AUTOMATION TOOLS FOR CULTURAL RESOURCE MANAGERS

Proceedings of a Corps of Engineers Symposium on Automation Tools and Database Development for Cultural Resource Managers

17 April 1990
Las Vegas, Nevada

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This report consists of papers presented at a symposium that focused on information management tools and geographic information systems (GIS) being used by cultural resource managers in the Corps of Engineers and other Federal agencies. Publication of symposium papers was made possible by joint funding from the Legacy Resource Management Program and the U.S. Army Corps of Engineers. Topics discussed include the use of easy-to-learn, readily available information management software as well as GIS software as day-to-day tools for cultural resource managers. Emphasis in these papers is on straightforward applications of automation technology to assist cultural resource managers to work smarter rather than harder.
4. (Concluded).

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Dr. Frederick L. Briuer, research archaeologist of the Resource Analysis Group (RAG), Environmental Resources Division (ERD), Environmental Laboratory (EL), U.S. Army Engineer Waterways Experiment Station (WES), organized the symposium and served as senior editor and compiler of the symposium papers. Mr. Evan Peacock, research assistant with Forest Products Laboratory, Mississippi State University, assisted with the editing of the symposium papers.

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Dr. Robert W. Whalin was Director of WES. COL Leonard G. Hassell, EN, was Commander and Deputy Director.

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17 April 1990, Las Vegas, Nevada
Corps of Engineers symposium held in conjunction with
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Lyon, Edwin (presenter and senior author), Michael Stout, and Van Button (co-authors)
Title: "[Archaeological] Database Uses in the New Orleans District"

Barr, Kenneth A.
Title: "[GIS Database] Applications for Archaeological Site Management, Rock Island District"

Dunn, Robert A. (presenter and senior author), and John Riggs (co-author)
Title: "Managing The Cultural Landscape: An Integration of GIS and Computerized Data Bases in Archaeological Resource Management"

Briuer, Frederick L.
Title: "Developing an Automated Data Base For Managing Complex Regional Archaeological Inventories"

Banks, Larry D.
Title: "Integration of Cultural Resources and GIS Data in the Southwestern Division"

Edging, Richard (presenter and senior author), John Isaacson, Keith Landreth, Craig Neidig, and Diane K. Mann (co-authors)
Title: "A Preliminary Assessment of Environmental Variables, Culture History, and GRASS Maps for the USMA Preservation Plan [GIS Applications]"

Canouts, Veletta (presenter and senior author), and Frank McManamon (co-author)
Title: "The Development and Use of a National [Archeological] Database"

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THE AUTOMATED DATABASE: A TOOL FOR MANAGING COMPLEX
REGIONAL ARCHAEOLOGICAL INVENTORIES

Frederick L. Briuer*

Introduction

In reading the US Army Corps of Engineers regulation titled "Project Construction and Operation Historic Preservation Program" (ER 1130-2-438), I am especially impressed with two obvious ramifications. First, there is a loud and clear message that operations and maintenance actions require no less attention to the provisions of the law, regarding cultural resources, than any other Corps action. In other words, there are no categorical exemptions from Federal Historic Preservation requirements for operations and maintenance actions simply because cultural resource management has traditionally been viewed as a Planning Division responsibility for such things as large inundation construction projects. Secondly, the reiteration of the responsibility to manage the Corps' historic properties in a spirit of long range stewardship necessitates a significant shift in priorities emphasizing the generally neglected provisions of section 110, not just section 106, of the National Historic Preservation Act (PL 89665). Section 110 requirements ought to be considered no less important but have been allocated back burner priority while our energy and resources have been traditionally directed toward what planners have conventionally perceived as more pressing legal requirements, i.e. "if we do not demonstrate compliance with section 106 our project cannot legally proceed". The focus of this paper will be on methods and techniques for developing automated regional databases as practical tools for more efficiently complying, in a holistic fashion, with all legal requirements.

Automation Tools for Cultural Resource Managers

An automated cultural resource management (CRM) database can simply be defined as the best available information serving as the defensible basis for responsible management initiatives. An automated cultural resource management database is very much like a savings account. Managers who invest in the

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acquisition of highly reliable archaeological, historical, ethnohistoric, environmental, geographic, geomorphic and other appropriately needed information can expect to be paid some handsome management dividends. An advanced and comprehensive database can form the scientifically defensible basis for innovative, cost effective and highly responsible management options. The argument against developing comprehensive, automated databases, is like someone arguing against starting a savings account because they have never had one before. It is never too late to start a savings account or an automated database for more efficient management.

An advanced automated CRM database has the potential for reducing requirements for conventional mitigation involving unnecessarily expensive and destructive excavation. Having made that statement, let me make it emphatic that I am not saying that investment in a database incorporating comprehensive information from nondestructive archaeological surveys and site monitoring projects should preclude orthodox mitigation involving excavation. What I am saying, is that the quality of information serving as the basis for informed management initiatives is going to be directly related to our chances of finding innovative, responsible, and preferably nondestructive management options to traditional mitigation involving destructive excavation. In this paper I will touch upon some specific examples of how comprehensive databases are resulting in handsome management returns on that investment. It's the age old dictum of "no pain, no gain."

This symposium involves several different kinds of databases. Valetta Canouts and Frank McManamon fully discuss the concept of a national database. The scope of such a commendable undertaking is enormous, considering the huge geographic area as well as the formidable extent of literature involved. The kind of database that Larry Banks discusses for the Southwestern Division of the Corps of Engineers covers some eight Corps districts, eight states and some 660,000 square miles. The databases discussed by Corps of Engineers district archaeologists from New Orleans, Rock Island and Little Rock represent much smaller geographic areas. The district and installation level databases discussed in this symposium have the distinct advantage of gaining a certain enclosure on a greater variety of valuable information not generally characteristic of larger region and state databases. The important thing to keep in mind is that each kind of database has it's particular strengths and weaknesses.
No single information management structure will be appropriate for all users and all management problems. For example, most state databases, with the notable exception of the Arkansas database, are coarse grained information structures with distinct limitations. These databases may involve a great deal of information in the sense that a large number of sites and a large amount of information may be involved. But at the same time the information can be expected to be rather limited for each site. Both national and state databases, at least at this point in time, can be classified as essentially horizontal databases displaying great breadth but essentially shallow in depth or complexity of relational, problem oriented, information. If we are really serious about resourcefully exploiting nondestructive management options, managers will need to do far more than simply plug into these coarse grained or horizontal databases as they are being developed.

Managers will need to develop their own vertical or fine grained databases. These will require a continued investment in selective, and highly reliable information for solving specific management problems. Neither academic researchers nor compliance agencies can be expected to take exclusive responsibility for acquiring and developing the data structures that managers require. This implies a certain hands-on commitment that is clearly demonstrated by the participants in this symposium. The particular kind of database discussed in this paper is fully relational, multidimensional and comprehensive by virtue of having invested over fifty person-years of effort in a directed and incremental information acquisition and refinement process extending over a decade of time for a relatively small geographic region (Briuer 1989 pp. 63-72).

Large sets of high quality fine grained data for any region are expensive, time consuming and labor intensive to acquire, to organize and to automate. The development of an automated regional database will be considerably less painful and easier to put together in digestible and financially justifiable bites, if a routine legal justification can be used as the ongoing funding mechanism for programming the necessary step by step field and analytical studies needed to generate high quality information. The recognition of overview and survey requirements for Federal actions with potential for unnecessary damage or destruction to significant cultural resources under section 106 of the National Historic Preservation Act is just such a routine funding mechanism. How do we as managers answer the question of whether or not a particular Federal action, such as recreation area improvements, timbering,
404 permits, navigation or dredging actions etc., will or will not have potential for adverse effects on significant cultural resources, if we don't have the necessary information, including literature searches and field surveys, to determine if significant resources will in fact be impacted?

Assuming that these and many other kinds of Corps actions will continue to require surveys and other field and analytical studies, there are essentially only three prerequisites necessary for developing comprehensive automated management databases: (1) a commitment to learn and resourcefully exploit readily available, easy to learn and easy use automation tools, (2) a well-thought out centrally orchestrated long-term information acquisition strategy and (3) a Standard Operating Procedure to ensure that each participant in the program will make consistent, useful and reliable contributions to the evolution of the database so that information incompatibility and duplication of effort is avoided.

Detailed specifications and standardization of survey and monitoring methods and recording procedures are essential. Were each contractor left exclusively to their own devices to conduct surveys for discreet areas as stand alone exercises for finding sites, one can be certain that there would be little data compatibility or information evolution in the long haul. By contrast, each survey can become an opportunity to acquire, revise and upgrade consistent anthropological, historical, environmental and management oriented information that adds to, or supplements, information acquired from all earlier projects resulting in information products. The result can be a very large, very diverse and comprehensive fine grained database. For an example of such standardization of methods see Bruier and Thomas (1986).

Obviously if each survey is viewed as an element or step in a long-range plan to acquire comprehensive information, this will require a central orchestration of effort. I would submit that such an orchestration should be an inherently governmental function, particularly if the work has to be done through a series of contractors none of whom is willing to accept responsibility for the quality of the work of any of the others, because each is essentially doing their own thing to meet legal requirements for some discreet compliance event. Just try to get even two archaeologists to agree on any standard operating procedure for accomplishing anything. Someone needs to accept the primary responsibility for formulating and implementing long range data management goals, including the full responsibility for assuring the
quality of the overall database as the sum, if not more than the sum, of all its contractor-contributed parts.

Most attempts to merge information acquired from different projects conducted by various archaeologists over time, have been done without standards for recording procedures. This has meant that regional data are at best going to be rather superficial, describing little more than the approximate location of resources and a few very obvious observations usually of a highly subjective nature. Attempting to use regional survey information put together in this fashion is invariably a futile exercise in attempting to add apples and oranges. Little wonder that archaeologists have developed a very jaundiced view about using the archaeological survey as a data gathering and hypothesis testing exercise in and of itself. This aversion for exploiting regional information derived from nondestructive methods seems to go hand in hand with the commonly held notion that "real archaeologists" dig sites. Given this intellectual climate it should not be in the least bit surprising that managers are often forced into unnecessarily expensive and destructive data recovery projects because they simply do not have the defensible information to support a fully responsible but less expensive and less destructive alternative.

An Example of a Fine Grained Comprehensive Database

The database described below was developed for the US Army Installation at Fort Hood Texas, a region of some 218,000 acres of Bell and Coryell counties Central Texas, intensively used for armored military training. Within this region some 2300 prehistoric and historic archaeological sites have been recorded through a series of survey and monitoring projects beginning in 1977. The survey of the Installation is essentially complete with about 95% of the undeveloped portions of the installation surveyed. The completion of the survey, the development of the automated database, a memorandum of agreement with the state of Texas and a Historic Preservation Plan demonstrates significant compliance with EO 11593 as well as sections 106 and section 110 of the National Historic Preservation Act.

The Fort Hood CRM database was put together using a variety of automation tools including D/BASE, CAD (computer aided drafting), INFORMIX, and GRASS, supported by the 'S' Statistical package. The database was originally run on MASSCOMP mainframe configured to a distributed network involving
various specialists in the Environmental Division of the Directorate of Engineering and Housing at Fort Hood (Goran et al. 1983). Specialists in the division include a wide variety of engineers, natural and cultural resource managers etc., each with access to this corporate database. The database contained CRM information as well as a wide variety and quantity of other environmental and management information for the installation.

The information system has been routinely used for day to day management practices involving the successful coordination of literally thousands of potentially destructive Army actions. Reliance on this environmental management information system has proven to be a low cost, efficient way to conduct a multidisciplinary environmental management program for a large military installation involved in a complex set of intense military impacts including potentially massive destruction to archaeological resources.

In putting together the data base all archaeological sites were mapped in the field on the best available maps and air photos. Through time, high resolution air photos were procured for all field work. Therefore, information from early surveys conducted without the luxury of excellent air photos, required constant upgrading. Consequently, more than half of the site in the inventory were eventually recorded or monitored more than once, some sites as many as four times. Each iteration of recording represented an opportunity to improve the database. Over eight hundred manhours alone were spent on one lab project to review all available site maps and air photos in order to consolidate and synthesize all information from multiple surveys occurring over several years.

The result of this special "big picture" site mapping project for the entire 339 square miles of the installation was a set of high resolution maps with a scale of one inch equal to 400 feet. These were available in digital format. All site boundaries and other key site locational information were digitized in the computer aided drafting (CAD) system in use at Fort Hood at the time. A CAD system was being used by the Engineering Plans and Services Division called IGAS (Interdigitated Graphics Analysis System). Several interesting problems surfaced as a result of this comprehensive computer mapping effort.

Most of the location errors encountered in this work were a result of the particular survey methods used or were a function of particular difficulties and errors made by field crews. A considerable effort was expended in correcting errors primarily associated with the edge effect when doing
multiple, cumulative surveys involving Universal Transverse Mercator (UTM) grid squares. Sites with the most serious recording problems became prime candidates for subsequent field monitoring projects designed to correct and upgrade unreliable data at problematic sites. Accurate locational information is absolutely essential, without it there really is no point in throwing all this digital information into something as sophisticated as a Geographic Information System (GIS) and cheerfully using it for such challenging things as complex computer analyses or negotiating site avoidance plans with the SHPO.

There are distinct advantages to an interactive process constantly incorporating new and more reliable information. It is not unlike designing and building fortifications. The diligent defender will exploit every opportunity to continually make their fortification more and more formidable. The Fort Hood example should also drive home the point that a holistic management view, where site locational and attribute information are seen as the sum of several separate parts, is far more reliable than data derived from any one survey. This same concept of holistic reliability is obviously not limited to locational information. Increasing our sample of observations on any variable should generally improve the reliability needed in complex relational databases.

Another important step in the development of the Fort Hood database was the conversion of the CAD site boundary files to GRASS. This laborious and time consuming step would have been totally unnecessary if GRASS digitizing capability had been available at the time. Instead of waiting around for the equipment authorization and procurement of GRASS digitizing equipment, the boundaries of 2,300 archaeological sites were digitized as polygons using the CAD system in use at that time by the Directorate of Engineering and Housing. This proved to have been a good choice because of the extreme accuracy of CAD maps. These extraordinary maps were immediately put to good use for day to day management purposes as well as further field survey and monitoring.

The conversion of vector based CAD site boundary data to raster based GRASS files turned out to be a eighteen month programmers nightmare. But thanks to the persistency of our colleagues at the US Army Construction Engineering Laboratory there now exists an invaluable GRASS version of the 2,300 archaeological site boundaries classified according to degree of recording confidence. Managers who have access to a CAD systems like Intergraph, should be spared the greatest part of that vector to raster ordeal now that
WES and CERL have written data conversion programs for vector IGDS data into GRASS vector files. The resourceful use of existing automation systems by Corps of Engineer cultural resource managers is to be encouraged in view of the fact that as of one year ago 36 of the 38 Corp Districts have operational Intergraph systems. As a word of caution, keep in mind that CAD visual display data requirements are not necessarily the same as data requirements with GIS applications in mind. Visual displays of spatial data in CAD can be a very different critter than GIS analysis of spatial and attribute data in a complex relational database. Both CAD and GIS have their strengths and limitations as management tools.

Structure of the Fort Hood Database

Listed below is a simplified description in outline form of the various data layers contained in the Fort Hood GRASS database. My purpose here is to simply give the reader an idea of the quantity and diversity of information that can potentially be considered as part of a cultural resource management database. For more detailed discussions regarding how the database was constructed and its management uses see (Williams et al. 1989; Briuer et al. 1990; and Williams et al. 1990). For a discussion on how the database described below was expanded to include valuable additional information pertaining specifically to historic settlement at Fort Hood see Jackson (1990).

I. Prehistoric Site Characteristics (approximately 1200 sites)
   Site Number (temporary and permanent)
   Precise location (UTM)
   Area of Site (sq.m.)
   Chronology (attributes pertaining to commonly recognized time periods)
   Project Code
   Site condition (scales for measuring physical condition)
   Presence/absence data
     10 variables e.g. midden, rockshelter, mound etc.
   Quantitative data
     44 variables e.g.
     counts of tools by type
     sample estimates e.g., amounts of burned rock, debitage etc.

II. Historic Site Characteristics (approximately 1200 sites)
   Site Number
   Precise location
   Area of Site
   Chronology
     Beginning date
     Ending date
Mean date
Occupation span
Site Condition
Presence/absence data
30 variables e.g. foundation, dump, chimney, well, etc.
Quantitative data
e.g. total count of artifacts

III. Grass Environmental Data Layers especially relevant to Prehistoric Sites

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Training frequency</th>
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<tbody>
<tr>
<td>Elevation</td>
<td>Training functions</td>
</tr>
<tr>
<td>Slope</td>
<td>Training intensity</td>
</tr>
<tr>
<td>Geology</td>
<td>Vegetation</td>
</tr>
<tr>
<td>Soils (3 layers)</td>
<td>Distance to water (7 layers)</td>
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<tr>
<td>Training areas</td>
<td>Soil ph</td>
</tr>
<tr>
<td>Environmental Zones</td>
<td>Land capability (6 layers)</td>
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<tr>
<td>Hydrology (4 layers)</td>
<td>Pre-settlement landscape</td>
</tr>
<tr>
<td>Erosion potential</td>
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</tbody>
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IV. Grass Environmental Data layers particularly relevant to Historic Sites

<table>
<thead>
<tr>
<th>Distance to drainages</th>
<th>Modern vegetation</th>
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</thead>
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<tr>
<td>Distance to roads</td>
<td>Land capability (12 layers)</td>
</tr>
<tr>
<td>Distance to communities</td>
<td>Soil ph</td>
</tr>
<tr>
<td>Aspect</td>
<td>Training intensity</td>
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<tr>
<td>Hydrology (2 layers)</td>
<td>Training functions</td>
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<td>Erosion status</td>
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<tr>
<td>Environmental zones</td>
<td>Slope</td>
</tr>
<tr>
<td>Survey areas</td>
<td></td>
</tr>
</tbody>
</table>

Management Applications

The GRASS database put together at Fort Hood has proven to be an invaluable project planning tool not only for a multitude of day to day military training operations where complex impact processes can be controlled on short term notice but also as a tool for more long range planning. Long range planning is necessary for constructing complex multipurpose ranges as well as a variety of other military construction projects where the precise location of archaeological resources can be taken into consideration in the earliest stages of the planning process. Long range planning is also necessary for other potentially destructive Army actions such as major military maneuvers, off road vehicle recreation events, and natural resource actions such as timbering programs or vegetation clearance using heavy equipment in order to improve the training quality of the land.

One specific example of how this technology and database has been successfully used as a planning tool for avoiding unnecessary archaeological
impacts as well as unnecessarily expensive and destructive data recovery mitigation was the construction of a water pipeline line running across a significant portion of Fort Hood's Eastern Training Area. Earlier right-of-way surveys in the Eastern Training Area resulted in entirely inadequate information to avoid impact to potentially significant archaeological sites. Such right-of-way surveys are like looking through the sample universe through a straw. Attempting to reroute a pipeline to avoid archaeological impacts on the basis of right-of-way survey information proved impossible because of the unknown character of the "edge effect" of the right-of-way.

It was only after the complete survey of the entire Eastern Training Area and acquiring more reliable locational information on the more holistic pattern of site distribution in the entire region that it became practical to confidently thread the route of the proposed pipeline through the maze of archaeological sites in the area. Compare in FIGS. 1 and 2 the pattern of sites depicted as centerpoints from a right-of-way survey to the "gestalt" pattern exhibited by a complete survey of the Eastern Training Area where each site has been carefully mapped as a closed polygon. This should graphically illustrate how the quality of survey data and the differences in mapping reliability will to a large extent determine just how successful a particular archaeological site avoidance plan is likely to be.

In addition to obvious installation planning applications that have been discussed elsewhere (Briuer, 1991 p. 99-101) there are other critical CRM responsibilities where comprehensive automated databases can play a vital role. The task of realistically identifying and measuring non-catastrophic gradual impact processes is not a self evident simplistic management exercise. Our ability to answer questions about the relative severity of complex, perhaps multiple impact processes, requires objective, and quantitative methods for impact identification, measurement, and monitoring (Briuer 1981: Carlson and Briuer 1986). Extensive automated regional databases used in conjunction with remote sensing technology offers some exciting, if not awesome, future possibilities.

The difficult task of evaluating the significance of complex regional inventories of archaeological sites is another management challenge where there are direct applications for automation tools. What is significant and what is not significant are questions that need to be answered on the basis of the best available information using methods that are explicit and replicable. Recent research using a large relational database, and GRASS, supported
Figure 1. Attempt to relocate a pipeline on the basis of known archaeology from a right-of-way survey

Figure 2. Failed attempt to avoid archaeological sites by original rerouting (dotted line). Successful attempt (solid line) threading pipeline through a complex pattern of sites on intensive survey coverage
by the S statistical package demonstrates this application but is well outside the scope of this paper (Briuer et al 1990 and Williams et al 1990). Other very recent examples of formal evaluations of regional inventories of archaeological sites that employ holistic, objective and quantitative methods for grappling with the concept of significance are discussed in Browning et al. 1991, McFaul et al. 1990, and McFaul and Doering 1991.

The Fort Hood database demonstrates the many advantages of a "Gestalt" or holistic approach to management and database development. Consider also that advanced CRM databases are still only one element or one kind of necessary information required in the total set of resource management and stewardship responsibilities. We need to be especially resourceful in networking with others for sharing expertise, equipment and information to reduce some of the enormous cost burden involved in automation. It makes little sense to attempt to develop extensive CRM databases in isolation. The financial expense as well as the expense involved in time and effort, not to mention necessary expertise and technical support, would simply be prohibitive. The lone wolf cultural resource manager is rapidly becoming as obsolete as the lone wolf scholar.

Survey of Corps District Archaeologists

Before wrapping up this paper I would like to share with you the results of a telephone survey of archaeologists from all Corps districts that I conducted in August of 1989. District archaeologists from all Corps districts were asked several questions regarding their access and use of automation tools for their CRM responsibilities. All but one of those interviewed had access to personal computers but basically their computers were being used for word processing. To some extent some archaeologists have resourcefully used their computer assets for cost tracking and financial concerns regarding contract preparation and administration. Less than a quarter of those interviewed are actually using their available computer assets for other demanding analytical tasks associated with cultural resource management. Over half of the archaeologists interviewed reported no attempt to develop automated cultural resource management databases (see FIG. 3).

In general, those archaeologists interviewed who have made the most innovative use of the analytical capabilities of available automation tools are those who have successfully networked with others and are taking full
Figure 3. CRM database development
advantage of corporate databases and shared resources. The innovative work of Corps archaeologists contributing papers to this symposium like Larry Banks, Ken Barr, Bob Dunn and Ed Lyon, became apparent during this survey along with a few others who unfortunately could not all be represented in this symposium. All these individuals have somehow managed to find the time to make use of this technology to work smarter rather than harder despite workloads that for all of us only increases. These are commendable efforts.

Some of you involved in military work are probably aware of ITAM (Integrated Training Area Management), I would suggest looking into its' possible applications for developing CRM data bases at those installations using the ITAM comprehensive approach to land management. I would also strongly encourage those archaeologists in the Southwestern Division to resourcefully take advantage of the sophisticated information management system using GRASS that has been set up for that division. The failure of archaeologists to use the Southwestern Division GRASS system ought not be considered an indictment of the system so much as an indictment of archaeologists who fail to recognize the value of the system as a management tool for their own purposes. I would also suggest considering a partnership approach with the research labs. The Fort Hood database was developed as a long range, centrally orchestrated but joint effort involving a team composed of in-house staff archaeologists, private sector contractors and resources from the Corps' research community. If we expect to meet the exemplary challenge expressed by Lt. General Hatch to become the Nations premier Environmental engineering organization, we need to be as resourceful as possible in getting all the help we can get.

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GIS APPLICATIONS AND CULTURAL RESOURCE PLANNING AT THE UNITED STATES MILITARY ACADEMY AND WRIGHT-PATTERSON AIR FORCE BASE

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Introduction

This paper presents an overview and discussion of USA-CERL's research at the United States Military Academy, West Point, New York and Wright-Patterson Air Force Base, Dayton Ohio. It will deal with the environment and culture history of the USMA and WPAFB (lower Hudson and central Ohio valley) regions, a discussion of GRASS (Geographic Resource Analysis Support System) generated research, integration of a database utilizing the RIM/GRASS interface (dbsites) and the identification of sites and archaeologically sensitive areas on these installations.

USA-CERL's archaeological and historical research is designed to produce a data base and management plan for impact assessment and preservation of cultural resources within installation boundaries. Rather than evaluating cultural resources on a case by case basis, the management plan creates a format where all resources can be evaluated in a consistent fashion and places archaeological and historic sites in a regional context. This is essential in evaluating an installation's cultural resources and their theoretical significance. The compilation and coordination of archaeological and historical data into a local framework assists installations and State Historic Preservation Officers in making decisions regarding both Section 106 compliance and cultural resource management.

Effective cultural resource planning depends on knowing where sites are likely to occur and what processes may have affected their contextual integrity. Accurate information relevant to these concerns depends on detailed environmental and archaeological analyses. The probability model and sensitivity analysis for USMA and WPAFB are working documents -- as additional archaeological information is gathered the model will continue to be refined. Three components are required for the construction of these models. First, an environmental analysis using a Geographic Information System (GIS) system like

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GRASS developed at USA-CERL; second, a time-sensitive model of prehistoric settlement constructed from regional archaeological data; and finally, correlation of these data sets to probable site locations. Refinement of the probability model depends on field testing and verification. For this paper probability is defined as the potential for existence of an archaeological site or site type within a given geomorphic situation.

The probability model generated for archaeological sites at the USMA and WPAFB consists of a correlation between archaeological information, e.g. site location and type, and environmental variables that include: elevation, slope, aspect, geology, vegetation cover, hydrology, soils and urban development (disturbed soils). Our sensitivity analysis relies on the twin concepts of contextual integrity and the depth of the resource. The greater the depth of a buried archaeological site, the lower its sensitivity because the potential for impact during a land-altering process is low. Our initial goals were to collect basic environmental, and cultural data, and to conduct an archaeological survey which, although preliminary, offers a guide to future preservation planning -- the overall mission of the USMA and WPAFB Historic Preservation Plans.

The known prehistoric and historic occupations at the USMA and WPAFB and the potential for cultural resources provide an opportunity to study the ways that prehistoric and historic populations exploited their environments in areas that have not been systematically studied. Other approaches to site location models have been based on site survey data (Lafferty and House 1986). In areas where these data are lacking, such as on most military installations, systematic site survey must be conducted to generate reliable prehistoric and historic settlement data. The preservation plans discussed here are examples of this process and represent working documents which will be used in the future to generate systematic survey data and refine site location predictions. The combination of prehistoric settlement patterns, site formation processes, and environmental data are major components of first generation site location models, i.e., systematic survey designs.

USMA and WPAFB Environments

USMA

The USMA occupies the west bank of the Hudson River, the adjacent highlands and Constitution Island. The Hudson Highlands are characterized by high
relief directly adjacent to the river and relatively few level alluvial terraces. Within its highland topography are a series of lakes, ponds and streams that are oriented northeast-southwest, dictated by the alignment of the Redding Prong. Major streams include Highland, Popolopean, Crows Nest and Woodbury. The Hudson River at this point is saline due to tidal influx. The eastern shore of the Hudson River from Constitution Island south to Demming Point contains an extensive littoral zone. The tidal marsh on the eastern portion of the island is the nesting grounds for a number of bird species and the spawning ground for resident and anadromous fish species (MacKinnon 1980). Both environments were undoubtedly important resources to the prehistoric/historic inhabitants of the area (Fig. 1).

The bedrock outcrops to the west of the river, and the uplands in general, contain numerous overhangs and rockshelters which, based on our archaeological survey and research from areas outside the installation, suggest a high probability for prehistoric and historic occupation. Potential rockshelters exist in all areas of the reservation where there is a sufficient gradient (>25% slope). Along the Hudson River, with its wide range of exploitable resources, these overhangs have a high probability of site occupation. In sum, the installation contains three major resource zones: the mountainous or upland zone with its oak-chestnut forest, freshwater lakes, and ponds; feeder streams, marshlands and narrow bottomlands; and the Hudson River with its seasonal fish runs and tidal marshes (Fig. 1).

WPAFB

Wright-Patterson Air Force Base is located east of Dayton, Ohio. Forming the western boundary to WPAFB, the Mad River contains features similar to the Greater and Little Miami Rivers including alluvial terraces, steep bluffs and ridges, and numerous streams including Mud Run, Hebble, Beaver, and Popular. In general, Mad River environs are characterized by high relief adjacent to the river, a broad floodplain and alluvial terraces south of the river. The alluvial terraces on the installation are the present sites of the installation's logistical facilities and associated residential housing (Fig. 2). Little arable farmland remains. Huffman Prairie located in the southwest portion of the base contains an intact prairie, now a part of the Miami Conservancy District. Limestone outcrops south of the river, and the uplands in general, contain numerous feeder streams which, based on our research from areas outside the installation, suggest a high probability for prehistoric and
Figure 1. United States Military Academy (USMA), West Point, New York, with known archaeological sites (*\)

historic occupation. Along the Mad River, habitation sites have a high probability of occurrence, but are most likely buried under alluvium and therefore are considered low sensitivity areas. In sum, the installation contains three major resource zones: 1) the Mad River floodplain with its oak-sugar maple forests; 2) the alluvial terraces above the floodplain; and 3) the uplands with numerous feeder streams.
Culture History

The following overview provides a background for the correlation of prehistoric settlement and subsistence data with environmental variables for Dayton, Ohio determining site type and location. General trends describing cultural change in eastern North America, understandably differ greatly from region to region. Refinements are based on the archaeology of New York and Ohio (Brose and Greber 1979; Curtin 1986, 1987; Funk 1976, 1979; Griffin 1978; Muller 1986; Snow 1980). An environmental background, a discussion of research questions and the probability of archaeological site locations within
the USMA and WPAFB are included in conjunction with USA-CERL'S Geographic Resource Analysis Support System (GRASS).

Several archaeological sites exist on or near the USMA from prehistoric rockshelters and basecamps to Revolutionary War fortifications and 19th century farmsteads, towns and industries. At WPAFB Adena and Hopewell earthworks and mounds exist within the installation. In addition, the Wright Brothers hangars (1904-1910) are located on Huffman Prairie described above.*

The prehistoric period includes a long time span during which important cultural changes occurred. Subsistence strategies and material culture underwent gradual diversification characterized by adaptation to local environments, long distance exchange and population increase. Deciduous forests containing oak, chestnut and hickory covered most of the Eastern Woodlands and were the most distinctive feature of North American environments as reflected in the adaptations and local specialization to these environments by prehistoric populations (Watson 1989). Eastern North American populations had diversified subsistence strategies including hunting, fishing, plant food gathering, and along some of the major rivers, plant cultivation. Several technological innovations occurred. The presence of atlatl weights in the Middle Archaic and the bow and arrow by the Late Prehistoric, suggest that hunting became more efficient. Ceramics introduced early in the Woodland period provided more efficient cooking and storage capabilities. Subsistence activities were organized in planned seasonal movements by groups occupying a variety of basecamps and extractive sites. Through time there is a trend towards larger and more permanent sites especially along major rivers where introduced and indigenous cultigens were utilized. The cyclical exploitation of a varied resource base created a need for special purpose camps. Among those identified are settlements, semi-permanent base camps, seasonal upland camps, quarries, and rockshelters (Curtin 1986; 1987; Funk 1976).

In the Woodland and Late Prehistoric periods horticulture and increasing populations narrowed subsistence options, yet increased emphasis on cultigens provided stable storeable food supplies. Some upland plant and animal species like nuts and deer remained important throughout the prehistoric era. This general model is based on archaeological evidence from the Midwest and Hudson River Valley, but there is considerable variability from region to region in

* Complete cultural and literature overviews for these installations are available upon request.
both the kinds of resources exploited and in settlement patterns that reflect this exploitation. For the New York Archaic Funk has stated (1976:252):

It is highly probable, that seasonal rounds were a basic aspect of the settlement pattern. The components on lakes, on major Hudson tributaries, and on low-lying Hudson camps doubtless represent warm weather hunting, fishing, and plant collecting stations, as suggested by the artifact inventories... In the fall, Sylvan Lake groups began to disperse to back-country locations where they concentrated their skills on tracking and killing deer. During the cold months some hunters, accompanied by their families, took refuge in rockshelters or caves and small open camps, but others occasionally perhaps in parties of band size seem to have lived on bluff sites or inland streams.

Storage pits, refuse pits and prepared burials are common on sites associated with prolonged habitation. Burials documented from the Midwest and southeast reveal increased social differentiation primarily determined by age, gender and individual achievement. Population increase and the growth of more localized adaptations are indicated by restricted mobility and argues for some population pressure (Buikstra 1977; Muller 1986). The salient feature of Late prehistoric cultures is a reliance on plants such as maize and beans in a horticultural complex keyed to alluvial bottomlands. The associated population growth affected the nature of the seasonal round and settlement patterns may have been altered through time. The new focus on agriculturally productive lands may have changed settlement patterns in the major river valleys.

Extensive trading of marine shell and copper, increased mortuary ritual, population increase, technological innovations, increase in conflicts as a result of competition over circumscribed resources, horticulture involving both native and introduced plants, and the development of a settlement system emphasizing agriculture reflect the growing complexity of groups throughout the East by the Late Prehistoric period.

The following statements about prehistoric settlement in the two regions are based on general trends used to construct a set of working hypotheses which have environmental correlates applicable to GIS analysis:

1) From Middle Archaic through Historic Periods there should be a significant functional variation between riverine and upland sites. This should be reflected in artifact density and diversity. From Middle Woodland on, habitation sites were aligned to major streams and rivers, the loci of good soils for horticulture and agriculture.
2) Archaic groups maintained wide-ranging settlement patterns. Larger base camps located on floodplains are deeply buried. Interverine and upland Archaic sites may cluster around major streams that flow into the Hudson and Mad Rivers. The structure of these sites is characterized by low artifact density and diversity indicative of short-term seasonal camps.

3) Late Archaic sites ubiquitous in both regions are associated with riparian and upland environments, reflecting a period of population increase and radiation into several zones. Terrace settlements and base camps were logistically tied to smaller base camps and specialized extractive camps in uplands or interfluvial environments. Settlements should contain high artifact density and diversity and suggest aggregation of bands during winter and summer. Upland and interfluvial sites such as rockshelters were essential for exploiting seasonal resources and contain a lower diversity of artifacts.

4) Woodland sites in the Hudson Highlands are generally rare until the latter part of the sequence. In the WPAFB Mad River area the Woodland period is represented by Adena mounds and Hopewell earthworks. Residential sites associated with these sites are dispersed but generally located on alluvial terraces. These sites should contain diverse assemblages with evidence of exotic materials representing long-distance exchange.

5) Late Woodland sites suggest a wide-ranging settlement pattern with sites located in diverse ecological settings. The introduction of the bow and arrow allowed more efficient adaption to interriverine and upland locations. By A.D. 1000, riverine-adapted maize agriculture became a major subsistence focus. The reorganization of subsistence strategies and nucleation of villages should make Late Woodland sites more visible and accounts for Late Woodland sites in both bottomland and upland zones.

6) Late Prehistoric populations retain the Late Woodland settlement and subsistence patterns with beans added to a long list of cultigens. Population centers or large agricultural villages should be confined to riverine locations; sizeable habitation sites and camps occur on tributaries and streams. Assemblages should reflect self-contained agricultural communities. The Hudson Highlands and Mad River may have functioned as both a non-agricultural catchment area for settlements located north and south of the Highlands and for groups in Ohio on the Greater Miami and Ohio rivers. These sites served as permanent habitation for smaller kin-based groups in hamlets and farmsteads. The uplands in both study areas are also high-probability areas for seasonal Late Prehistoric and Historic camps. Late Prehistoric groups in both areas followed a pattern of seasonal movement similar to historic tribes' subsistence and settlement patterns.

GIS Applications

A full discussion of GRASS applications involved in producing survey designs for the USMA and WPAFB is not possible for this paper;* however, two

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* Open prehistoric sites, late 18th and early 19th centuries rural settlements and extraction industries (farmsteads, mills, furnaces), and Revolutionary War fortifications comprise the many components of the Hudson Highlands and potential settlement data for GRASS applications.
problems will be addressed which were solved by GRASS and are representative of the kinds of applications possible with GIS programs like GRASS. At the USMA, the location of potential rockshelter sites was identified using environmental variables like distance to water, slope and aspect. At WPAFB, the location of undisturbed soils which had not been altered by installation construction was identified as a significant criteria for the location of archaeological sites, along with environmental variables like distance to water, elevation, and the agricultural productivity of the soils.

The installations were stratified based on environmental variables such as elevation, slope, aspect, soils, vegetation, and hydrography. From this, we generated a series of maps showing the distribution or co-occurrence of these variables on the installations. From these maps areas were determined for systematic field survey.

USMA

Available archaeological data from areas surrounding the USMA show a clear preference by prehistoric peoples for occupation of rockshelters and caves with varying degree of permanence. The settlement system is representative of a seasonal round with a riverine focus during the spring and summer, such as abundant seasonal fish runs. Fall exploitation was focused on the forest products in the uplands like nuts and deer. A summer/winter dichotomy in settlement focus corresponds to the spring/fall exploitation patterns with summer occupation of the upland zone located in areas which can exploit the prevailing winds for their cooling effects but generally as ephemeral camps logistically tied to larger riverine basecamps and settlements, typified by the aggregation of several smaller groups. Conversely, the winter focus is characterized by intensive utilization by small groups of rockshelters protected from the northwestern prevailing winds. Locations on the installation which are potential rockshelter sites were identified through computer applications available in GRASS. Using the digital elevation model (DEM) for the installation, slope and aspect map layers were constructed. First, slope data were used to identify all areas >20 degrees slope. This would identify those areas with sufficient gradient to contain cliff faces, or potential rockshelters. This new data layer (>20 degrees slope) was used as a mask and overlayed on the distance from water model. This identified all areas of greater than 20 degrees slope within 300 meters of water. The last step in the process was to combine this data layer with a subset of the aspect data.
containing southeastern (winter) aspects through the use of the Gcombine application of GRASS. This final data layer identifies all areas which fit the winter rockshelter criteria suggested in the archaeological literature for the Hudson Valley (Funk 1976). In the Hudson Highlands southeast facing rockshelters have the highest probability for winter prehistoric occupations. The results of this research will contribute to general models addressing environmental variables that determine prehistoric rockshelter locations (Hall and Klippel 1988; Fig. 3).

To test the consistency of the rockshelter model over the entire installation, a second approach was used to identify cliff faces and potential

Figure 3. Location of potential winter rockshelters at the United States Academy, West Point
rockshelter locations. This approach involved the "neighbors" application to identify those cells which exhibited a rapid increase in elevation compared to their neighbor cells, which instructed the computer to identify edges in the elevation data. With this application the user can define the neighborhood to be considered, and the increment of increase in elevation or slope which is considered significant. In this instance, the cell resolution of the data is 25 meters. Therefore, a neighborhood of 3 cells represents a lineal distance of 75 meters. The increment of increase in elevation was 30 feet. Thus, if a neighboring cell had a net increase or decrease in elevation of 30 feet or more compared to its neighbors it was assigned that value and the process was repeated for each cell in the map. This new map layer was then recalculated against the original elevation map using Gmapcalc with the expression Gmapcalc "cliffs=(maxelev-elev)>n" where maxelev is the output from the neighbors application, elevation is the original DEM and n equals the user specified increase considered significant, in this case 30 feet. The output of this application is a cell map which identifies edges in the data on elevation. The cliff cell map was compared to the winter shelter cell map to see if they correspond. The correspondence between the two approaches was very close, considering the fact that the winter shelters maps only represented the south-east quadrants of the aspect map.

The winter rockshelter maps were sampled using Grandom to produce a 1% sample of this survey stratum, including potential rockshelter locations. In addition, data sets were combined representing 1% of the total area of "high probability" locations generated using the Grandom application of GRASS. The remaining areas of the installation were considered "low probability" for identifying prehistoric sites. The firing ranges and off-limits training areas were removed from the remaining sample and a 1% sample of "low probability" areas in 100 meter x 100 meter grid squares was selected. These two sample sets were then used as the basis for an archaeological survey of the installation.

WP AFB

An examination of the Soil Conservation Service (SCS) data for WP AFB showed that much of the original land surface on the installation had been altered during the construction of facilities and airstrips (Figs. 2 and 4). A time-sensitive model was constructed from an analysis of the known archaeological sites in the WP AFB vicinity. From this model the installation was
stratified into zones based on elevation, distance to water and soil type. Of particular importance was the distribution of agriculturally productive soils for the location of Woodland, Late Prehistoric and Historic sites. Many of these soil types had been disturbed; nevertheless a soils map was digitized. From this data layer an undisturbed soils map was generated through the GRASS
This was then used as a mask for the further analysis of potential prehistoric site locations on the installation. A 10% sample of the installation's 8000 acres was assigned in high and low probability areas. An archaeological survey is currently underway and results will be compared to the probability model for further refinement and retesting.

The three elevation/physiographic zones (floodplain, terrace and upland) were useful in insuring that sample areas covered the variability exhibited on the installation. Survey for each general time period covered all elevation zones and were selected from areas with undisturbed soils. Low and high probability areas were defined in relationship to distance from a water source that included the Mad River and related streams. Those undisturbed soils >300 meters from water were considered low probability for Archaic basecamps and most upland hunting/extraction camps. Areas of undisturbed soils >300 meters from water in unproductive agricultural soils were considered low probability for Woodland and Late Prehistoric sites. These criteria obviously overlap but do allow some control over both the temporal/cultural and environmental variables like soils and distance to water. By surveying some areas which we consider both high and low probability we can refine and test these variables.

** Figure 4 shows the areas selected for archaeological survey at WPAFB. The 400 acre tract shown in the southern portion of the installation falls within disturbed areas but is a high impact zone for proposed construction.
using RIM, a public domain relational database developed at the University of Washington. An interactive interface has been developed for RIM by Central Washington University which allows database records to be queried and displayed graphically on GRASS generated map layers within the GRASS application "dbsites." This database contains both the management and environmental criteria allowing all known sites on the installation to be displayed along with their database record. New records can be added by filling out the site record forms within the dbsites interface providing cultural resource managers the ability to keep the database current and to refine probability models of archaeological distributions on their installations. By using the Gwhat-f application in GRASS a site list can be piped through a series of map layers generating the environmental attributes at each site for up to 15 different map layers. This can then be read into RIM and combined with existing data records to produce a database that can then be loaded into dbsites. The end result is a database which is fully interactive with GRASS and can be updated and queried as new research problems arise.

Discussion and Conclusions

The cultural overview and environmental analysis in GRASS have provided a working model for cultural resources management at the USMA and WPAFB. The assemblages identified to date represent Late Archaic through Historic components. On the USMA there was an extensive prehistoric occupation in both rockshelters and in open areas dating to the Late Archaic and Late Prehistoric Periods. The majority of sites also contained later Revolutionary War and early 18th century materials. Major settlement patterns include an Archaic and Woodland occupation of the Highlands and riverine areas but generally on a seasonal basis. Early American settlements have higher frequency on all of the major streams which flow into the Hudson River. These occupations represent both farmsteads and small industries. A third major component is the Revolutionary War fortifications, redoubts and hut cantonments which were placed in strategic areas on the sides of the river and on the western side of the installation. A final component is the Academy itself, with numerous historical structures.

Based on GRASS research a general probability model can be proposed and buttressed by the ethnohistorical evidence and our archaeological survey. Three environmental zones can account for the major subsistence foci and for
the majority of prehistoric and historic settlements in the USMA: the Hudson River and Constitution Island, feeder streams and their bottomlands, and the sheltered uplands known as the Hudson Highlands.

The upland forest areas which were exploited as hunting and collecting areas reflect the availability of this site type usually in conjunction with the larger sites located near the river north and south of the installation. This zone includes numerous rockshelters and overhangs adjacent to a number of streams, marshes and ponds and made this zone a productive area despite the rugged topography. Mast forests were rich in edible nuts, roots, fruits, and building materials and in animals such as deer, elk, bear and turkey. It is suggested that rockshelters served as habitation sites during the winter during the Archaic Period. In the Hudson Highlands, and as reported from other sections of the Eastern Woodlands, rockshelters were favored habitation and processing sites (Hall and Klippel 1988).

The expanses of floodplain conducive for large villages and agricultural fields important in later periods are rare. Sites located in valleys or river bottoms served as summer base camps. From these locations prehistoric inhabitants most likely exploited the uplands and mountains of the Hudson Highlands. While we can say that these were preferred habitats for specific subsistence strategies we do not have the temporal data to document changes in the use of these areas from Archaic through Woodland. Our study, designed to assess the archaeological resources of the installations, targeted both high and low probability areas. It is clear that zones removed from the Hudson River Valley were utilized extensively in the West Point area.

Based on our Grass maps and on available archaeological evidence from the Mad River region (WPAFB), it was proposed that all groups would select areas for semi-permanent residence within 300 meters of a water source. Prehistoric vegetation reconstructed from soil types in the area is very general but does provide some baseline. Terraces and uplands not flooded annually contained hardwood species. Terraces contained the most diverse ecotones and abundant resources. Habitation sites are understandably more frequent in this zone.

The Archaic and Woodland/Late Prehistoric Periods of prehistoric occupation formed two very general divisions for the survey designs. As discussed above, general trends in the settlement systems for these occupations can be assigned for the Mad and Ohio River valleys and to a certain extent their tributaries. Smaller tributaries are more problematic due to the lack of
systematic archaeological survey in the area and its proposed utilization by prehistoric populations.

The speed with which GRASS can manipulate diverse data sets and produce a series of survey models is a tremendous asset to archaeological research design and field testing. Traditional approaches might indicate that most sites are situated on or near terraces, rockshelters, and marshlands; however they are limited in their analysis of environmental variables. GRASS map layers can utilize the co-ocurrence of variables and the potential relationships between environmental data and archaeological site location. The use of programs like GRASS in conjunction with archaeological survey provide a powerful analytical tool for the development of preservation plans for the USMA and WPAFB, offering archaeologists an interpretive environment for analyzing a region or installation's cultural resources.

REFERENCES


ARCHAEOLOGICAL DATABASES IN THE NEW ORLEANS DISTRICT

Edwin Lyon, Michael Stout, and Van Button*

Introduction

The cultural resources management responsibilities of the New Orleans District of the U.S. Army Corps of Engineers (NOD) have, for the Corps at least, an unusual structure. This reflects the complicated geography of southern Louisiana. Meandering rivers and changing wetlands and coasts dictate overlapping linear projects. New Orleans has the largest civil works program of any Corps District and has not one reservoir and attendant block of fee lands to manage. NOD has surveyed project lands for cultural resources for nearly twenty years, including main line levees, hurricane protection levees, dredging, erosion control programs, and other projects. These surveys have produced a large amount of site data and maps.

This complexity means that computerized information management and mapping hold considerable appeal to NOD. Computerized records help us to more effectively use previously acquired data and avoid repetition in surveying. It means we can readily retrieve such information as may exist on newly identified impact areas for ongoing construction, operational projects and planning studies. In theory, at least, it makes it easier to actually do research with the ordinary data collected for mundane compliance purposes. It also makes it easier to keep data current.

Cultural resource computer databases used by the New Orleans District include: a database of historic sites, archeological sites, and historic structures for Plaquemines Parish (GOPHER); a version of the Louisiana State archeological site database (LACAD); and a comprehensive database of Louisiana shipwrecks on navigable waterways within NOD. In addition to database files, we also use sets of U.S.G.S. quadrangle-based layered Intergraph design files for both the Plaquemines Parish and Baton Rouge areas including boundaries of cultural resource surveys and Corps projects, site locations, and other geographic data. These files were created by contractors in AUTOCAD and translated into Intergraph design files using the DXF (Data Exchange File) format. The New Orleans District, in common with most of the rest of the Corps of

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Engineers at the present time, uses Intergraph Computer Assisted Drafting (CAD) packages for much of its design and other mapping work.

The Louisiana Comprehensive Archeological Database

A frequently used database is the Louisiana Comprehensive Archeological Database (LACAD). The State Archeologist's office began work on computerizing the State site files in 1986. In 1988 completion of this project was funded by the New Orleans and Vicksburg Districts who share responsibilities in the State of Louisiana. Because NOD is the single most frequent user of the site file, support for computerization quickly paid for itself by avoiding research trips to Baton Rouge.

The procurement was structured as the acquisition of a generic "job" via purchase orders, one for a database of NOD's parishes (or counties as they are known outside of Louisiana) and another for the Vicksburg District. Our procurement encountered certain problems. The action was a small purchase (under $20,000). The contracting personnel assigned the job lacked previous experience with archeology or acquiring professional services. Our justification for sole source was ignored and all comers were solicited in the Commerce Business Daily (CBD). When we discovered this we complained to the contracting specialist. "Everyone always wants sole source," she said. Trying to explain that it would be hard for a firm other than the State Archeologist to provide an official copy of the State Archeologist's files did not work. "Well," she said, "if that's so, then no one else will respond, right?" Seventy requests for the scope of work arrived in the first week the notice ran in the CBD. Most looked untouched by human hands, as if they had been generated by a computer program. Contracting responded by cancelling the procurement advertisement, and the job was awarded sole source to the State Archeologist's Office.

Since that rocky start, the project has been uneventful. The LACAD database is a dBase III PLUS file of more than 3,000 records. The complete database for the New Orleans District takes up two megabytes of space on the hard disk of our government-issue Zenith 286 PC clone. Back-up is provided by a copy of the record on a separate set of floppy disks. We use the Cultural Resource Information System (CRIS) developed by the U.S. Army Construction Engineering Research Laboratory to access the database rather than a software shell provided by the State Historic Preservation Office (SHPO). Each record
in the IACAD file is a set of typical State site form entries for an individual archeological site.

We are using the database regularly, albeit simply. A typical use would involve evaluating the impact of a project consisting of three miles of channel dredging and disposal of dredged material on four parcels of adjoining marsh totaling 110 acres. IACAD would be accessed to provide information on the five sites shown on conventional maps to be in the project vicinity. The IACAD data would be used for the material to write a simple descriptive paragraph for the cultural resources section of an Environmental Impact Statement.

IACAD, in its original form, had certain structural problems in common with many georeferenced databases (see Peucker and Chrisman 1975:55*). Problems occur when data is coded without attention to the kinds of analyses which are planned. Solving the problem of how to adequately represent, in computerized format, the reality the data describe, is all too frequently an exclusive focus. Unfortunately, choices in how computer data files are structured can make some kinds of analyses difficult or even impossible.

IACAD's structure was built around description of the components of sites. Thus each component had a set of subfields pertaining to it. Cultural affiliation, for instance, was recorded in seven fields each with 21 acceptable values. It was cumbersome to do any search of the database related to cultural affiliation (for example, how many Paleoindian sites exist?). To do this the computer had to search through the entire database for each of the seven fields. This slowed searches down and made the programming commands for simple Boolean searches irritating (SELECT IF (culafil_1 = paleo, OR culafil_2 = paleo, OR culafil_3 = paleo, OR culafil_4 = paleo, OR culafil_5 = paleo, OR culafil_6 = paleo, OR culafil_7 = paleo).

To escape this unpleasantness we created a single compound field for attributes coded by component. It is a single field for cultural affiliation with seven blocks of space (one for each potential component) separated by colons. This allows searches to be done by the expedient of string searching the single field in lieu of searching each of seven fields. Doing the same for the other data coded by component compressed the entire database, and sped up computer searches.

It is particularly important to use such file compression tricks with archeological databases. Archeological data differ in structure from the economic and behavioral data for which standard statistical and database manipulation packages are designed. Archeological files tend toward fewer records, but the records have a very complex internal structure. This complex internal structure poses daunting demands on computer memory. Eliminating unnecessary complexity makes analysis go much more smoothly.

Currently, we are working on a method to allow direct modem access to the Statecfile. The next logical step is cleaning up the database. The State was understandably very clear in specifying that the database furnished was an accurate copy of the paper records, but that correcting all errors in the paper record was a separate project not financed by NOD. The most exasperating errors are erroneous UTM coordinates.

Security concerns are addressed simply. The Louisiana State Archeologist has stipulated that the database will be accessed only by appropriately qualified archeologists. The data reside on a password-protected hard disk which only NOD archeologists can access.

How and what sort of access to provide other federal agencies is an unresolved issue of some concern. The State Archeologist feels that the Corps may be perceived as receiving special treatment. We do not feel that is a problem (naturally). We bought and paid for entering data into LACAD. The State is responsible for quality control and updating. The State's legitimate concern relates to releasing versions of the database, and hence losing control of it. They are legally responsible for the accuracy and security of the data. Once a copy of it is out, regardless of promises or guarantees, that security can no longer be given with absolute assurance. It is exactly the computer records most pronounced benefits, the ease of manipulating and accessing massive quantities of data, which pose the gravest risk of compromise.

Shipwreck Database

A second major information resource in NOD is the Shipwreck Database. This database is a dBase III PLUS file of all recorded shipwrecks within the boundaries of NOD. The project accomplished two goals: identifying high probability waterways for historic shipwrecks and determining if guidelines for assessing significance of shipwrecks can be developed. At present, the
database has 1800 records. Most are historic wrecks (i.e., pre-1936); however, modern sinkings are included as well. Post-1936 vessel sinkings were included for two reasons. First, a ship sunk after 1936 could easily date to the nineteenth century and thus be of historic value. Secondly, the locations of modern sinkings are of value in assessing magnetic and sonar anomalies.

The creation of the database was part of a larger effort to develop management guidelines for underwater resources in our district. These guidelines were needed for two basic reasons. First, due to the unique geography of south Louisiana, its history has been molded by water transportation. Boats have played, and continue to play, a significant role in the social and economic life of the region. Secondly, the Louisiana SHPO provided little help in terms of expertise or guidelines in dealing with underwater resources. The passage of the Abandoned Shipwreck Act of 1987 has enabled the SHPO to take a much more proactive stance to underwater cultural resources. The SHPO has added an underwater archeologist to his staff and has prepared a plan for managing underwater cultural resources.

The database was created through a delivery order under an indefinite quantities contracts which also required the preparation of an historic overview of waterborne commerce organized by waterway, and evaluation of shipwrecks by type in terms of historical importance and research potential. This effort began in August 1987 and was completed in 1989. The preparation of management guidelines was scheduled to follow the contract effort.

The first task in the development of this database was the accumulation of funding for the contract. Funds were garnered from various projects with the potential for impacts to historic shipwrecks. The next step was the preparation of a scope of services and, finally, negotiation of the contract. The total costs for the contract including the historical research and database creation was $68,000.

The data structure was developed by the contractor based upon his review of existing computerized archeological databases, especially the Texas shipwreck database. The structure contains 50 fields, divided into four groups: locational information (19 fields), vessel description (16 fields), wreck site information (6 fields), and documentation (9 fields).

A number of data sources were utilized for compilation of the shipwreck records including published wreck lists, cultural resource investigations involving shipwrecks, historic maps showing wreck sites identified, and selected literature containing data on wreck locations.
Several significant management objectives were realized with the comple-
tion of the database and the accompanying historic overview and analyses.
First, the database provides a complete and immediate inventory of recorded
shipwrecks which can be searched through any of the 50 fields. Thus, searches
can be performed by waterway or segments of waterways, by UTM coordinates, by
vessel type, by date of loss or construction, or published reference, etc.
Secondly, the report serves as an initial historic overview for every navig-
able waterway in the New Orleans District.

Each stream was assigned a shipwreck probability rating. It is impor-
tant to note that these shipwreck probability assignments are not based solely
upon the presence or absence of recorded shipwrecks. This is due to another
of the significant findings of this research effort; that is, the recognition
that the historical record of vessel sinkings provides only a biased and
incomplete sample of the archeological database. This recognition is the
result of three underwater resource surveys conducted in the NOD over the past
few years where a total of 14 wrecks were recorded in the literature, but
142 were identified in the field. Analysis of the database reveals that the
historic record is heavily biased towards large commercial vessels and against
smaller commercial, local, and folk boats.

The assessment of probability for significant underwater resources uti-
lized several complementary data sets. These include: (1) the number of
known boat wrecks in a waterway identified in the historical record; (2) the
intensity of vessel use and waterborne commerce on a waterway as documented in
the historical literature; and (3) the natural and human impacts on shipwrecks
along individual waterways. Utilizing these criteria, a range of probability
zones were assigned to the various waterways. These probability rankings,
however, must be viewed as preliminary. Future surveys can not be limited to
those waterways presently assigned moderate to high probability until an ade-
quate sample has supported the assessment criteria.

Finally, the database and resulting analysis of its content provides a
district-wide basis for significance evaluations by vessel type. The compila-
tion of the widely dispersed information on historic shipwrecks allowed the
development of an evaluative framework for individual wreck sites.

Upon completion of the contractor’s draft report and database, it was
employed in several remote sensing surveys performed in advance of proposed
dredging of the Atchafalaya River. Two aspects of these surveys are of rele-
vance to this paper. Because the overview and shipwreck inventory was
available, it was not necessary to perform project-specific historical research in advance of the surveys. This resulted in an estimated cost savings of $20,000 to $30,000. The other aspect of interest was the discovery of twelve historic vessels along Bayou Shaffer, a waterway with no recorded shipwrecks in the historical literature. It's important to note that the historical research also failed to document any significant navigation on Bayou Shaffer. Thus, this bayou was not even included in the list of navigable streams with a probability of containing historic vessels. The study results provide further confirmation of the failure of the historical record to accurately represent the archeological resource base, and the dangers in applying the preliminary probability assessments.

A number of shortcomings limit the use of the Shipwreck Database. The first is, GIGO (garbage in, garbage out). The fragmentary nature of the historic record limits the precision of the database and cautions against careless application. Second, the locational data available are very unreliable. Most shipwreck reports are vague, containing such locational descriptions as "five miles below New Orleans" and "near Morgan City," etc. Reported loss locations do not necessarily match present archeological position.

Third, typology assignments are made difficult by the inconsistent application of terms through time and by different authors. Finally, the database is largely a listing of unconfirmed wreck locations - less than 1% have been examined.

We are now formulating special area studies based upon patterns recognized in the Shipwreck Database, such as identifying Mississippi River ports, potential ship graveyards, or particularly difficult navigational reaches for 19th century vessels.

**Future Directions**

Our plans for the future involve creating a Geographic Information System (GIS) which will be accessed using Intergraph hardware and a variety of software systems. This will allow us to use data from dBase III PLUS files such as SHIP and LACAD. We are working toward an integrated set of digitized maps linked to specific cultural resource data. These data will include at a minimum resource locations, survey boundaries, Corps lands, and a basic set of geographic data (e.g., major rivers and streams, soil associations, geological features). It will take several years to reach this goal for the entire
district. We have learned from the archeological databases we have developed, and we are building on our experience to develop improved systems to manage archeological data.
Introduction

Rock Island District Geographic Information System (GIS) specialists in conjunction with the District Archeologist undertook a project to demonstrate the use of GIS as an integrated approach to the management of cultural and natural resources. A spatial database was created for a 10 mile stretch of the upper Mississippi River including political boundaries, roads, hydrology, real estate tracts, archeological site and survey locations, forestry data, and aerial photography. Information pertaining to these resources traditionally has been kept on maps at different scales, sometimes with different projections, which are archived at the agency responsible for each particular resource. In some cases, the information is kept as text. GIS provides a technique for storing spatial information and ancillary data in digital form, enabling input, display, editing, report generation, and map production.

Background

The Rock Island District is located in the Corps of Engineers North Central Division (CENCR) and includes the eastern two-thirds of Iowa, the northern half of Illinois and small portions of Missouri, Wisconsin and Minnesota. The District headquarters is located in the Clock Tower Building, an 1868 structure which is part of the Rock Island Arsenal Historic Landmark District. The Rock Island District's major land holdings include three reservoir projects in Iowa and approximately 63,000 acres of land adjacent to 12 pools of the Upper Mississippi River.

To date the District has completed sample archeological surveys, geomorphological landform modeling, and cultural resource management plans for the three Iowa reservoirs. The management plans were completed by three separate contractors in 1984 and 1985. Each contractor used different approaches to consolidating many decades of data into a useable plan. Archeological site

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data from the Saylorville Reservoir was compiled into an Apple computer based data system, later transferred by the U.S. Army Construction Engineering Research Laboratory (CERL) to run under the IBM based ASIS program and has been most recently modified and updated for use with DBASE III plus by District Staff. Geographic information was not automated at Saylorville.

The Coralville Reservoir Management plan represented the District's first large scale use of a computer automated system for geographic data. Mapping for the entire project area was accomplished with a computer aided drafting and design system (CADD) and included 33 layers of information relevant to geomorphological landforms, topographic and cultural features from U.S.G.S. 7.5 minute quadrangle maps, Universal Transverse Mercator coordinates (UTMs), a project wide great grid based on 1000 meter units keyed to UTMs, and archeological survey and site locations. For more detailed information on the Coralville GIS, the reader is referred to a paper presented at the U.S. Army Engineer Topographic Laboratory's Workshop on GIS in the Government, which was held in Springfield, Virginia.* More recently this entire database has been updated based on additional survey data and converted to run on the District's MASCOMP Computer using the Geographical Resource Analysis Support System (GRASS) software developed by CERL.

Archeological sample surveys, historic overviews and geomorphological landform modeling has been completed for seven of the District's twelve Mississippi River pools. Historic overviews and geomorphological modeling have also been completed for two additional pools as a baseline for future archeological pool surveys along the river. The balance of this paper discusses a recent study conducted to assess the viability of creating a spatial database with this information.

Problem

The National Historic Preservation Act requires Federal agencies to inventory and protect historic properties on their lands. It also requires them to consider the impact of their actions on significant historic properties, including archeological sites. Rock Island District activities along the Mississippi River which may have such effects include channel maintenance,

recreation facility development, forestry management, real estate outgrants, issuance of special use permits, and issuance of regulatory permits under the Clean Water Act.

Each of these distinct CENCR activities is graphically represented, often on maps from different series and at different scales. To assess the impact of these actions on archeologically sensitive areas, it traditionally has been necessary to seek out the numerous volumes of maps and data relevant to the action and compare them with the archeological information which is plotted on the 7.5 minute U.S.G.S. maps. This required the manual manipulation of many pages of large and often awkward maps and the visually difficult task of matching project locations from maps of differing scales.

As a solution to this problem the District assessed the capability and cost effectiveness of creating a spatial data base with this information. One aspect of the project was to assess the practicality of training and using student aides to input primary map data. This was important for future recommendations due to the present CENCR work load and the need to accomplish CENCR missions in an efficient manner.

Extant Information and Equipment

1. District GIS Background. Since September 1986, CENCR has been operating the GRASS software with image processing capabilities developed by CERL. This software enables planners, resource managers, engineers, and scientists to input spatial data and to store, display, update, correct, analyze, and output maps and reports. National High Altitude Program (NHAP) color infrared aerial photography for all CENCR river miles along the Mississippi River and Illinois Waterway at a scale of 1:58,000 has been scanned optically and digitized to create a spatial data base. Approximately one-third of the U.S.G.S. 1:24,000 scale quadrangle maps have been digitized manually to create additional data including: the sailing line, political boundaries, hydrography, roads, rail-roads, and public lands.

Previous GIS projects within CENCR include modeling placement of dredged material; determination of potential borrow areas; remote measurement of water quality parameters; cultural resource management at Coralville Lake, Iowa (previously discussed); and evaluation of habitat areas at Bay Island, Missouri.
2. District-Specific Information. Rock Island District's Real Estate Division had information on all lands under Federal ownership or with Federal easements. The Environmental Branch of the Planning Division had maps showing historically identified archeological sites and sites discovered during the recent Pool 17 and 18 archeological surveys. Conservation land usage information also was available, as was information on the boundaries and characteristics of forest compartments which had been compiled by CENCR Operations Division's foresters. For consistency with standard archeological procedures, township, range, and section lines were added in addition to the UTM positional information.

Pursuant to Section 110 of the National Historic Preservation Act, CENCR has completed systematic archeological sample surveys for seven of the twelve Mississippi River Pools located in CENCR. In conjunction with the pool surveys, geomorphological landform modeling and historic archival documentation was developed. The archeological survey of Pools 17 and 18, which includes the present project area, resulted in the documentation of approximately 150 archeological sites.

The objective of the current project was to demonstrate the use of GIS in an integrated approach to management of cultural and natural resources. To this end, it was necessary to obtain, enter, organize, and analyze data within a spatial data base, providing archeologists and other managers with a tool to more efficiently and effectively monitor and manage cultural and natural resources.

Study Area Selection

The following considerations were determined to be most important in the selection of an area for this project:

1. That all levels of geographic information desired for the project were currently available at CENCR;
2. That the most current archeological data available in CENCR covered the project area;
3. That upcoming CENCR actions, including timber sales and execution of a Shoreline Management Plan, would affect the area; and,
4. That data for each level of information proposed for digitization in this area were relatively complex. Thus, estimated person/hour projections for future digitization projects would provide an upper limit rather than be unrealistically low.
These considerations resulted in selection of the Toolesboro, Iowa/Illinois quadrangle as the study area.

Data

1. Aerial Photography. NHAP color infrared transparencies had been purchased previously from the U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service (ASCS) and scanned to create red, green, and blue files. A 100-micrometer scanning interval was used to create 5.7 meter pixels. Data are available as three files, one each for the blue, green, and red information in the color infrared transparency, representing green, red, and reflected infrared information from the land surface.

2. Linear Data. U.S.G.S. 1:24,000 scale color separates were used as source material for digital information on: the sailing line, political boundaries, hydrography, roads, railroads, and public lands. A contractor digitized this information and converted it to a modified form of digital line graph (DLG) optional format 3, which is accessible by the GRASS software. This information had been digitized previously and contributed to the selection of Toolesboro as the study area.

Procedures and Implementation

The NHAP transparency first was rectified to serve as a base map. Using 15 points for the rectification, the root mean square error of the residuals was approximately 2.3 meters. The data were resampled to create 5 meter pixels.

Vector information was included from tape, as digitized by the contractor. Other vector layers were digitized by a student aide and the GIS specialist, and labels were attached. Individual map layers were displayed and printed in hard copy to check for accuracy in reference to the rectified image.

Computer files containing information relevant to the various data layers were generated. Macros were written to output maps depicting: (1) archeological sites overlaid on the base aerial photo and their location by legal section; (2) the location of archeological sites within forest compartments; and (3) the location of known archeological sites in relation to surveyed areas. Slides and printouts were generated as hard copy. Tabular information was produced for reference, as required. Acreage of the forest compartments in the Toolesboro spatial data base was calculated and compared with existing data, verifying the accuracy of the technique.
Discussion

The utility of creating spatial data bases, such as Toolesboro, will be dependent on the number of managers, representing the various CENCR activities, who are willing and able to use the data base created. Benefits will continue to accrue, with the proportional share of total cost decreasing with each addition of information to the data base. Concurrently, the additional data will increase the data base's value for subsequent users.

Through increased understanding of the interrelationships between the discrete types of data within spatial data bases, GIS becomes one of the most powerful management tools for the future. Economic and recreational use of federally owned lands must be balanced against the benefit of managing and protecting the nation's historical and environmental resources for present and future generations.

Hardware and software costs are falling at the same time as technological improvements are occurring. This combination of events likely will result in projects of this type proving less costly and more efficient and result in increased availability of data in a digital form.

Conclusions

This project resulted in the creation of a data base containing information within the boundaries of the Toolesboro, Iowa/Illinois quadrangle. Two scanned rectified NHAP aerial photos serve as the base map. Digitized vector layers created are: (1) hydrology; (2) roads; (3) sailing lines; (4) county boundaries; (5) public land; (6) legal section lines; (7) real estate tracts and easements; (8) archeological sites; (9) archeological survey sites areas; (10) forest compartments; (11) legal section lines; and (12) conservation land.

The successfully integrated available data in cell (the NHAP image) and vector format are compatible, enabling visual examination of vectorized information over an aerial photograph. By converting the vector files into cell files, a variety of analyses were successfully performed. These included: visual representation of proximity of present archeological sites to areas already surveyed (and ownership in areas known to contain archeological sites), lands available for conservation projects which do not include
archeological sites, and types of landforms on which the particular archeological sites of interest are situated.

Knowledge was gained on the time required to generate a data base of this type. The practical experience of doing such a project has provided insight into its degree of difficulty and the resource outlay required to accomplish it. It was proven that information, either limited or very complex, can be integrated to help manage cultural resources. It indeed is feasible to use student aides for data development, provided quality assurance and quality control procedures are employed by GIS technical staff to ensure the validity of the data created. GIS technical expertise is essential where analyses are performed utilizing the data.

A detailed time and cost analysis of the data base development has not yet been completed. It is obvious that some data are more costly to input due to their complexity, but the value of these data is generally proportional to the cost. Due to GIS expansion in government and private sectors, more vendors of data are entering the marketplace. Our work suggests that costs be scrutinized for each data class, with the costs and benefits of data developed internally compared to the costs of data developed by vendors. Exchange of data also may provide economical data from other sources.

Future Directions

In the near term, future projects likely will involve a similar approach, with the development of project-specific information for small areas around particular project sites. As this process continues, these areas will be patched together along their edges to create data bases encompassing larger portions of the rivers. Some areas of CENCR will not require highly detailed information, but it is anticipated that satellite images or aerial photography and vector data available from U.S.G.S. and other sources will be incorporated into these areas as they become available. While it would be ideal if highly detailed information were available for all of the river miles within CENCR, acquisition of such data would be cost prohibitive and would involve information about many areas which are not related to current CENCR missions.

CENCR has recently acquired a Sun Spark 4/60 workstation and ARC/INFO software. Using this equipment we have successfully imported archeological site data from the Illinois State GIS database. The digital geographic data covers the entire Illinois and Mississippi River corridors in Illinois within
the Rock Island District. The successful importation of data from the Illinois database is an important first step to negotiating access to a diverse state database. Once acquired it will provide valuable input to all CENCRe activities within the State. The Illinois Archeological site data is the largest single layer within CENCRe GIS.
MANAGING THE CULTURAL LANDSCAPE: A GEOARCHEOLOGICAL APPROACH TO CULTURAL RESOURCE MANAGEMENT

Robert A. Dunn and John Riggs*

Introduction

In the face of shrinking operational budgets and increasingly more stringent Federal regulations, it has become imperative for the Corps archeologist to identify and protect high site potential areas from disturbance when the money for intensive archeological surveys is not available. The weak link in the cultural resource management chain has always been the down-time spent waiting for funds or manpower to inventory lands for cultural resources. This is particularly true at military installations where the prevention of land impacts may be beyond the control of the Federal land manager given the responsibility for the protection of archeological sites. By the time funds are appropriated and scopes of work prepared for archeological survey contracts, archeological sites have been destroyed by construction, vehicular traffic, military maneuvers, and a host of other impacts.

One approach to Cultural Resource Management (CRM) which has been successful in identifying high site potential areas incorporates a geomorphological analysis of the landscape. The goal of this kind of analysis is twofold: first, to delineate the geomorphic features present, i.e., the landforms; and secondly, to understand the geomorphic processes which created that landscape. Once the geomorphological analysis has been completed, it can be tested through archeological investigations specifically designed to identify cultural deposits and buried surfaces which would have been available for prehistoric occupations. The end result of this two-stage effort is a geomorphologically derived model of site distribution; in essence, a probability statement about where cultural deposits are most likely to be encountered on the landscape.

This site distribution model subsumes two important components: 1) site selection by the aboriginal inhabitants of the landscape and 2) site preservation (i.e., which subset of sites has been preserved through time). In terms

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of the aboriginal inhabitants' site selection, the model must be ecological in nature, i.e. "archeology as human ecology." In terms of the preservation of the cultural deposit, it is "taphonomic," i.e. "archeology as paleontology." This linkage of ecology and geomorphology is not new. Butzer (1982:260-264) described a landscape approach to settlement and survey very similar to the one advocated here:

On completion of such an archeological landscape survey, site patterning can be evaluated in terms of preservation, spatial lacunae, concentration in specific landscape units, and relation to potential biotic resources, which can be simulated from soil data and substrate conditions reflected in the satellite imagery. The groundwork has now been laid for a more comprehensive settlement analysis and systemic interpretation. Detailed excavations at one or more sites, coupled with a bioarchaeological research program, become appropriate at this state (Butzer 1982:264-265).

This last point is an important one. Management must mean more than just avoidance of impacts. Archeological resource management involves both the allocation of money and a careful consideration of how to maximize the scientific results of costly investigations. We are used to hearing that the Corps of Engineers is "not in the business of archeological research." Archeological survey and excavation is done only to comply with myriad Federal laws. The important thing is to "be in compliance." Today, this perspective is changing, focusing less on legalistic compliance and more on the spirit of the National Historic Preservation Act and the National Environmental Policy Act.

The management approach we present here has this research emphasis. Federal land managing agencies must do research within reasonable budgetary constraints. The question is, "How can we do this most effectively and efficiently?"

What is the Geoarcheological Approach?

Beginning with Executive Order 11593, Federal agencies were given the mandate to inventory, evaluate, and nominate to the National Register all significant historic properties. Most Federal agencies, including the Corps, were extremely slow to undertake systematic attempts to locate archeological sites. They looked to the National Park Service (NPS) both for guidance and implementation. The Corps transferred funds to NPS in the early years to undertake sample surveys. Most surveys at this time were compliance oriented,
triggered by particular construction projects, many involving reservoir construction. The lack of an in-house archeological staff within the Corps exacerbated the problem.

The passage of the Archeological Resources Protection Act (ARPA, P.L. 96-95) in 1979 and the 1980 amendments to the National Historic Preservation Act (NHPA, P.L. 96-515) made cultural resource management a new mission for other Federal land managing agencies, including the Corps. Section 110(a)(2) of the 1980 version of NHPA codified the recommendations of Executive Order 11593. More serious attempts began to be made to comply with the law requiring archeological inventory surveys and the evaluation of archeological sites, both prehistoric and historic. Still, there was no implementing regulation and no clear guidelines from the National Park Service or the Advisory Council on how to accomplish this mission. Not until 1987 did the Corps issue Engineer Regulation 1130-2-438 which gave clear guidelines to Corps districts on how to implement Section 110 of the NHPA of 1980. The National Park Service guidelines to all Federal agencies on Section 110 came out in 1988, a full year after the Corps had acted.

The archeological surveys carried out in the Little Rock District throughout the seventies and early eighties were fairly typical of what was done across the country. Inventory surveys, those not linked to specific construction projects, were most often sample surveys incorporating some type of ecological stratification. Even though the New Archeology was at its peak in academic circles, surveys with a precise research question orientation were rare. The "research" question was simply this: "What kind of cultural variability exists in the project area and how best can we sample it in a statistically valid way?"

Sabo (1981) illustrates this approach in A Manual for Archeological Surveying in Northwest Arkansas:

Climate, topography, soils, drainage patterns, vegetation patterns, animal distributions, and a variety of other factors all have an important effect on where human populations choose to live and where they carry out their daily activities. An understanding of local environmental characteristics may thus provide clues as to where sites are likely to be found. It is necessary to recognize, however, that past environment characteristics may have differed significantly from modern conditions (Sabo 1981:2).

The emphasis here is on site selection rather than site preservation. There is no explicit geomorphological consideration except for rare statements like the following:
"Since the locations of sites almost never are distributed uniformly across the landscape, where sites are searched for may have a significant effect on what is found" (Sabo 1981:5).

As an intern at the Illinois State Museum in 1981, Dunn found that, in the Midwest at least, geomorphology and archeology had fused to form a new and dynamic subdiscipline known as "geoarcheology." Ed Hajic and Tom Styles in Illinois, as well as Art Bettis and Dave Benn in Iowa, had begun to incorporate increasingly more sophisticated landscape modeling in designing their archeological surveys. Their geoarcheological investigations attempted to understand the nature of site distribution across large portions of the Midwest which were being impacted by construction projects for reservoirs and highways.

Bettis, Benn, and O'Brien (1985:121) noted that temporal and monetary restrictions prevented total surface survey and extensive subsurface testing of large project areas. Models of both site distributions and preservation were needed to fulfill sampling strategies. Earlier studies (e.g., Butzer's work in the lower Illinois River Valley) had demonstrated that Holocene environments and landscapes were not stable and that archeological models for cultural adaptations in the Midwest had to consider the physical environment as a variable rather than a constant (Bettis, Benn, and O'Brien 1985:121). When the senior author started working for the Corps of Engineers' Rock Island District in 1983, he had an opportunity to work with Benn and Bettis at the Saylorville Lake project above Des Moines, Iowa. The great utility of this geoarcheological approach with its emphasis on understanding the evolution of valley landscapes became evident.

To bring the reader to the same point of illumination it is necessary to briefly discuss the "big picture" defined by Bettis, Benn, and O'Brien (1985:123). The so-called "big picture" involves the preconception of archeological materials in systematic geomorphological contexts. It derives from the belief that natural site formation processes cannot be adequately understood and explained from the perspective of an empirical study of one site. Benn and Bettis argue that site data must be combined with a clear understanding of geomorphological processes to form a model of the preservation and destruction of archeological materials in earthen contexts prior to attempting investigation of a specific site.

There are four important corollaries to the "big picture" approach as presented by Bettis and company:
1) the archeological record is a dependent variable in the geological system. Archeological deposits are subject to modification by geologic and pedologic processes;

2) due to the complex responses to fluvial systems, the presence, absence, or condition of specific deposits will vary according to their position within the drainage network. Archeological deposits are prone to the same conditions of complex response that formed and continue to modify the drainage network;

3) by conceptualizing the landscape in three dimensions, the volume that must be considered for archeological remains increases exponentially. Most notions of cultural settlement patterns and methods of sampling populations of sites must be considered outdated if they are based on a two-dimensional earth-surface model; and

4) because of the enormous volumes of sediment in which archeological sites may be buried, archeologists cannot realistically attempt to locate all sites, nor can the exact locations of buried or destroyed sites always be defined. What this means is that significant numbers of archeological sites may never be discovered. Therefore, in a geoarcheological approach, the initial stage of investigation involves developing predictions about where sites can and cannot exist because of landscape evolution.

Bettis, Benn, and O'Brien (1985:121) note that the geoarcheological studies which have been undertaken since the mid-1970s can be grouped into three categories:

1) prehistoric-landscape modeling;
2) assessment of the nature and/or completeness of the depositional record; and
3) site-specific studies aimed at understanding site-formation processes and prehistoric environments.

The work done so far in the Little Rock District has included all three categories, with greater emphasis on the first two since the last category comes more into play with data recovery/mitigation efforts.

The Approach to Landscape Modeling

An archeologically-sensitive geomorphological analysis of a project area can be expected to provide the following information to the land manager (Smith 1986:21):

1) information on the spatial and temporal distribution of geomorphic environments which may be of great use in predicting archeological site occurrence and extent over a large area;

2) information which will be helpful in predicting the probability of site destruction by natural geomorphic processes;

3) paleoenvironmental data critical to the evaluation of the cultural resources of a site or region;
4) a landscape/landform classification and delineation necessary to establish site-landscape/landform associations (using known sites);

5) guidance for the location of areas which are likely to contain buried sites; and

6) guidance for the location of areas which are likely to contain sites of specific ages or cultural components.

In essence, the geomorphological analysis creates a landscape model. The next step, and one which is critical for future success, is archeological testing of the landscape model. This provides the land manager with empirical verification of the site location model. This "landform testing" can incorporate surface-oriented pedestrian surveys, backhoe trenching, and mechanized coring such as the Giddings soil corer or the chain-drive Bull corer mounted on a highly mobile four-wheel drive truck. It may also incorporate remote sensing ranging from aerial photos to satellite imagery. In a practical sense, landform testing involves a carefully considered program of sample survey and excavation to provide ground truth to the geomorphological model for three-dimensional site distribution.

Because of the previously discussed corollaries of the "big picture" approach set forth by Bettis, Benn, and O'Brien (1985), managing landforms becomes increasingly more attractive when funds for 100 percent intensive archeological surveys are drying up. In the area of site inventory, a geomorphological approach provides a vertical (three-dimensional) dimension to archeological survey and allows the land manager to pinpoint certain areas for investigation while dismissing others. In the area of site evaluation, it gives us critical information on settlement patterning in three dimensions, particularly information on the temporal correlation of sites and prehistoric use of the landscape at different points in time.

Because of the enormous volumes of sediment involved, archeologists cannot realistically attempt to locate all sites, nor can the exact locations of buried or destroyed sites always be defined. Consequently, significant numbers of archeological sites may never be discovered. This is certainly true with surface-oriented statistical approaches. With a geoarchaeological approach, we increase the probability of finding sites through survey, but we also increase the probability of preserving sites by identifying, protecting, and carefully investigating high site-potential landforms. By managing the landform, we can do a better job of managing America's prehistoric heritage.
Management Implications

In 1986, the Geotechnical Laboratory at the U.S. Army Waterways Experiment Station (Vicksburg, Mississippi) hosted a workshop entitled "Application of Geomorphological and Paleoenvironmental Analyses to Corps of Engineers Cultural Resource Surveys." Attendees included archeologists from almost every Corps district in the continental United States. The primary objective of that workshop was to review basic concepts of geomorphology, especially how geomorphological data could be used in planning, conducting, and analyzing data from cultural resource investigation. Since that workshop, many more geomorphological studies have been conducted throughout the Corps to identify sensitive landforms and focus subsequent survey efforts on these areas. The ideas which have been discussed here may represent the next step, from survey of landforms to actual management of landforms. If this can be demonstrated to be a more effective, more efficient, and more cost effective way to manage cultural resources, it will truly have a significant impact on the way in which archeological resources are managed in this country.

The approach presented here is a logical extension of the "landscape survey" approach suggested by Butzer (1982:260-266). It also has many elements in common with what has been termed the "paleo-geographic approach" by Weinstein and Kelly (1984). Bennett (1987:10-3) describes the geoarchaeological approach as one in which the archeological record is a characteristic of the landscape, not the other way around. If the archeological record is composed of all those alterations to the landscape made by humans, it seems appropriate to view the landscape (composed of landforms) as the fundamental object of the management process. Dunnell and Dancey (1983:272) have argued that "the archeological record is most usefully conceived as a more or less continuous distribution of artifacts over the land surface with highly variable density characteristics." By viewing landforms as three-dimensional repositories for concentrations of artifacts, features, etc., many of the pitfalls of traditional cultural resource management can be avoided, particularly in the area of predictive modeling.

Critique of the Traditional Approach

Bennett (1987:10-1 to 10-13) provides a very creative and useful critique of traditional CRM from an archeological contractor's perspective. We
have chosen to include it here because as part of the "gray literature" of contract archeology it has not received wide circulation. Secondly, I believe it has shaped our own thinking about the geoarcheological approach.

Bennett's "straw man" is a predictive modeling effort for the Sparta Mine Prospect undertaken in the early 1980's by the Arkansas Archeological Survey in south-central Arkansas (Lafferty et al. 1981). The Sparta Survey contains three major premises which seem reasonable enough at first reading:

1) the presence (and absence) of those clusters of materials we call sites are related to environmental factors (i.e., the location of sites is regarded as the dependent variable);

2) the elements in the natural environment with which sites correlate as dependent variables can be specified (i.e., not only do environmental factors determine site locations, but we can identify those factors); and

3) we can understand the nature of the interplay of the various environmental factors -- first, we can understand how the factors interact with each other, and become able to weigh the relative strengths of the varieties of environmental factors or characteristics; second, we have a basic understanding of human physical needs and the ways in which humans have acted to meet these needs (i.e., we can model the behavior patterns for different sorts of strategies such as maximizers, optimizers, satisfiers, etc.).

Proceeding on these theoretical assumptions the Sparta Mine study, like many other similar studies, standardizes a four-step methodology. These steps include the following:

1) a decision will be made as to which of the thousands of possible environmental variables or factors or combinations are to be considered, e.g., nearness to water;

2) a map will be prepared to show the distribution of these elements across the space;

3) after the space has been prepared, the site locations will be placed against this background; and

4) once the two maps have been coordinated, a search for positive and negative correlations between the sites on one hand and the mapped environmental elements on the other is undertaken.

Bennett argues convincingly that such an effort is fatally flawed because it is based upon three fundamental conceptual errors:

1) The failure to recognize that the natural environment is a dynamic system;

2) the failure to recognize the complexity involved in using terms and methods from other disciplines; and

3) the failure to come to grips with the problematic nature of the site concept.

First, as a dynamic system, the environment is greater than the sum of its parts. It is simply not possible "to understand the system solely by
reference to its constituent parts without some understanding of how these parts interact. It is the relationship between the variables at least as much as the variables themselves which characterize the environment." Secondly, a dynamic system produces changes through time not only in its products but within processes as well. The consequences of this are twofold:

1. "It is a dubious undertaking to use environmental factors or processes present in the contemporary environment to predict the results of site location decisions made on the basis of environmental factors or processes which are no longer present (e.g., nearness to water in the contemporary environment does not count for much in predicting prehistoric site locations if stream locations have changed through time)."

2. We must consider the effect a dynamic system has on the archeological record. For example, fluvial processes alone account for differential preservation and destruction of countless sites every year. As Bennett says: "Nearness to water is a poor prediction for site location if the streams have scoured out (or buried) all the sites in the floodplain."

On the misuse of complex data from other disciplines, he is particularly concerned about the misuse of terms and concepts borrowed from the earth and life sciences:

For our concerns, however, by far the greatest offense has been in the use of data derived from soil surveys, usually the county soils book. Probably because these books contain maps with lines drawn on them, these works have been taken over wholesale by archeologists without the slightest regard for either the purposes they were intended to serve, the methodologies employed in their production, or the theoretical assumptions upon which they rest. Soil types have been treated as mutually exclusively entities (which they are not) and accurate to a scale of 10's of meters (which they are not). Attempts have been made to look at certain properties of the soil types (slope, drainage, productivity) as independent measures of site location properties without recognizing how much these data are autocorrelated (Bennett 1987:10-8).

On the subject of the site concept, Bennett's criticism is particularly thought provoking:

In archeological parlance, sites are places where artifacts or other evidence of human presence are found. The notion that such things as sites exist and that they are the places to which one goes to learn about the past is about as fundamental an idea as there is in archeology. It is the central notion around which all cultural resource management efforts are organized. However, it is clear that the discipline has now gone beyond the ability of this concept to aid in conceptualizing past human behavior. It has taken us as far as it could in our effort to understand the past and now stands as a formidable impediment to further research.

Dunnell and Dancey (1983:271-272) make this point rather forcefully:

Recent regional scale studies have cast doubt on the value of the concept of site. Thomas (1975) has begun a long overdue critique of the notion, characterizing it as 'inessential' and 'even slightly irrelevant

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in some kinds of field research.' It is even more deleterious than his comments imply. The uncritical use of the concept amounts to assuming that all significant cultural information occurs within high-density clusters of artifacts. This simply is not the case. Most sites in a traditional sense represent domestic or activity loci from which the exploitation of the surrounding environment took place. Using site to structure recovery limits data collection to a small fraction of the total area occupied by any past cultural system and systematically excludes nearly all direct evidence of the actual articulation between people and their environment. As a result, we are forced to puzzle out the connections from the grossly incomplete, complex, multifunctional deposits called sites.

In our context perhaps the most pernicious aspect of this is that the use of the concept site in almost all studies of site distribution reduces all clusters of artifacts to the same status. Ceremonial mound sites, quarries, isolated dart points, scatters of a handful of flakes all have the same status. They are sites. They each have their own individual state numbers. They are all discrete points on the map.

The bottom line of all this criticism is that these three major problems result from a flawed interpretive stance in which the archeologist attempts to force the objects of analysis to respond to certain questions within the parameters in which he/she has chosen to frame those questions. The failure to deal with the environment as a dynamic system, the neglect of professional colleagues' (e.g., soil scientists) expertise with environmental phenomena, and the leveling of diversity of the archeological record (e.g., sites as equal discrete points) all stem from this attempt to dominate the data. Interpretation is a process of interaction, a dialogue of sorts, between the researcher and the object of analysis (Bennett 1987:10-11).

The Little Rock District Database

We now shift our focus from theoretical concerns to the practical problem of implementing a landform management approach. The following civil works projects within the Little Rock District have had a Phase 1 geomorphological reconnaissance: Ozark Lake, Dardanelle Lake, Pools 1-9 of the Arkansas River Navigation System (ARNS), Norfork Lake, and Bull Shoals Lake. On the military side, Fort Chaffee has also received a geomorphological reconnaissance. Work at Pine Bluff Arsenal began in January of 1990.

For each project, landforms have been delineated and mapped on 7.5 degree USGS quads (scale 1"=24,000"). Each project has received an initial analysis of the geomorphic processes which created the landscape. The geomorphological analysis was performed by Dr. Lawson Smith and/or
Mr. Joseph Dunbar of the Geotechnical Laboratory, U.S. Army Waterways Experiment Station, Vicksburg, Mississippi. The work was sponsored by the Little Rock District on the senior author's initiative.

These projects cover a tremendous diversity of physiographic regions. Bull Shoals and Norfork Lakes are Ozark Mountain Valleys which have been flooded by impoundments of the White and North Fork Rivers, respectively. Pools 7-9 of the ARNS form an alluvial valley of rather restricted width incised into the Pennsylvania sandstones and shales of the Ouachita Mountains. Below Little Rock (Pools 2 through 6 and Norrell Lock and Dam), the Arkansas River enters the geologically less restrictive Mississippi River Valley. Both Dardanelle and Ozark are west of Pool 7-9 and are part of the Ouachita Mountains physiographic province.

Fort Chaffee, located in western Arkansas near the city of Fort Smith, is a 72,000 acre training facility for the U.S. Army Training and Doctrine Command (TRADOC) and the home of the Joint Readiness Training Command (JRTC). It is located within the Arkansas River Hill and Valley Belt of the Ouachita Mountain physiographic province. The varied landscape at Fort Chaffee encompasses long, steep-sided ridges and parallel valleys with occasional narrow gorges, broad low rolling hills, a small segment of the relatively flat Arkansas River floodplain, and several large tributary valleys including Vache Grasse Creek and Big Creek (Bennett 1989:1). All of these projects have received sample archeological surveys prior to, as well as after, their initial geomorphological analyses.

Managing the Archeological Database

"Management" as defined here consists of the following elements:

1) inventory of sites and landforms. In addition to a computerized database of sites we are creating a database of landforms (using GRASS 3.1) as potential repositories for both buried deposits and surface manifestations;

2) evaluation of significance, comprising:
   a. formal evaluation of archeological sites according to National Register criteria; and
   b. establishing spatial and temporal correlations of cultural deposits in order to understand their research potential within a specified regional context; and
3) preservation. Implicit in this term is not only the preservation of sites, but also of landforms as three-dimensional repositories of cultural deposits where no archeological surveys have taken place (or are not expected to take place in the immediate future).

The Technical Aspect

The practical implementation of this geoarchaeological approach is best illustrated by a concrete example. This could be done using a Corps flood control study or a Section 404 permit review. We have decided to use a typical Real Estate easement request to illustrate how this approach might be implemented and the technical problems that might be encountered in the review process.

The first element in the review process is to establish the legal location of the project area. This only needs to be specific to the section(s). The second step is to calculate a UTM grid that completely encompasses the project area. With these data in hand, we access the database of archeological sites maintained by the Arkansas Archeological Survey in Fayetteville via an IBM PCAT, Procomm telecommunication software, and a modem. Since the AMASDA database maintains the locations of the archeological sites by both of the above-mentioned elements, a query using both items would not likely allow any site in the project area to go undetected in the event of an error in the database or in the initial query calculations.

The initial query as to whether a currently reported site will be impacted can be easily answered. The real problem arises when no sites exist in or near the project area. Does this mean that no sites exist or simply that no one has looked?

To provide assistance in this question, the Little Rock District utilizes a GIS computer, a MASSCOMP 5450 that operates GRASS software (version 3.1). Within the map layers of a given lake are such categories as specific lake levels, elevation contours, Corps park boundaries, roads, streams, general geology, geomorphology, soils, areas of archeological survey coverage and other similar items. The list of archeological sites located in the AMASDA query can be set against this backdrop of map data. Through the evaluation of environmental factors near previously recorded sites within the larger area, a model can be formulated to assess the potential for sites in unsurveyed areas.
An example of the model follows in a simple chi-square test between the known archeological sites and the geomorphology of the White River Valley on the Forsyth, Missouri quadrangle.

Summary

Based on our hypothetical example, a simple predictive model emerges. Within the interior of the Ozark Mountains, quaternary (Late Holocene) terraces show a strong positive correlation with prehistoric cultural deposits; steep side slopes show a strong negative correlation. In this particular case, other landforms fall out as more-or-less indifferent choices for the deposition/preservation of cultural material. The differential site potential of the landforms within a project area will determine whether an archeological survey is required or, in the case of inventories of large areas, where such surveys would be most productive.

Management of high site-potential landforms is an effective way to preserve buried cultural deposits when funds for National Register eligibility testing are not available or when there are insufficient funds to perform 100% archeological surveys of large tracts of land. Furthermore, this geoarcheological approach allows scarce Federal funds to be used most efficiently to pinpoint areas where intensive surveys would be most productive (e.g., in the review of permit applications for the Corps' Regulatory Program and the completion of inventories required by Section 110 of the National Historic Preservation Act).

References Cited


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INTEGRATION OF CULTURAL RESOURCES AND GIS DATA  
IN THE SOUTHWESTERN DIVISION

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The Cultural Resources Overview of the Southwestern Division (SWD), as initially designed between 1982 and 1984, did not include integration with a Geographic Information System (GIS). It did, however, include considerations for remote sensing applications as planning tools in archeological investigations. The contract awarded to the Arkansas Archeological Survey required preparation of a volume on the uses of remote sensing, and it was this particular aspect of the contract that stimulated integration with the Geographic Resources Analysis Support System (GRASS) developed by the Corps' Construction and Engineering Research Laboratory (CERL) at Champaign, Illinois. That integration was proposed by Dr. Fred Limp at the Arkansas Archeological Survey, but not until several other alternatives were evaluated. The proposal was also made by Dr. Limp on the grounds that while the Survey was compiling these data for the contract requirements, it made little sense to not develop the data in such a way that it could easily, at relatively little additional expense, be incorporated into a GIS. At least the additional expense had little to do with funds for the Survey. Costs will be addressed later.

The SWD Overview has been completed with results published in a fifteen volume series of reports for the eight state area involved. The geographic boundaries of the Overview include those areas within the Southwestern Division's Civil Works and Military jurisdictions; therefore, it also includes portions of the Lower Mississippi Valley Division's Civil Works area of jurisdiction (Memphis, Vicksburg, and New Orleans Districts) lying west of the Mississippi. The area includes a total of 1,768,948 square miles. The report series contains:

(1) six regional syntheses published in seven volumes prepared jointly by highly respected archeologists and physical anthropologists (or bioarcheologists as the term may apply), and in some cases by ethnohistorians. Report preparations involved fifty-six individuals. The study units were intentionally designed to transcend political, state and District boundaries. They are based on more archeologically sensitive physiographic-hydrologic delineations that conform as near as possible to "culture areas." Because of financial limitations, the contract

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required documents prepared in less detail than would be expected of a thorough synthesis; hence, the term "overview" was used. In reality, however, the specialists produced reports in varying levels of what most called syntheses. Benefits to the Corps and the public considerably outweigh the cost (in some cases the specialists had to be told when to stop);

(2) a Paleoenvironmental Overview for the entire geographic area of the Division prepared under a separate contract by Dr. Jonathon Davis from the Desert Research Institute;

(3) the volume on remote sensing (The Use of Multispectral Digital Imagery in Archeological Investigations), written by Fred Limp;

(4) the citation data base that will be discussed in more detail is also automated and designed for compatibility with the National Park Service's National Archeological Database (NADB). The basic volume of citations is accompanied by three indices of cross references for some 7,000 entries;

(5) Guidelines for Development of Historic Properties Management Programs; and finally

(6) An Executive Summary of highlighted and sensitive issues and needs developed specifically for the attention of executive-level management in the Division.

For management of the automated citation data base, and stimulated by an increasing awareness of the powerful tool that integration with GIS could offer, SWD purchased a computer system. Since the Arkansas Archeological Survey designed the program, and knows more about it than anyone else, we asked them to conduct an 18 month demonstration-training project for use of the system by SWD personnel. What we do with the system at the end of the demonstration project has yet to be determined, but several alternatives are being considered. At the present time, the Corps-owned hardware is located at the Arkansas Archeological Survey and will be used via terminals located in the five SWD Districts (Albuquerque, Fort Worth, Galveston, Little Rock, and Tulsa) along with six of the major military installations within the SWD.

Selection of a computer system that would satisfy all identifiable present and future needs for management of the program involved a number of SWD staff (particularly Jim Cates, Pete LaFlamme, and Gary Lakin) and others over a period of about two years. Their assistance was greatly appreciated. The lessons and "fowl" language I learned in that process are almost worthy of another paper.

For those interested in details of the associated hardware, an inventory is provided below, but will not be specifically discussed unless answers to questions from the floor are necessary. The hardware includes:
1) a 6300 Masscomp Computer (whose company was bought out by Concur-
rent shortly after equipment purchase) with 8MB Memory in a 7 slot pedestal;
2) a 325MB 5.25" Winchester Type Hard Disk;
3) a 150MB 1/4" Cart Tape Drive;
4) a GA 1000/C, 19", 4 Plane Color Independent Graphics System;
5) Graphics Memory Increment upgrade from 4 to 12 Plane system;
6) High Performance 8-line RS-232C MUX;
7) Super Lightning Floating Point Accelerator;
8) 8-user upgrade license;
9) Network File system license; and
10) automatic up and down loading of data from UNIX based INFORMIX
RDBMS to MS-DOS PC Clipper based version.

We have installed four dial-up phone lines and the system can presently
accommodate no more than twenty users, although the system can be upgraded for
a larger number of users. It is important to note that the memory (and asso­
ciated disk space) is also upgradable to about anything we could ever imagine
a need for.

The system can be accessed at 1200-9600 Baud speed(s) and is remotely
operable from PCs with TTY emulators. Use of the graphics associated with
GRASS is performed by a menu option that allows downloading with a magnetic
tape from the main computer to individual workstations. One of the most cost-
effective benefits of the system is an Ad Hoc query program that James Farley
of the Arkansas Archeological Survey added to the menu which allows users to
query the system for any desired data, log off, and then obtain the data at a
later time. Thus there is no need for staying on a long distance phone line
while the data is being obtained for display. Use of the magnetic tapes sent
to individual workstations for the use of GRASS is also a tremendous advantage
and savings.

We have a total of $100,000 invested in the hardware, software, the
contract for the demonstration project, the phone lines, and maintenance of
the system until March of 1991. Some of the uses for which the system is
currently (or in the near future will be) available for all the offices or
installations include:

1) a Citation Data Base containing queries of categories for searching
by state, county, stream drainage, worktype (type of work upon which citation
is based), group (cultural affiliation name or code), material (material types
discussed in citation), keyword, date of publication, title, and author or
editor;
2) worktypes and worktype codes. Some examples are: major excavation (Code 93); archaeological survey, indeterminant (Code 85); and primary document, original (Code 12); and

3) searching by keyword through GRASS data layers.

There are currently fifty-eight map layers that have been developed from GRASS with data obtained from the USGS National Atlas of 1979 for use with the Overview, but the numbers, types, and configurations of data layering that can be developed for any specific purpose include almost any parameters and types that one could imagine -- the ultimate potential is staggering. Examples of those currently in the system are:

1) physical subdivisions (total of 12 within the six study units. Delineated on a Division-wide basis;
2) geological bedrock. Delineated on Division-wide basis;
3) surficial geology. Delineated on Division-wide basis. Distinctive from layer 2 because of inclusion of alluvium, etc.;
4) biogeographical divisions. Division-wide basis;
5) major early Indian tribes;
6) linguistic stocks. Delineated on Division-wide basis;
7) potential natural vegetation. Delineated Division-wide. Based on vegetation patterns as they would occur without modern human intervention;
8) major forest types. Delineated Division-wide;
9) archeological site density per square mile. Delineated by county (609 total counties involved);
10) number of burial sites per archeological site. Delineated by county;
11) number of burials per burial site. Delineated by county;
12) burial site density by county;
13) burial sites per square mile. Delineated by county;
14) counties with archeological sites in excess of 150;
15) density of sites determined eligible for listing on the National Register of Historic Places by county;
16) number of buildings listed on National Register by county;
17) 1980 population density by county;
18) population change between 1960-1980, by county;
19) digitized bedrock geology of State of Arkansas by individual formations;
20) digitized soils for State of Arkansas;
21) gas pipeline route across State of Arkansas with numbers and locations of archeological sites affected within a 100 meter radius;
22) Ozark National Forest in Arkansas with archeological site to water proximity analysis; and

23) archeological site potential. Delineated Division-wide and based on 172,000 archeological sites. Sensitivity and potential numbers of sites are determined from a combination of factors, i.e. soils, water, and vegetation with known archeological sites.

Conclusion

The potential of this system, only realized in part so far, should be obvious to everyone. We have only begun use of the system, and although there are many known applications already, there is no question that we will have found many more, and perhaps even better uses once the system has been used as the tool it is intended for. Perhaps the greatest attribute of the system is the relational data base that can be applied to any type of land and resource management and is "user friendly." It should be noted that GRASS has been officially designated by the Soil Conservation Service as the GIS system they will be installing in all county Soil Conservation offices within the next decade. Fred Limp has been heavily involved in that effort. As mentioned above, other GIS data bases are also available, but from evaluations of some of our more knowledgeable folk within and outside the SWD, GRASS appears to offer greater flexibility and use than any of the others for our purposes being discussed here.

The system as a whole is a powerful tool that, if put to its full potential, can virtually revolutionize our management tasks and possibly even the way we do archeology. I definitely believe that it is going to have a tremendous impact, not only on what we do in the Corps, but on research archeology performed in more academic arenas rather than the applied areas we concentrate on. No one who has access to such a system can ignore its use and continue to perform effectively. I also believe those in academia must come to grips with the potential impact of such a system on future graduate studies. When, in a couple of hours, I can sit down and come up with enough data for a good start on a dissertation level research project, what will dissertations or masters' theses look like ten years from now? Those without access to such systems will most likely find themselves far behind those who do in a relatively short amount of time.

We now have an automated system for management of cultural resources in SWD. What we do with it, only time will tell. The one point I want to leave
with you is the fact that the proper use of such a system requires commitment, not only from the user, but from the organization. This includes training, having top quality staff to maintain the system, long term goals, and money.

By the end of our demonstration project next year, we hope to have a much clearer picture of the future use in practical application and budgetary requirements of the system. I am in the midst of preparing a master plan for use of the system in the SWD. Already new features are available that make parts of what we are just getting into almost obsolete. We have also been working with Dr. Veletta Canouts from the National Park Service in developing a cooperative agreement for expansion of the data base and availability to a broader user group. The future should be interesting.
Introduction

The National Archeological Database (NADB) is being developed to ensure more effective preservation of archeological resources. Once archeological remains are removed from their in situ context, the quality of the information they contain depends upon three factors: first, the curation of the remains so that they can be restudied to confirm or modify interpretations; second, the maintenance of records linking the remains to their context; and third, the descriptive, analytical, and interpretive reports. These remains, records, and reports become essential parts of the archeological record that must be preserved and made accessible for the future if the record is not to be irrevocably lost.

Ten years ago, the U.S. General Accounting Office (1981) reported to the House Committee on Interior and Insular Affairs that archeological reports were not being disseminated and that the lack of this information was hampering management decision making and possibly causing costly duplication of effort. Development of the Reports portion of the National Archeological Database began in 1984, with funding authorized by Congress, to provide quicker and more complete access to information about existing archeological reports. The database is designed to be used as an index, basic summary, and finding aide for archeological reports produced in the United States, territories, commonwealths, and associated states.

The history of NADB-Reports is illustrative of the information management issues that arise in the context of a rapidly advancing technology, locally and regionally distributed databases, and national inventories. A software program designed and developed, between 1984 and 1989, to facilitate data entry for NADB-Reports is up and running on local, stand alone

* This is a revised version of the paper entitled "The Development and Use of a National Archeological Database" which was presented at the 1990 U.S. Army Corps of Engineers Annual Meeting.

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microcomputers. The next step is to bring these locally distributed databases into a national system whereby report inventories flow smoothly into the national database and out to user communities. To effect the establishment of the national system depends more upon State and Federal cooperation and coordination than further technological developments. The Reports records must be verified, corrected, and long-term commitments made to maintain and update the database on a yearly basis.

An inventory of reports is a necessary precursor to the effective dissemination of the information contained in the reports. But it is also imperative that copies of these reports are made available. Undoubtedly computer applications in the areas of text storage and retrieval will aid the dissemination of this information. Until these applications become more commonplace, however, archeologists will have to tackle some of the problems posed by limited distribution. Archeologists have been quite persuasive in arguing that popular writing is necessary to disseminate results to the general public. It can also be argued that published debates over the relevancy of certain methodological and theoretical approaches must be joined by archeologists using cultural resource management (CRM) databases.

CRM Literature: A Glut of Information

The term "gray literature" is used to describe archeological reports that are uncataloged, uncollected, and often unavailable even in major libraries (see Gould and Handler 1989). It is also synonymous with cultural resource management (CRM) reports resulting from legislatively mandated archeological activities. The spate of Federal laws passed to protect cultural, especially archeological, resources in the 1960s and 1970s brought about a concomitant, but exponential increase in compliance reporting. Although the profession recognized that the "principal payoff from CRM programs [lay] in the reports they produce[d]" (Lipe 1984:5-6), the number of reports quickly overwhelmed traditional publishing outlets, not to mention the ability of individual archeologists to absorb the abundance of data in them.

The number of reports thought to comprise the so called "gray literature" has been estimated at 200,000. This figure is undoubtedly low as the number of reports that have been entered into NADB-Reports today totals approximately 85,000. These reports were entered while the NADB-Reports software was being developed, and the number does not represent a systematic
account of the backlog of reports yet to be entered. Recent compilations of statistics on Federal archeological activities indicate that about 20,000 archeological investigations by or for Federal agencies occur yearly (Keel, McManamon, and Smith 1989). Even if only half of these result in reports, the yearly growth is substantial.

The problems encountered in publication did not mirror differences between government and academic publishing as much as they reflected shortened time schedules for analysis and report writing and lack of sufficient funds to disseminate published reports. Prior to 1970, the Government Printing Office published a number of major archeological reports (e.g., the River Basin surveys and reports; the National Park Service's and the Smithsonian Institution's publications series). However, the review process and length of time in press for these reports paralleled that of university presses. The need for timely reporting on increasing numbers of archeological projects has tightened laboratory and writing schedules, collapsed the process of peer review, and led to limited distribution reports. As late as 1982, Renfrew told the Society for American Archaeology that one of the greatest problems facing the Society was the lack of "a coherent policy for dealing with great masses of data" (Renfrew 1983:11). The same can be said for disseminating information about these data.

The magnitude of the problem facing the profession is significant when one considers that Federal agencies sponsor, either in licensing or as an undertaking, the majority of the archeological investigations in the country. The all but invisible reports of these investigations are extremely important, not only to chart local, state, and national preservation efforts, but to provide an informational database upon which all researchers can build to further the interpretation of the archeological record.

Control of the Literature

Twenty years ago, the number of archeological investigations was small enough that archeologists could exchange information about their work informally. Researchers could easily recall publications that were significant to their own activities, particularly the Phase I and Phase II studies carried out in the 1970s when, in many cases, large tracts of land were being assessed for the first time. The present situation is quite different.

The number of articles published in journals, as well as monographs, has risen dramatically. While we have not researched the numbers of journals
regularly read by archeologists, the number of journals listed in the NADB-Reports code table stands at 450. Most of these are archeological journals.

In addition to the number of archeological projects driving up the report rate, the number of practicing professionals has increased. "There is an element of truth in the quip that half the scientists who ever lived are alive today" (Denning 1987) ... and they are writing reports.

Attempts to apprise the profession of these reports have produced mixed results. Voluntary efforts to abstract CRM reports in American Archeology (a.k.a CRM Abstracts) or to submit reports to the National Technical Information Service (NTIS) have not been successful. The Archeological Assistance Division of the National Park Service regularly sent CRM reports to journals for review between 1982 and 1990. Probably fewer than 25% of the reports have been reviewed. One of the more informative and successful ways of reaching the profession is the incorporation of CRM reports in a university publication series. Unfortunately, very few efforts have been made to synthesize or rework the information contained in the majority of these reports (Longacre 1981; Davis 1981; but see Powell and Rice [1981], Steponaitis [1986:366], and Smith [1988] for incorporation of CRM investigative findings into regional research designs and summaries).

Timely Reporting

Unlike many archaeological publications, CRM reports must provide information for decision making that is constrained by time limits. While project schedules can foster timely reporting of the work, tight schedules can and do affect the format, content, and distribution of the information. Instead of presenting papers at professional meetings or writing for professional journals, archeologists relate progress through compliance reports, usually several reports which are generated at different stages for decision making. Depending on the history of the project, these reports may or may not be synthesized into an overall final report, requiring researchers to examine a number of documents to acquire all the relevant information.

Timeliness is a two-edged sword because to produce timely reports, researchers must depend upon the timely reporting of other investigations. The absence of such reports may seriously compromise decision making. If the reports exist but knowledge about their existence does not, the information is never considered, and the informational database is diminished accordingly (see Hester's [1984:33] account of such an incident).
Rapid Communication

The inescapable conclusion is that more rapid and effective means of conveying report information are necessary. Toward that end, archeologists have moved computers into the field (e.g., Dibble and McPherron 1988). They use computers to analyze and present their data. Also, they have begun to build databases to access this information for use in other applications, many of which are conducted at a broader scale than when the data were first gathered and analyzed (see also Gaines and Gaines 1980).

In the area of communication, many researchers in other disciplines have already developed special user networks to share information. Archeologists today use electronic bulletin boards to transmit information (e.g., in academia, Bitnet; at the National Park Service, CompuServe; in archeological specific bulletin boards such as ASVNET or ESAFNET [Society for American Archaeology 1987]).

Bibliographic lists of relevant reports are one of the first systematic data sets to circulate among researchers in various disciplines. In archeology, such bibliographies provide initial access points to literature concerning the way cultural resources have been interpreted and evaluated relative to the discipline's current criteria of significance. In corridors and meeting rooms at recent professional meetings, we hear that the computerization of such listings is under consideration or is being started by individuals with a computer and a strong desire to know "what is out there."

A systematic accounting of what has been written and where copies can be obtained is of national concern if we are to reduce redundancy, maintain continuity, and strive for comprehensiveness in archaeological analysis and reporting. As we have noted, library holdings inadequately reflect the number of reports which have been and continue to be written about archeological investigations, and the compilation of archeological bibliographies about certain areas or topics by individuals is haphazard at best. The development and establishment of the Reports portion of the National Archeological Database is a much needed response to facilitate communication within the archeological and historic preservation community.
The NADB-Reports Database

The Reports Portion of the National Archeological Database is an expanded bibliographic inventory of reports that make substantial contributions to understanding the archeological record. As such the database is not limited to the "gray literature", although the majority of reports that provide basic information about the presence or absence of archeological resources in specified areas are usually CRM reports.

The National Archeological Database is both an information system and a software program. It is important to make a conceptual distinction between the software used to enter and access data and the concept of a reports database. Although the Archeological Assistance Program developed computer software with certain software and hardware requirements, databases that contain information about archeological reports exist in other computer systems on the local, state and regional, and national levels. The ultimate goal in establishing and maintaining the Reports portion of the National Archeological Database is to link these various computerized databases of reports into a nationally integrated system.

NADB-Reports Records

There are approximately 85,000 records in the Reports portion of the National Archeological Database that have been entered using NADB-Reports software (Canouts 1990). These records pertain to a number of different types of publications, such as books, chapters in books, limited distribution reports, journal articles, dissertations, and meeting papers.

In addition to the citation data, these records contain information about the report, including geographic area and type of work performed, keywords identifying the content of the report, the sponsoring agency, and the location(s) where the report is on file. These additional categories anticipate general areas of interest, and the information in them is recorded according to archeological standards or conventions.

While the system design and the development of the software are inextricably linked, the structure of this database relative to other databases is probably quite similar. It has not been too hard to agree on data standards for citation data and the other supplemental information. The Archeological
Assistance Program is promoting the use of these reporting standards throughout the CRM community.

The data entry categories are used to build queries. Probably the most important categories are the geographic area covered by the report and keywords characterizing the content of a report. Although not required, we are urging that UTM coordinates be entered for each record. The use of GIS applications requires that "things" be located spatially. For many purposes, a search for reports of investigations carried out in particular counties is all that will be required, and there are indeed county base maps for GIS applications. However, archeological data are usually linked more specifically to the natural landscape than to geopolitical boundaries, and greater locational detail is desirable and, in most cases, necessary.

There are no constraints on keyword entries, except that a word or string cannot exceed 45 characters. This freedom in data entry, however, is countered by the difficulty of conducting searches without an index or a thesaurus. As over 500,000 keywords have been entered for 85,000 reports, one can see the task quickly becomes one of systematization and organization. Other disciplines, such as art, architecture, and conservation, have begun thesaurus projects, funded at the level of several hundreds of thousands of dollars and extending over several years.

It will be a mark of the discipline's maturity if archeological terms can be systematized over the next decade. Perhaps archeologists, eschewing systematics, will prefer to wait for the addition of full text, such as abstracts, to the records. Even if technology speeds up searches on text strings, however, the scale of the effort suggests that some ordering will be necessary, and this ordering will necessarily impact research to the extent that research inquiries will need to conform to an ordered body of data. Computer-generated indices, especially if on-line assistance is available, might overcome the problem of thesaurus controlled versus free text searches, but other problems relating to scale might then arise.

The CRM reports are not only "gray", but the records of the reports now residing in the master database are "dirty" (after Thompson 1987). The software used to enter the data has undergone extensive development, and there have been four major versions used by contractors (Canouts 1990). These records have had to be converted from one program to the other, and while the conversion was successful, for the most part, there are errors that require human intervention to correct. This is a very labor intensive process.
Data, whatever their nature, are seldom clean (Thompson 1987). Instead of imparting a negative assessment, however, the systemization of the information and access to the reports records can have a positive effect by revealing missing data, inconsistencies, and miscoded entries, all of which are, when found, easily corrected (see, for example, the cleanup project for the Conservation Information Network's bibliography [Getty Conservation Institute 1990]). The more serious problems relate to the nature and quality of the records in the database. How relevant are the entries? The computerization of information about these reports will enable archeologists to have a better understanding of the work being undertaken and will enable them to demand better information (i.e., better data entry), and perhaps even more importantly, better reports from their colleagues.

NADB-Network Partners

Whatever the computer technology, the continued existence and expanded use of NADB will depend on guaranteed, long-term support. Many projects have failed because of this lack of commitment (see, for example, Shetler 1987). The maintenance and growth of the database require organized action that will assess and monitor the records keeping. The Archeological Assistance Program has identified the State Historic Preservation Offices (SHPOs) as initial data collection points (Canouts 1990). There are several reasons for this: (1) SHPOs maintain, as one of their functions, an inventory of historic properties, including archeological sites, and they usually maintain a library of reports written for public archeological projects in the state; (2) SHPOs are the consulting parties in the 106 review process and they review compliance reports; (3) SHPOs share a similar preservation mission; and (4) the identification of a limited number of data entry points improves consistency, eliminates duplicated effort and duplicated entries, and allows for sustained technical support. Thus, the Archeological Assistance Program presently is working with individual SHPOs to establish a NADB-Network of partners.

What is the role of Federal or other public agencies in this partnership? If Federal agencies have on file reports that are not in the SHPO offices, they should contact the SHPO and inquire how they might submit this information. The SHPO may request that the Federal agency enter the data electronically, especially if the SHPO is not using the program or does not have an alternate automated bibliographic database. Federal agencies also can
contact the Archeological Assistance Program regional offices directly to work out a plan for supplying information about reports that are not on file with SHPOs.

Federal and other agency historic preservation offices will be able to request copies of the NADB-Reports software program to enter reports data for internal use. In the next two years, as an attempt is made to enter as many of the backlogged reports as possible, we may request copies of these records, minus proprietary records, in order to add nonduplicate records to the National Archeological Database.

General Access to the NADB-Reports Database

Obviously we are making a logistical distinction between data-providers and general users of the NADB-Reports database. The first step is to set up the system that will guarantee continued data entry and updates. The next step is to make the information in the database available to archeological and preservation communities to use in research, assessment, and decision making activities.

The 85,000 records in the database are not yet available for general distribution. The distribution is not being held up because the records need cleanup editing, although the better the records, the better reception and the more useful the database. Rather, widespread distribution of the records requires that we design a system that can be supported with the present level of staff and resources.

The current set of data files require over 100 Mb of storage on a microcomputer. The time it takes to query the database depends on the configuration of the microcomputer, and user patience can be strained running open-ended searches on keywords, for example. In fact, in order to speed up the search for keywords in the Clipper version of the NADB-Reports, we have added a keyword category code. Although the industry will probably keep pace in increasing storage and speeding up search time in microcomputer environments, the direction that we are looking involves programming for a microcomputer-minicomputer interface. That is, data will be entered on a microcomputer but will be accessed through an on-line minicomputer system. There will probably be variations on this design because SHPO offices have different computer systems. For the near future, we do not envision data providers entering data
directly into an on-line system. Procedures for ensuring quality control must be developed and logistical support must be in place before this could occur.

We do envision an on-line system that will allow users to customize their own queries. Fortunately, the Arkansas Archeological Survey designed such a system when the initial development of NADB was undertaken (U.S. Department of the Interior, National Park Service 1984). The system used by the Arkansas Archeological Survey forms the basis of the bibliographic system that now resides on a regional archeological database prototype being designed for the Southwestern Division of the US Army Corps of Engineers (Banks, this volume). We are presently working with Arkansas to convert records between the Clipper compiled, microcomputer version and the Informix, minicomputer version of NADB developed by Arkansas. There is also a plan underway to beta test an on-line version of NADB-Reports in FY 1991. We anticipate greater Federal involvement in supporting an on-line system designed to meet the user demands of Federal agencies and their contractors and consultants.

Within the National Park Service, we are also working to interface NADB with the Cultural Resources Management Bibliography (i.e., CRBIB), a listing of all cultural resource reports done for units of the National Park system that is available servicewide. We will try to identify other regional or service centers which provide bibliographic support for Federal agencies, as well.

At the present time there is no national umbrella for archeological and historic preservation databases in which to situate the National Archeological Database. There are individual databases that are managed by different organizations. Foundations such as Getty, for example, are managing art and conservation databases, and the National Park Service has bibliographic, inventory, and cataloging databases (e.g., Cultural Resource Management Bibliography [CRBIB], National Register [NR], Automated National Catalog System [ANCS]). The Research Libraries Group has a national network of libraries, archives, and special collections (RLIN) linked for searches of bibliographic data in their holdings. Advanced computing networks (i.e., Internet or NSF-Net ["Riding the Internet" 1991; Denning 1985]), might also provide for general user access to NADB-Reports. However, one of the most important features required of any platform-program interface will be the ability to query the database for selected data.
Dissemination of Reports

At the same time that the National Archeological Database is providing an inventory of archeological reports, it is also causing an increased demand for access to these reports. The SHPO offices will bear the brunt of the requests. There is positive aspect of the demand, however, in that SHPO offices should be better advised about the work being conducted in the state. Although NADB-Reports records provides keywords, the database cannot substitute for the consultation process and for actually reading the reports.

The majority of the reports (85%) now in the database have a limited distribution, and acquiring copies will be difficult. The U.S. General Accounting Office (1981) reported that the National Technical Information Service (NTIS) was ineffective as a central repository. Only 274 reports had been submitted by 1980 with the majority being submitted by the National Park Service. In the latest catalog of selected bibliographies, NTIS listed a new "published search" of 338 Archaeological Cultural Resource Site Surveys (Jan 1983-Jul 1989) under the heading of Archaeology (U.S. Department of Commerce 1990).

In 1985 the Society for American Archeology (1985) began to investigate the possibility of supporting the Smithsonian Institution as a national repository for hard copy CRM reports. Such a repository would supposedly hold more than reports; the curation of field notes, photographs, maps, artifact catalogs, and electronic data have also been considered. The potential of and problems associated with large centralized, regional repositories were explored at an earlier symposium held at the Society for American Archaeology meetings in St. Louis in 1976 (Marquardt, ed. 1977). Although opinions differed as to the best organizational model, for example the expansion of current museum curation facilities, the symbiosis of Federal research centers located adjacent to or on academic campuses, or the creation of a new preservation agency, the symposium members agreed that Federal support was essential for the development of such repositories (Marquardt 1977:38). Recent discussions between the Archeological Assistance Program and the National Anthropological Archives at the Smithsonian Institution about the latter serving as a repository have highlighted the need for regional and national support in cataloging and curating such large collections.

Regulations outlining the responsibilities of Federal agencies for curating archaeological collections were first proposed in 1979. The final
curation regulations (36CRF79) were passed in September of 1990 (U.S. Department of the Interior 1990a). In the intervening period, several agencies have either contracted specifically for curation services (e.g., the U.S. Army Corps of Engineers’ Richard B. Russell Reservoir Project) or built special repositories to house collections from large projects (e.g., the Bureau of Reclamation’s CAP Roosevelt Project) or from specific geographic areas (e.g., the Bureau of Land Management’s Anasazi Heritage Center). Most Federal agencies rely on a number of different repositories for curation services that range from very good to very bad (Jelks 1990, Trimble and Meyers 1991). The new curation regulations will have a beneficial effect in calling for assessments of collections and new agreements with repositories. The diversity of repository agreements has already caused some Federal agency officials to explore means for centralizing collections, which in turn, raises again the controversial issues discussed by the SAA symposium participants: that is, the centralization of collections away from traditional university and museum repositories. The difference now is that the military base closings offer potential underground storage facilities that are being given more than casual consideration by Federal agencies.

How do hard copies of CRM reports fit with these collections? Should they? A newly proposed amendment to the current curation regulations states that report information pertaining to the collections must be submitted for inclusion into the National Archeological Database (U.S. Department of the Interior 1990b). Required data entry includes information about where a copy of the report can be obtained. Obviously, having all the information pertaining to a collection available in the same place is advantageous, and archeologists appear to perceive no difficulty in having to travel to museums or other types of repositories to carry out their research on collections. What they experience as the greater difficulty is accessing reports for background information. And as there is no necessarily perceived correlation between physical collections and paper reports, traveling to archival facilities to review reports does not appear to be advantageous.

As we have already noted, the major archival facilities for CRM reports are now the SHPO offices which have responsibility for compliance review. The National Technical Information System (NTIS), the Defense Technical Information Service (DTIS), the Library of Congress, and the National Anthropological Archives at the Smithsonian Institution also receive CRM reports from Federal agencies. Until 1990, the Archeological Assistance Division accepted three
copies of CRM reports from Federal agencies. The sheer volume of reports overwhelmed our ability to send these reports out for review or to maintain a library. Fortunately, the Anthropological Archives agreed to accept copies of the reports. Unfortunately, the labor involved in archiving all the "gray literature" is beyond logistical capabilities of most archives, and the Anthropological Archives is no exception, doing little more than minimal accessioning.

If there were more reports repositories, clearly the costs of time and travel to consult the "gray literature" would be reduced. Without further coordination, however, such searches would still be inefficient and ineffective. This coordination is clearly the function of the Reports portion of the National Archeological Database to provide an inventory of the literature that is pertinent to the user's search parameters and to list the locations of the reports.

NADB-Reports serves the role of a conceptual centralized catalog of CRM reports in the absence of a physically centralized body of CRM reports. It is not even clear that a national archive of archeologically specific CRM reports would satisfy all the user demand. Interestingly, many of the cultural resource management reports of the National Park Service and other preservation programs are sent to the National Trust Preservation Library. Archeologists would undoubtedly be interested in some of the reports, even though archeological reports are specifically excluded from submission at the present time. Archeology is an eclectic discipline, drawing information from a number of different sources, including reports on the built and natural environments. The National Trust Preservation Library will soon go on-line at the University of Maryland; other reference and abstract databases are already on-line. The other functions of the National Archeological Database can be developed to identify such specialized databases not only outside of archeology, but for specialized geographical and topical interests within the discipline.

An inventory of references is to reports what a catalog is to material objects, and what a site file is to archeological sites. Landsat images of site topography, holographic images of artifacts, and electronic reproduction of reports are not only the promise but the reality of current computer applications. Electronic networking allows us to do more than "transfer...data files"; it allows "real-time collaboration," that is, interactive communication at a networked workstation that will enable researchers to locate, use, and share data output with fellow researchers (Denning 1987:573). All of
these applications require data gathering and reorganization before they can be effectively used, however.

We have already embarked on a feasibility study to investigate the possibility of disseminating reports using CD-ROM technology (Wendorf and Kemper 1989; Wendorf, Kemper, and Crass 1990). Substantial funding would be involved, and the assessment is proceeding cautiously. Making the inventory of NADB-Reports available through read only CD-ROM disks and the addition of text summaries or abstracts is a likelier first step. Even if the costs of manufacturing CD-ROM disks falls, there are critical decisions that have to be made about which reports to reproduce and when, not to mention the organizational structure which will be required to implement the decisions.

Increased use of databases in inventorying site and artifact data and increased use of computer graphics to model relationships decreases the need to extract and manipulate data from a report format. In fact, desktop publishing is making use of file transfer to integrate database, text, and graphic files into a final report (Schnapp 1990). As Federal agencies, museums, and other repositories request computerized records from contractors and researchers working with collections, these data files are the more appropriate resource for data extraction and manipulation. However, the problems of archiving electronic data, integrating similar data from different projects, or providing access to "others" data have not even begun to be discussed by the profession, though some experiences with databases such as SARG (Southwestern Anthropological Research Group, Gaines and Gaines 1980: 468-469), SARCAR (Smithsonian Archeometric Research Collections and Records, Bishop 1990), the Radiocarbon Data Base (Kra, 1986; Beck 1987:374), and Arkansas' integrated archeological databases (Scholtz and Chenhall 1976; Limp et al. 1990) provide some direction (also Bishop et al. 1990).

Summary

The National Archeological Database is intended to improve the long-term preservation and use of archeological reports and data. These components of the archeological record are of increasing importance as the in situ portion deteriorates and is destroyed. The Reports portion of NADB is an essential inventory of existing reports. It provides an important summary of their contents, and equally important, it serves as an aide in locating these reports.
The NADB-Reports software that we have designed and are using is a stand-alone program. It can be used in environments where archeologists and managers need help in automating bibliographic information. What is more important, however, is what this program stands for in terms of the information that is being entered. These data categories and values form the basis for standards of reporting about archeological activities on a national level. We are working with the National Council of State Historic Preservation Officers and other preservation organizations to ensure that these standards have wide applicability in terms of data transfer.

Ultimately, NADB-Reports or other reports database will be integrated within automated systems being developed in offices across the country for day-to-day management purposes. On the national level, however, the NADB-Reports database will continue to exist as a distinct entity. It will enable managers and researchers, for the first time ever, to operate on a national scale in articulating the many accomplishments and addressing the various concerns of the archeological preservation community.

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DISCUSSANT COMMENTS ON THE SYMPOSIUM "AUTOMATION TOOLS AND DATABASE MANAGEMENT FOR CULTURAL RESOURCE MANAGERS"

Lawrence E. Aten*

Introduction

I would like to begin this discussion by congratulating Fred Briuer for taking the initiative to put this session together, and the Corps of Engineers for being forward-thinking enough to encourage the kinds of exploratory activities that make it possible for you as an organization to produce the reports we’ve heard today on such a robust set of important issues.

I have read all of the papers with interest and note that each touches on one or another of several fundamental issues in the development of automation tools for cultural resources management. And so, rather than take time to comment on the specific local problems each paper may have represented, my approach will be to weave these issues together into some observations about the general questions of developing automation tools. As some of you may know, GRASS also is the National Park Service’s geographic information system standard and so we too are grappling with similar issues.

Management Versus Research

To begin, let me say that I quite agree with the point made by Dunn and Riggs that cultural resources management and research activities must be approached together. A similar but more specific point is made by Briuer that each survey should be viewed as a step in a long range plan to acquire comprehensive information. The notion that compliance data collection entails something other than research is one I have never been able to comprehend. To approach both legal compliance and research (in the sense of a genuine expansion of understanding) is a much harder job, though, and perhaps this is the real reason the general practice has tended to become a mechanical exercise of marching through 36 CFR 800.

The pursuit of cultural resources management and research requires more professional skills, a thorough knowledge of the literature for an area, and

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an ability to broadly associate and integrate "management" opportunities with research needs to produce intelligent answers to management questions and to enhanced understanding about cultural resources. The kind of integrated automation techniques being addressed in this seminar make achievement of this joint goal much more feasible.

Prerequisites to Successful Management Databases

Several of the papers addressed in one or another way certain requirements for successful comprehensive automated management databases. Briuer notes 3 prerequisites: commitment to learn and use the tools; long-term information acquisition strategy; and standard operating procedures for database construction and expansion. Similarly Banks noted the need for organizational commitment, funding, training, and staffing.

These points cannot be emphasized too much. The day has virtually disappeared, almost before it ever arrived, for the technologically inclined CRM professional to be the "compleat" system operator. The systems are too complex for one individual to understand the computer's operating system, and the peripheral equipment like digitizers, tape drives, pen plotters, and so on, as well as the GIS software, the non-spatial databases, and also to focus on the professional activities of data element standards, research designs, field work, and on and on. Organizations must be prepared to fund and staff with information management or GIS specialists the systems they desire to establish, or the whole enterprise of integrated automation tools is doomed. This is a lesson the National Park Service is starting to learn, and I noticed the Rock Island District projects reported by Barr and Bottorff entailed collaboration of archeologist with GIS Specialist.

The second point is that there needs to be a data acquisition plan that is adhered to until completed. Several papers illustrated such an approach -- Briuer, Dunn and Riggs, Barr and Bottorff, Lyon, Stout and Button -- but the thrust of the plan was quite different in each case. Although operations vary in different districts, they also share many similarities. I would recommend that the Corps try to evolve some consensus on what will be the nature of core or critical data acquisition.

The third point was that there should be standards for database construction and expansion. Several papers note the need for core data elements for databases and for standard definitions to facilitate data comparability.
and, occasionally, combination. Canouts and McManamon note the need for systematic archeological terminology to facilitate keyword searches of NADB-Reports. And, of course, this is a problem with the National Register database as well.

Data standards (for both definitions and coding) are essential. At a national level, there are a few data elements that should be standardized to facilitate comprehensive statements about such things as "How much survey of Federal lands has been accomplished?" Other data elements may be appropriate for standardizing at an agency-wide level. Yet others are only necessary to standardize at a Statewide or district level. A data element dictionary, nevertheless, is a crucial step we all must work on in the foreseeable future.

In addition, the Corps may find it valuable to consider not only standard terminology, but also standard ADP solutions to common management problems, and nominal or standard data layers that should be available in all districts to enable routine cultural resources management activities to be handled in a timely way. Both the Briuer and the Barr and Bottorff papers seem to be close to identifying nominal data layers and standard solutions for certain common management problems.

Likewise, it is important, as one develops automated database solutions, particularly for relatively standard applications, to record and share the cartographic models used so these need not be reinvented in every other office with the same or similar activities to perform.

Changes in the Way Work is Done

Banks notes that use of the Southwest Division automated databases have only begun and that while many applications are known already, "...there is no question but what we will have found many more, and perhaps even better, uses once the system has been used as the tool it is intended for."

There is no question that automation is reorganizing how traditional work operations are done. One could argue that automation to this time has only had a superficial effect on archeology. While it unquestionably has facilitated the faster accumulation of more information, and more efficient handling of text, graphics, publications, and so on, I think the revolutionary consequences of automation are only beginning. Spatial and non-spatial relational databases working in tandem will open opportunities for wholly new forms of compiling information. It is all very well to point out, as was done
in the Dunn and Riggs paper, that it is an analytical flaw to consider site distribution as predicted by a single environmental variable rather than as an outcome of complex interactions of environmental variables. But how does one operationalize this? The revolution in capability now coming to us may for the first time allow it to be done in a practical way. We are only now entering an era of access to methods that do not force us into such extreme oversimplifications.

One consequence of this is that managers (both cultural resource and administrative) have to be prepared to live for a few years with the uncertainty associated with changes in how work (research, administration, and management) is done and indeed probably with changes in whole methodologies. Unfortunately, in this situation we can't anticipate uses, consequences, innovations, etc. as fully as we have come to expect in conventional research design or systems analysis procedures.

Types of Systems Linkages

One of the future hallmarks in the use of both spatial and non-spatial automated databases is going to be the linkages to other databases near and far. The grandest scale of linkage yet achieved in cultural resources management is that of the five districts and 6 military installations connected to the Southwest Division database located at the Arkansas Archeological Survey. Several other papers mentioned modem linkages and other data transfers within their own office or to the State Historic Preservation Office.

Canouts and McManamon described the progress of the National Archeological Data Base toward a national system whereby data flow into the national database and out to users. As of yet, however, the separate nodes of the system aren't linked together. In order to make databases such as this successful, there needs to be a mechanism more reliable and compelling than voluntarily working together for the common good. In this case applying the rule of organizational commitment described earlier means that supporting NADB would not be optional for States; it has to become a requirement.

If the State programs are to become the primary source for data entry and maintenance, then we will have to seek supplemental grant funds for this and make the activity a program requirement. This is not an impossible dream; in several contexts over the past year I have witnessed a growing concern among senior officials and members of Congress at the inability to marshal
cultural resources inventory information at critical moments when it really was needed. I think obtaining adequate support for State programs to perform this activity is possible as part of a larger effort to resuscitate the comprehensive Statewide survey programs.

Canouts and McManamon also noted that many Federal and State preservation offices have indicated that they need a capability to integrate their data management systems to link inventories, reports, and administration. Briuer makes the corollary point that no single information management structure will be appropriate for all users. This is indeed an important need, one that my own office currently is working to solve through production of a data dictionary-driven software module that can be readily adapted by the user to serve any cultural resources application, including inventory, and be readily linked to other modules adapted to related applications. Although not ready for general release yet, this module currently is being tested in an SHPO office.

Increased Need for Technical Support

Canouts and McManamon stated that one of the logistical problems caused by the changes in how work is done is not just the increased demand for information once the existence of specific pieces of information becomes more generally known, but the need for technical support in a larger sense. Knowing more about what information exists, there will be a need for more people to see the information. CD-ROM projects were mentioned but the scale on which information is likely to be needed may invite commercialization -- there certainly are precedents for this in organizations such as University Microfilms and Chadwick-Healey. Beyond this, there will be an agency -- and possibly interagency -- need for technical support systems of some sort to maintain the data element standardization processes, to train GIS and other Information Management Specialists on the routine cultural resources applications, to disseminate automation methodologies for performing cultural resources activities, assuring quality control in systems such as NADB that will originate in many locations, and so on.
Maintaining and Upgrading Databases

Briuer noted the need for perfecting data from early surveys and for incorporating new and better information. We need to at least provide the opportunity in our databases for recording the results of monitoring known historic properties periodically to update information on their condition and status. Doing such monitoring is generally not feasible yet for most organizations, but some day this is data we all will believe to be essential and it is not too early now to plan for having it.

Also part of maintaining and upgrading databases is the seemingly endless need to clean up data. Canouts and McManamon suggest that aggressively pushing indexes and other data access may provide one incentive to archeologists to originate "cleaner" data. This probably is an option that could be elaborated and used by Corps' archeologists responsible for contract technical direction. Dunn and Riggs, by adopting the objective of identifying landforms with archeological site potential as a management goal also demonstrated, perhaps not intentionally, an alternative approach to dirty data by lowering resolution in the questions they asked to ones that may fruitfully use data that is "unclean" at a higher resolution.

There are yet other issues worth raising -- in particular that noted by Briuer and by Dunn and Riggs that our CRM focus should shift relatively more toward Section 110 and be relatively less exclusively on Section 106 -- a view that I believe is exactly correct, but I think my allotted time probably has expired.

In closing, let me say again that the Corps of Engineers cultural resources and environmental planning personnel should draw a lot of satisfaction from how you have moved aggressively into automated data management. One of the strengths of your organization that should not be underestimated is that, because of the nature of the Corps' mission, it does not fear technology, an environment that some in other agencies do not enjoy. That notwithstanding, you may be justifiably satisfied about how far you have come and where you seem to be heading. I hope that at some point in the future you will be joined on this journey by other Federal agencies, including the National Park Service.
The papers in this volume address a number of important problems faced by the Corps of Engineers, Department of the Army and other Federal agency cultural resource managers. Each of the papers presents a pragmatic solution to real world problems. The applications presented here must be "industrial strength". They must withstand use and abuse by real people who have real problems to solve. That such systems exist is a compliment to the developers and a clear sign of the benefit of such an approach. In the real world such systems do not continue no matter how elegant. If they don't do the job they die. While we can therefore applaud these success stories we need to also be aware of some more fundamental issues which are raised by actual, as opposed to trial, computerized systems. There is a substantial body of literature, most of it seemingly written by James Martin, which does an excellent job of introducing us to the concerns and solutions to many of the computer oriented problems. There is no need to replow this already well cultivated ground. Instead, I would briefly discuss an even more fundamental class of concerns which focuses on the organizational and worldview changes which successful use of the technologies require.

Even though more than two decades have passed since computerized methods were introduced into mainstream archeology, it is fair to say that computer methodologies remain a new technology for many archeologists. This is particularly true in situations where the computer applications are designed to become part of the routine operation of organizations such as the Corps of Engineers and not simple limited research tools. As a result, it remains beneficial to consider the fundamental organizational changes which both must occur and will result from adoption of computer methods. While archeologists frequently study prehistoric and historic technologies and the changes that they might have induced in past societies, they are less comfortable with focusing the same attention on potentially similar changes occurring in their own societies. In this sense, this commentary may be viewed as a brief

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consideration of the anthropology (or perhaps sociology!) of computer applications in our field. While most of our concerns with computer methodologies rightly focus on the technology and the substantive results produced, in a more fundamental sense the critical issues are how they will affect not only how we do our work but how will they change what our work is.

Much has been made of the fact that the adoption of word processing is the single most productive arena of computer applications yet achieved. What is not recognized in this apparently simple statement is that word processing is one of those few automated tasks where the adoption of the new technology only slightly alters the existing operation. The writer is still a solitary person communicating with a computer keyboard rather than a typewriter. The techniques are simple automated analogues for their manual ancestors. No new "modes of thinking," organizational shifts or realignments in information flow are required. Such is not the case when organizational databases are developed and used or when a unit shifts to the use of a geographic information system. To develop a database which has wide useability, a "corporate" database in modern computer parlance, a number of fundamental issues must be faced and realistic answers to truly knotty questions produced. For example, if we are to develop an archeological site database we must define what we mean by an archeological "site". If we record environmental information about these sites, we must decide what information is important to record. If we assign a cultural affiliation to our sites we must decide what characteristics define a "Paleoindian" occupation or a "Late Mississippian" one.

Not only must we come up with many definitions but the definitions must be acceptable to a sufficiently wide group of people that the resulting data may be of use. It is essential that more than the database developers feel that the definitions are useful because the development of a computerized database is a task of considerable magnitude and only is reasonable if the effort can be amortized over time and many users. Unfortunately, because of the fundamental nature of many of the issues, developing answers that are acceptable to many of our associates may be difficult. This is particularly problematic when those who are critical of the definitions have not themselves had to arrive at structured resolutions because they have not felt the need to utilize automated methods.

One solution to the problem is to characterize those who are critical of new computerized systems as technological neanderthals who "just don't understand." And that might just be true. On the other hand these "neanderthals"
may rightly be pointing out inadequacies which have been created because we have made some quick, "practical" solution to our problem which, because it has not been well considered, will lead us to the old GIGO state ... garbage in garbage out. Good intentions and powerful technology are not in and of themselves sufficient. In contrast, new technologies and old world views are a mix doomed to failure. A similar situation pertains to GIS systems. If anything the development of a GIS database is of even more effort than an archeological site database. The effort required to develop such a database is not simply an individual effort with individual rewards. The scale of most realistic GIS efforts mandates a major institutional commitment and data acquisition expenses that must be amortized over multiple users.

All of this presents a situation which many individual archeologists find discomfiting. The tradition of the solitary scholar is strong in our field and there are numerous situations in which projects conducted by committee have been failures. The point of this is not, however, that we must avoid such an approach but is instead to suggest that our traditional ways of approaching our data may also require transformation as much as do our technologies.

To argue by analogy lets us compare ourselves today to the situation faced by the infant air transport industry in the 1920s. Lindy the Lone Eagle was a national hero and mail planes and barnstorming dominated. The solitary pilot in competition with the elements was the stuff of novels. Many archeologists today are like Lindy or those barnstormers...we cannot help but admire them and perhaps even wish that we were back in those simpler times, but, when it comes to traveling, we don't want to sit in those open cockpits navigating by the seat of our pants. We want large, safe 747s with three pilots, a myriad of electronics, FAA ground controllers and the entire air industry infrastructure. We gain much but we also lose some as well. If we are to make use of modern computational technology we must move beyond Lucky Lindy. Just as he would be out of place in a modern jet's pilot seat, archeology's traditional analytical concepts and even the organization of our research strategies must change. It is in the area of conceptualization and organization, more than in any specific technique, that fundamental change must take place. And it will...one does not need to be visionary to realize that. One simply has to look carefully at other fields. The changes caused by technology are inevitable. The only question is how long it will take and how many
failures in our current thinking will be needed before the necessary organizational changes are made.

Let me give a single example of how a technology now just emerging will fundamentally change archeology. This is the techniques of virtual reality. Virtual reality is a computer based technology in which a three dimensional simulacrum is created of a location. The user experiences the location through a helmet which has two very small computer screens located over each eye. As the head is turned or the wearer moves, the new "view" is computed and displayed on the screens and the wearer has the clear sense of moving through and into the image. It is possible to walk through an as yet unbuilt building and to look through imaginary windows to an imaginary landscape. Using sensor gloves the participant can pick up objects, touch them, drop them, or move them to a new location. While it "feels real" neither the object or the location exists beyond the computer simulation. Such systems are in existence now and are rapidly undergoing development and improvement. It should not require a tremendous leap of imagination to see how such systems might be used in archeological analysis. That they have a tremendous potential should be evident to everyone, what is more complex is to decide how we should be recording our archeological data so that it can be integrated into such systems and how these systems will change how we write about the past. Maybe we no longer will write about the past but instead experience it. If this is true how does that alter the current balance between "research" and "interpretation." We could imagine a reviewer in the future first viewing the simulacrum based on Study a and then Study b in order to assess the relative merit of the two theories or site evaluations. Mitigation would entail recovery of sufficient data to reliably recreate the site. We would no longer mitigate through data recovery but through site re-creation.

My point in this discussion has been to challenge us to look beyond the important but essentially superficial aspects of these new technologies and to consider how we need to reorganize our current approach to our data, its recovery, and its storage. These challenges are more in the realm of the social and conceptual than they are technological.