GIS Collection Development within an Academic Library

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Abstract

Locating usable spatial data is essential for the application and use of Geographic Information Systems (GIS). GIS data collection development constitutes a core element of GIS services within academic libraries. Managers of geospatial resources require a fundamental understanding of the nature and use of GIS data. In the creation of a GIS collection development policy, library professionals should consider the established collection development policy, needs of the GIS user community, campus GIS services, and library infrastructure. Library professionals also need to employ a variety of online resource guides and spatial search engines and navigate a network of government agencies, academic institutions, commercial enterprises, and GIS professionals to locate, select, and acquire spatial datasets. When making decisions regarding GIS data acquisition, the selector should consider cost, availability, license agreements and distribution policies, documentation, data structures, and software and hardware.

Introduction

Since the late 1990s much has changed in the world of Geographic Information Systems (GIS): computer memory has become more accessible, the fields of geographic information science and spatial analysis have spread across disciplines, government agencies and commercial enterprises have developed massive spatial databases, high-resolution satellite imagery has become publicly available, a suite of software has been developed to meet the specialized needs of industry, and the Internet has emerged as a tool for data dissemination and visualization. There has also been a significant increase in new GIS positions within academic libraries as they struggle to

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develop, maintain, and expand their GIS services. These positions include GIS specialists, GIS/data librarians, GIS/map librarians, digital cartographers, spatial data specialists, and GIS coordinators. Nevertheless, the principles of GIS have not changed all that much over the past few years. Tomlin defines GIS as "a configuration of computer hardware and software [and personnel] specifically designed for the acquisition, maintenance, and use of geographically referenced data" (1990, p. xi). When developing GIS services, three core components must be addressed: computer hardware and software, personnel, and data management (Longstreth, 1995). While all GIS service elements are equally important, a particular emphasis exists regarding the GIS data (Jablonski, 2004; Lamont, 1997, van Loenen & Onsrud, 2004), especially since data development or conversion can be extremely labor intensive (Goodchild & Longley, 1999). As a result, the availability of preexisting data often determines the feasibility and geographic area of a research project. This article examines the development of a spatial data collection within an academic setting and addresses the selection, acquisition, and source of spatial data.

The Nature of GIS Data

A fundamental understanding of the nature of GIS data is required before one can locate and use spatial data. The terms spatial data, geospatial data, and GIS data—that is, digital, geographically referenced data—will be used interchangeably in this article. GIS data are generally used to represent or model both physical and administrative geography. Physical features encompass both anthropogenic and natural features on or below the surface of the earth. Anthropogenic features typically include cultural phenomena, such as roads, railways, trails, buildings, and bridges. Natural features include rivers, lakes, shorelines, soils, elevations, etc. Abstract or administrative features are generally cultural divisions or boundaries created and used by organizations and agencies to administer their affairs and resources. These typically include national, state, county, election district, school district, municipal, zoning, zip code, neighborhood, census tract, and parcel or property boundaries. The Committee on Licensing Geographic Data and Services provides a detailed synthesis of geographic data types available in the United States (2004, Appendix C).

Two basic methods exist for representing geographic features within a GIS (DeMers, 1997, pp. 97–101). The vector data structure is composed of an ordered list of points and represented by points, lines, and polygons. Vector graphics model discrete geographic features such as administrative boundaries, roads, buildings, and rivers. A graphic vector object is usually combined or linked with attribute information stored in a separate spreadsheet or database. The raster data structure is composed of a grid of cells or pixels used to model continuous data. The resolution is a measure of the dimension on the ground represented by each pixel. Typical raster datasets include digital elevation models (DEMs), satellite imagery, digital orthophotography, land use/cover, and georeferenced digital images of maps.

GIS data are scaled models or abstractions of reality (Goodchild & Longley, 1999). Understanding the scale and precision of spatial data is essential for both locating and using GIS data. The scale of data is described as a representative fraction such as 1:100,000 (Chrisman, 2002, p. 98; Clarke, 2003, p. 120). The representative fraction is a ratio of units measured on the map to units measured on the surface of the earth. In the example above, one inch on the map equals 100,000 inches on the surface of the earth. The smaller the ratio is, the larger the scale is. For example, a scale of 1:1,200 is considerably larger than a scale of 1:24,000. Datasets of larger scale usually possess more detail and a higher level of accuracy than those of smaller scale (Decker, 2001, pp. 16–19). The capture and generalization of features and attributes will likely vary from scale to scale. The map in Figure 1 shows the differences in representation of the Cape Cod shoreline using different scale data. In application, researchers must consider whether the scale of the data will yield needed results. For instance, if a researcher wants to conduct a site selection project to locate a new optimal location for assisted living in Boston based on municipal transit, a 1:1,000,000 scale transportation dataset will not be appropriate for the study. The scale is too small for the level of detailed information required. Hence, for the purposes of collection development, selectors should take into consideration the scale most appropriate to the needs of their patrons.

Scale requirements also impact where a selector must go to locate and acquire data. In the example above, a selector would probably need to go to Massachusetts state agencies as well as the City of Boston itself to acquire the necessary data because these agencies are more likely to maintain that level of detail in their GIS data.

Collection Development Policy

Much of the literature regarding GIS collection development suggests following an organization's current collection development policy (Lamont, 1997; Larsgaard, 1998, pp. 5–6; Stone, 1999). While this is often the case, there are times when the GIS collection development policy does not coincide with the organization's traditional collection policy. For example, at the Harvard Map Collection, the collection is global in nature with special emphasis on the United States, New England, and the greater Boston area. Our GIS collection certainly parallels the printed collection in this respect. However, while this is a good place to start, we must be careful: we have learned that the users of GIS are not necessarily part of the same user community as users of printed geographic information. These two groups of patrons often have different backgrounds and research needs. A typical example is an economist interested in the spatial econometric modeling of a given area. The economist wants to calculate the distances between

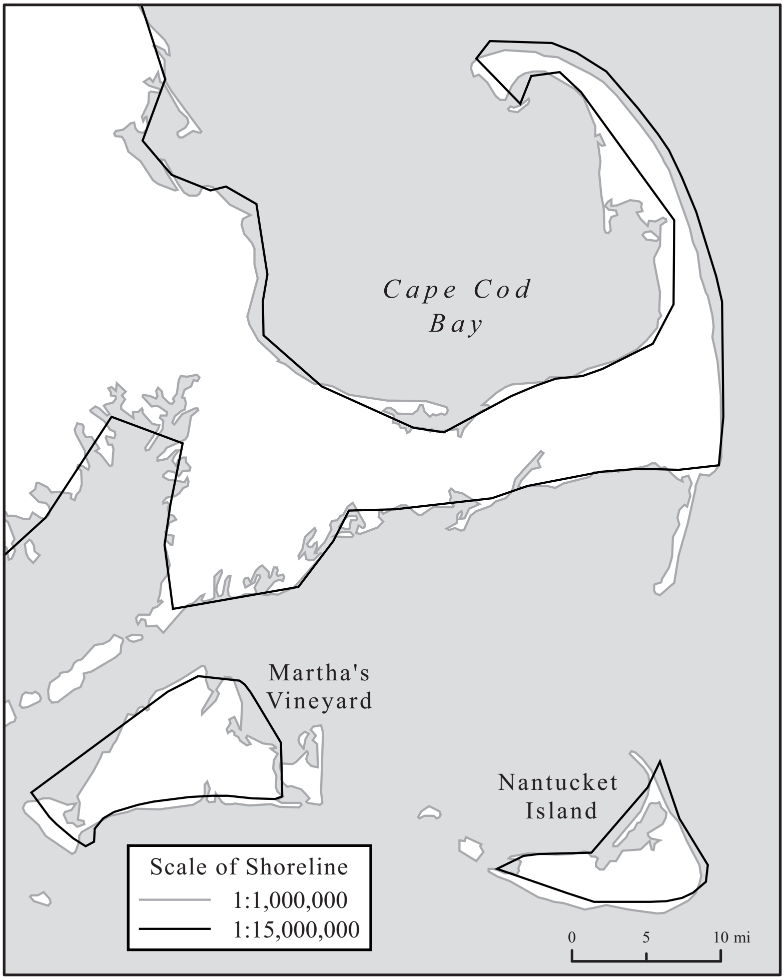

Figure 1. Cape Cod shoreline shown using different scale datasets.

thousands of features, such as cities or businesses or census block groups, resulting in robust distance matrices. Normally their studies would be too computationally intensive to use printed information. Another difference we have discovered at Harvard is that while current events influence the use of printed maps, they have had little impact on the use of GIS data. We purchased robust datasets of North Korea, Iraq, and Afghanistan, and they have received little or no use. The similarities or dissimilarities between printed map users and GIS users will vary from institution to institution. Understanding the needs of both communities of users will lead to better collection development decisions.

The content of GIS data also may span traditionally separate areas of expertise in library collection development, but it often makes sense to consolidate GIS services and data, despite varying subject matter. For example, the Harvard Map Collection does not collect printed geologic maps, but it does collect geological spatial data and applies the same approach to census data. GIS personnel are capable of helping users with this data, despite the fact that these areas do not fall within the Map Collection's areas of print-based concentration.

In addition, the differences between maintaining printed geographic information and GIS data may also impact collection development decisions. For instance, the Harvard Map Collection collects large-scale urban datasets of selected cities across the United States that it would not ordinarily collect in printed form because of the storage issues. In essence, although the established collection development policy provides a good foundation, the GIS collection development policy should also be influenced by the GIS user community, campus GIS services, and the library's infrastructure.

In formulating a GIS collection development policy, it is best to observe users' needs and requests for a few months to a year before making significant changes (Larsgaard, 1998, pp. 1–3; Stone, 1999). In an academic environment, collection development policies need to support teaching, research, and applications (Longstreth, 1995). A needs assessment is the best approach (Martindale, 2004). To begin a needs assessment, keep a database or spreadsheet of spatial datasets requested, noting the area of interest, type of data, contact information, and department. This information is useful in identifying and evaluating GIS data usage and trends. The information and statistics gathered can also be used to justify decisions regarding spatial data acquisition and services. Conducting outreach to departments using GIS can also be very useful. Ask what their most frequently used datasets or types of GIS applications are. These departments may also contribute their own data to the library's collection or contribute additional funds for data acquisition.

Data Selection and Acquisition

User demands, budgets, license restrictions, availability, data formats, and staffing resources influence decisions about selecting spatial data for acquisition. Focusing on the needs of the user community as a whole, rather than the special purpose or special project datasets, is critical (Longstreth, 1995). At Harvard, for instance, we generally only purchase and acquire datasets that we feel will be used somewhat frequently by students, faculty, and staff for teaching and research purposes. For that reason, we rarely purchase satellite imagery. To begin with, it is expensive. Also, when someone is conducting a remote sensing project, they usually need a very specific area at a very specific time period or periods. In most cases, it is unlikely that anyone else will use that dataset in the future. However, we have purchased some high-resolution satellite imagery of foreign cities to help supplement our collection, generally when we are unable to acquire their urban-scale GIS data.

Financial considerations and licensing are certainly a key factor. Commercial and government datasets can be expensive, ranging into the thousands of dollars. Federal depository libraries may receive some U.S. government datasets for free (Lamont, 1997). Many public agencies and commercial vendors offer educational discounts. Mention that the data are for academic/noncommercial use and try to pay a one time charge, avoiding recurring subscription fees. The price of GIS data often relates to the licensing or usage restrictions of the data (Stone, 1999). When the library selector purchases GIS data, the selector is usually purchasing a licensed copy of the data. The licensing of a spatial dataset or product means "a transaction or arrangement . . . in which the acquiring party . . . obtains information with restrictions on the licensee's rights to use or transfer the information" (Committee on Licensing Geographic Data and Service, 2004, p. 25). At the Harvard Map Collection we generally encounter three types of license agreements:

- A free-use license, in which the data can be freely distributed to the general public
- A Harvard-wide site license, in which the data can be disseminated via a server or the Web to Harvard users (students, faculty, and staff) provided they have a Harvard identification or personal identification number (PIN)
- A single-use Harvard license, in which the data can only be used on a single computer at a time, but Harvard users can subset the data and take it away with them to work in a computing lab or at home

Read and negotiate the license agreement carefully. Always try to get a site license. A site license is less restrictive than a single-use license and makes the data much easier to disseminate. Some vendors provide a site license agreement at no additional cost. Some vendors charge five to ten times the amount of a single-use license for a site license, and some vendors refuse a site license altogether. Be honest and upfront with the respective agency or seller. Tell them that at the very least students and faculty need to be able to work at a single computer and subset the data in order to take some of it away to work on on their own. If an academic library cannot at least get that basic license, the product is usually not worth the money. Shop around and compare prices from different dealers. Many of them offer the same datasets at competitive prices. I have had good success with companies such as East View Cartographic, Map Mart, and LeadDog regarding licensing (see Table 1). East View Cartographic in particular has a long tradition of working with libraries. Other companies such as GfK Macon and Bartholomew generally offer more restricted-use data. Finally, partner

Table 1. Frequently Used Commercial Data Providers

Company Name	Web Site
ESRI	http://www.esri.com
East View Cartographic	http://www.cartographic.com
Map Mart	http://www.mapmart.com
GfK Macon	http://www.gfk-macon.com
GIS Data Depot	http://data.geocomm.com
LAND INFO	http://www.landinfo.com
LeadDog Consulting	http://www.goleaddog.com
Collins-Bartholomew	http://www.bartholomewmaps.com
ACASIAN	http://www.asian.gu.edu.au
Digital Globe	http://www.digitalglobe.com
GeoEye	http://www.geoeye.com
MapInfo	http://www.mapinfo.com

with other departments or libraries to combine funds to purchase the more expensive datasets. The Harvard Map Collection regularly partners with Harvard's Government Documents Library to purchase GIS data related to both collections.

Another important factor regarding the collection of GIS data is the online availability of the data. Is it better to download or order them on disk from the agency? Several issues influence this decision. Are the data frequently used? Are the data only available temporarily? Is the site unstable or unreliable? Are the files too large to download over the library's current bandwidth? Is there a cost involved? At Harvard we acquire all of the GIS data from the State (MassGIS) and the City of Boston on disk even though much of that data is available online. The data receive such heavy use and some of the files are so large that it just does not make sense to keep downloading them over and over again.

When acquiring GIS data, it is important to get the data in an easily accessible format and media. Will the data be easy to use in their delivered format, or will staff time have to be spent converting the data to make them useable? Converting data from one format to another can be time consuming, and datasets can be enormous. This has become less of an issue in recent years as data providers frequently offer a variety of deliverable formats. I strongly suggest products or formats that reduce GIS staff time. It is well documented in the literature that GIS services can easily double your staff's workload (Larsgaard, 1998, p. 8; Longstreth, 1995). At Harvard we have had great success with foreign and domestic census products that bundle the joined census attribute data with their corresponding boundaries. Although these products tend to be expensive, they greatly reduce patron and staff time spent joining the two disparate datasets. One example is the suite of census products produced by Geolytics (http://www.censuscd.com/). Their products make accessing U.S. census data within a GIS significantly easier and greatly reduce personnel time (Florance, 2004). I have also had success with bundled census GIS products of China (All China Marketing Research Co. & China Data Center, 2004), India (ML Infomap, 2003), and Australia (Australian Bureau of Statistics, 2003).

Data is usually either downloaded from the Internet or put onto CD, DVD, or more recently portable hard drives. Raster data files tend to be very large and often come in compressed tiles or sections. In addition to acquiring the uncompressed tiles, try to get a single mosaicked image in compressed form such as JPEG2000, MrSID, or ECW. The single compressed image makes the data much easier to disseminate and work with. When ordering digital orthophotography from a commercial vendor, try to get an additional complete mosaicked image resampled at a much lower resolution. Users often want to print an image of an entire city or large area. Sending several high-resolution TIFFs or a giant SID to a printer often crashes the printer; creating pyramid layers can help as well. For very large datasets, those over a couple gigabytes, I have found portable external hard drives more stable and easier to use than CDs or DVDs. Some datasets will occupy several CDs or DVDs and switching from one CD to another is taxing and speeds are slower. In short, select formats and media that work best for the library's environment and that minimize staff time.

Acquiring local, large-scale GIS data requires establishing contacts with state, county, and municipal agencies. Many states have developed mature geographic information systems and widely disseminate their data. Policies regarding availability, pricing, and licensing vary widely among county and municipal agencies. Some local agencies provide all of their data for free, some agencies charge tens of dollars, some agencies charge hundreds of dollars, some agencies charge thousands of dollars, and some agencies refuse to provide data altogether. Try to attain the data for free or at least nearly free. I mention that the data will only be used for academic/noncommercial purposes and that we will act as an archive for the data. I usually mention that I manage and serve as the contact for GIS data for Harvard University, and I find this a more effective approach than sending all of the students directly to the agency. If the agency does not comply, I provide its contact information to all of the interested students, and students can be very resourceful and determined. Be persistent but patient: e-mail and call, but give agencies time to respond and keep in mind that their primary goal is to service and manage their town or county GIS, not disseminate their data to the world.

The final deliverable product should include documentation. The documentation or metadata is critical, as metadata provide valuable information about the data. Government agencies or private vendors usually do not provide Federal Geographic Data Committee–compliant (FGDC; http://www.fgdc.gov) metadata (van Loenen & Onsrud, 2004). However, many data providers do not provide any metadata at all! At the very least, try to get information concerning the author/creator of the data, date for which the data are relevant, basic explanation of the attributes, source of the data, scale, projection, coordinate system/datum, and units of measure. Metadata are crucial for the use, management, and dissemination of spatial data. Without this information, the data are of little value.

Evaluation of the products before selecting them for acquisition is essential. Read the documentation carefully. What scale is the data? What sort of attributes come with the data? What is the source? What is the licensing? Download samples, open them up, and take a look at them using GIS software. Read reviews if they exist, talk to other GIS or library professionals, and post questions to listservs about the data. One of the better listservs is GIS4Lib, administered by the University of Washington (http://mailman1.u.washington.edu/mailman/listinfo/gis4lib). Be watchful of vendors who "improve" and repackage Digital Chart of the World data (VMAP0), a spatial database of the world at 1:1,000,000 developed by the National Geospatial-Intelligence Agency (NGA). Quite often the "improvements" are minimal, and they are just selling you something you can get for free.

You might find it useful to draft a formal document outlining the GIS datasets selected for potential acquisition. In this document include the dataset or product, description, cost, license, and contact information. Review the items with the appropriate staff and select products for acquisition based on user needs, budget, licensing, quality, online availability, deliverable format, and staffing resources. Although a large amount of publicly available data can be found online, institutions should own a few inexpensive core datasets that meet most users' needs (see Table 2). Locating and evaluating the datasets and negotiating price and licensing require a significant amount of time. I generally prepare a small collection development proposal for more immediate demands in the fall and a more in-depth lengthy proposal in the spring.

Finding Data

Undoubtedly the most critical part of developing a GIS collection is locating data. Navigating the labyrinth of GIS data sources is not easy. Currently there are many sources for GIS data: U.S. and foreign governments, state and local governments, academic institutions, commercial data providers, utility companies, and others (Committee on Licensing Geographical Data and Services, 2004, chap. 3). In order to find data, one must utilize electronic and print resource guides, online data dissemination engines or portals, relationships with GIS professionals, commercial data providers, and printed map resources.

Attempting to locate free or low-cost, publicly available data is essential, since most academic research in the United States relies on this form of geographic information (van Loenen & Onsrud, 2004). Over the past few years, GIS professionals and librarians have developed guides to locating geospatial data. Many academic institutions have created virtual collec-

Table 2. GIS Datasets Recommended for Acquisition

Product	Description
ESRI Data & Maps	Contains a variety of data for the world, Canada, and Mexico, as well as general and detailed data of the United States. The product should meet many users' needs. It ships with ArcGIS software. Contact your software license administrator or ESRI (http://www.esri.com) for a copy.
Global GIS—Global Coverage DVD	Contains a wealth of USGS and other public domain data, including global coverages of elevation, landcover, seismicity, and resources of minerals and energy at a nominal scale of 1:1 million. It is available at http://www.agiweb.org/pubs/globalgis/.
TIGER/Line	Extracts of selected geographic and cartographic information from the Census Bureau's TIGER database. Free for federal depository libraries. Available from the U.S. Census Bureau (http://www.census.gov/).
Landview	A desktop mapping system for Environmental Protection Agency (EPA), Census Bureau, and USGS data. Free for federal depository libraries. Available from the U.S. Census Bureau (http://www.census.gov/).
World Vector Shoreline Plus	Originally developed by the National Geospatial-Intelligence Agency (NGA), it contains worldwide coverage of political boundary lines and shorelines at a scale of 1:250,000. It is available from the USGS (http://www.usgs.gov/) as well as several commercial vendors in a variety of formats.
National Transportation Atlas Database	A set of national geographic databases of transportation facilities for the United States. Available free from the Bureau of Transportation Statistics (https://www.bts.gov/pdc/index.xml).
Statewide Data	Statewide GIS data. Contact local state agency.
Local County or Citywide Data	Large-scale GIS data. Contact local municipal or county agency.

tions of Web links to frequently used sources of geographic information. These online resource catalogs are great places to start the hunt. Three good examples are the University of Arkansas Libraries (http://libinfo.uark.edu/GIS/us.asp); Stanford University Libraries (http://www-sul.stanford.edu/depts/gis/web.html); and the Harvard College Libraries (http://hcl.harvard.edu/research/guides/cartography/resources/online.html).

Printed guides to geospatial data are another good resource. Decker's (2001) *GIS Data Sources* and Ralston's (2004) *GIS and Public Data* are helpful for understanding, finding, and using geospatial data. Decker's work provides a basic introduction to GIS data and collection development as well as useful appendices to state and federal sources of geographic information. Decker's book is a must for spatial data librarians. Ralston's guide

Table 3. Frequently Used Geospatial Clearinghouses and Data Portals

Name	Web Site
Geospatial One-Stop	http://gos2.geodata.gov/wps/portal/gos
National Spatial Data Clearinghouse	http://clearinghouse1.fgdc.gov/
GIS Data Depot	http://data.geocomm.com/
Geography Network	http://www.geographynetwork.com/data/
USGS EROS Data Center	http://edcwww.cr.usgs.gov/
The National Map	http://nationalmap.gov/
NGA Geospatial Engine	http://geoengine.nga.mil/
The Harvard Geospatial Library	http://hgl.harvard.edu
Alexandria Digital Library	http://alexandria.sdc.ucsb.edu
Global Land Cover Facility	http://glcf.umiacs.umd.edu/index.shtml

provides information for some of the most useful publicly available data in the United States and includes information regarding formats, uses, and sources of unrestricted data.

Seekers of spatial data must also make use of geospatial clearinghouses or data portals (Tang & Selwood, 2005). Geospatial clearinghouses are Internet sites devoted to disseminating spatial data online following the FGDC guidelines for organization and metadata (Decker, 2001, p. 57). Some useful data portal sites are provided in Table 3. Although the sites take a while to learn and their stability is sometimes unreliable, they offer a wealth of free data and meet much of one's data needs.

For large-scale data, such as building- or property-level information, a selector must often establish relationships with the local county or municipality itself (Cobb, 1995). GIS resides in a variety of departments within local agencies such as planning, engineering, information technology, GIS, and the assessor's office. A good place to start is the county or municipal Web site to get contact information. Some counties and municipalities disseminate their data online, but many will require an e-mail or phone call to access the data. Getting to know your local GIS professionals will greatly help you in acquiring localized datasets.

Developing GIS relationships is essential for finding GIS data in general (Cobb, 1995). Join regional professional associations and attend regional conferences and workshops. For instance, the Northeast Arc Users Group (NEARC) is a regional organization for GIS and mapping professionals in the northeast. It provides an opportunity to meet local GIS professionals and learn about regional GIS activities. New York City and Boston both have formal and informal GIS user groups that get together and discuss GIS projects, jobs, and new data acquisitions, among other topics. Building relationships and establishing a network of GIS colleagues extends nationally as well. Join national organizations and attend their conferences, such as the North American Cartographic Information Society (http://www.nacis.org) or the Environmental Systems Research Institute (ESRI) User's Conference (http://www.esri.com/events/uc/). The key is to find an organization that meets your needs. Most of these local and national organizations also maintain listservs. Listservs provide a great opportunity to post questions about data sources. GIS4Lib, mentioned previously, is particularly useful for locating GIS data. *Directions Magazine* provides an additional list of GIS listservs (http://lists.directionsmag.com/discussion/). Mapping professionals frequently e-mail or phone each other while hunting for data.

If you cannot locate data that are publicly available, look to commercial data providers (see Table 1). There is an increasing number of commercial vendors that lease and sell GIS data. Commercial vendors offer a variety of raster and vector data such as topographic and administrative boundary datasets, digital elevation models, digital orthophotography, satellite imagery, and digital georeferenced maps for a wide array of GIS applications.

When GIS data are not available or accessible for a given area, researchers must often derive the GIS data from map sources. This is most common when users need historical data or international data at a scale greater than 1:250,000. Maps must go through a process of conversion before they can be used within a GIS (Hohl, 1998; Lee & Pun, 2001). They must be converted to a useable GIS form either by using digital imaging technology or a digitizing tablet. Maps are digitally imaged either by overhead photography or by a large-format scanner. The digital map image is then georeferenced, which converts the digital image from a nonreal-world coordinate system (image space) to a real-world coordinate system (Verbyla & Chang, 1997). Next, the user digitizes or traces (vectorizes) the necessary features on-screen (heads-up digitizing) and encodes the features with the appropriate information. Using a digitizing tablet, the user tacks the map or a copy of the map on the digitizing tablet, registers the map to the tablet, and then traces or extracts features using the digitizer puck. Depending on the number of features, digitizing can be a severely labor intensive process. This process of data conversion or data development is widely used in the mapping industry. If a library does not have access to the necessary equipment for digitization, many maps can be ordered in digital form from government agencies and commercial data providers. It is important to note that just as GIS data can supplement a printed map collection, printed maps can supplement a GIS collection. Therefore, the acquisition or inclusion of maps in print and digital form can be a valuable part of a GIS collection development strategy.

In short, be prepared to spend time looking for data. However, the more one does it, the easier it gets. The Web sites become easier to find and navigate, and the data portals become easier to use. After a while, public agencies and commercial dealers occasionally contact the GIS librarian when they have new GIS data available for distribution.

A GIS collection is not built over a month or a year but matures over time. The collection development process requires a fundamental understanding of the characteristics and uses of spatial data. It also requires the use of online resource guides and spatial search engines as well as the development of relationships with the user community, data providers, GIS professionals, and other librarians. In the formation of a GIS collection development strategy, library professionals should incorporate the established collection development policy, needs of the GIS user community, campus GIS services, and library infrastructure. When making decisions regarding GIS data acquisition, the library professional must also consider cost, availability, license agreements and distribution policies, documentation, data structures, and software and hardware. Utilizing each of these resources and incorporating each of these issues should help library personnel build a valuable GIS collection.

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