PARTNERSHIPS AND OPPORTUNITIES: THE ARCHIVAL MANAGEMENT OF GEOGRAPHIC INFORMATION SYSTEMS

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ABSTRACT: This article provides an overview of geographic information systems (GISs) technology and applications. It discusses its implications for archives, including a review of the existing literature. Finally, the article recommends a strategy for managing such systems based on the study of an environmental GIS application in a federal research center and on the vision recently expressed by David Bearman and Margaret Hedstrom. A multi-staged approach to the archival management of GISs is recommended and new partnerships are suggested to aid archivists in the future management of these systems.

Introduction

Geographic information systems (GISs) are complex, powerful tools with "vast potential...for solving environmental and human management problems."[1] Representative of what Terry Cook has described as the second generation of electronic records, GISs present a number of challenges to archivists.[2] This article presents an overview of GIS technology and applications; discusses their implications for archives, especially as related to appraisal, access, and preservation; and looks at these issues in relation to a GIS currently being used at a federal research center.

Defining GIS

No universally accepted definition exists of what constitutes a GIS. The Federal Interagency Coordinating Committee on Digital Cartography (FIC-CDC) provides the following definition:

> A geographic information system is a computer system designed to allow users to collect, manage, and analyze large volumes of spatially referenced and associated attribute data....The major components of a GIS are: a user interface; system/data base management capabilities; data base creation/data entry capacity; spatial data manipulation and analysis packages; and display/product generation functions.[3]

Frank Horvath adds to this definition by stating that "GIS allows data 'themes' to be selectively overlain on base maps where spatial relationships and distributions can be visualized."[4] Antenucci et al. use GIS "in a broad sense to refer to all automated systems used primarily for the management of maps and geographic data."[5] Together, these definitions help illustrate the basic concepts and capabilities of GISs.

By focusing on three key parts of the FICCDC definition, one can gain better understanding of GIS technology. The data base creation/data entry capability is what allows data to be brought into the GIS. The system/data base manager is what is used to create databases that can be manipulated by the spatial data manipulation and analysis package. The true power of GISs lies in this ability to overlay different data sets with the same spatial reference onto a base map. Horvath describes this process:

> A GIS uses spatial data that consists of points, lines, and polygons (multi-sided shapes) associated with a geographical location. The data take the form of roads, lakes, rivers, soil associations, plant communities, and a wide range of cultural and natural features. The data are associated in a geographically relevant plane and are separated by type ("theme") into different computer files ("levels") which can be composited ("overlain") on each other to show their spatial relationships. The data can be shown at various scales and displayed on a computer screen or plotted as high-resolution maps.[6]

GIS Applications

Examples of GIS applications help illustrate these concepts. Geographic information systems are used in many different settings, such as public and private agencies and businesses. Antenucci et al. summarize the following categories of use as identified by Francis L. Hanigan: business applications; election administration and redistricting; infrastructure management; map and database publishing; oil, gas, and mineral exploration; public health and safety; real estate information management; renewable resources management; surveying and mapping; transportation and logistics; urban and regional planning; and research and education.[7]

One such specific application is that of the Michigan Department of Natural Resources (MDNR) which is developing a GIS to help manage competing demands on the state's shore and water resources.[8] Base maps of shoreline areas will be overlaid with various themes being developed by the MDNR. Some of these themes include land ownership, soil types, survey data, energy facilities, human population, fish distribution, and amphibian and reptile abundance. Overlaying these themes on base maps of a particular shoreline area provide a powerful visual tool that will help in making future land use decisions.

Archaeologists and historic preservationists also are developing historical applications. These communities increasingly use a combination of historic maps and newly gathered data to help assess the impact of proposed land use and development, to identify archaeological sites, and to recreate the landscape view as seen by people in earlier times.[9]

Challenges to Archivists

The scope of the above system descriptions and data definitions indicate that GISs are important systems for archivists to consider under the range of archival electronic records management programs. GISs not only record the functions, activities, and decisions of an organization or agency through the data they contain and the information they generate, but also the data compiled in the GIS development represent a highly expensive and potentially reusable resource (if appropriately gathered, identified, and preserved).

By their very nature, however, GISs present a number of challenges to archivists charged with their long-term management and preservation.[10] These challenges are well summed up by Dorothy Ahlgren and John McDonald in one of the first papers to discuss the archival management of GISs:

> The complexity of the structure, the changing nature of the information as it flows through this structure, and the variety of media involved present a challenge for the archivist who is concerned with archival management of the entire system.[11]

Ahlgren and McDonald were concerned with the full range of information produced by the system, including draft maps for publication; output on disk, magnetic tape, or paper; monthly and annual reports; and memoranda, policy documents, and correspondence.[12]

In addition, Ahlgren and McDonald raised the following concerns and questions regarding the archival management of GISs:

> At the records control stage, there is the need to identify those individual components in the system to which retention periods should be applied. During the appraisal stage, those forms of recorded information which are to be acquired must be identified. The acquisition, processing, and control functions are also affected by the complexity of the system. In what forms should the information be acquired? What parts of the system, once acquired, will adequately reflect the original contents, uses and purposes of the system and yet also best satisfy the potential needs of the research community?[13]

These issues and questions remain important in developing a framework for the archival management of GISs.

In recent years, the use of GISs has grown dramatically, and along with this, the analysis and modeling capabilities of GISs also has grown, adding to the challenges archivists confront in understanding and managing these systems. The archives literature concerning GISs remains sparse, but this is slowly changing. In 1990, Katharine Gavrel outlined the growth and applications of GISs, and she predicted that their use in the creation of information would "provide an opportunity to return to the appraisal or selection of records as a whole."[14] A recent paper by Daniel Jansen describes in greater depth the challenges in managing GISs, and he provides some guidance for archivists in preserving the evidential value of these systems.[15] Other approaches to the archival management of GISs appear in summaries of professional meetings. In April, 1994, David Bearman invited records managers and archivists from around the world to share their experiences in electronic records management. One of the speakers, Michael L. Miller of the Environmental Protection Agency, "proposed how the notion of evidential value could be incorporated in the appraisal of such systems," and he devised a list of questions to use in addressing these issues.[16] The 1993 meeting of the National Association of Government Archives and Records Administrators, summarized by David Bearman in *Archives and Museum Informatics*, included presentations by Tom Eiber and Les Maki of the Minnesota Land Management Information Center, who discussed standards, size, and access issues in a GIS, and a presentation by Theodore Hull of the National Archives and Records Administration (NARA) who spoke about NARA's participation in standards development and their first appraisal of a GIS run by the Bonneville Power Administration.[17] Although brief, these summaries point to archivists attempting to manage these systems. Despite these references in archival journals, other work by archivists resides in difficult to locate reports or unpublished documents, and in most cases, it simply does not exist. At this time, the best way for archivists to improve their management of GISs is to attend appropriate professional association meetings, network with their colleagues, and follow the GIS literature.

Looking outside the archival profession, other communities are concerned with many of the same issues and may make useful allies.

Two surveyors in particular, Ralph Smith and Gary Hunter, have discussed important points related to the archival management of geographic information systems. Ralph Smith, of Central Mapping Agency in Toronto, Canada, recognizes a role for archivists in managing GISs. He identifies data management problems that add to the complexity of managing GISs.[18] The most important of these problems for archivists are standards, destruction of data, current and non-current data, and data volume.

The untimely and/or inappropriate destruction of electronic records and data is of concern to archivists, and the profession needs to become more involved in the management of these records. Archivists recognize what Smith states about the ease of deleting electronic records. He addresses the need for the scheduling of these records through the development of rules and procedures to preserve electronic records and to code data when it is first input to determine how long it is to be kept.[19] Establishment of policies that express the importance of keeping these records, as well as participation in the systems development stage, are two steps archivists must take in order to properly schedule and preserve GISs and the data they contain.

GISs are constantly updated, so the disposition of non-current data is of concern to archivists who need to protect the creating agencies legally and preserve the record of their transactions. Gary Hunter, when writing about the preservation of GISs, discusses the distinction between current and non-current data and the importance of preserving the latter. He defines current data as that "essential for the daily activities of the agency concerned and...in regular use, whereas non-current data are those assessed as having no further apparent operational value to the agency."[20] The values of non-current data that Hunter, a professional surveyor, notes are useful for decision-making have a very familiar ring to archivists:

> First, data having administrative value are often vital because they document important decisions, precedents or actions. Next, records of fiscal value provide essential information about the means by which an agency collected, controlled and spent its finances, whilst legal value may be found

> in data recording the entitlements, interests and obligations of both governments and private citizens.[21]

For example, in a natural resources environment, data that document the environmental status of an area before clean-up and restoration is important in showing the success of these efforts and in identifying the actual condition of particular areas. This information is potentially important to an organization for any of the three values identified above. Research value, not mentioned by Hunter, also is important.

Management Strategies

Like Smith, Hunter places the burden of preserving these data sets on GIS managers, not archivists. He provides some valuable insight for archivists, however, on how this data is managed and preserved. GIS technology offers several methods for retaining and processing current and non-current data. These include "time-windows" to request that data from a particular time period be used; the microfilming of maps as they change over time; purposeful implementation of a system using current and non-current data sets; and time encoding to reconstruct a view from a specified period.[22] Archivists must take advantage of the natural concerns of organizations and GIS managers in preserving the evidence of these systems, and they must work with and evaluate the methods used by GIS managers to preserve it. Professional surveyors, like Smith and Hunter, are natural allies for archivists. Archivists, however, cannot count on them to understand what really needs to be preserved; it is archivists who understand the need to retain the context and evidence of these electronic records. Simply microfilming maps generated from a GIS may not preserve this evidence. As the technology matures and standards are developed and implemented, it will become easier for archivists to preserve electronic records in their software dependent format, thus retaining more of the context and evidence of the system. The preservation of information in a software dependent format, however, has problems related to proprietary use of the software. Lineage information programs help answer the challenge of documenting the commands used to create GIS coverages, while at the same time, solving the proprietary issues.[23] GIS professionals are researching these problems, and it is important for archivists to keep up with developments in these areas.

Because of the large costs associated with gathering data for GISs, it is important that standards be developed for sharing this data with others who need it. Standards are important to archivists because they provide the means by which these systems can be accessed and used in the future. Currently, no uniform standard exists, but many are being developed or implemented in various countries, and archivists should be aware of these. The U.S. Department of Commerce recently published the *Spatial Data Transfer Standard* (SDTS). This standard provides a mechanism for the transfer of digital spatial information between noncommunicating parties using different computer systems.[24] For archivists, the SDTS promises to help preserve the informational value contained in the GIS, but it is unlikely to be described at the level required by archivists, nor does it adequately address the evidential value of GISs.[25] The Federal Geographic Data Committee (FGDC) Metadata Content Standard lists a number of data exchange formats and provides a standard scheme for describing geospatial data to aid potential users in determining if a needed set of data already exists in a format they can use.[26] In Canada, the Ontario Ministry of the Environment is developing the Map Data Interchange Format.[27] *Spatial Data Transfer Standards: Current International Status*, a book edited by H. Moellering, provides a comprehensive overview of spatial data transfer standards in use or being developed in countries around the world.[28] As Smith states:

> Without standards, GIS users will not be able to recall intelligent archived data and integrate it with current data for spatial trend analysis....In the electronic era, it is not sufficient to prepare only images and text for archives; data, relationships and process must also be archived.[29]

Smith puts the responsibility for preserving the data, relationships, and process on those creating the GIS. He sees the role of archivists to be "not the indexing and storing of records, but their retrieval and dissemination for use by others."[30] This is an interesting idea for archivists to consider, and one that will be discussed later.

Lastly, Smith discusses the size of GIS systems—a management problem for both systems developers and archivists—and some technological solutions for coping with this.[31] In addition, Antenucci et al. describe storage formats familiar to archivists working with electronic records, such as tape drives, magnetic disks, and optical disks.[32] Storage of geographic information systems and data is of concern to archivists who wish to bring the system physically under their control.

Instead of bringing GISs under their physical control, archivists should consider applying the new model of archival activity advocated by David Bearman and Margaret Hedstrom. This model recognizes the inadequacies of traditional archival methods when applied to electronic records management. Historically, archivists have been taught to survey, schedule, appraise, dispose and accession, describe, preserve, and access records.[33] This approach is unsuccessful when applied to electronic records management because it focuses on outputs rather than outcomes and it does not guarantee access to records of continuing value, especially in a time of down-sizing and right-sizing.[34] Bearman and Hedstrom instead propose the reinvention of archives based on a model that advocates "steering rather than rowing, empowering others rather than serving, becoming enterprising and customer-driven, and decentralizing."[35] Geographic information systems are a perfect example of electronic records that, as Bearman and Hedstrom explain, "require the on-going maintenance of a range of hardware and software and continuing migration of both data and applications, both of which activities are never ending and very expensive."[36] These systems are ripe for the type of policy development, legal sanctions, regulation, and cost-sharing strategies discussed by Bearman and Hedstrom. The author believes, however, that it will be a long time before the strong legal and policy measures that Bearman and Hedstrom foresee will become a reality. Until then, archivists should appeal to the inherent preservation concerns of other professionals involved with these systems to assist them in successfully managing these records.

The development and use of metadata is one part of Bearman and Hedstrom's new model of archival activity.[37] Although the idea of using data about data to describe electronic records is relatively new to both archivists and systems managers, GIS is one area where progress is being made.[38] For example, the FGDC recently finalized a metadata content standard to document geospatial data acquired or developed by the Federal Government. The FGDC developed this standard for the following reasons:

> The standard was developed from the perspective of defining the information required by a prospective user to determine the availability of a set of geospatial data, to determine the fitness [sic] the set of geospatial data for an intended use, to determine the means of accessing the set of geospatial data, and to successfully transfer the set of geospatial data. As such, the standard establishes the names of data elements and compound elements to be used for these purposes, the definitions of these data elements and compound elements, and information about the values that are to be provided for the data elements. The standard does not specify the means by which this information is organized in a computer system or in a data transfer, nor the means by which this information is transmitted, communicated, or presented to the user.[39]

NARA serves on the FGDC, so, hopefully, the standard will address archival needs for metadata. This standard needs to be analyzed closely from this perspective, however, since it will be used by many federal agencies.

A Possible Management Approach

Describing a GIS currently in use at a federal scientific research center illustrates the archivist's challenge in managing a geographic information system.

The Great Lakes Science Center (GLSC) is an office of the National Biological Service (NBS). The mission of the NBS is to provide leadership in gathering, analyzing, and disseminating the biological information necessary to support the sound management of the Nation's natural resources. The GLSC supports this mission through research, inventorying and monitoring, and information transfer activities related to the Great Lakes ecosystem. Throughout its history, the GLSC has been particularly concerned with Great Lakes fisheries resources, and especially the restoration of the lake trout *(Salvelinus namaycush).* Since the 1950s, millions of hatchery-reared lake trout have been stocked into the Great Lakes to supplement native lake trout populations that were depleted or exterminated by sea lamprey predation and overfishing. These attempts to establish self-sustaining populations have been largely unsuccessful because stocked fish have not naturally reproduced in sufficient numbers in four of the five Great Lakes. Scientists have speculated that this lack of success may be partly due to the stocking of lake trout over unsuitable substrate at locations other than those once used by native lake trout for spawning. Current fishery management plans call for stocking over historical spawning grounds, under the assumption that lake trout will return to spawn at substrate that protects their eggs and fry from predators, and from wave, current, and ice action.[40] The success of this approach depends on precise knowledge of the substrate and location of each historical spawning ground. Several years ago, the GLSC employed a GIS to provide the detailed information necessary to pinpoint these areas.[41]

The GLSC system currently runs on a single personal computer and uses the PC ARC/INFO geographic information system.[42] A "tool box" of general capabilities, provided by PC ARC/INFO, is used for many different applications "from regional planning to land record management to cartographic production."[43]

The data used by GLSC to create base maps of the Great Lakes and their underwater contours were obtained from two sources. The main source was digitized data provided by the National Ocean Survey (NOS). Incomplete information from this set was read from National Oceanic and Atmospheric Administration lake charts and added to the NOS data. As discussed previously, the first application of the GIS system was to help pinpoint and analyze the substrate composition of historical lake trout spawning areas. The substrate information was gathered using side-scan sonar.[44] The side-scan sonar data was digitized and entered into the PC ARC/INFO GIS. Because bathymetric, water depth data, can be gleaned from the side-scan sonar record, this also was entered into the GIS. Thus, the GLSC system is currently capable of producing a base map for a particular lake or lake area, and then overlaying it with substrate and water depth data (Figure 1). The PC ARC/INFO system also is able to perform statistical analysis on the information presented. For example, it can determine what percentage of substrate types (mud, sand, gravel, etc.) occur at particular water depths. Maps produced from the PC ARC/INFO system have been used in several studies around the Great Lakes to help determine substrate and water depth features important for lake trout reproduction. Possible future plans for the system include the addition of other environmental data, such as lake trout location, to the maps to help better understand the factors that influence reproductive success in lake trout.

At the present time, this system is not managed archivally, except by the system manager, a fishery biologist, who saves important coverages produced by

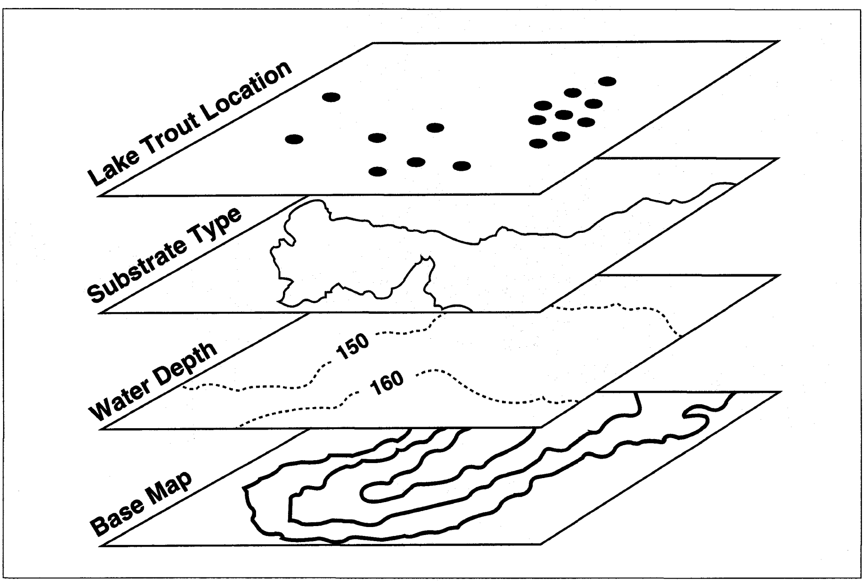

Figure 1
Concept of Data Layers Illustrated by the GLSC GIS.

PC ARC/INFO. The original side-scan sonar data is also preserved. This is done because he and other researchers have a professional stake in the integrity and output of the system, especially that output which is communicated in the professional literature.[45]

The following outline suggests a possible multi-stage approach to the archival management of this system. Such a model builds upon established electronic records methods, yet works toward the new model of archival theory advanced by Bearman and Hedstrom. This approach also relies upon the natural interest of the GIS manager and system users to preserve information generated by the system. The efficacy of this approach, and hopefully also its wider application beyond the system in question, is based upon three main premises. First, the political, organizational, and legal structures and the technical capability, are not yet in place in most organizations to make Bearman and Hedstrom's approach workable. Second, 1995 saw the imposition of a federal mandate (as discussed further below) requiring the broad sharing of metadata on spatial data that coincides well with a second phase of managing the system. Third, since the GLSC system is already operating, the opportunity to "get in" at the system development stage has passed. Therefore, a method needs to be developed that "catches up" with the system and that helps solidify partnerships with those developing the GIS. The proactive, progressive approach of Bearman and Hedstrom provides a challenging goal for archivists. Their methods, however, will not be successful if mutual respect does not exist among archivists and the other professionals involved in creating and using electronic records. Archivists must prove, and then continue to prove, that they bring important knowledge to the information table. As Bearman and Hedstrom acknowledge, "archivists are not considered as potential allies even when management discovers that it cannot account for recent functions or activities."[46] In the case of GISs, as the example below illustrates, the level of knowledge required by archivists is considerable and not easily obtained.

Implementation

As a first stage, the archivist continues the process already begun with the manager of the GLSC PC ARC/INFO system, i.e., learning about its purpose, how it was built, how it is used, and what are the long-term plans. The archivist works on gaining a better understanding of the technology involved, the information the system creates, and how it creates and stores it. This is critical because as Jansen states, "discovering where in the GIS to isolate...evidential value will require that archivists obtain a greater understanding of GIS structure and use."[47] Next, the archivist looks at building an archival management program around the natural concerns the biologist has for preserving data bases and information produced by the system. Through this process, the archivist and system manager begin to form the mutually beneficial relationship that will keep this partnership alive.

At the beginning, the archivist must acknowledge some realities of a research environment. First of all, many scientists are not willing to make available unpublished data (for legitimate reasons) and institutional policies are not yet compelling enough to force them to do so. The archivist, therefore, must work with the biologist to first manage those parts of the GIS that are published or that the scientist, for some other reason, is willing to share. Theoretically this sounds heretical, but practically, it is the only way to begin. Secondly, a partnership implies that each person shares in the costs and benefits of the partnership. Certainly, the organization benefits from the archival management of the GIS, but what does the system manager, who the archivist relies on to keep up with system changes, gain from the arrangement? When this question was put to the manager of the GLSC system, he suggested that the archivist serves as a link with other projects who wish to use or add data to the system.[48] This enhances data collection. For example, if side-scan sonar is being used to gather substrate data, what other data might be gathered in the same field trip that could easily expand the system to serve another need, and that might link with existing projects creating a much more powerful set of data? If the archivist creates this link by "advertising" the system through an Internet home page, for example, and serving as the first point of contact for information about the system, then the potential partners for the organization could be anywhere in the world. As mentioned previously, Smith believes the role of archivists in managing GISs is their retrieval and dissemination for use by others. Although archivists know their role extends beyond this, it may be this service that archivists contribute to the partnership. Finally, archivists must answer a question posed by Michael Miller:

> Are archivists and records managers working in electronic environments pushing to achieve a higher standard for electronic records systems simply because they can or because they need to respond to new demands.[49]

The approach outlined below does not attempt to document everything the system produces because the partnership process would not begin, for reasons already discussed, if this is the archivist's goal. As archivists gain more experience in electronic records management, and as technology advances to better serve the archivist's needs, Miller's question becomes increasingly important in the appraisal of GISs. It is at this point that archivists may see themselves moving away from the traditional archivist's role in appraising records to "defining record keeping regimes for employees to follow but not deciding about specific records."[50]

Assuming the above caveats, a practical scheme for managing the GLSC PC ARC/INFO includes the following steps:

1. The archivist accessions the files containing the NOS and manually entered NOAA data used to create the base maps. These are accessioned in an ASCII format with an ASCII read.me file that describes who created the data and what the data sources were. The coverages and attributes are also saved in the same format.[51] This information is important to save because it represents a significant investment of time by the GIS manager to fill in the missing pieces from the NOS data set, and it is the basis for the information produced by the system.
2. Scheduling records is difficult because data are not added and information is not produced on a regular schedule. Open communication between the archivist and the system manager is vital in order to learn of major system changes. In this scenario, the archivist and the GIS manager sit down, on a project-by-project basis, and discuss what system products are available. For example, once a project is complete and the information published in a scien-

tific journal, the archivist and system manager meet, so the archivist can identify the important archival products of that work. During this meeting, the GIS manager and the archivist assign the metadata that describes the overall project (who was involved and why), the data sources used, the coverages created, and how the information was used. Log files have been suggested as a way of documenting the evidential value of the system, but in PC ARC/INFO, the log files consist only of the commands used to create and modify the coverage, they do not specify which data sets and coverages were combined to create the final product or what detailed modifications were applied within the command.[52] Thus, they do not truly document the evidential value of the GIS, and they must be expanded. The system manager also assists the archivist in identifying correspondence, reports, printed maps, video, raw data, and other non-digital products that relate to the project. At this time, the GLSC system manager is not very familiar with the FGDC Metadata Content Standard, and thus he is unsure how to apply it and how it fits the data and system products. This is an area that the archivist and system manager can pursue together for the benefit of both, but each professional will require additional training to implement this standard.

3. PC ARC/INFO does not allow the metadata to be stored in the coverage describing it. This presents problems for relating the evidential value directly to the output. The archivist, however, has several options for working around this problem. In the first option, the system manager makes the maps available as bit maps, with their assigned metadata. Users can then read the text and view the maps, yet not violate software licensing. Or, since ARC/INFO allows export as other GIS formats or ASCII equivalent into other systems, these exports or "dumps" could be done on a request basis. Again, metadata points to and describes the available information. As a second option, the GIS manager or the archivist, with appropriate licensing, can allow users to view, query, print, and relate coverages, but not create new coverages, using PC ARC/VIEW by either visiting the archives or accessing the information through a network. Separate read.me files contain the metadata describing the coverages. PC ARC/VIEW costs substantially less than the full ARC/INFO program. PC ARC/VIEW is also easier to learn than PC ARC/INFO, but it still requires the archivist and users to be trained, so it is not an ideal solution for the casual user. Lastly, if the requestor already has the appropriate software to view and manipulate the database, then direct access could be permitted to the database or working coverages. In all options, the archivist has the ability to accession the information, or parts of it, or the archivist can work with the system manager to provide access through a local area network, which might in turn be accessible through the Internet. In the earlier stages, as the archivist gains familiarity with the GIS, it is beneficial to be closely involved in managing the system. As each professional, the archivist and the system manager, works to implement a management scheme that benefits the organization and users, the archivist can shift efforts toward steering rather than rowing.
4. If major updates occur in the program, the archivist, in conjunction with the system manager and/or principal scientists, decides whether to convert "old" data, so that it remains usable in current PC ARC/INFO software versions.

The above approach does not solve all the challenges facing archivists who manage GISs. More research is needed to determine whether the existing standards are practical to implement and whether they answer the needs of archivists. In addition, many GISs are constantly changing, and the approach described above is not practical for appraising or scheduling records in these instances, although it does offer a starting point for the partnership between the archivist and the system manager. Assigning metadata is also difficult in large, constantly changing systems; technological tools to automate this data are needed to save time for both the archivist and GIS manager. The long-term storage and retrieval of the system also must be addressed. What happens if the organization decides to scrap the GIS? How will the archivist maintain the system? Archivists have generally taken two approaches for preserving digital documents and systems. The first is to translate them into a standard form that is independent of any computer system, and the second is to preserve the entire software and/or hardware system.[53] The method described for the GLSC system employs both strategies. Jeff Rothenberg points out, however, that something is lost each time digital bit streams are translated to other media and that it is ultimately futile to try and maintain the original system.[54] Neither current technology nor archival approaches to electronic records adequately address these issues. Thus, it will be difficult to manage GISs in the long-term without technological advances to aid electronic records management. Archivists must understand the technological gaps in order to drive the solutions to these challenges.

Partnerships and Opportunities

On April 11, 1994, President Clinton signed an Executive Order entitled, *Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure* (NSDI). This order requires the Secretary of the Interior, through the FGDC, to establish an electronic National Geospatial Data Clearinghouse for the NSDI.[55] As summarized by Al Fisher, National Data Administrator for the U.S. Fish and Wildlife Service, this Executive Order requires federal agencies to do several things:

> Beginning nine months from the date of the order, each agency must document all new geospatial data it collects or produces using the metadata standard being developed by the FGDC. Within one year of the date of the order, agencies must also do the following: adopt a schedule for documenting previously collected or produced geospatial data; adopt a plan establishing procedures to make this data available to the public; adopt internal procedures to ensure that the agency accesses the Clearinghouse before it expends Federal funds to collect new data; develop standards for implementing the NSDI; and ensure that any data collected meets relevant standards adopted through the FGDC process.[56]

This environment creates an opportunity for federal archivists to get involved in managing GISs, particularly if they volunteer to create some of the metadata as well as help provide access and reference. As this process continues, there will be increasing emphasis on standards that also will assist archivists in managing these systems. These developments might be considered the second generation management of second generation electronic records.

If archivists are successful in these earlier stages, they will naturally begin to experience some of the benefits and objectives that Bearman and Hedstrom envision. Archivists will be better off if they reach this point through teamwork and cooperation with GIS managers rather than through reliance on policies and regulations that might never materialize. Technology for creating metadata, storing electronic records, generating audit trails, and manipulating data will continue to improve. The non-physical control that Bearman and Hedstrom discuss will be easier as the technology develops. Pressure on federal agencies to participate in the NSDI will make it easier for archives, such as NARA, to learn about GISs produced by the Government. State and local governments may mandate the same ideas, due to the expense of data collection. However, archivists must resist taking a "hands-off" approach, or they will be not be viewed as professionals with a vested interest in the successful management of electronic records. Archivists must follow Bearman and Hedstrom's advice and be customer-driven. This applies to internal, as well as external customers. If archivists can do this, they will be seen as valuable partners in the management of information.

Opportunities exist for archivists in the management of geographic information systems, but many new challenges also face archivists. Any living, breathing GIS contains information of which its creators and users are very protective. Geographic information systems are not like inactive paper files that go off to the archives when their useful life is over; they are filled with data that people spent hours, days, or even years collecting. The creators of these systems will not turn them over to archivists without a great deal of trust in the profession, as well as a belief that archivists can help them manage it. As systems, technology, and institutions change, archivists may find themselves with inactive GISs to manage; this may really present a challenge if archivists have not educated system managers and institution administrators about the values of preserving the evidence of the organization's functions, decisions, and transactions. Finally, archivists need to seek new partnerships. As librarians look to multimedia automation systems that not only describe GISs, but that also provide direct access to these systems through paths to other software, archivists may find an ally in reference services. Thus, success in managing GISs comes not only from meeting challenges that exist now, but also thinking creatively about those that lie ahead.

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NOTES

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45. Gregory Kennedy, interview by author, Ann Arbor, MI, 7 June 1994.
46. Bearman and Hedstrom, 85.
47. Jansen, 195.
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49. Duffy et al., 330.
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51. "The coverage is the basic unit of data storage in ARC/INFO...It defines the locational and thematic attributes for map features in a given area. A coverage is defined as a set of features, where each feature has a location (defined by coordinates and topological pointers to other features), and, possibly, attributes (defined as a set of named items or variables)." See Morehouse, 437.
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