A GIS APPROACH TO CULTURAL RESOURCES MANAGEMENT
AND NEPA COMPLIANCE

Konnie Moeller
Argonne National Laboratory
Argonne, Illinois

NAEP 21st Annual Conference
Practical Environmental Directions: A Changing Agenda
June 2-6, 1996
Houston, Texas

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.
DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.
A GIS APPROACH TO CULTURAL RESOURCES MANAGEMENT
AND NEPA COMPLIANCE

Konnie Moeller, Argonne National Laboratory, Argonne, Illinois

ABSTRACT
Cultural resources management and historic preservation compliance are best approached within the broader framework of natural resources planning and land management. Argonne National Laboratory is currently assisting federal agencies with the development of computer-based resource management systems for large facilities, and cultural resources management and preservation are components of these systems.

Common problems faced in federal land management are carrying out responsibilities for extremely large parcels of land; collecting and processing large quantities of environmental data, including many different variables; gaining access to data typically in a variety of formats from widely scattered sources; and finding sufficient time to make informed planning decisions.

A device for addressing these problems is a computer-based tool called a geographic information system (GIS). With a GIS-based resource management system, land managers can manage large complex databases quickly and easily, integrate numerous variables into the decision-making process, and improve the effectiveness of resource planning and environmental compliance. GIS tools are often applied to the management of various natural and cultural resources, such as forests, wetlands, and archaeological sites. However, within the even broader context of environmental compliance, especially compliance with the National Environmental Policy Act, resources need to be evaluated collectively in order to assess environmental impacts cumulatively -- not separately.

In the area of cultural resources, Argonne is using the GIS tool to demonstrate how federal facilities can manage large, complex databases, integrate cultural resource data with other environmental variables, model distributions of resources to aid in inventory and evaluation, link the data to quantitative and impact models, and effectively manage and monitor resource planning activities and environmental compliance. Spatial and tabular data regarding surveys, archaeological sites, and historic buildings can be stored, manipulated, updated, and displayed in the context of a larger environmental database (e.g., wetlands, vegetation, hazardous waste). Predictive modeling capabilities can streamline planning by enabling the coordination of the management of archaeologically sensitive areas with other environmental compliance concerns. Impact modeling capabilities, such as hydrological modeling of erosion and deposition of sediments, also aid in the assessment of cumulative impacts to natural and cultural resources.

INTRODUCTION
A geographic information system (GIS) is a computer-based tool that allows the user to manipulate a large amount of locational data (spatial and tabular) to determine relationships from that data. The user can then further manipulate, analyze, and display the data according to the needs of a specific application. The data can be manipulated to change the scale, rotate the image, generate new data layers, or create composite maps. Analysis can include routing (best way to get from 'point a' to 'point b'), buffering, and the linking of statistical packages, databases, and quantitative models to the

---

1 Work supported by the U.S. Department of Energy, Office of Energy Research, under contract W-31-109-Eng-38.
The utility of the GIS tool for managing cultural resources is that it permits
the user to (1) manage large, complex databases, (2) integrate cultural
resource data with other environmental variables, (3) model the distribution
of resources to aid in inventory/evaluation, (4) link the data to quantitative
and impact models for analysis, and (5) effectively manage and monitor
resource planning activities and environmental compliance.

Database
The cultural resource spatial database typically includes survey areas, known
prehistoric and historic archaeological sites, potential historic sites based
on historic maps, historic structures, and areas of resources significant to
Native Americans. A considerable body of information is usually associated
with each of these areas of concern.

Survey data include survey name (or number), reference, contractor name,
principal investigator, date(s) the survey was conducted, number of acres
covered, method (surface reconnaissance, subsurface testing), level of
intensity, transect intervals, shovel-test intervals, number of sites located,
and site numbers. All of this data can be coordinated using a GIS. This small
set of data may reside in a database to be linked directly to the spatial data
through a common spatially referenced identifier, such as the survey name (or
number). Alternatively, it may be entered as attribute data within an internal
GIS database as the survey areas are input on the system.

Information about known (i.e., recorded) archaeological sites includes data on
site forms, reports, artifact inventories, eligibility status for listing on
the National Register of Historic Places (NRHP), site maps, stratigraphic
profiles, field notes, photographs, excavation reports, and letters of
consultation. A general database containing site information for a large area
can be linked to the site number. A more specific database, such as an
artifact inventory for an individual site, can also be linked to the spatial
data if a spatially referenced identifier, such as an excavation unit number,
is available. Letters, photographs, and even complete reports can be scanned
and linked by site number and called up on the system when needed for quick
reference. A "point and click" method of data retrieval further augments
accessibility and ease of use.

Historic map sources are commonly used before a cultural resources survey to

spatial data. The display of the data can include hard-copy maps and
statistical summaries, as well as computer screen images.

Such a system provides a cost-effective approach to facility planning and
operations management by organizing diverse sources of data, centralizing the
data for ease of accessibility and use, and providing a means to
simultaneously consider numerous variables critical to planning and management
activities at a large facility. These activities include facility operations
(e.g., management and monitoring of buildings, roads, utilities), emergency
response, waste management, and environmental compliance.

Argonne National Laboratory (Argonne) is currently assisting federal agencies
in developing computer-based resource management systems using a GIS, with
particular focus on natural and cultural resource planning and compliance.
Each system is designed to incorporate available data to make most efficient
use of time and money; new data acquired through remote sensing technology are
also being incorporated.

An inter-disciplinary approach to facility planning and management is critical
to ensure that activities are conducted in a timely fashion and in a manner
consistent with the regulatory guidelines of the National Environmental Policy
Act (NEPA 1969). Cultural resources should be linked with natural resources
within the framework of NEPA to adequately address issues of cumulative
impacts.

GIS AND CULTURAL RESOURCE MANAGEMENT

The cultural resource spatial database typically includes survey areas, known
prehistoric and historic archaeological sites, potential historic sites based
on historic maps, historic structures, and areas of resources significant to
Native Americans. A considerable body of information is usually associated
with each of these areas of concern.

Survey data include survey name (or number), reference, contractor name,
principal investigator, date(s) the survey was conducted, number of acres
covered, method (surface reconnaissance, subsurface testing), level of
intensity, transect intervals, shovel-test intervals, number of sites located,
and site numbers. All of this data can be coordinated using a GIS. This small
set of data may reside in a database to be linked directly to the spatial data
through a common spatially referenced identifier, such as the survey name (or
number). Alternatively, it may be entered as attribute data within an internal
GIS database as the survey areas are input on the system.

Information about known (i.e., recorded) archaeological sites includes data on
site forms, reports, artifact inventories, eligibility status for listing on
the National Register of Historic Places (NRHP), site maps, stratigraphic
profiles, field notes, photographs, excavation reports, and letters of
consultation. A general database containing site information for a large area
can be linked to the site number. A more specific database, such as an
artifact inventory for an individual site, can also be linked to the spatial
data if a spatially referenced identifier, such as an excavation unit number,
is available. Letters, photographs, and even complete reports can be scanned
and linked by site number and called up on the system when needed for quick
reference. A "point and click" method of data retrieval further augments
accessibility and ease of use.

Historic map sources are commonly used before a cultural resources survey to
identify areas of potential historic locations. These map sources can be scanned as an image to be incorporated in the management system or they can be digitized as GIS data layers. A scanned image is useful for visual inspection and for keeping all of the data in one place, but it is not necessarily spatially referenced. It can still be linked to other data on the system, but only as an image (similar to a photograph). As a data layer, the historic map is spatially referenced and can be used in a more analytical way, such as overlaying it with referenced aerial photographs to aid in pinpointing the areas of concern in the field. Problems often arise with the older historic maps, however, because of inaccuracies and distortions of scale in the original maps. The needs of the user and the quality of the source map will best determine in what format the historic map will be most helpful.

Data on historic structures are stored in a similar manner to data on archaeological sites, linked on the system to the individual structures and accessed through a "point and click" procedure. Data include information typically found on structure inventory forms, such as, date of construction, methods and materials of construction, dimensions, architect, description, past and current uses, alterations, history (including associations with significant persons or events), description of surrounding area (for contextual purposes), and condition and integrity of the structure. Associated architectural/engineering drawings, photographs, and floor plans can be scanned and linked to the structures. These data are important for evaluation of the architectural value of a structure. Compliance data, such as eligibility status for listing on the NRHP and correspondence with historic preservation agencies, can also be linked for rapid assessment of the status of various structures.

Areas containing resources significant to Native Americans can also be integrated into the management system in a manner similar to the other data sets discussed above. These data would also overlap with several other data sets important to a resource management system. Data layers of archaeological sites (including burial sites), threatened and endangered species, wetlands, certain plant communities and animal habitats, and topographic features, may all contribute to this resource area. Letters of consultation, minutes of meetings, inventories of repatriated items, and other data pertinent to establishing and maintaining good rapport with the Native American groups, as well as assuring compliance with the American Indian Religious Freedom Act and the Native American Graves Protection and Repatriation Act, can be added to the system.

A GIS-based resource management system helps the user centralize this complex set of information onto one system by linking the different data sources to the spatial data. Queries of the cultural resource data for a proposed project can then be made on one system without the need to consult a variety of disparate sources of information (usually scattered about several locations). This ability saves considerable time and effort.

Integration of Cultural Resources Data with Environmental Variables

Cultural resource data do not exist in a vacuum. The data are tied to other environmental variables and must be considered within this larger context. For example, certain plant species or topographic features may be significant resources for Native Americans; site locations may be predicted on the basis of certain favorable environmental characteristics (e.g., distance to water, slope, aspect, topographic setting); or previous disturbance to an area may have destroyed the eligibility of any potential cultural resources for inclusion on the NRHP and thus removed the need for any further investigation (pending SHPO concurrence). A GIS-based system allows the simultaneous integration and consideration of all of these factors (and more).

This integration of environmental variables with cultural resource data is also critical to the compliance process. Compliance concerns can be addressed more efficiently by considering all potential impact receptors at once. The GIS tool can be used to visualize what impacts a proposed project might have,
whether it affects a wetland, an archaeological site, or the habitat of a threatened or endangered species. The planning process can also be simplified by querying the data for areas that do not contain protected resources yet still contain the necessary characteristics required for the project. Although it is possible that no areas will be indicated as suitable for the project, the decision maker will be better equipped for siting alternatives with the least potential for impact, or siting the least costly alternatives with regards to mitigation strategies.

Historic structures are not as closely tied to environmental variables as are the archaeological resources, but they are a major component of the facility infrastructure, which includes buildings, roads, and utilities. Data on historic structures can be integrated directly with the building infrastructure GIS layer by facility/building number, thus eliminating the duplication of a data set. Many different databases can be linked to the same data layer; therefore, the historic structure database will not interfere with any other databases tied to the infrastructure, such as an emergency response database, personnel database, or building maintenance database, all of which could be linked by facility/building number. This arrangement also allows the user to access other databases for additional information, such as identification of buildings contaminated by asbestos, or buildings scheduled for demolition over the next 10 years.

**Modeling Site Distributions**

In complying with the provisions of NEPA and moving toward long-term stewardship of natural and cultural resources, large federal facilities face formidable challenges in maintaining up-to-date environmental data. The inventory of resources often play "second fiddle" to project-specific compliance activities. Use of a GIS-based system to efficiently handle compliance activities makes more time available for updating and expanding the environmental database. One way to maximize the advantages of using a GIS is to use the available environmental data to model resource distributions. From this predicted distribution, priorities can be established on the basis of such factors as future projects, disturbance, and contamination as to which areas require immediate attention versus those that are less critical to day-to-day operations of the facility.

Argonne has used a GIS to develop a predictive model for prehistoric archaeological sites as part of a larger resource management system. A predictive model is an efficient way to initially identify areas with the highest potential for containing prehistoric archaeological sites (Kohler and Parker 1986; Allen et al. 1990). These areas can then be investigated to verify that potential. The model output can be used as a planning tool for cultural resource management to prioritize future inventory surveys. The results can also be used by facility operations managers in planning future projects so as to avoid areas with high potential for cultural resources (as well as to avoid wetlands, contaminated areas, and the like).

Results of the model (areas of low, medium, and high potential) are being integrated with areas containing a history of ground disturbance (based on remote sensing sources and field data) to further reduce the total area indicated as medium and high probability. A random sample of areas will be groundtruthed to validate the determinations for all three probability classifications. If the areas with the potential for containing archaeological sites are identified and avoided, and future development is limited to areas with a low probability for containing cultural resources, much less time, money, and effort will be required to satisfy regulatory requirements for future activities. Such an approach also allows for more efficient priority-based planning of needed surveys in the areas more likely to contain cultural resources.

**Modeling Impacts to Cultural Resources**

The predominant type of impact assessment conducted for cultural resources involves proposed construction projects (e.g., buildings, pipelines, roads).
Therefore, the most obvious use of a GIS is to overlay proposed construction facility layouts ("footprints") on cultural resource data layers. These overlays provide immediate indications of impacts to known sites and structures, as well as impacts to areas with high potential for cultural resource sites (high-potential areas). The need for surveys, evaluation, and mitigation measures can then be determined from this visual assessment, with all of the supporting data linked directly for easy retrieval. An additional benefit is that alternative siting options can immediately be evaluated simply by moving the "footprint" to avoid a significant impact.

Although cultural resource impact assessment is often confined to the projection of ground disturbance based on location-specific engineering designs, impact assessment must sometimes address the indirect effects of dynamic natural systems. For example, the construction of a road could increase slope erosion. The elimination of vegetation cover in an exposed area could accelerate the deflation of sediment by wind. The lowering of a lake level could alter the behavior of the streams that empty into it. All of these natural systems, which involve the action of wind, water, and gravity, have been mathematically modeled by geomorphologists and geohydrologists. Such models have been linked to GIS for applications in the earth sciences, and could be used to predict the effects on known or predicted cultural resources.

Two models involving use of a GIS have been used by Argonne to address impacts. A watershed model, ANSWERS, developed by EPA to identify soil movement within watersheds (Beasley and Huggins 1981), has been modified and linked to the GIS. Impacts due to soil erosion and deposition can be considered for a number of resource areas, including cultural resources. By overlaying areas of known or predicted archaeological sites with locational-based results of the watershed model, areas of potential impact on cultural resources can be predicted. In cases of heavy erosion, areas may be destroyed at a high rate requiring inventory, evaluation, or mitigation depending on the status of known or potential site locations. These impact projections require ground-truthing for verification of the results. Remote sensing applications are also possible for monitoring the areas in which impacts are projected.

The second model is a noise model, NOISEMAP, developed by the U.S. Air Force (1992) which was used to identify areas of possible impact to historic buildings from vibration damage potentially linked to ordnance and vehicle testing activities. The model produces noise contours for different activities. These contours can be overlain on displays of known historic structures in the area of the facility. Structures located within the contour boundaries are then identified as requiring further investigation. Data for those particular structures can be called up on the system to indicate eligibility status and any past compliance activities.

CONCLUSION: Resource Planning and Environmental Compliance

In conclusion, a GIS-based resource management system makes possible the implementation of effective management to protect cultural resources, direct surveys where they are most needed, reduce costs by eliminating unnecessary surveys, plan future activities with rapid access to cultural resource data, and consider potential impacts to significant sites, historic structures, and areas of concern to Native Americans early in the planning process.

On a broader scale, a GIS provides the means to effectively manage and monitor natural and cultural resource planning activities and environmental compliance. Resource protection, mitigation, and regulatory compliance can be concurrently considered for ongoing and future activities on the basis of full and up-to-date environmental information. The ability to link models to the GIS-based system puts integrated analytical tools at the investigator’s fingertips. The visual component of a GIS provides an effective means of communicating the environmental consequences of management decisions to others.
REFERENCES


