was held at the Society for American Archaeology's annual meeting that focused on GIS applications for archaeological predictive modeling; an edited volume by Wescott and Brandon summarizing that symposium is currently in press.

The principle behind archaeological predictive models is that there are patterns in the distribution of settlements and activity locations and that these patterns are related to or influenced by environmental characteristics. Through the creation of models from known site distributions and their relationship to the environmental setting, a previously unsurveyed area could then be modeled as to where settlements are most likely to occur. Spatial distribution, pattern recognition, and environmental data management are three areas well-suited to GIS analysis; hence, there is a natural fit between GIS and archaeological predictive modeling. Because of the large number of papers that have been written on this topic, only a subset is presented here, and when two or more articles are presented in an edited volume, the entire book is cited. Examples of predictive modeling efforts in addition to those cited above are presented in Allen et al. (1990), Johnson and North (1997), Lock and Stancic (1995), and Maschner (1996). The application of expert systems and exploratory data analysis tools for settlement pattern and modeling applications has also been discussed (Johnson and Turner 1993; Williams et al. 1990).

The ability to model the terrain can be particularly important to a researcher interested in recreating a paleoenvironment. For example, one of the major criticisms of archaeological predictive modeling is that current environmental features are used to predict locations of past events (Ebert, in press). However, certain types of data (soils data, for example) can be systematically collected and analyzed to help a researcher reconstruct the past environment. A GIS is also capable of incorporating remotely sensed imagery into an analysis that can be useful for detecting patterns of environmental change. In addition, surface modeling techniques can be used to project future environmental changes on the basis of the potential occurrence of a major event, such as a 100-year or

500-year flood. Depending on the situation, managers could find these types of scenarios helpful for developing emergency plans for preserving and protecting significant sites.

Settlement Patterns (Intersite Analysis)

Not only is the recognition of patterns of site distribution a prerequisite for modeling site locations, it is itself an important topic of study. GIS has been and is being used to assist archaeologists in investigating relationships among sites as well as relationships between site distributions and the landscape. Early examples of using GIS for settlement pattern analysis can be found in studies conducted by Chadwick in the late 1970s (Chadwick 1978, 1979). The latest settlement pattern studies using GIS include those by Kvamme and Joachim (1989), Ruggles and Church (1996), Silbernagel et al. (1997), Stancic et al. (1995), and Van Leusen (1993).

Intrasite Analysis

To date, intrasite analyses using GIS have focused on spatial distributions of artifacts and activity areas within a site, including the addition of the third dimension (depth) to the analysis. Currently, GIS is not used for this type of analysis as often as it is used for landscape-scale analyses. One reason that has been postulated to account for this phenomenon is that higher costs are associated with excavation than with survey (Biswell et al. 1995). Other examples in the literature that discuss intrasite analyses include papers by Hinshelwood and Dalla Bona (1994), Dalla Bona (1995), Meffert (1995), and Sanz et al. (1995).

Site Catchments, Cost Surfaces, and Viewsheds

Analyses of site catchments, cost surfaces, and viewsheds are types of analyses that are well-suited to GIS technology. The purpose of catchment analysis is to relate an archaeological site to the surrounding landscape and define its "limits of influence" or its "economic range" (Hunt 1992). In cost surface analyses, the areas in and around a site are defined in terms of the cost (in time, energy, and/or risk) involved in using them. Viewshed analyses address lines of site from particular locations to help explain why some sites are located where they are. For example, Krist and Brown (1995) used viewshed analysis along caribou migration routes to show that sites were located in suitable areas for hunting. Most articles pertaining to these topics were written during the early 1990s (Gaffney and Stancic 1991; Gaffney et al. 1993; Hunt 1992; Limp 1990, 1991; Ruggles et al. 1993). Other more recent studies include those by Wheatley (1995, 1996), Ozawa et al. (1995), and Lake et al. (1998).

Archaeological Data Management

A great deal of the literature discusses the most basic contribution GIS can make to archaeology: data management. Archaeological investigations, both at the survey and excavation levels, generate tremendous amounts of data. Much of these data are spatial in nature. GIS offers the archaeologist a versatile tool for organizing, maintaining, analyzing, and displaying that data. There are many examples of publications that have covered this topic (40+), but only a few are cited here: Blasco Bosqued et al. (1996), Harris (1986), Malcolm-Lim (1995), and Wescott (1996). One weakness of GIS that has

been noted is the difficulty of incorporating the temporal dimension with the data (Arroyo-Bishop and Lantada Zarzosa 1995; Castleford 1992).

Cultural Resources Management and Environmental Planning

The application of GIS for cultural resources management (CRM) incorporates everything discussed so far. However, the real world elements of time and money factor in at a much higher level in the CRM arena than in a research context. The person paying the bill is interested only in meeting the minimum compliance requirements quickly and at minimum cost. A bulldozer is typically at the heels of the archaeologist conducting the survey. GIS in this context is being used to try and educate developers, planners, and managers about the importance of survey strategy and early planning to avoid emergency compliance situations. However, the data management benefits of GIS in the case of CRM are particularly useful in meeting, or at least responding to, the last-minute requests that are unfortunately so typical. Publications that illustrate how these types of CRM issues have been dealt with in the United States and abroad include Altschul (1990), Barnes (1994), Bohard (1992), Palumbo and Powlesland (1996), and Van Leusen (1995), among others. Publications that have focused on the use of GIS for CRM and site protection include Katsaradis and Tsigourakos (1993), Middleton and Winstanley (1993), Kishor et al. (1991), and Moragues and Alcaide (1996).

Publication Trends

The distribution of information on GIS and archaeology indicates some interesting trends. For this paper, I used three primary sources to ascertain these trends: an annotated bibliography (Petrie et al. 1995), an Internet search of documents and conference abstracts, and my own working knowledge of the subject matter (including discussions with colleagues and conferences attended). I discovered that more than 400 publications and conference papers have been written on this subject. In summary, more than 50% of these sources are books, CDs, or proceedings from conferences on GIS and archaeology/anthropology or computers/quantitative methods and archaeology. Only 4% of the articles are in books about other topics. This distribution is ideal for archaeologists already somewhat interested in the technology, but it is not likely to promote a wider interest from others within the discipline. Approximately 15% of the information is available in journals (about 55% in 23 different archaeological journals, and 45% in a variety of environmental and geographical journals; $n = 18$). Another 13% of the information is in monographs or university or government reports. The remainder of data are from newsletters, theses, and unpublished conference papers. The following discussion provides more details on the distribution of the data.

Books

As indicated above, the bulk of the published literature on GIS and archaeology is found in edited volumes that pull together updated and expanded versions of presentations from both archaeological and GIS-related conferences in the United States and abroad. These books also typically include a number of introductory or explanatory chapters that were not previously presented to better integrate the conference material. Until recently,

these books focused on a wide range of GIS applications in archaeology, providing a broad overview of the types of studies for which GIS can be useful. For example, the Gaffney and Stancic book (1991) focuses on a particular region but still covers a number of different applications. These books have been particularly helpful for familiarizing prospective GIS users/archaeologists with the technology. However, some specialization is starting to occur in the literature, as can be attested to by the latest book in press by Wescott and Brandon, which focuses on a particular application of GIS: predictive modeling. A number of books -- again typically edited volumes that focus on the archaeology of particular regions (Pinon Canyon: Andrefsky 1990, Aegean Area: Kardulias 1994) of particular time periods (Mesolithic in Europe: Vermeersch and Van Peer 1990), or other topics, such as mathematical archaeology (Voorrips 1990), cognitive archaeology (Renfrew and Zubrow 1994), the information age (Reilly and Rahtz 1992), and method and theory (Schiffer 1989) -- also contain an article or two on GIS.

Journals

Roughly 15% of the published literature related to GIS and archaeology is published in a wide variety of peer-reviewed journals. Among these are archaeological, geographical, and general environmental science journals. About one-third of the publications in archaeological journals are presented in *World Archaeology* (e.g., Brandt et al. 1992), *American Antiquity* (e.g., Kvamme 1990b), or *Journal of Field Archaeology* (e.g., Romano and Schoenbrun 1993). The other two-thirds are widely scattered, with no more than two articles having been presented in any one journal. Examples of other archaeological journals that have published on the subject include *Ancient Mesoamerica* (Fedick 1994), *The Public Historian* (Knoerl 1995), *Plains Anthropologist* (Kvamme 1992), *Antiquity* (Maschner and Stein 1995), and *Biblical Archaeologist* (Peterman 1992). The most popular journal overall covering GIS and archaeology is *Geo-Info Systems* (e.g., Werner and Brock 1992). Other GIS and environmental journals that have published articles on GIS applications in archaeology are *GIS World* (Bruschini 1990), *Cartographic Journal* (Collier et al. 1995), *Landscape Ecology* (Silbernagel et al. 1997), *Mapping Awareness of GIS in Europe* (Stead 1993), and the *Journal of Environmental Planning and Management* (Wager 1995). More than 20 more journals that I have not listed here also contain GIS and archaeology-related articles, but many are listed in the annotated bibliography by Petrie et al. (1995).

The variety of journals in which GIS/archaeology articles are published is most likely a consequence of many factors. I postulate that a major reason is that GIS technology can be used in so many different ways. It is not a focus of research but a tool to help investigate research problems.

Newsletters and Internet

Other sources available for finding information on GIS and archaeology include newsletters and the Internet. Many of the newsletters will just contain a brief synopsis of a project or program that is using GIS, a brief overview of GIS, or a review of a book, article, or conference, such as the Center for the Study of Architecture (CSA) Newsletter, SAA Bulletin, Anthropology Newsletter, the CRM Bulletin published by the National Park Service, or the Archaeological Computing Newsletter. In many cases, more detailed

information than that presented in the newsletters can be found in other publications. The articles presented in the Archaeological Computing Newsletter seem to be the most informative. Internet sites are becoming more popular and are helpful for seeing what types of projects are ongoing. There are also websites that link to a number of related websites that make searching easier. However, caution should be exercised by carefully evaluating the information found on the internet. These sources are not peer-reviewed and anyone can enter data on a website. The Internet is also very dynamic and websites may be added and/or deleted on a daily basis; websites may also be outdated and the date of the last update for the website should always be checked. Internet sites are also helpful for contacting researchers directly about their projects.

Conference Papers

Conference papers are one of the most popular ways to present information on the latest applications of GIS in archaeology. They are also the most difficult sources to find. Some conferences publish their proceedings, others publish only the abstracts, and many publish nothing more than a title. These conferences range from general conferences on archaeology (e.g., Society for American Archaeology [SAA] [Whitley 1996], Congress of the Union of Prehistoric and Protohistoric Sciences [UISPP] [Hansell and Ranere 1997]), the environment (e.g., Geological Society of America [GSA] [Wells et al. 1996], National Association of Environmental Professionals [NAEP] [Wescott 1996]), or GIS (e.g., GIS/LIS [Peregrine 1988], Environmental Systems Research Institute [ESRI] [Katsaradis and Tsigourakos 1993]), to specialized, regional, or internal agency conferences or meetings (such as the Transportation Research Board's annual meeting or the Army Materiel Command Lessons Learned Workshop). Proceedings are the most useful source of information for those who did not attend the presentation. Abstracts can be misleading since they tend to reflect the intentions of the author several months before the conference took place rather than the actual content of the presentation given. Titles can be ambiguous, making it difficult to tell if a presentation was truly relevant. On occasion, a buzzword like GIS may be used in a title to draw people to a presentation even though GIS was only used to create a figure of the study area.

Fortunately, many conference papers on GIS and archaeology have been published in the edited volumes identified in this article. However, many other papers need higher levels of visibility, especially considering the low percentage of articles presenting solid GIS research in the journals.

General Observations of the Author

GIS can no longer be described as new technology. Initially, because of researchers' general unfamiliarity with the technology, publications and presentations focused on what GIS is and what it could do for archaeology. Although I was extremely surprised at how much information was available, it seemed to me that in many ways, we have not moved very far very fast. The information most readily accessible seems to have stayed at that same introductory level, including this article. However, it is clear that more researchers have become familiar with the technology and are incorporating it into their research focus. If GIS is truly making any headway as a significant research tool in archaeology, the trend should be that GIS appears in increasingly diverse sources of

archaeological literature. And although it is happening slowly, at least it does appear to be, in fact, happening. Increases in the numbers of GIS-related articles in non-GIS books on archaeology and continued diversity among journals may be ways to test that GIS is progressing successfully in the archaeological community. Fewer books and symposia focusing on GIS and archaeology might also be another indicator as the research will have taken precedent over the tools that have aided the analyses.

Conclusion: Implications for the Preservation and Protection of Archaeological Resources

There are several ways GIS can be used to preserve and protect archaeological resources. First, it can be used for the effective management of archaeological data that already exist. This application incorporates the use of GIS for data management (putting all of the relevant data in one readily accessible place) and for communication through graphical display (a picture is worth a thousand words).

One way the data management capabilities of GIS could specifically affect preservation and protection efforts is by using the system to track known resources and impacts to those resources. For example, one could use a GIS to 1) look at patterns in the types and distribution of resources most heavily impacted, 2) study the location of the resources in relation to the surrounding area (are more resources being impacted in high-traffic areas? in flood zones?), 3) record the protection measures being used for each resource in a GIS database, and 4), at various points in time, assess the effectiveness of those measures and investigate changes in patterns. The results of this analysis could then easily be communicated to others who might be in a position to help preservation efforts.

Second is the use of GIS for planning purposes. When making planning decisions about a project that will ultimately impact the environment in some way (e.g., commercial development, highway extension), this use involves a host of variables other than archaeology. Upfront planning that includes the consideration of archaeological resources is the best archaeologists and preservationists can hope for. At least for U.S. federal projects, this consideration is mandated under the National Environmental Policy Act of 1969 and Section 106 of the National Historic Preservation Act of 1996, as amended. Provided that sufficient information is available, GIS can help streamline the analyses of impacts from a proposed project. Various GIS layers -- of the project area (e.g., construction footprints), survey areas, and known archaeological sites and historic structures -- can be studied simultaneously to determine if there would be any direct impacts. Indirect impacts may also be determined, but not necessarily in as straightforward a manner as direct impacts. For example, a hydrological model may be used to determine indirect impacts due to erosion and deposition of sediment. Erosion may adversely affect a site, or it may protect it by depositing additional sediment on top of it (Hoffecker 1997). Regardless, a composite map of the impact areas could be used to communicate determinations of effect or no effect to all parties involved in the federal action (e.g., the State Historic Preservation Officer) as well as the public.

Although cultural resource management is a subset of this larger environmental planning and management issue, it can be much more complex -- beyond the simple presence vs absence of "significant" resources at a future construction locale. Research

priorities and protection strategies also need to be integrated into the CRM process. Because the archaeologists typically are not the ones making the decisions that will ultimately affect cultural resources, communication becomes their only weapon. GIS is a tool that has facilitated their ability to communicate visually in terms that other people can understand.

Although there is a tremendous amount of debate regarding the utility of archaeological predictive modeling, I believe that this is another issue, related to planning and CRM, that has important implications for the preservation and protection of archaeological resources. I do not advocate modeling site locations as a replacement for thorough archaeological survey, nor do I believe that many of the other researchers who advocate modeling do either. But from a planning perspective, the generation of a model that can predict the potential of an area to contain archaeological sites is extremely helpful. If nothing else, it highlights areas that could cost more to develop, as well as areas that would involve the least amount of effort (i.e., areas that have already been adequately surveyed and do not contain significant sites). From a budgeting and scheduling perspective, this information is invaluable. From a larger-scale perspective, a series of models could help lay a framework for a CRM or research program, placing priorities in areas most likely to be affected in the future or in areas most likely to add significantly to our knowledge of the area. Models could also highlight areas where extra security or protection measures might help preserve potentially significant resources (e.g., an area with a high potential for containing archaeological resources that is located in an area subject to erosion or vandalism).

In conclusion, the value of applying GIS technology to archaeological research should be relatively clear. Initial deterrents to accepting the technology, such as high startup costs for purchasing computer hardware and software, are no longer a major issue as costs have declined significantly. The technology is much more accessible now, and data availability has significantly improved. What has not changed is the commitment in terms of time: to plan carefully how the GIS will be set up and applied and, even more importantly, maintained. The amount of time and effort required to accomplish this is still great and will remain so. Some sources of data can also still be costly, especially some remote sensing data, and training may also be needed. However, the long-term benefits should outweigh these costs. Benefits include the ability to access great amounts of data quickly; access that data visually, conduct internal analyses; link the data to external models; and graphically communicate issues of concern (such as gaps in knowledge or impacts to significant sites), plans, and alternatives for addressing those issues to others. In a world where time is money and knowledge, or the control of information, is power, GIS is likely to continue to play an important role in archaeology. As a tool to aid in the preservation and protection of archaeological resources, the potential is there, and some headway has certainly been made regarding data management issues and CRM.

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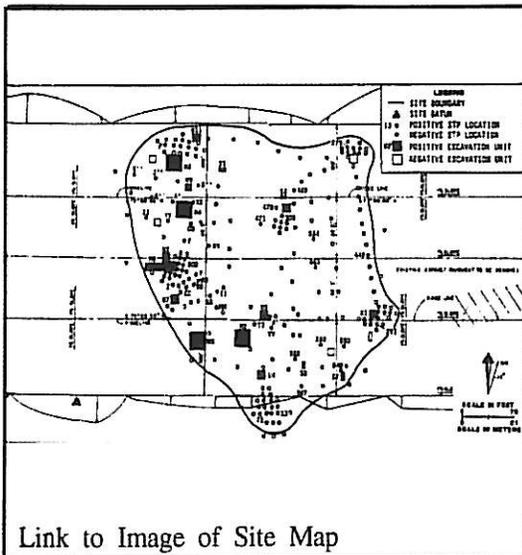
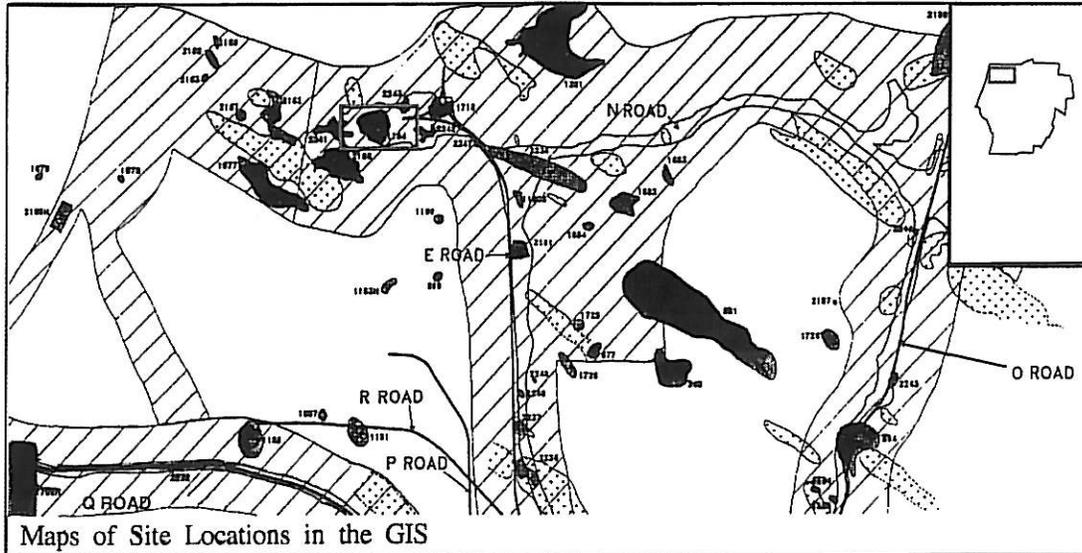
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Archaeological Site Inventory



Site Number: 1154

Description: General camp with a high density lithic scatter (reworked) and bone and shell fragments. 1,199 chert flakes recovered, 1 chert uniface, 1 lithic core.

Elevation: 54 to 61m (178 to 200 ft) above mean sea level.

Area: Approx. 8,100 sq. meters.

Geomorphic Setting: Elongate parabolic aeolian dunes.

Soil: Soil uncompact fine to medium sand.

Nearest water: Approx. 20m North

Vegetation: Coastal sage scrub community.

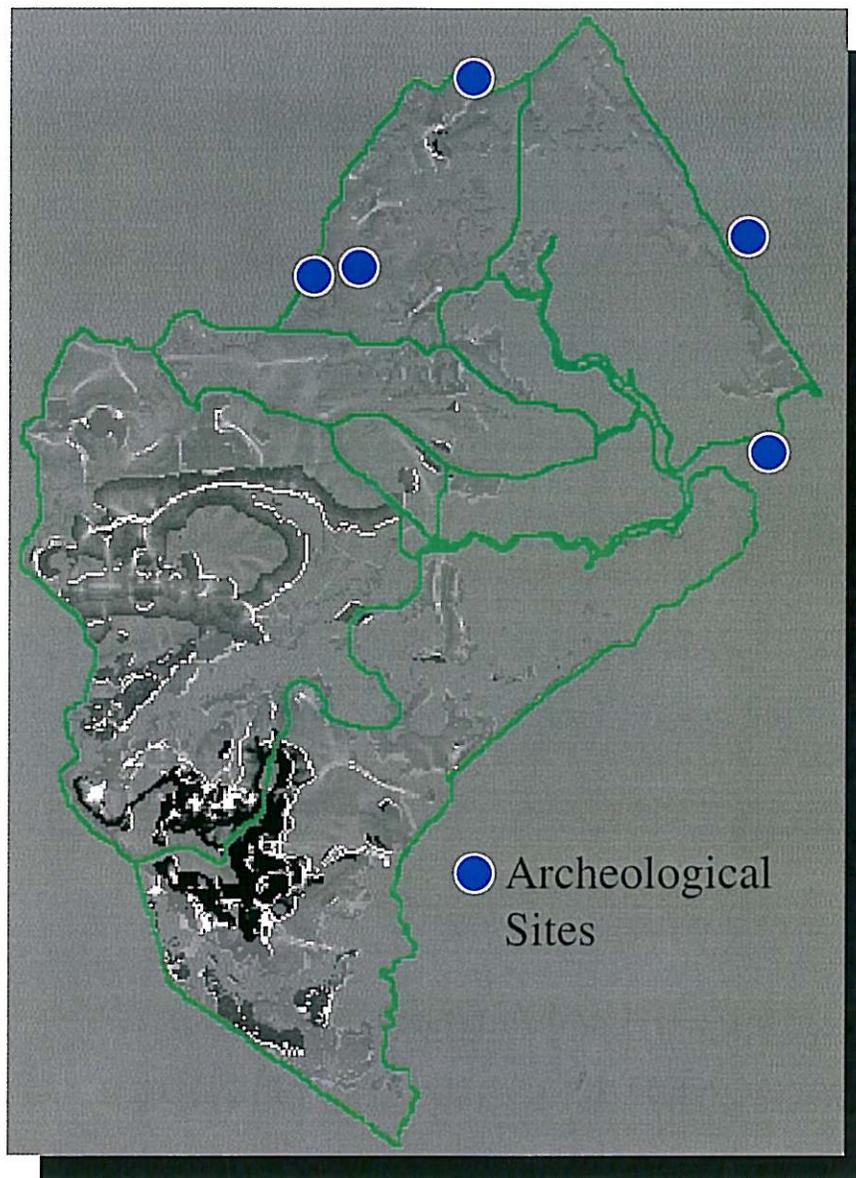
Reference: "Archaeological investigations in the vicinity of somewhere, USA", August 1997

Link to Report about Site



Proposed facility footprint with predictive prehistoric archaeology model results and potential historic sites from map sources.

Simulation Soil Movement with Archeological Sites



High
Erosion

No
Movement

High
Deposition