
A Partnership Framework for Geospatial Data Preservation in North Carolina

STEVE MORRIS, JAMES TUTTLE, AND JEFFERSON ESSIC

ABSTRACT

The North Carolina Geospatial Data Archiving Project (NCGDAP) is a joint project of the NC State University Libraries and the NC Center for Geographic Information and Analysis focusing on collection and preservation of state and local agency digital geospatial data resources. The project is being carried out in collaboration with the Library of Congress under the National Digital Information Infrastructure and Preservation Program (NDIIPP) in a partnership with the NC OneMap initiative, a statewide framework for data coordination and distribution. A core project objective is the engagement of established spatial data infrastructure in the challenge of long-term preservation of digital geospatial data. Key issues related to engaging spatial data infrastructure include initiation of data inventories, development of content exchange networks, cultivation of metadata standards and practices, and leveraging the experience of agencies that are already making efforts to retain historical data. The NCGDAP work triggered the creation of new data preservation partnerships both within the state and across a set of states that are participating in a new NDIIPP Multistate initiative.

INTRODUCTION

The content domain of digital geospatial data includes such data resources as geographic information systems (GIS) datasets, digitized maps, remote sensing data, and tabular data that are tied to specific locations. These complex data objects do not suffer well from neglect, and long-term preservation will involve some combination of format migration and retention of critical documentation. At the state and

local government level geospatial data resources are created by a wide range of agencies for use in applications such as tax assessment, transportation planning, hazard analysis, health planning, political redistricting, and utilities management. These data resources are, in general, of greater detail and more current than data available from federal agencies, yet production points for these resources are diffuse—99 of 100 North Carolina counties have GIS, as do many cities—posing numerous challenges to the archive development process. Many of the targeted data resources are updated on a frequent basis—daily or weekly in some cases—yet data dissemination practices, for the most part, focus on providing access to current data. Although often created with specific applications and functions in mind, these data resources are used in applications ranging far beyond those initially intended. End-user applications that might make use of historical and time series data include analyses of urbanization, environmental change, demographic change, land use change, and past uses of individual sites.

In October 2004 the NCSU Libraries and the NC Center for Geographic Information & Analysis entered into an agreement with the Library of Congress to pursue preservation of state and local digital geospatial data as part of the National Digital Information Infrastructure and Preservation Program (NDIIPP) (Library of Congress, 2008b). The goal of the North Carolina Geospatial Data Archiving Project (NCGDAP) has been to inform development of a national digital preservation infrastructure through a “learning by doing” approach focused on identifying, acquiring, and preserving content within the context of the NC OneMap initiative and its framework of partnerships with state, local, and federal agencies. Although the collection-building aspect of this project is focused solely on the state of North Carolina, the project is expected to serve as a demonstration project that will inform data archiving and time series development more generally. While the technical aspects of project work have been reported elsewhere (Morris, Nagy, & Tuttle, 2008; Morris & Tuttle, 2007), this article focuses on the partnership components of the project and summarizes key outcomes and findings from the project in that context.

RISKS TO DIGITAL GEOSPATIAL DATA

While key feature data layers such as land records, street centerlines, jurisdictional boundaries, and zoning are constantly changing, current data management practice commonly involves overwriting older versions of data, which are then no longer available for historical or trends analysis. Emerging Web services or API-based technologies pose further challenges to the archive development process as it becomes easier to get and use data without creating a local copy—secondary archives often being in part a by-product of providing data access. Even if

the data has been saved, there is a chain of possible failure events that can impede permanent access to data:

- To the extent that such data is saved, it may be stored in such a way that it is not discoverable.
- If the data is discoverable, policies may not have addressed the issue of what sort of access should be provided to older versions of data.
- If the data is accessible, there is a possibility that the storage media will no longer be readable.
- If the media is readable, the data files themselves may be corrupt.
- If the files are not corrupt, it is possible that the files will be in a format that is no longer supported by current software.
- If the format is useable, it is possible that the documentation needed to use and understand the contents of the data will not exist.

While digital geospatial data inherits preservation challenges that apply to digital resources in general, this content area also presents a number of domain-specific challenges to the preservation process (Zaslavsky, 2001; Bleakely, 2002). Preservation challenges identified in the project have been outlined in detail elsewhere (Morris, Tuttle, & Farrell, 2006). Vector data (point/line/polygon) and spatial databases are subject to particular risk, given their complexity, relative absence of non-proprietary formats, and the propensity for data to be overwritten. Key image data resources, notably digital orthophotography, are not typically at risk of overwrite, yet data from older flights are known to have become less discoverable and less accessible.

PROJECT PARTNERSHIPS

NCGDAP builds on earlier efforts by NCSU Libraries, beginning in 2000, to acquire and preserve state and local geospatial data. That effort began in response to rising user demand for local data and a growing sense of long-term risk to this newly emerging content. Attempts to meet the challenge of engaging and archiving content from well over one hundred local agencies helped to cultivate an understanding of the need for an infrastructure-based approach to archive development. It became clear that a preservation effort could only scale by building from existing data infrastructure that has evolved as part of the National Spatial Data Infrastructure (NSDI). Spatial data infrastructure—which incorporates local, state, and federal government agencies as well as the private sector—had already been focused on such issues as data standards, best practices, data sharing agreements, metadata production and harvesting, catalog development, and services integration (FGDC, 2008d). However, archiving and preservation had not yet become an area of focus in these efforts.

The primary manifestation of spatial data infrastructure in North Carolina is NC OneMap, a combined state, federal, and local initiative

that is focused on allowing users to view geographic data seamlessly across North Carolina, search for and download data for use on their own GIS, view and query metadata, and determine agency data holdings through an online data inventory. (NCGICC, 2008c) Included in the NC OneMap vision statement is the assertion that “Historic and temporal data will be maintained and available” (NCGICC, 2003). While primarily focused on access and content standardization, NC OneMap has offered a means by which to engage a large number of local agencies in the process of creating a digital preservation infrastructure.

PROJECT WORK PLAN OVERVIEW

NCGDAP was conceived as a demonstration preservation experience in which the archive being developed is not so much an end in itself as it is a catalyst for discussion among the various elements of spatial data infrastructure. That discussion, which includes libraries and archives as well as GIS agencies, is centered not just on preservation processes and best practices but also on roles and responsibilities of the various players within the geospatial community. The project was also seen as a way to generate learning experiences about domain-specific technical challenges associated with preserving geospatial data. To support the archive development process a demonstration repository using DSpace was deployed, and a robust repository ingest workflow was developed to handle the transformation of complex multi-file, multi-formats formats into discrete digital repository items (Morris & Tuttle, 2007; Morris, Nagy, & Tuttle, 2008). The longer-term project objective is to shift archiving functions to relevant state agencies and the State Archives as well as to cultivate an increased commitment to temporal data management on the part of the data producers and data custodians.

PARTNERSHIP FRAMEWORK

NCGDAP builds upon an existing statewide organizational framework, key components of which are the North Carolina Geographic Information Coordinating Council (GICC), the North Carolina Center for Geographic Information & Analysis (NCCGIA), and the NC OneMap Initiative. NCSU Libraries, as lead institution in NCGDAP, has also collaborated in the development of data infrastructure within the state.

NC OneMap

The project is tied closely to NC OneMap, a statewide framework of geographic information based on partnerships between municipal, county, regional, state, federal agencies, utilities, and others. The project indirectly serves to complement and advance North Carolina’s component of several national geospatial initiatives including the National Map, Geo-Spatial One-Stop, the National Spatial Data Infrastructure (NSDI), and also the efforts of the Federal Geographic Data Committee (FGDC). Of

particular importance is NC OneMap's role as North Carolina's chief expression of the National Map, a consistent framework for geographic information, providing public access to high-quality, geospatial data, and information from multiple partners to help support decision making by resource managers and the public. The National Map is the product of a consortium of federal, state, and local partners who provide geospatial data to enhance the nation's ability to access, integrate, and apply geospatial data at global, national, and local scales (USGS, 2008).

NC OneMap is closely tied to a national digital network through a series of connected initiatives devoted to access, integration, and utilization of geospatial data. State and local data provides much of the highest resolution and most current data available within such networks. NCGDAP, through its connections with those initiatives, is—by example, through the development of practices and through existing partnerships—exploiting an opportunity to raise the profile of digital preservation and long-term access as issues to be addressed in these existing and emerging national geospatial networks. The manner in which key components of the NC OneMap network, in turn, support the work of archive development are outlined in Table 1.

Partner: North Carolina Geographic Information Coordinating Council

The North Carolina Geographic Information Coordinating Council (GICC) is established by legislation and is charged with improving the quality, access, cost-effectiveness, and utility of North Carolina's geographic information and promoting geographic information as a strategic resource for the state. The council creates policy and resolves technical issues related to North Carolina geographic information and GIS systems and fosters cooperation among government agencies, universities, and the private sector. The legislation also established several committees that support the GICC, including the State Mapping Advisory Committee, the Local Government Committee, and the GIS Technical Advisory Committee. The GICC and its constituent committees have served in an advisory capacity to NCGDAP, and regular project reports have been provided to these groups.

Partner: North Carolina Center for Geographic Information and Analysis

The North Carolina Center for Geographic Information and Analysis (NCCGIA) is the primary state GIS agency and serves as staff to the GICC. In this role, NCCGIA is responsible for implementing the goals and strategies of the GICC (NCGICC, 2008a). In the course of the project NCCGIA has been active in playing a coordinating role in a broad range of partnership and infrastructure development initiatives both within the state and in the national context. NCGDAP participation in these initiatives ensures that preservation issues are addressed in much larger project contexts that involve significant government agency and industry support. Benefits

Table 1. NC OneMap: Key Components and Value to NCGDAP

Component	Function	Value to NCGDAP
Partners	Partnership is not limited to data interchange but also addresses commitment to adherence to geospatial data standards, keeping data current and maintained, and providing data access through on-line mapping services (OGC Web services).	The NC OneMap network provided the organizational context for NCGDAP. NCSU Libraries and Library of Congress are listed on the NC OneMap website as "Supporters and Collaborators" of the NC OneMap network.
NC GIS Inventory	The statewide NC OneMap GIS Inventory offers a catalog of GIS data produced by government agencies (and others) as well as a Who's Who in GIS. Participating agencies are provided with a metadata building block for each data set cataloged. The inventory is an ongoing process, with data producers able to update information at any time.	The inventory provides a key source of information for NCGDAP, dramatically lowering costs associated with data identification.
Data Download	Free public download of a wide range of state agency data is provided. Some local agency data is also now available. FGDC metadata is made available with data downloads.	The NC OneMap data download provides a convenient point of aggregation for archival data acquisition of state agency data. Data are presented in a consistent manner with full FGDC metadata.
Web Services Catalog	Interoperable web services published by state and local agencies form the "geospatial backbone" of the state. NC OneMap partners establish OGC-standard WMS services for use in the NC OneMap Viewer or in other environments.	The NC OneMap Web Services Catalog has provided the basis for NCGDAP testing of WMS services reliability and might provide the basis for explorations of WMS harvesting.
NC OneMap Viewer	Partner WMS services are accessible through the NC OneMap Viewer. Multiple years of orthoimagery are available by WMS.	NCGDAP work in the future will focus on the issue of getting more temporal data into the NC OneMap Viewer and web services access environment in order to help socialize the problem of data preservation.
Metadata Outreach and Support	NC OneMap provides support for metadata creation. Template records are made available for the following key framework data layers: Building, Cadastral, Municipal Boundaries, School Attendance Districts, and Street Centerlines.	NC OneMap metadata outreach efforts promote metadata availability for the archive. Template records and the NC OneMap starter block help to promote structural consistency and metadata quality.

Table 1. *continued*

Component	Function	Value to NCGDAP
Cost Sharing Arrangements	The cost of flying and producing orthoimagery (aerial photography) has been traditionally borne by local governments. As part of the NC OneMap initiative, state and federal government agencies work with local governments to leverage cost-share opportunities and offset the financial burden to each organization. The program helps to ensure that current and past imagery exists statewide to meet the business processes of local, state, and federal agencies.	Imagery produced through the cost share program is made available to NCGDAP as part of the "orthophoto sneakernet." Since the imagery has been produced under cost share, open rights are guaranteed to the archive. Participation in the cost sharing program requires adherence to a set of minimum best practices which includes registering data with the statewide inventory, producing metadata, and making data available to the public.

accrue to the preservation effort in terms of increased availability of data, greater efficiency in data acquisition, and improved consistency of data and metadata. Utilization of the existing organizational infrastructure has allowed the project access to broad, ready-made audiences for preservation outreach.

Partner: NCSU Libraries

NCSU Libraries, the lead organization for NCGDAP, has partnered with state and local agencies on data access issues for the past fifteen years. While the main focus of the library GIS data services program is on providing data access and support to NCSU faculty, staff, and students, the library has also partnered at the statewide level on such issues as map server development, data directory management, and data archiving. NCSU Libraries represents the University of North Carolina system on the State Mapping Advisory Committee and has participated in a wide range of statewide committees and working groups. The library also provides NCSU representation to the Open Geospatial Consortium (OGC) standards organization.

Partner: State Archives

From the beginning of the NCGDAP work it had been expected that the demonstration project would lead to a more formal involvement of the State archives in the state's geospatial data archiving effort. State archives functions such as local records outreach and retention schedule development serve as existing infrastructure, which might be leveraged into geospatial data management. A key outcome of the NCGDAP effort has been to initiate the integration of the State archives into the spatial data infrastructure of the state.

Participation in NDIIPP Network Development

While NCGDAP is focused on the issue of bringing data preservation into the realm of spatial data infrastructure development, it has also become clear in the course of the project that infrastructure development history of the geospatial community would provide learning experiences of value to the Library of Congress-led effort to develop a sustainable, national digital preservation infrastructure. NCGDAP has actively participated in a range of formal and informal collaborations within the NDIIPP network, and these events and venues have provided an opportunity to cross-fertilize between projects and to cultivate new collaborations.

FINDING DATA FOR THE ARCHIVE

The scope of NCGDAP includes state and local geospatial data in North Carolina. Data produced at the state level is typically more detailed and current than data produced at the federal level but not as detailed and current as data produced at the county and municipal level. Data producing roles at the state versus the local level do vary somewhat state to state within the United States, with some states following a decentralized data production pattern, as found in North Carolina, and other states having data production more strongly centralized at the state level. The scope of data production at the different levels of government in North Carolina is outlined here.

State Agencies

In addition to NCCGIA, over twenty state agencies in North Carolina have active GIS programs that are involved with geospatial data production and use. Key agencies include the Department of Transportation (NCDOT), the Department of Environment and Natural Resources (NCDENR), the North Carolina Flood Mapping Program, and the Department of Agriculture. Both NCDOT and NCDENR include several subdepartments with their own GIS programs.

County Agencies

Geospatial data development has typically been initiated by the county tax assessment (or land records) office and focuses on development of resources such as high-resolution digital orthophotos, street centerlines with addresses, and municipal boundaries, all of which are needed for tax assessment operations. Digital orthophotos provide the base material for creation of vector layers such as land parcels and so are typically the first data resource created.

Municipal Agencies

Many municipalities in North Carolina have developed GIS systems, which are used as part of ongoing work in areas such as land use planning, zoning, utilities management, park and open space planning, and emergency

response. City governments typically acquire the relevant county data as a base resource and then develop additional, needed data layers as a result of ongoing operations.

Other Sources

Other data producing organizations include Council of Governments, Metropolitan Planning Organizations (MPO), university research groups, nongovernmental organizations, and private land-holding organizations.

The Role of Data Inventories in Content Identification

One of the biggest challenges in archive development is determining what data is available in the one hundred counties and many municipalities in North Carolina. It is necessary to minimize the intrusion on the time of local agency data producers that, especially in rural counties, operate with small staffs, which are often as small as one person. "Contact fatigue" arising from redundant requests for data or for information about data holdings can stretch local staffing resources and blunt enthusiasm for local participation in infrastructure-based approaches such as formal inventories. Information acquired through informal methods is spotty, subject to transcription errors, and quickly becomes outdated. Formalized, comprehensive, routinized inventory processes, which have been vetted by the data producers and stakeholders, more efficiently serve general industry data discovery and access needs while also supporting archival efforts. An added benefit is that inventory systems can produce basic metadata for documented data resources. To inform the archive development process NCGDAP utilized inventory information from current inventories as well as historical inventories.

Historical Inventories

Since the mid-1990s, a number of efforts have been undertaken to track the spread of GIS activity among local government agencies (Morris, Nagy, & Tuttle, 2008). These inventories typically have been incomplete given the complexity of the task of surveying 100 counties and 140 cities. All of these inventory results became obsolete quickly in the absence of an ongoing process for update. In the early stages of the project NCGDAP undertook an analysis of these older surveys in order to find out what information is available. The project also sought to learn from past inventory experiences in order to provide input into future data survey efforts. Historical surveys and inventories might be used for future research in terms of time series analysis focused on:

- shifts in use of formats over time;
- changes in agency responsibility for geospatial data management and services;
- data availability;

- trends in access and distribution policies;
- shifts in use of commercial software packages.

The Current NC GIS Inventory

The original NCGDAP work plan proposed development of a next-generation inventory instrument that would support an ongoing inventory process for NC OneMap. However, in the period between the original proposal and the completion of the final project work plan in December 2004 the National States Geographic Information Council (NSGIC) initiated an “all states” approach to the development of a survey instrument so that each state need not develop its own process and tools. NSGIC developed the RAMONA (Random Access Metadata Tool for Online National Assessment), an inventory tool the primary purpose of which is to track the status of GIS in U.S. state and local government, aiding the planning and building of spatial data infrastructures. RAMONA provides one consistent platform for the nation that is designed to work in concert with the Geospatial One-Stop (GOS) portal, a federal metadata clearinghouse.

In 2006 RAMONA was implemented within the state as the inventory component of the NC OneMap Program (NCGICC, 2008b). In support of NCGDAP data inventory requirements, NCCGIA led implementation and will be continuing with administration, reporting, and analysis operations related to the RAMONA tool’s implementation within North Carolina as the NC OneMap GIS Inventory (NCGICC, 2008b). Individual data producing agencies within the state are responsible for inputting and updating information about data holdings and data projects. Availability of the inventory information supports acquisition efforts by lowering contact and selection costs and minimizing impact on data custodians. An interim report summarizing data availability and related results was released in November 2007 (NCCGIA, 2007).

County and City Data Directories

Since 2000 NCSU Libraries has maintained directories of county and city geospatial resources in North Carolina. (NCSU Libraries, 2008a) These directories document agency contact points, data downloads, Web mapping applications, and Web services. While these directories support the discovery needs of data seekers, they also support NCGDAP project work by making data access and contact information available in a single place. The county directory in particular is widely used and commercial and public interest is such that it is the third most highly used entry point into the entire NCSU Libraries website. NCGDAP has also experimented with making the data access links indexable and discoverable as KML “place-marks” that have been exposed for indexing and discovery in “geosearch” environments.

GETTING DATA FOR THE ARCHIVE

Initial project data acquisition plans were significantly modified in response to concerns within the data community about the volume of requests that state and federal agencies as well as others were imposing on local agencies (NCGICC, 2006). In addition, a dramatic increase in volume of data becoming available for acquisition forced a decision to only pursue a subset of available data while trying to: (a) maximize the learning experience, (b) catalyze a community discussion about data preservation, and (c) minimize negative impacts on statewide efforts to coordinate data acquisition efforts (the “first, do no harm principle”).

The project proceeded on a two-track data acquisition approach that divided data sources into two groups: “low friction” and “high friction.” In low friction situations there are few or no technical or legal barriers to acquisition data could be acquired at minimal cost. In the meantime, NCGDAP worked to support a variety of partnership efforts focused on increasing the number of low friction situations through the development of content exchange networks and the cultivation of open data sharing arrangements that have been explored in the GICC Ad Hoc Local/State/Federal Data Sharing Committee and other GICC groups (NCGICC, 2007).

Legal or financial factors that would contribute to a situation being considered high friction include:

- requirement that a formal agreement be signed;
- requirement of payment to cover the costs of data transfer;
- ownership of data by a secondary owner, in which case rights for redistribution are not clearly established.

Technical factors that would contribute to a situation being considered high friction include:

- lack of network access to the data;
- complicated data extraction interfaces that make it costly or impossible to acquire complete data coverage via network access.

INTERAGENCY COLLABORATION ON DATA ACQUISITION

A major challenge for the project has been to find a sustainable and affordable way by which data for 100 counties and as many as 140 municipalities could be made available to a central archive. Data acquisition experience prior to the project and especially in the early stages of the project made it clear that an infrastructure-based approach to data acquisition was needed in order to reduce acquisition costs and remove technical, legal, and financial barriers to data acquisition for the archive. Archiving aside, pressure within the data community for an infrastructure-based approach to data transfer arose from increasing local agency frustration with the volume of data requests received from state and federal agencies and other organizations such as universities.

State and federal agencies acquire local data to support their own operations and in order to support data improvement and enrichment efforts at the state and federal levels. For example:

- The U.S. Census Bureau acquires local data in order to improve the Census TIGER mapping data.
- The NC Department of Transportation uses local agency street data to build and enhance a statewide street network dataset.
- The North Carolina Department of Agriculture & Consumer Services, Emergency Programs Division, in support of their Multi-Hazard Threat Database, maintains a database of local government data in order to provide rapid emergency response and planning capability to the emergency response community.

By 2006 the issue of efficient content exchange among government agencies as well as academic and commercial consumers had become increasingly prominent in the geospatial data community. A wide range of federal and state agencies were requesting geospatial data from local (county and municipal) agencies, resulting in contact fatigue on the part of local agencies, which typically have small staffs and are not prepared to handle the volume of requests. Furthermore, while the data volumes available from individual local agencies can be quite substantial (hundreds of gigabytes per orthophoto flight), many of the local agencies lack significant technical or network infrastructure. The problem of content exchange was highlighted at the August 2006 NC Geographic Information Coordinating Council Meeting, at which the chair of the Local Government Committee (LGC) released a brief report describing issues related to state government agencies' requests to local government for local government data (NCGICC, 2006).

The preservation challenge came to be increasingly intertwined with the more general problem of coordinating data sharing at the local, regional, state, and federal levels. The LGC report on the content exchange problem recognized the role of NCGDAP in addressing the issue, stating as one of its recommendations that the State Mapping Advisory Committee, in searching for a solution, should consider "the activities of the Library of Congress partnership between NC State University Library and CGIA. This project, which focuses on archival and preservation of geospatial data, may provide insights that are applicable to the data sharing problem" (NCGICC, 2006).

Local/State/Federal Data Sharing Committee

The Local/State/Regional/Federal Data Sharing Ad Hoc Committee was created in February 2007 to address issues brought forward by the Local Government Committee (LGC). The North Carolina Geographic Information Coordinating Council (GICC) appointed an ad hoc committee

to study the problem and develop specific recommendations that address the concerns of local, regional, state, and federal government agencies. NCGDAP was involved in the work of the committee through representation from NCCGIA and NCSU Libraries.

Recommendations of the Local/State/Regional/Federal Data Sharing Ad Hoc Committee were provided in a report to the GICC in November 2007 (NCGICC, 2007a). The recommendations focus on:

- fostering partnership development across all organizations and levels of government;
- avoiding wasteful duplication of effort;
- optimizing the use of technical infrastructure to address business needs for information exchange;
- ensuring effective and economical leveraging of geospatial resources for public benefit.

The committee identified ten data sharing recommendations for consideration by the GICC, and the approved recommendations have been publicized and used to encourage cooperation among all government agencies. Among the recommendations was the item: "Data producers should evaluate and publish their long term access, retention, and archival strategies for historic data." In addition, seven core practices were suggested to help data producers and content providers meet the intended goals for solving the issues with statewide data sharing, including the suggestion that custodians should "establish a policy and procedure for the provision of access to historic data, especially for framework data layers" (NCGICC, 2007a).

Emerging Content Exchange Networks

Against the background of increased local, state, and federal collaboration on development of data sharing infrastructure, formal data sharing mechanisms are beginning to emerge. Formal, structured data exchange networks, even if developed for other business reasons, support data archiving efforts by providing a low cost and routinized means to acquire data, which is authenticated, documented, and for which rights have been clarified.

NCStreetmap (Street Centerline Data Distribution System) In March 2006 the Working Group for Roads and Transportation (WGRT), (NCGICC, 2006a) operating under the State Mapping Advisory Committee, was formed to address the specific challenge of transportation data transfer. Thirteen state agencies are represented along with federal and local agencies as well as NCSU Libraries, representing archiving concerns. In 2008 the work of the WGRT culminated in the development of NCStreetmap (NCGICC, 2008e), which will make street centerline data for participating counties available to federal, state, regional, and university data users. The benefit to NCGDAP

of this effort lies in having a more efficient method to acquire centerline data. Although this initiative is focused initially only on transportation data, it is expected that other resources such as parcel data will be addressed in similar efforts.

Digital Orthophotography Sneakernet

The August 2006 GICC Local Government Committee (LGC) report on data exchange cited particular challenges with regard to digital orthophotography transfers. Orthophoto collections are quite large in size, making network transfer unfeasible. Data from a single county's orthophotography flight can exceed 200 GB in size and some counties have data for several years. From an archive perspective, convincing an individual agency to both agree to share the data and to commit staff time to transfer hundreds of gigabytes of data to an external storage device presents a barrier to acquisition. Key points in the report include:

- “Uncompressed aerial imagery cannot be easily distributed over a network. The time required to transfer aerial imagery for a county may be hours and transmission failure is common.”
- “Currently no single state government agency has the capacity to store aerial imagery for all or even most of the counties in North Carolina. State agencies that acquire aerial imagery from counties cannot easily store and redistribute the data to other state or federal agencies.”
- “Some counties, even those that provide their vector data through a download capability, simply do not fulfill requests for aerial imagery due to the burden on staff and computer resources” (NCGICC, 2006).

In 2006 NCCGIA initiated administration of a routing slip approach to transfer, by external storage device, of county aerial imagery to state organizations and NCSU Libraries. Through this exchange system, local government orthoimagery that is subject to federal cost sharing is automatically made available to a range of agencies and organizations, including NCGDAP, dramatically lowering acquisition costs and effectively removing both technical and rights barriers to data sharing.

Frequency of Capture

Many vector (point/line/polygon) data layers are subject to ongoing update, the frequency of which may be a reflection of the pace at which the described features themselves change or a function of the operational processes of a particular agency. Cadastral or property data, for example, will tend to change on a fairly continuous basis in some agencies, while other agencies may handle updates in batch processes. Road and municipal boundary data also change but at a lower rate. One challenge faced by NCGDAP was to determine, with stakeholders, the frequency with which specific vector data layers should be acquired for archival purposes. Such

a plan would have to be both cost effective and minimize the amount of data loss between captures.

Early in the project, as outreach to local agencies was under way, it became clear that there was much to learn from individual agencies that were already creating data snapshots for their own business needs. While some anecdotal information about current practice had been acquired in the course of site visits and discussions with data custodians, it quickly became clear that there was a need to more formally and systematically engage data producer input. In 2006 the project elected to conduct a formal survey of local agency practice, with explicit focus on frequency of capture of key framework data layers. An initial set of draft questions was developed by NCSU Libraries, NCCGIA, and State archives, and then refined through discussions with the State Mapping Advisory Committee and the Local Government Committee (LGC). The survey targeted four framework data layers for detailed information gathering: parcels, street centerlines, jurisdictional boundaries, and zoning (NCCGIA, 2006a).

Survey Results

The survey was sent to a set of local government GIS contacts covering all one hundred counties and twenty-five of the largest municipalities. Fifty-eight percent of targeted agencies, sixty-one of one hundred counties and eleven municipalities, responded to the survey. In brief, about two-thirds of local government GIS coordinators are taking time to capture geospatial datasets, at least on an annual basis. It should be noted that, in formulating the survey, it was very difficult to draw a distinction between regular data back-up for disaster recovery purposes and retention of geospatial records for archiving purposes, and it is expected that there were a number of false positives among those responses indicating archiving activity (NCCGIA, 2006).

One notable aspect of the survey has been the manner in which the effort has socialized the problem of preservation within the state's geospatial data community. The process of reviewing and refining the survey together with various organizations as well as the actual survey process itself served to generate more awareness of the problem of digital preservation than any other outreach mechanism employed in the course of the project. As part of the NCGDAP project extension work a second local government survey as well as an initial survey of state agencies were executed in June 2008.

Building the Business Case for Data Preservation

In order to engage the attention and resources of data producers, data custodians, and the state's geospatial data community it has been necessary to work toward building the business case for retention of historical data. Apart from acknowledging statutory drivers for data preservation, as outlined in Public Records Law and other requirements, administrative

rules, laws, and policies, it has proven useful to promote and highlight business uses of historical data in a way that is tangibly related to the work and business problems faced by the data community. Early project outreach focused on acquiring anecdotal use cases for older geospatial data, some of which include: land use change analysis, resolution of legal challenges, changes in the amount of impervious surfaces (which increase the propensity for flooding in a given area), shoreline change measurement, and site location analysis. In order to more systematically acquire information about business reasons for retaining older data a component of the Frequency of Capture survey was designed to solicit county and municipal agency feedback on this topic. According to the survey results, there are several business rules and needs that drive retention, including: historic mapping, tax administration rules, information technology policies, records for resolution of legal issues, records retention policies, and land use change analysis.

As a follow-up measure, in late 2008 NCCGIA will execute a business case survey in which state and local agencies will be asked to provide case descriptions involving archival data based on previous experience and pending projects. For each business case the survey will solicit information about resources required, scope of effort, benefits and results, and fiscal outcomes. Agencies will also be asked for examples of when a project could have been served better if archival data were available.

THE ROLE OF STANDARDS AND BEST PRACTICES IN DATA PRESERVATION

A key component of spatial data infrastructure is the development and support of standards and best practices for data creation, data discovery and access, and metadata development. Wider adoption of standards and practices by data producers leads to a greater consistency of data and metadata received by the archive, making it possible to automate ingest workflows and lower archive development costs.

Metadata Standards

Metadata plays a central role in facilitating discovery as part of searchable or browsable indexes. Metadata also supports use of geospatial data by informing the user about data structure, content, georeferencing system used, data lineage (or processing history), rights, and recommended use. Additional ancillary documentation such as data dictionaries for attributes (e.g., land use codes for land use polygons) may also be required in order to properly use the data. The Federal Geographic Data Committee (FGDC) published the Content Standards for Digital Geospatial Metadata (CSDGM) in 1994, and federal agencies were mandated to begin using the standard in 1995 (FGDC, 2008a). The standard, which reached version 2 in 1998, has since been widely adopted at the state government

level, with a lower level of adoption at the local level. The state of North Carolina was an early adopter of the standard and NCCGIA has actively promoted the standard at the state and local level through grant-funded workshops and outreach. In the near future the current FGDC metadata standard will be supplanted by the North American Profile of the ISO 19115 metadata implementation specification for geographic information, using the ISO 19139 XML schema implementation (FGDC, 2008c).

Metadata is often absent when data is acquired from local agencies. To the extent that existing metadata is received with the data, the metadata often needs to be enhanced in the following ways:

- *Synchronization* in order to improve concurrence of the data with the metadata
- *Normalization* to adhere to a standard structure in order to support further metadata processing, including metadata element extraction as part of repository processing
- *Remediation* to fix major errors and to enhance the suitability of key access fields for use in catalog and discovery environments

In practice, the inconsistent nature of structure and content in received metadata makes this added value work very expensive. Project challenges and solutions with regard to metadata are outlined in detail elsewhere (Morris, Tuttle, & Farrell, 2006; Morris, Nagy, & Tuttle, 2008).

Enhancing Metadata Production

Given the cost of processing heterogeneous metadata resources, the key to achieving efficient and cost-effective handling of metadata may lie in the development of formalized content exchange networks and data infrastructures in which the metadata is tightly bound to the data and flows within a standard framework that ensures metadata currency and authenticity while also promoting consistency in structure and content. Recently developed and emerging data inventories and networks are beginning to help meet these needs. Specific, recent operational examples of such infrastructure include:

- The NC GIS Inventory, using RAMONA, which facilitates easy creation of at least minimal metadata by creating a metadata starter block that results from inventory submissions (NCGICC, 2008b).
- NC OneMap metadata templates for key framework data layers, which promote consistency both in content and structure of metadata (NCGICC, 2008d).
- NCStreetmap, the new centerline data distribution system, which allows for at least minimum metadata to pass through the network in such a manner that the metadata is authenticated and consistently structured in such a way as to be suitable for automated ingest processes (NCGICC, 2008e).

Through metadata outreach, NC OneMap assists data providers in the construction of useful metadata documentation for common geospatial datasets and supports implementation of the FGDC metadata standard.

Content Standards

Heterogeneous approaches to dataset naming, attribute naming, and attribute classification schemes create both short- and long-term barriers to understanding and use of content. Data custodians are discovering that naming and coding inconsistencies complicate the process of data sharing even in the context of present day use. While good metadata can make it possible to interpret these components, such metadata is unfortunately often absent or may not include the data dictionaries associated with names and codes found in the data. "Framework data" content standards provide some hope for improved consistency in the content and structure of geospatial data (FGDC, 2008e).

Open Geospatial Consortium Data Preservation Working Group

One NCGDAP project objective had been to insert preservation use cases into the Open Geospatial Consortium (OGC) standards development and interoperability initiative processes. The OGC defines standards covering a wide range of geospatial data interoperability and service scenarios, but preservation had not been in the scope of activity. As an offshoot of participation in the EDiNA GRADE preservation project in the UK (EdiNA, 2005), NCSU Libraries teamed with EDiNA to present on the intersection of preservation issues with the OGC specification development space at the November 2005 OGC Technical Committee Meeting in Bonn. At this event a set of seven points of intersection between the digital preservation problem and existing OGC specification development activities were outlined (Robertson & Morris, 2005). A second thread of discussion focused on the NARA-led FGDC Historical Data Working Group, in which NCGDAP participated (FGDC, 2008b). Representatives of NARA, NCSU Libraries, EDiNA, and others engaged in ongoing archiving discussions leading to the establishment of the OGC Data Preservation Working Group (OGC, 2008).

The role of the Working Group, as outlined in the charter, is to address technical and institutional challenges posed by data preservation, to interface with other OGC working groups, which address technical areas that are affected by the data preservation problem, and to engage in outreach and communication with the preservation and archival information community. In particular, the working group will create and invite dialog with the broad spectrum of geospatial community and archival community constituents which have a stake in addressing data preservation issues.

MOVING FORWARD WITH NEW PARTNERSHIPS

New geospatial data preservation initiatives have begun under the leadership of the state's stakeholder community, with NCSU Libraries continuing to support these efforts in an advisory and catalytic capacity. It is expected that these efforts will be closely aligned with the most immediate business needs of those stakeholders, with the "who, what, where, why, and how" of data archiving being addressed in very practical terms and in a manner that is designed to maximize the likelihood of active participation of the data custodian community in the preservation effort.

NC GICC Archival and Long-Term Access Archival Committee

In response to increasing interest and awareness of the data archiving problem within the geospatial data producer and custodian community, the NC GICC formed a new Archival and Long-Term Access Committee in February 2008. The committee, which includes members from state agencies, local agencies, federal agencies, as well as one regional and one academic organization, is chaired by the GIS Database Administrator of Wake County Geographic Information Systems. The working group will develop a set of recommended practices for data archiving, addressing some of the following issues:

- What content should be preserved?
- How often should data snapshots be captured?
- Where should the archived data be stored and made accessible?
- What data formats, compression formats, and media should be used? Should joined attribute data be included?
- Who should be responsible for creation and long-term storage of archived data?
- What are the business reasons for retaining and providing access to older data?

To establish a framework for the efforts of the working group, a proposed draft set of guiding principles for the formulation of recommended practices has been assembled by the chair of the working group. These proposed principles include:

- Recommended practices should not place an undue additional workload on state and local GIS professionals. Retention strategies should be easy to accomplish as part of the agencies' normal workflow.
- An organized and structured approach for life cycle creation, management, and sharing of geospatial content brings order and efficiencies to the retention and archival process.
- Technical approaches recommended should be designed to minimize the risk of loss of data over time.
- Archiving practices should be consistent with all other GICC-approved

standards and recommendations (data sharing recommendations, security guidelines, etc.).

- Recommendations should be consistent with electronic records guidelines, policies, and requirements published by the NC State Archives, Archives and Records Section.
- Existing retention policies and schedules of local and state agencies should be considered in the development of recommendations.
- Existing infrastructure should be employed as much as possible (e.g., the NC OneMap Inventory).
- Recommendations should address geospatial data that are currently not digital (e.g., scanned versions of older aerial imagery and orthophotography).

NDIIPP Multi-State Geospatial Initiative

A second major outcome of NCGDAP has been the initiation of the NDIIPP Geo Multi-State Archiving and Preservation Partnership (GeoMAPP) project (GeoMAPP, 2008; Library of Congress, 2008a). Co-led by the North Carolina Center for Geographic Information & Analysis and the North Carolina State Archives, this project will demonstrate, learn, and report on strategies to enable long-term access and preservation of geospatial content. Kentucky and Utah are acting as partners, with involvement of state geospatial agencies as well as state archives from each state. NCSU Libraries is participating in the project in an advisory and catalytic capacity. GeoMAPP is exploring ways to expand the capabilities of state governments to provide long-term access to geospatial data. Geospatial and archival staff in the participating states are working together to identify, preserve, and make available data with ongoing research or other value. A key project component involves the testing of a geographically dispersed content-exchange network for the replication of state and local geospatial data among several states to promote preservation and access.

The project will seek to identify core requirements and existing capacity of partners. The project is of interest to state geospatial coordination offices because the practice of moving content in an organized way across jurisdictional boundaries furthers state interests in national spatial data infrastructure, which supports many business processes requiring access to geospatial content. Project activity will include structured facilitation, collaboration among the geospatial and archival community, network building, and outreach to other state partners and stakeholder associations.

MAJOR PROJECT OUTCOMES AND FINDINGS

NCGDAP has focused on leveraging existing spatial data infrastructure into the data preservation effort, increasing awareness of the data preservation problem in the geospatial data community, and maximizing

the learning experience that derives from the effort to develop a demonstration repository. Major project outcomes and findings are outlined below.

Engaging Spatial Data Infrastructure

At the outset it was understood that an infrastructure-based approach was needed to address preservation of geospatial data given the size and complexity of data resources and given the diffusion of production points at the state and local level. In terms of understanding the role that spatial data infrastructure might play in preservation, a number of learning experiences have emerged in the course of the project, including:

- Formal, structured data exchange networks, even if developed for other business reasons, support data archiving efforts by providing a low cost and routinized means to acquire data, which is authenticated, documented, and for which rights have been clarified.
- The path to digital preservation may lead through other more compelling business problems. There is a significant overlap between the conjoined problems of business continuity and disaster preparedness and the lower priority problem of digital preservation.
- Regional efforts, for example at the Council of Government level, serve as building blocks for statewide infrastructure and provide diverse tested environments for network development.
- State archives and state libraries have the potential to serve as significant components of state data infrastructures. Local records outreach and retention schedule processes serve as existing infrastructure, which might be leveraged into geospatial data management.

Understanding an Evolving Content Domain

The geospatial data domain involves a complex mix of both data and services. In terms of understanding the evolving geospatial content domain, a number of learning experiences have emerged in the course of the project, including:

- PDF has emerged as a significant geospatial format. The ability of PDF to capture and preserve elements of cartographic representation makes it a powerful tool for capturing finished output in a way that the underlying datasets cannot. Much underlying data intelligence is lost, but not to the extent that is the case with image snapshots. Complex PDF documents, including those in the GeoPDF format, present new preservation challenges of their own.
- There is significant local agency interest in resurrecting old analog maps for use in the digital environment. This interest creates a point of engagement and dialog around the issue of preserving current geospatial data for use in future historical analyses.
- The true counterpart to the old, preserved map is not the current GIS

dataset but rather the cartographic representation that builds on that data. The representation is the result of a collection of intellectual choices and application of current methods with regard to symbolization, classification, data modeling, and annotation. These representations typically occur in a complex proprietary project file format (difficult to preserve) or in an ephemeral Web services interaction. Increasingly PDF is providing an option for static representations.

- Important data community documents such as inventories, standards, and policy or best practices documents must themselves be archived; in more than one case inventory information that had been retired from agency websites was retrieved from the Internet Archive.

Engaging Industry

There is a degree to which one might consider the geospatial industry to be to some extent “temporally impaired.” In terms of understanding how to engage the geospatial community, both data producers and users, in the preservation challenge, a number of learning experiences have emerged in the course of the project, including:

- Promotion of temporal analysis opportunities and requirements indirectly promotes data preservation by cultivating demand for older data.
- Data is more likely to survive if users are made aware of the data’s existence and the data is being actively sought and used.
- Software and data vendors are increasingly coming to see maintenance and use of temporal data as an important customer problem.
- The best outreach and engagement efforts may be those that are indirect in nature. For example, the process of working with the data community on reviewing and refining a survey on current data retention practices served to socialize the problem of digital preservation more than any other outreach mechanism employed in the course of the project.

Outreach and Engagement

While data preservation has been a low priority in the geospatial industry, emerging industry interest in temporal data use created numerous, mostly unexpected opportunities to engage the data community. Key outreach and engagement outcomes included:

- Elements of spatial data infrastructure within the state, including the NC Geographic Coordinating Council (GICC) and its various subcommittees, were directly engaged in project work.
- A survey of current local government data archives practices documented the current situation and helped to socialize the problem of data preservation within the data community.
- Through partnerships with EDiNA (UK) and the National Archives and Records Administration, NCGDAP played a leading role in the formation

of a Data Preservation Working Group within the geospatial standards organization: the Open Geospatial Consortium (OGC).

- The project led to the initiation of the NDIIPP-funded Geo Multi-State Archival and Preservation Partnership (GeoMAPP).
- State archives were informally engaged in the project work and will be formally engaged in the project extension and multi-state work.
- A new Archival and Long-Term Access Committee was formed under the NC GICC, with representation from federal, state, regional, and local government agencies.

CONCLUSION

In the years following the original project proposal it became necessary to make a number of modifications to the project work plan and to modify project focus. In light of other state and federal data acquisition efforts it was necessary to re-think method and scope of data acquisition. In terms of populating the archive, there was a reduction in efforts to acquire data in “high friction” situations, and an increase in efforts to increase the instances of “low friction” data acquisition through cultivation of common infrastructure in cooperation with statewide partners. The emergence of new content forms and the development of new distribution methods forced a re-thinking of what data was acquired and how to acquire it. In light of pronounced industry interest in the data preservation problem, far more national, international, and private industry outreach and engagement took place than was initially planned.

Working within the context of existing spatial data infrastructure has made it possible to achieve a deep level of engagement with the community of geospatial data communities and custodians on the issue of data archiving and preservation. Archive development approaches that focus on leveraging existing data infrastructures promise to lower the costs for archive development over the longer term. Continued work through new partnerships such as GeoMAPP and the GICC Archival and Long-Term Access Committee promise to deepen the level of direct involvement of the geospatial data producer and custodian community in the data preservation effort.

REFERENCES

- Bleakely, D. R. (2002). Long-term spatial data preservation and archiving: What are the issues? *Sand Report, SAND 2002-0107*. Sandia National Laboratories. Retrieved January 15, 2009, from <http://www.prod.sandia.gov/cgi-bin/techlib/access-control.pl/2002/020107.pdf>
- EDiNA. (2005). GRADE, scoping a geospatial repository for academic deposit and extraction. Retrieved January 15, 2009, from <http://edina.ac.uk/projects/grade/>
- Federal Geographic Data Committee. (2008a). Content standard for digital geospatial meta-data (FGDC CSDGM). Retrieved January 15, 2009, from http://www.fgdc.gov/standards/projects/FGDC-standards-projects/metadata/base-metadata/v2_0698.pdf
- Federal Geographic Data Committee. (2008b). FGDC historic data working group. Retrieved January 15, 2009, from <http://www.fgdc.gov/participation/working-groupssubcommittees/hdwg>

- Federal Geographic Data Committee. (2008c). FGDC/ISO metadata standard harmonization. Retrieved January 15, 2009, from <http://www.fgdc.gov/metadata/geospatial-metadata-standards>
- Federal Geographic Data Committee. (2008d). National spatial data infrastructure (NSDI). Retrieved January 15, 2009, from <http://www.fgdc.gov/nsdi/nsdi.html>
- Federal Geographic Data Committee. (2008e). NSDI framework. Retrieved January 15, 2009, from <http://www.fgdc.gov/framework/>
- GeoMAPP (Geospatial Multistate Archive and Preservation Partnership). Retrieved January 15, 2009, from <http://www.geomapp.com/>
- Library of Congress. (2008a). Multi-state geospatial content transfer and archival demonstration. Retrieved January 15, 2009, from http://www.digitalpreservation.gov/partners/states_nc/states_nc.html
- Library of Congress. (2008b). National Digital Information Infrastructure and Preservation Program (NDIIPP). Retrieved January 15, 2009, from <http://www.digitalpreservation.gov/>
- Morris, S. P. (2006, Fall). Geospatial Web services and geoarchiving: New opportunities and challenges in geographic information services. *Library Trends*, 55(2), 285–303.
- Morris, S. P., Tuttle, J. (2007). Curation and preservation of complex data: North Carolina geospatial data archiving. In *Proceedings of DigCCurr 2007*, an International Symposium on Preservation. Retrieved January 15, 2009, from http://ils.unc.edu/digcurr2007/papers/tuttle_paper_4-3.pdf
- Morris, S. P., Tuttle, J., & Farrell, R. (2006). Preservation of state and local government digital geospatial data: The North Carolina geospatial data archiving project. In *Archiving 2006 Proceedings*. The Society for Imaging Science and Technology.
- Morris, S. P., Nagy, Z., & Tuttle, J. (2008). North Carolina geospatial data archiving project: Interim report. Retrieved January 15, 2009, from http://www.lib.ncsu.edu/ncgdap/documents/NCGDAP_InterimReport_June2008.pdf
- North Carolina Center for Geographic Information & Analysis. (2006). North Carolina geospatial data archiving project: Frequency of geospatial data capture. Retrieved January 15, 2009, from http://www.nconemap.com/Portals/7/documents/NCOneMap_NDIIPLocalGovSurvey_1106.pdf
- North Carolina Center for Geographic Information & Analysis. (2006a). North Carolina geospatial data archiving project: Frequency of capture of geospatial data, survey questions. Retrieved January 15, 2009, from http://www.nconemap.com/Portals/7/documents/Appendix%20NCOneMap_NDIIPLocalGovQuestions_1106.pdf
- North Carolina Center for Geographic Information & Analysis. (2007). NC OneMap inventory report. Retrieved January 15, 2009, from <http://www.nconemap.com/Portals/7/documents/RAMONAdb012908.pdf>
- North Carolina Geographic Information Coordinating Council. (2003). NC OneMap vision statement. Retrieved January 15, 2009, from <http://www.nconemap.com/Portals/7/documents/visiondoc.pdf>
- North Carolina Geographic Information Coordinating Council. (2006). Requests by state agencies for data produced by local governments. Report from the Local Government Committee. August 16, 2006. Retrieved January 15, 2009, from http://www.ncgicc.com/Portals/3/documents/GICC_presentations_081606.zip
- North Carolina Geographic Information Coordinating Council. (2006a). Working group for roads and transportation. Retrieved January 15, 2009, from <http://www.ncgicc.com/Default.aspx?tabid=162>
- North Carolina Geographic Information Coordinating Council. (2007). NC GICC Ad Hoc Local/State/Federal Data Sharing Committee. Retrieved January 15, 2009, from <http://www.ncgicc.com/Default.aspx?tabid=156>
- North Carolina Geographic Information Coordinating Council. (2007a). NC GICC Ad Hoc Local/State/Federal Data Sharing Committee final report. Retrieved January 15, 2009, from http://www.ncgicc.com/Portals/3/documents/GICC_presentations_110707_FINAL.zip
- North Carolina Geographic Information Coordinating Council. North Carolina Geographic Information Coordinating Council. (2008a). Retrieved January 15, 2009, from <http://www.ncgicc.com/>
- North Carolina Geographic Information Coordinating Council. NC GIS Inventory. (2008b).

- Retrieved January 15, 2009, from <http://www.nconemap.net/GISInventory/tabid/288/Default.aspx>
- North Carolina Geographic Information Coordinating Council. (2008c). NC OneMap. Retrieved January 15, 2009, from <http://www.nconemap.net/>
- North Carolina Geographic Information Coordinating Council. (2008d). NC OneMap metadata. Retrieved January 15, 2009, from <http://www.nconemap.com/Home/Metadata/tabid/280/Default.aspx>
- North Carolina Geographic Information Coordinating Council. (2008e). NC Streetmap. Retrieved January 15, 2009, from <http://www.ncstreetmap.com/>
- NCSU Libraries. (2008a). North Carolina County GIS data. Retrieved January 15, 2009, from <http://www.lib.ncsu.edu/gis/counties.html>
- NCSU Libraries. (2008b). North Carolina geospatial data archiving project (NCGDAP). Retrieved January 15, 2009, from <http://www.lib.ncsu.edu/ngcdap/>
- Open Geospatial Consortium. (2008). Data preservation WG. Retrieved January 15, 2009, from <http://www.opengeospatial.org/projects/groups/preservwg>
- Robertson, A., & Morris, S. P. (2005). Long-term preservation of digital geospatial data: Challenges for ensuring access and encouraging reuse. Open Geospatial Consortium Technical Committee Meeting. Retrieved January 15, 2009, from <http://www.lib.ncsu.edu/ngcdap/presentations/Architecture%20WG%20OGC%20Bonn%209th%20Nov%20Robertson%20Morris%20public.ppt>
- U.S. Geological Survey. (2008). USGS geography: The national map: Retrieved January 15, 2009, from <http://nationalmap.gov/>
- Zaslavsky, I. (2001). Archiving spatial data: Research issues. *San Diego Supercomputer Center Technical Report TR-2001-6*. Retrieved January 15, 2009, from <http://www.sdsc.edu/TR/TR-2001-06.doc.pdf>

Steve Morris is the head of Digital Library Initiatives at NCSU Libraries and has worked for the past fourteen years in the area of facilitating access to geospatial data. He is principal investigator in a partnership with the Library of Congress focusing on preservation of digital geospatial data. Steve has master's degrees in both geography and library and information studies.

James Tuttle is the digital repository librarian at North Carolina State University Libraries. James is the technical lead on the North Carolina Geospatial Data Archiving Project and has been responsible for developing the technical infrastructure, repository ingest workflow, and curation processes for project data.

Jefferson (Jeff) Essic is geospatial data services librarian at NC State University. In this role he is responsible for assisting students and faculty with GIS data needs and software support. His accomplishments include his involvement for the past three years with NCGDAP, development of the Historic Digital NC Topographic Maps collection, and reprogramming of NCSU Libraries' GIS Lookup data catalog system.