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This study is a content analysis of a sample of GIS services websites in academic

libraries.  Websites studied belong to academic institutions that are participants in the

Association of Research Libraries GIS Literacy Project and are designated Federal

Depository libraries.   This study specifically explores how academic libraries present

GIS services on their websites and identifies potential barriers the websites may pose to

users.  Results indicate difficulties in website navigation and lack of advanced browsing

applications for spatial data searching.

Headings:

 Geographic Information Systems

 Academic Libraries

 Usability

 Web Design

 Spatial Data

AN ANALYSIS OF GIS SERVICES WEBSITES IN ACADEMIC LIBRARIES

by
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**INTRODUCTION**

Geographic Information Systems, or GIS, simply put is mapping software. Although GIS is used to make maps, its capability of "managing geographic feature location data and data related to those features" also proves to be a powerful utility (Cox & Gifford, 1997, p. 449). Through development of user-friendly desktop applications, GIS seems to be everywhere. In recent years, as the popularity of Geographic Information Systems grows and demand for applications and data related to it increases, more and more libraries offer GIS among their repertoire of services. Foremost among libraries offering GIS services are academic libraries. At last count in 2001, the Association of Research Libraries listed 100 institutions as participants in its GIS Literacy Project. The institutions are primarily composed of academic libraries (*ARL/GIS Participant Roster,* 2001). The project aims to promote GIS services and "to address diverse user information needs" (Adler, 2004). One of the needs for GIS use is spatial data. Libraries providing GIS services must provide access to spatial data resources. In addition to spatial data sets being available on CD-ROM, many data sets are available in an electronic format stored on servers. Such spatial data sets are not typically indexed in libraries' online catalogs, therefore information about finding and accessing spatial data resources must be provided through library websites. In the past ten years there have been many research articles published concerning academic library website usability, GIS services in academic libraries, and GIS resources on the Internet. At present, there seems

to be no overlap in the research regarding how academic libraries use websites to promote their GIS services and present spatial data resources or of users' perception of these phenomena. Through the literature related to GIS services in libraries, spatial data resources and the Web, and current academic library website design and usability, this paper will examine the relationships between them and offer suggestions for further research in designing library websites for GIS services .

## LITERATURE REVIEW

### GIS Services in Libraries

Keeping abreast of new and developing technology is imperative for libraries as they are constantly looking to improve their patrons' access to information and new learning opportunities. Thus far this is the case with GIS. GIS has been around for decades, used mostly by geographers, but the 1990's saw a few events that paved the way for GIS' entrance to libraries. First, the Government Printing Office started distributing data in machine-readable form. Next, the development of affordable desktop GIS applications made the technology widely available (Deckelbaum & Bruman, 1999; Soete, 1997). The Association of Research Libraries stepped up to the plate and partnered with the largest GIS vendor, Environmental Systems Research Institute (ESRI) and other commercial providers to create the ARL GIS Literacy Project to bring GIS home to libraries (Cheverie, 1995; Stone, 1999). A number of articles address implementations of GIS services at academic institutions. These facilities have to tackle services, personnel, technical, financial, and coordination issues associated with GIS services (Suh & Lee, 1999). To those five issues, the author adds data and users, and further explores the literature according to each of these categories.

*Services*

According to Ronald Jantz, five things to consider when establishing GIS services

are:

1. A GIS service should be made broadly available to students,
2. Encourage professors to include GIS capacity into a course,
3. Support individual research, which would utilize the GIS software,
4. Provide GIS in a specific department that has continuous and demanding needs for mapping capabilities,
5. Create partnerships among local industries and academic departments for utilizing the GIS service (Howser & Callahan, 2004).

*Personnel*

From helping patrons generate a map, to assisting researchers with complex

spatial and statistical analyses, GIS services cover a broad spectrum of activities. To help

library staff and patrons know what to expect, many academic libraries have instituted

policies regarding the level of GIS services provided (Cheverie, 1995). A library may

provide GIS services on an appointment-only basis or develop a GIS lab complete with

instruction depending on users' needs. (Soete, 1997). Technical and GIS expertise of the

staff should also be considered when developing GIS Service (Howser & Callahan,

2004). In terms of reference service and GIS, libraries must be aware that:

1. GIS services demand in-depth assistance not possible at a regular reference desk,
2. Librarians have to achieve a certain level of knowledge and skill to provide assistance,
3. The use of specialized software and equipment is required for dealing with questions (Suh & Lee, 1999).

Using GIS takes advantage of many skills librarians already have such as evaluating user

needs, selecting data, cataloguing and preparing data, and designing and managing public

services (Soete, 1997). Although being armed with these traditional skills primes library

staff for involvement with GIS, the steep learning curves still mean imperative and on-going training for them. ESRI provides most of the GIS training for academic library staff and offers free training for users associated with the schools. Librarians and staff can participate in GIS consortium and listservs, take part in on campus GIS classes, and develop relationships with departments which use GIS in order to bolster their learning experience (Stone, 1999).  A number of academic libraries have answered the call for the demand of GIS services by creating GIS-specific positions such as North Carolina State University's GIS and Data Services Librarians (Argentati, 1997).

### *Technical Considerations*

Not only do GIS services put demands on library staff, but on library resources as well.  A diminutive setup minimally requires a fast-processing computer loaded with GIS software and plenty of memory.  As GIS service expands, equipment like large format scanners, plotters, and printers become necessary, as do servers for networked access to large amounts of spatial data (Howser & Callahan, 2004).  GIS service Web presence entails developing system architecture for the public interface front-end and the organization of the back-end load (Suh & Lee, 1999).

### *Financial Considerations*

Investing in staff training and purchasing resources for GIS services puts a heavy financial burden on library budgets.  Another piece of the puzzle, data, does not come cheaply either.  The expensive process of collecting and formatting spatial data often means access is not free or publicly accessible (Lamont, 1997).  Through site licensing of GIS software, distributed storage of data, and tightly focused data collection, libraries can pull the reigns in on their GIS services budget (Soete, 1997).

*Coordination*

The coordination effort of library GIS services does not stop at managing personnel and technology.   Successful GIS services also depend on collaboration outside the library.  The library with its capacity for data storage linked with multidisciplinary studies proves fertile grounds for such cooperation (Shuler & Obermeyer, 2001). Geography faculty and students or any other academic departments on campus known to use GIS provide a pool of talent and experience ripe for coordinating training and instruction efforts (Howser & Callahan, 2004).  These departments more than likely house spatial data as well, and the libraries' capabilities lead to a natural partnership with them for data management and distribution to wider audiences.  Coordinating with local research firms, GIS firms, realty firms, and utilities companies can also be a boon to obtaining spatial data (Lamont, 1997).

*Data*

Data drive GIS applications. If the spatial data in a collection used in GIS applications is inaccurate or insufficient, the coordinated efforts, the trained staff and the expensive equipment necessary for a library's GIS services become moot points (Soete, 1997).   Libraries offering GIS services need to be prepared to deal with issues of data quality and provenance.  Metadata, or information about the spatial data itself, plays a significant role in determining data's authenticity and reliability. Metadata provide documentation about the location of the data and the content and structure of the information (Nebert, 2000).  In online catalogs, some of the GIS metadata are incorporated into the bibliographic records to aid users in finding suitable spatial data (Lamont, 1997).   In academic libraries, collecting spatial data from university

researchers or local firms requires developing quality metadata in-house.  The metadata is important to users in determining data's fitness of use for a project (Deckelbaum & Bruman, 1999).  In the mid-1990's, the Federal Geographic Data Committee worked to facilitate spatial data exchange by developing the National Spatial Data Infrastructure and establishing metadata standards (Kowal, 2002; Tsou, 2002).

*Users*

No academic library's GIS Services are complete without users.  Along with technical support provided by staff and access to GIS equipment, some of their data needs include spatial files, attribute data and digital base maps.  Novice users in particular require tremendous amount of staff time (Lamont, 1997).  As mentioned previously, in order to design successful services, users' needs must be known.  To this end, Kimberly Kowal defines three types of GIS users and explains their needs.  High level users need spatial data and access to GIS workstations to process data, perform analyses, and create highly specialized maps.   Midlevel users need access to interactive mapping applications on the Web to generate maps with more generally available data like statistical data and boundaries. Agencies like the U.S. Census and the U.S. Geological Survey provide many such services, smaller non-profit and local agencies are beginning to offer them as well. Websites like MapQuest which provide driving directions and maps also belong to this category of interactive mapping software.  Low level users need access to static maps. Many digital map collections are freely available on academic library websites, commercial vendor sites like Microsoft TerraServer, and individual sites such as The David Rumsey Historical Map Collection (Kowal, 2002).

**Spatial Data and the Web**

As GIS services grow in academic libraries and elsewhere, the World Wide Web

takes center stage as a necessary tool for finding, assessing and visualizing spatial data.

GIS services exist all over the Web.  They are so seamlessly integrated into the Internet

that people may not even realize that GIS applications are involved in their favorite map

and driving directions website or in their bank's website function for locating the nearest

ATM.  GIS Web presence can fall into five categories:  education, commercial,

information providers, interactive mapping and online data searching (Pienaar & van

Brakel, 1999).  One of the largest information providers, the federal government, has

made much of their data available through its many agency websites, such as the Health

and Human Services Agency, Department of Labor, Department of Education and U.S.

Bureau of Census (Shuler & Obermeyer, 2001).  The aforementioned National Spatial

Data Infrastructure, responsible for coordinating government and non-government spatial

data collection and management activities, also developed the National Geospatial Data

Clearinghouse (NGDC) as a means of data discovery and preventing duplication of effort

in data collection (Nebert, 2000).  The NGDC and other similar resources provide plenty

of data, but present libraries with the challenge making the data accessible to users.  With

a grant from the Federal Geographic Data Committee, a Cornell University library

created the Cornell University Geospatial Information Repository (CUGIR) which

provides a Web-based system to distribute spatial data.  Cornell developed a partnership

with the state of New York to have the state's data included in the CUGIR as well

(Herold, Gale, & Turner, 1999).  The University of Florida undertook a similar project by

building a WebGIS and geodatabase for Florida wetland data.  Although not associated

with the library, the project aims to provide global access to current spatial datasets to

users with limited GIS experience (Mathiyalagan, Grunwald, Reddy, & Bloom, 2005).  In

addition to providing spatial data metadata to help users determine fitness of use, many

libraries and other institutions embarking on spatial data access projects have taken

advantage of GIS Web applications to allow users to visualize the data.  The Australian

Geodynamics Cooperative Research Centre and PANGAEA-the global network for

geological and environmental data- both use interactive map browsing applications for

presenting spatial data (Cox & Colvil, 2002; Diepenbroek et al., 2002; Schlitzer, 2002).

Closer to home, the University of Idaho helped the Idaho Geospatial Data Center develop

map browsing software called GeoLibrary for the state's public-domain data (Jankowski,

Stasik, & Jankowska, 2001).   With this kind of technology developing widely, academic

libraries, if they have not done so already, can take the opportunity to reinforce their GIS

services through giving their users a more intuitive tool with which to search for and

view spatial data.

## Library Website Design and Usability

The Web offers academic libraries many resources to enhance their GIS services.

It also provides a venue from which to offer their services.  Focusing on traditional

library services and the online catalog, usability studies of academic library websites to

date have not specifically addressed GIS services.  However much of the feedback and

results of these general studies purvey solid guidelines applicable to designing GIS

services and data finder Web pages.  Accessibility of websites should be addressed first

and foremost above other design considerations.  Lilly & Van Fleet (1999) stated that 8%

of Web users have a disability or disabilities related to speech, hearing, mobility or

cognitive impairment or a combination, however "90% of Web pages have some

barriers" for this user group (p. 7).  Improving Web accessibility for people with

disabilities also improves access for able-bodied users.  According to Raward (2001),

addressing the multiplicity of users and delivering to them differing library perspectives

including:

> 1. A gateway to resources.
> 2. A means of communication for primary users
> 3. Menus of information about innovative services, collections and projects
> (p. 124)

 present interesting challenges for academic library Web pages.  For this task Raward

(2001) developed a 100 question Usability Index Checklist for evaluating website design

which includes the following four categories:

> 1. Finding the information
> 2. Understanding the information
> 3. Supporting user tasks
> 4. Presenting the information (p. 129).

Several usability studies allude to website design as an ongoing process (Battleson,

Booth, & Weintrop, 2001; Cobus, Dent, & Ondrusek, 2005; George, 2005; Tolliver et al.,

2005).  As users' needs change, so shall the websites.  To this end the goals of iterative

library website design should include creating user-centered interface, enhancing

usability and expanding resources of the library's website (George, 2005).  Using the

theories of usability experts Jakob Nielsen and Jeff Rubin, usability studies used "think-

aloud" protocols to record participants' thought processes or link-recording software to

log their mouse clicks and keyboard strokes as they worked through pre-determined tasks

(Battleson et al.; Cobus et al.; George, 2005; McGillis & Toms, 2001; Travis & Norlin,

2002; VandeCreek, 2005).  The most common stumbling blocks for users of academic

library websites was encountering library jargon and experiencing confusing navigation (Augustine & Greene, 2002; McGillis & Toms, 2001; Travis & Norlin, 2002; VandeCreek, 2005). With a low associated cost, a little usability testing goes a long way for academic libraries wishing to continually meet the constantly changing needs of their users.

## Present Study

This study will explore how academic libraries present GIS services on their websites and identify potential barriers the websites may pose to users. As a student in semester-long introductory GIS course, the author came to rely heavily on the academic library's GIS services website. The experience revealed the complexities an academic library faces in providing GIS services information and spatial data resources both in the library and through its website. The experience also generated an interest in how other academic libraries use their websites for providing information about GIS services. Using the topics discussed in the current literature, the framework for analysis will be built upon general Web design and usability, GIS services in academic libraries, and spatial data issues including resources, metadata, and accessibility.

## METHODOLOGY

The present study contributes to research on academic libraries, specifically their online presence and utility to users. Review of literature reveals a good amount of research about GIS in academic libraries, but none aimed directly at the libraries' GIS services Web pages or websites. The present study also attempts to start filling in this gap and bring to light further research opportunities in the area. As stated earlier, the GPO's decision to make government data available electronically and ARL's partnership

with ESRI and other companies to form the ARL GIS Literacy Project provided the

impetus for GIS services to develop in academic as well as other libraries.  The author

employs the research method content analysis in the current study because it allows

flexibility in which characteristics are examined and to what degree as well as in

determining the number of websites to be included in the study.  Content analysis

according to Babbie (2004) "is the study of recorded human communications" (p. 314).

Through the content analysis of a handful of academic libraries' websites which are

designated GPO repositories and participants in the ARL GIS Literacy Project, the author

intends to assess how academic libraries are using websites to convey information about

GIS services to users, and identify potential barriers users may encounter when using the

websites to ascertain what GIS services are available to them, to learn how to use GIS

applications, and to locate, evaluate and acquire spatial (GIS) data.  The author chose

academic libraries fitting these criteria because they have been among the first to add GIS

to their library services and they serve as examples for other libraries wishing to develop

GIS services of their own.

**Identifying Eligible Institutions**

Because no current resource exists that lists academic libraries providing GIS

services, the first challenge was identifying potential candidates before undertaking any

evaluation.  Consulting the ARL GIS Literacy Project's Participant Roster of over 100

institutions, public and state libraries and academic libraries outside of the United States

were eliminated leaving 69 academic libraries within the United States of America

participating in the project (*ARL/GIS Participant Roster,* 2001).  When cross-referenced

with the GPO Access website's "Locate a Federal Depository Library" tool, all of the 69

schools listed were found to be depository libraries as well (*Locate a Federal Depository Library,* 2006).

**Locating Academic Library GIS Services Websites and Defining Level of Service**

Participating in the ARL GIS Literacy Project does not guarantee that an institution's libraries offer GIS services, though they are most likely to have at least limited GIS resources.  For each of the 69 academic libraries identified earlier, the author located the main library website, and using the site index or site search box, tried to find a library department, collection, or center website with GIS services information.  Due to the present study's focus on GIS services websites, the level of GIS services the academic libraries provide must be high, defined by Kowal (2002) as "GIS software is used off-line, and the Web functions as a means to locate and retrieve data" (p. 109).  To this end, an academic library's GIS services website had to provide information meeting the following criteria to be defined as providing a "high" level of service:

- Workstations equipped with GIS software applications
- Access to spatial data
- Resources for finding and downloading spatial data

Thirty-five of the 69 academic libraries from the ARL/GIS Roster have GIS services websites and were classified as delivering a high level of service. See Appendix 1 for the worksheet containing the details of the classification.  The thirty-five institutions were further classified using the Carnegie Classification online tool to determine size classifications and public or private status of the institutions (*2005 Carnegie Classification initial release,* 2006). See Appendix 2 for details.  Due to time constraints of the study and the amount of time required to analyze each website, six of the 35

eligible websites were chosen for content analysis.  The six institutions hosting the websites are roughly representative of the size and status classifications of the overall 35 institutions.

<div align="center">**Evaluation Questions and Procedure**</div>

Without past research to guide the way to evaluating academic libraries' GIS services websites, the author developed a series of general questions to assess websites in accordance with the literature concerning GIS services in libraries and general usability of academic websites and from the author's own experience as a new user of GIS.  For each of the six websites assessed in the analysis, the following questions were applied and other observations made. Because of the amount of spatial data resources available, the author placed particular emphasis on spatial data resources analysis, while applying a broader approach to other areas.

<div align="center">*Questions Related to Navigation and General Website Design*</div>

- Is the GIS services website easily reached from the main library website?
- How many links from the main page is the GIS services website?
- What is the name of the GIS services website?
- Is the GIS services website layout straightforward?

<div align="center">*Questions Related to Staff and Resources Information*</div>

- Does the GIS services website provide information about computing resources, workstations with GIS software, printers, etc.?
- Does the library have a dedicated GIS staff (rather than a government documents or map librarian covering GIS duties as well)?
- Does the website include information about GIS resources elsewhere on campus?

<div align="center">*Questions Related to Services and Instruction Information*</div>

- Does the GIS services website provide an overview of GIS?
- Does the GIS services website spell out what kind of GIS services the library provides?  Reference, instruction, research assistance, GIS software instruction, etc.?

- What kind of instruction or tutorial information does the GIS services website provide?

*Questions Related to Spatial Data Resources: Organization and Access*

- How are spatial data resources organized on the GIS services website?
- Does the GIS services website clearly indicate which resources are external (on the Web or outside of the library collection) and which resources belong to the library?
- Does the GIS services website indicate which resources can only be viewed or downloaded by institutional affiliates?
- Can the metadata of the spatial data be viewed?
- Does the library website utilize any of the available data browsing tools, e.g. a map browser?

Answers and observations were recorded for the analysis of each of the six websites. Further details are found along with the results in a later section.

**Limitations of the method**

The subjective nature of the evaluation questions developed by the author, the fact the ten websites evaluated were not chosen randomly or by any other scientific means, and having the author as the sole researcher performing the evaluation introduces a fair amount of bias into the analysis. Further, no GIS service websites of academic libraries not participating in the ARL GIS Literacy Project were included. Only the general academic website usability literature and the author's own GIS experience guided development of the evaluation questions. The validity of the questions was not tested. Despite its limitations, the study lays the groundwork and provides insight for further research in the usability of academic library GIS services websites.

**RESULTS**

Results for the content analysis of the six selected academic libraries' GIS services websites are presented according to the line of questioning described in the methodology with emphasis on each website's treatment of spatial data organization.

**Navigation and General Website Design**

The names of the six libraries' GIS services websites and the number of links the user must navigate from the main library website to get there are listed in Table 1.

**Table 1**
Finding GIS Services Websites

| *Institution Name* | *GIS Services Website Name* | *Finding GIS services website from the main library website: not difficult, somewhat difficult, very difficult* | *Number of links from Main Library Website* |
| --- | --- | --- | --- |
| North Carolina State University | NCSU Libraries Geospatial (GIS) Data Services | not difficult | 3 |
| Princeton University | Princeton Digital Map and Geospatial Information (GIS) Center | not difficult | 3 |
| Stanford University | Branner Earth Sciences Library and Map Collection- Geographic Information Services | very difficult | 3 |
| University of Colorado-Boulder | Map Library-GIS in the Map Library | somewhat difficult | 3 |
| University of Virginia | Geospatial and Statistical Data Center | not difficult | 3 |
| Washington State University | Washington State University Libraries Geographic Information Systems | not difficult | 2 |

Analysis of the navigation and design of the GIS services websites also involved observing the layout and organization of content and the ease of navigation through the individual pages of each website. All but two of the six websites have layouts that pose some kind of navigational difficulty. Most of the main GIS services websites studied have a straightforward structure of links organized into four to seven clearly labeled headings. The difficulties arise when navigating from the main GIS services website through a link. Problems include: no indication of how many pages into the website, inconsistent navigation sidebar links, inconsistent placement of navigation side bar links,

lack of or inconsistent use "back to main page" links.   Table 2 contains more detailed

descriptions of the navigation for each of the six websites.

**Table 2**
Navigation of GIS Services Websites

| Institution Name | GIS Services Website Navigation |
|---|---|
| North Carolina State University | straightforward; links listed under 6 headings and each page within the site had the same sidebar and a link to the main page at the bottom |
| Princeton University | confusing; no indication of leaving Princeton site when links are to outside resources; some links from the main page have a sidebar some don't; for the pages with side bars, they are not consistent nor do they always appear in the position on the page: none of the pages within the site give an indication of how "deep" it is in relation to the main site. |
| Stanford University | confusing; after leaving the main site none of the subsequent pages indicate where it is in relation to the main site; it seems all the same links that are present on the main GIS site are present in all the subsequent pages, but in different arrangements. |
| University of Colorado-Boulder | straightforward; only three pages to navigate |
| University of Virginia | confusing; after leaving the main site, there is no indication of where the current page is in respect to the main site, and there are no "back to main" links. |
| Washington State University | confusing; although the main GIS website contains only 7 links, it is presented inside a frame of the main library page.  The library's main navigation menu remains constant on the left, whenever the user follows a link from the GIS frame.  Some of the 7 pages linked from the main GIS page have a link "back to the main page", and some do not, resulting in use of the Back button on the browser. |

**Staff and Computing Resources Information**

The presence of information regarding staff and available resources on each GIS

services website was observed and recorded in Table 3.  It was observed that four of the

six libraries have designated GIS staff, and two of the six GIS services websites provide

information about other GIS resources around campus.

**Table 3**
GIS Staff and Resources Information

| Institution Name | Number of GIS staff | Titles of GIS Staff | Number of GIS-equipped workstations/other equipment | Does the GIS services website provide information about other GIS resources on campus? |
|---|---|---|---|---|
| North Carolina State University | 1 | Data Services Librarian | 2 | Yes |
| Princeton University | 1 | GIS Librarian | 7/printer, scanner, cd-burner | No |
| Stanford University | 2 | GIS Manager, GIS and Map Librarian | 4 | Yes |
| University of Colorado-Boulder | 0 | n/a | 1 | No |
| University of Virginia | 1 | GIS Analyst | available, but no number given | No |
| Washington State University | 0 | n/a | 1 | No |

## Services and Instruction Information

Although not always immediately discernible, through careful examination of

each GIS services website selected for this study, the author located descriptions of

exactly what each library's GIS services entailed. First, websites were examined for the

presence of a general overview defining GIS and its uses. Only two of the four websites

provide an overview. Next, the websites were observed for information about GIS

services. All websites indicate that GIS services include reference assistance for locating

spatial data. Other services offered and not offered are varied for each library. Some

GIS service activities listed on the websites include research consultation, GIS

instruction, help opening and viewing spatial data files, extracting data from specific

spatial data formats, converting data for use in GIS applications,  and retrieval and

acquisition of spatial data sets. Most of the websites studied offered information about individual appointments for GIS reference and instruction consultation. Stanford University's GIS services website is the only one of the six that states the user must first complete GIS tutorials before scheduling individual consultation. See Table 4 for detailed results for GIS services descriptions.

**Table 4**
Details of GIS services offered

| *Institution Name* | *GIS Overview?* | *Services Provided* |
|---|---|---|
| North Carolina State University | Yes | access to a wide range of data resources; assist researchers in identifying data; acquire data; on-site individualized assistance by appointment; assistance to non-NCSU users resources permitting |
| Princeton University | No | access to geospatial data; digital map services; geographic information systems (GIS); ongoing reference; research consultation; instruction |
| Stanford University | Yes | GIS reference services; GIS consultation by appointment upon completion of a tutorial |
| University of Colorado-Boulder | No | reference assistance with locating GIS data; limited help with opening and viewing data files; do not provide technical support for the use of GIS software; cannot provide help with GIS projects or custom maps |
| University of Virginia | No | Acquire and retrieve statistical and spatial data sets; Help patrons locate physical maps; Assist patrons in using statistical and GIS software; Support instructors teaching statistical and spatial analysis; Extract data from TIGER, DLG, DRG, and other formats ; Convert/translate data between different GIS and statistical packages; Scan oversized images |
| Washington State University | No | provide help in locating and accessing data sets; convert data for use with ArcView; answer general questions about ArcView; provide referrals for questions that cannot be answered |

To see what kind of independent learning resources are available to users, each of the websites were then carefully examined for the presence of information regarding GIS tutorials and instruction.  All of the websites studied provided information about GIS software vendor-produced online classes and tutorials.  All of the websites also provided external links to various kinds of online instruction and tutorials produced by individuals, state and federal agencies, and other universities.  Stanford University and the University of Virginia's GIS services website included links to internally developed documents providing instructions for specific tasks involving GIS software and particular types of spatial data.  In addition, Princeton University's and the University of Virginia's GIS services websites contain information about workshops, trainings, or classes offered periodically around campus or that can be scheduled through the library.   Only Washington State University's GIS services website includes links to information about college-level GIS classes offered at WSU and neighboring University of Idaho.  It also lists contact information of local GIS agencies.

### Spatial Data: Organization and Access

Each of the GIS services websites in the present analysis has a different approach to the treatment of spatial data resources and issues surrounding them, therefore the results for each GIS services website are presented individually by institution.  The results pertaining to the organization of the Web pages containing spatial data resources are lengthy, therefore only brief summaries are presented in this section.  See Appendix 3 for the full detailed results.

### *North Carolina State University(NCSU)*

NCSU's GIS services website does not provide any general information for finding and using spatial data. The website's information about spatial data is organized under two headings, "GIS Data NCSU Libraries" and "GIS Data on the Web."

NCSU GIS services website clearly indicates internal and external spatial data resources by organizing them under different sections. Although internal resources are listed alphabetically, the external resources are categorized geographically.

Besides listing their internal resources in an alphabetically ordered list, NCSU's GIS services website employs a browsing tool for finding spatial data, and the link to it is listed under the "GIS Data NCSU Libraries" heading. The "GIS Lookup" tool allows users to browse for data thematically using a list of keywords. The results returned by the tool provide the user with metadata and information about accessing the data. Along with the results, the tool gives the users suggested related keywords with which to perform additional searches. Spatial data is not indexed in the library's online catalog.

### *University of Colorado-Boulder (UC-Boulder)*

The University of Colorado-Boulder Map Library's GIS services website does not offer general information for finding and using spatial data. Regarding spatial data, the website contains the links "GIS Data on CD-ROM/DVD" and "Links to Online GIS Data."

Although spatial data resources on UC-Boulder's GIS services website are organized under headings that seem to distinguish resources belonging to the library from external resources, external website resources are included on the "GIS Data on CD-ROM/DVD" Web page.

The University of Colorado Boulder's GIS Services website offers a link to the online catalog for locating spatial data, but does not have a browsing tool. The online catalog records for spatial data provide minimal metadata.

### *Princeton University*

No general information for spatial data searching and use exists on the Princeton University Library Digital Map and Geospatial Information Center website. It contains links labeled "Geospatial Data" and "Internet Resources."

The organization of spatial data resources on Princeton's GIS services website does not clearly differentiate between resources belonging to the library's collection and external resources.

Following up on the mention of a GIS server on the "Geospatial Data" Web page, the author, through the use of Princeton University's site index, located a link to the Princeton University Library's Digital Map and Geospatial Information Center's Metadata Explorer tool. It uses map browsing technology, to help users locate spatial data and maps geographically (Jankowski et al., 2001; *Geography network,* 2006). The tool also enables narrowing the search by data content type and theme. Results offer full metadata viewing. Princeton's spatial data is not indexed in the library's online catalog.

### *Stanford University*

The "Geographic Information Systems (GIS) at Branner Library" website contains a heading labeled "Data" under which are four related links labeled:

- Guidelines for Finding GIS Data
- GIS Data on the Web
- Branner GIS Data Collection
- GIS Data on AFS

Stanford's Library GIS services website is the only one in the current study providing general information for geospatial data and use.

By organizing spatial data resources into two distinct sections, Stanford's GIS services website clearly distinguishes resources belong to the library's collection and external resources.

Besides links to the library's online catalog, no other tool or application for browsing exists on Stanford's GIS services website. Online library records for spatial data do not explicitly provide metadata.

### *University of Virginia (UVA)*

On the GEOSTAT website (the University of Virginia's Geospatial and Statistical Data Center) there is a link labeled "Browse Geospatial Resources." Following the link opens a Web page titled, "Digital Maps and Geospatial Data Links." In the lower half of the Web page there are four links labeled:

- Virginia Gazetteer Searchable Database
- Subject
- Format
- Geographic Coverage

The "Digital Maps and Geospatial Data Links" Web page also contains a section called "Quick Links to Spatial" containing links labeled:

- Virginia GIS Data
- City/County Planimetric Data
- Aerial Photos for Virginia
- State Level Distributors and Clearinghouses

UVA's GEOSTAT does not organize the library's spatial data resources separately from external spatial data resources. Both are listed together, and the onus is on the user to use small icons to differentiate between the two.

UVA's GEOSTAT website provides a browsing tool for the state of Virginia's spatial data holdings, the Virginia Gazetteer. The tool's search results provide full metadata viewing and an option to view the actual data, if applicable.  UVA's GEOSTAT website does not provide a browsing tool for other spatial data in UVA's collection, nor are spatial data holdings available in the library's online catalog.

### *Washington State University (WSU)*

The Washington State University Libraries Geographic Information Systems website provides a link to a "Guide to Geospatial Datasources."

WSU's GIS services website does not differentiate between the library's spatial data resources and external spatial data resources.

It appears that WSU's small collection of spatial data is indexed in their online catalog.  However no other browsing tool exists for finding spatial data. WSU's online catalog records do not contain metadata.

### DISCUSSION

The six GIS services websites were analyzed due to their common content and purpose.  From the results it seems the six websites are also similar in the potential barriers they may pose to users.  The following discussion addresses the possible barriers due to navigation and design, information about GIS services and resources, and spatial data resources.

### Navigation and Design

The difficulty of locating some of the GIS services websites from the main libraries' homepages is the first potential barrier a user may encounter.  If users cannot find the GIS services website, its utility as a resource is lost from the start.  The concern,

that when department links are only available on interior pages of the site, users may not be aware of the numerous services offered, was raised in usability study Carnegie Mellon University (George, 2005). As noted by McGillis and Toms (2001), although library websites may have good visual design, their capability as gateways to many types of content has yet to be fully realized, including content regarding explanation of available services.

Given the user can find the GIS services website, the next foreseeable obstacle becomes navigating within it. Table 2 in the previous Results section highlights some examples of barriers the author encountered when navigating the websites. Literature in academic library design and usability addresses the importance of link color changing after use to facilitate navigation, but many of the issues raised in Table 2 are not addressed (Harpel-Burke, 2005).

Many of the spatial data resources available on the GIS services websites are presented in long lists categorized by several headings forcing the user to perform a significant amount of scrolling to view them all. A usability study at Hunter College revealed users had difficulty when presented with numerous categorized links on one Web page, and solved the problem by presenting each category as a link to a new page with only links falling under that category on it (Cobus et al., 2005).

The author did not ascertain if the websites analyzed were designed by librarians or by Web designers. Bearing in mind that librarians that do develop websites are mostly self-taught and that the task is secondary in their job responsibilities, it is no surprise that barriers due to design and navigability arise (Raward, 2001). Perhaps in academic libraries where librarians who do not have significant training in Web design and

development are responsible for creating websites, a Content Management System would offer a feasible alternative (Tolliver et al., 2005).

## Library GIS Services and Resources Information

Some of the barriers pertaining to overall navigation and design potentially impact how users find information about the services, resources, and instruction the libraries provide regarding GIS. Cheverie (1995) notes that it is helpful for libraries to institute policies regarding the level of GIS services and resources that is available to the user. Although the six library GIS library websites provide ample information to the user about the kind of resources and the level of service the libraries offer, often the information is not centrally located on one page, or the information not displayed prominently. The author analyzed each of the websites looking for particular items and information, while a general user may not employ the same level of attention. Without prominently presenting the information defining what the libraries do and do not offer in terms of GIS on their websites, a mismatch may arise between the user' expectations and what the libraries can actually do to meet them.

By not providing information about resources, academic libraries' GIS services websites may inadvertently prevent users from finding tools to address their needs as well. Libraries are centers for collaboration and have links across campus and into the community beyond (Shuler & Obermeyer, 2001). There are likely other departments on campus with GIS capabilities (Howser & Callahan, 2004). Yet only two of the six academic library GIS services websites in the present study provided any information about other GIS facilities and resources on campus. Only Washington State University's GIS services website offered any contact information for off-campus local agencies

providing GIS services, which may provide access to unique spatial data resources (Lamont, 1997).

All of the websites in the current study offer plenty of resources for learning about GIS including links to tutorials and information about classes provided both by the libraries and through commercial vendors. Making users aware of independent learning opportunities helps the librarians alleviate some of the burdens of GIS's steep learning curve. Online learning tools and classes outside of the library prevent librarians tasked with providing GIS services from spending the bulk of their time attending to the needs of novice users (Lamont, 1997). Although the websites have enabled users to find GIS learning opportunities, only North Carolina State University and Stanford University present definitions for GIS and how it can be used. Providing an overview to GIS and its uses on the website may attract new users to the library's GIS services, while neglecting to provide an overview could possibly alienate potential users from exploring the services.

**Spatial Data Resources**

As far as spatial data resources are concerned, the six websites provide plenty of them to their users. Even libraries with small collections data available on CD-ROM, have links to numerous electronic resources and resources available on the Web. The problem for users becomes how to sort through this vast amount of data and how to determine the fitness of use of the data without having to acquire it first. Although grouping of varied spatial data resources alphabetically, thematically and geographically provides some directions, users still must scroll through lengthy lists as mentioned in the previous discussion on website navigation and design.

Some of the websites have begun to use browsing tools to aid users in finding spatial data searches and help overcome the obstacles of searching long lists of data resources. Only Princeton University has implemented a map browser, similar to GeoLibrary developed at the University of Idaho, which allows users to search for spatial data by using a map of the world to narrow the search geographically (Jankowski et al., 2001). However there is no link to the tool on Princeton's spatial data resources Web pages on their GIS services website and not providing the tool to users creates another barrier. Users cannot use it, if they do not find it. Although the author explored just six GIS services websites, only 33% of them implement a form of map browsing or other specialized application for accessing spatial data. With the wide variety of spatial data storage and browsing technology available, the author had expected the percentage to be closer to 50%. The lower percentage may be due to the possibility that implementing such browsing tools requires significant time and technical expertise libraries may not have immediately available. It is also possible the actual percentage of all 35 eligible websites is higher than for the six websites studied.

Once users find spatial data they may want to use, another issue they face is accessing the spatial data if it is not on a CD-ROM or freely available on the Web. Some of the websites have organized some or all of their collection on servers. To download the data housed on the servers, users first must be affiliated with the university, and then configure their computers to set up a path to the server, connect to the server, and navigate to the particular data set they wish to download. Such a process may be confusing to users who are accustomed to simply clicking on a link to download files.

In his paper about the development of the Geospatial Data Clearinghouse, Nebert (2000) highlights the importance of metadata for helping users determine spatial data's fitness of use and its authenticity. For each of the six GIS services websites in the present study, metadata for spatial data resources is available in varying levels meaning that either all, some, or none of the metadata are available for any number of different kinds of spatial data resources on any of the six websites. Without being familiar with the intricacies of spatial data, it was difficult for the author to determine whether the websites did not provide metadata for certain data or certain data did not have metadata available for provision.

## Further Research

GIS services and academic library websites are both still a relatively new phenomena. It is no wonder that through the present exploratory study of a handful of GIS services websites has revealed some potential roadblocks for users. The need for further research in the general design of library websites with an emphasis on navigation is clear. For library services websites, usability tests would help determine what kinds of information users need and where it should be placed on the site. If it is not possible for a library GIS services website to implement browsing tools for finding spatial data, perhaps usability testing of the websites existing organization of spatial data would indicate ways to improve it. Surveys of users of academic library services as well as librarians and staff providing services would be beneficial in bridging the gap between what the users need and what services are available. As for GIS in particular, further research in managing spatial data is needed. As GIS applications become more and more

user-friendly, and as more and more data becomes available, the demand for tools that make searching for and determining fitness of use of spatial data will grow as well.

## CONCLUSION

Academic libraries have met the challenge of providing GIS services to users by gathering resources, training staff, and setting up shop fairly quickly with the help of the ARL GIS Literacy Project. For such accomplishments, academic libraries should be commended. The present study's general approach to examining GIS services websites, however, reveals some room for improvement in how academic libraries use the Web to present services. Both the Web and GIS are powerful technologies that in the hands of libraries and librarians give users the ability to explore and analyze information and data in different ways and synthesize them into meaningful resources for personal, research, and business purposes.

Academic libraries by nature exist to serve and have embraced the Web's capabilities to reach out to their users and provide them with a portal to the vast resources and services available. However, the extent of libraries' success in using the Web for such purposes continues to be called into question in the current study as well by recent usability and design research. Despite well-intentioned designs for library services websites, users continue to face barriers to navigation and locating resources.

Regularly assessing and revising policies helps academic libraries adapt GIS services to strike a balance between ever-changing needs of users and finite library staff, equipment, and budgetary resources. For policies to be fully effective, users must understand them. Information about policies, the level of GIS services users can expect

from academic libraries, and what kind of GIS resources are available need to be clearly communicated to users through GIS services websites.

Spatial data resource management is a critical component to GIS services as more data are generated every day. GIS services websites are academic libraries' portal for users to search for spatial data, yet users must scroll through lists upon lists looking for relevant data. Users must also try to ascertain the data's fitness of use through metadata, if any metadata are available. Many applications available specifically for browsing spatial data resources and viewing metadata on the Web, and more are being developed. Incorporated into academic library GIS services websites, these spatial data management alternatives are capable of eliminating the burden of maintaining long lists of spatial data resources and simplifying the spatial data search process for users.

By exposing some of the potential barriers users may face when using GIS services websites, and offering further research opportunities, the current study serves as a springboard into improving overall library Web design, library GIS services, and access to spatial data resources.

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**APPENDIX 1:** Worksheet for Identifying Library GIS Services Websites

| Institution | Library GIS Services Website? | GIS Workstations | Data Resources |
|---|---|---|---|
| Amherst College | none | n/a | n/a |
| Brown | http://www.brown.edu/Facilities/University_Library/gis/index.html | yes | yes |
| Colorado State University | none | n/a | n/a |
| Columbia University | http://www.columbia.edu/acis/eds/ | yes | yes |
| Cornell University | http://www.library.cornell.edu/olinuris/ref/maps/map.htm | yes | yes |
| Dartmouth College | http://www.dartmouth.edu/%7Emaproom/gis.htm | yes | yes |
| Duke University | http://docs.lib.duke.edu/maps/guides/gis.html | yes | yes |
| Emory University | none | n/a | n/a |
| Georgetown University | http://www.library.georgetown.edu/dept/govdocs/gdgis.htm | yes | yes |
| Harvard | http://hcl.harvard.edu/libraries/#hmc | | |
| Indiana University | http://www.libraries.iub.edu/index.php?pageId=1517 | yes | yes |
| Iowa State University | none | n/a | n/a |
| Johns Hopkins University | http://www.library.jhu.edu/collections/gpml/mapsandgis/index.html | yes | yes |
| Kent State University | none | n/a | n/a |
| Louisiana State University | http://www.lib.lsu.edu/soc/geo/gis.html | yes | yes |
| Massachusetts Institute of Technology | http://libraries.mit.edu/gis/index.html | yes | yes |
| Michigan State University | http://www.lib.msu.edu/coll/main/maps/svcs.html | yes | yes |
| New York University | none | n/a | n/a |
| North Carolina State University | http://www.lib.ncsu.edu/gis/ | yes | yes |
| Ohio State University | none | n/a | n/a |

| Institution | Library GIS Services Website? | GIS Workstations | Data Resources |
|---|---|---|---|
| Oklahoma State University | none | n/a | n/a |
| Pennsylvania State University | http://www.libraries.psu.edu/maps/ | yes | yes |
| Princeton University | http://www.princeton.edu/~geolib/gis/ | yes | yes |
| Purdue University | none | n/a | n/a |
| Rice University | http://www.rice.edu/fondren/gdc/ | yes | yes |
| Southern Illinois University - Carbondale | none | n/a | n/a |
| Stanford University | http://www-sul.stanford.edu/depts/gis/ | yes | yes |
| State University of New York – Albany | http://library.albany.edu/about/gis.html | yes | yes |
| State University of New York – Buffalo | http://ublib.buffalo.edu/libraries/asl/gis/GIS-training.html | yes | yes |
| Temple University | http://library.temple.edu/articles/subject_guides/gov_docs_maps.jsp?bhcp=1#link_04 | yes | yes |
| Tulane University | none | n/a | n/a |
| University of Arizona | http://dizzy.library.arizona.edu/library/teams/sst/geo/guide/gis/ | yes | yes |
| University of California – Riverside | none | n/a | n/a |
| University of California - Santa Barbara | none | n/a | n/a |
| University of California-Berkeley | http://www.lib.berkeley.edu/EART/ | yes | yes |
| University of California-Los Angeles | none | n/a | n/a |
| University of Chicago | none | n/a | n/a |
| University of Colorado Libraries | http://ucblibraries.colorado.edu/map/gis/gis.htm | yes | yes |
| University of Connecticut | none | n/a | n/a |

| Institution | Library GIS Services Website? | GIS Workstations | Data Resources |
|---|---|---|---|
| University of Florida | http://www.uflib.ufl.edu/maps/MAPCOMPUTE.HTML | yes | yes |
| University of Georgia | none | n/a | n/a |
| University of Houston | none | n/a | n/a |
| University of Illinois- Urbana Champaign | none | n/a | n/a |
| University of Iowa | none | n/a | n/a |
| University of Kansas | http://www.lib.ku.edu/gis/ | yes | yes |
| University of Kentucky | none | n/a | n/a |
| University of Maine | http://www.library.umaine.edu/geoscan/ | yes | yes |
| University of Maryland - College Park | http://www.lib.umd.edu/GOV/geospatial.html | yes | yes |
| University of Massachusetts | none | n/a | n/a |
| University of Michigan | http://www.lib.umich.edu/nsds/ | yes | yes |
| University of Minnesota | none | n/a | n/a |
| University of Missouri - Columbia | none | n/a | n/a |
| University of Montana | none | n/a | n/a |
| University of Nebraska - Lincoln | none | n/a | n/a |
| University of Nevada - Reno | none | n/a | n/a |
| University of New Mexico | http://elibrary.unm.edu/subjects/maps.php | yes | yes |
| University of North Carolina - Chapel Hill | http://www.lib.unc.edu/reference/gis/gisserv.html | yes | yes |
| University of Northern Iowa | none | n/a | n/a |
| University of Oregon | none | n/a | n/a |
| University of Pittsburgh | http://www.library.pitt.edu/libraries/gis/gis.html | yes | yes |
| University of South Carolina | none | n/a | n/a |

| Institution | Library GIS Services Website? | GIS Workstations | Data Resources |
|---|---|---|---|
| University of Southern California | none | n/a | n/a |
| University of Tennessee | http://www.lib.utk.edu/cic/gis@ut/ | yes | yes |
| University of Utah | none | n/a | n/a |
| University of Virginia | http://fisher.lib.virginia.edu/services/lab.html | yes | yes |
| University of Washington | http://www.lib.washington.edu/maps/gis3.html | yes | yes |
| Virginia Tech | none | n/a | n/a |
| Washington State University | http://www.wsulibs.wsu.edu/gis/index_f.html | yes | yes |

**APPENDIX 2:** Carnegie Classification of 35 Institutions with Eligible GIS Services Websites

| Institution | Status | Size |
|---|---|---|
| Brown University | Private not-for-profit | Medium four-year, highly residential |
| Columbia University in the City of New York | Private not-for-profit | Large four-year, highly residential |
| Cornell University-Endowed Colleges | Private not-for-profit | Large four-year, primarily residential |
| Dartmouth College | Private not-for-profit | Medium four-year, highly residential |
| Duke University | Private not-for-profit | Large four-year, highly residential |
| Georgetown University | Private not-for-profit | Large four-year, highly residential |
| Harvard University | Private not-for-profit | Large four-year, highly residential |
| Indiana University-Bloomington | Public | Large four-year, primarily residential |
| Johns Hopkins University | Private not-for-profit | Large four-year, highly residential |
| Louisiana State Univ & Ag & Mech & Hebert Laws Center | Public | Large four-year, primarily nonresidential |
| Massachusetts Institute of Technology | Private not-for-profit | Large four-year, highly residential |
| Michigan State University | Public | Large four-year, primarily residential |
| North Carolina State University at Raleigh | Public | Large four-year, primarily residential |
| Pennsylvania State University-Main Campus | Public | Large four-year, primarily residential |
| Princeton University | Private not-for-profit | Medium four-year, highly residential |
| Rice University | Private not-for-profit | Medium four-year, highly residential |
| Stanford University | Private not-for-profit | Large four-year, highly residential |
| SUNY at Albany | Public | Large four-year, highly residential |
| SUNY at Buffalo | Public | Large four-year, primarily residential |
| Temple University | Public | Large four-year, primarily nonresidential |
| University of Arizona | Public | Large four-year, primarily nonresidential |
| University of California-Berkeley | Public | Large four-year, primarily residential |
| University of Colorado at Boulder | Public | Large four-year, primarily nonresidential |

| Institution | Status | Size |
|---|---|---|
| University of Florida | Public | Large four-year, primarily nonresidential |
| University of Kansas Main Campus | Public | Large four-year, primarily nonresidential |
| University of Maine | Public | Medium four-year, primarily residential |
| University of Maryland-College Park | Public | Large four-year, primarily residential |
| University of Michigan-Ann Arbor | Public | Large four-year, primarily residential |
| University of New Mexico-Main Campus | Public | Large four-year, primarily nonresidential |
| University of North Carolina at Chapel Hill | Public | Large four-year, primarily residential |
| University of Pittsburgh-Main Campus | Public | Large four-year, primarily residential |
| University of Tennessee, The | Public | Large four-year, primarily residential |
| University of Virginia-Main Campus | Public | Large four-year, primarily residential |
| University of Washington-Seattle Campus | Public | Large four-year, primarily nonresidential |
| Washington State University | Public | Large four-year, primarily residential |

**APPENDIX 3:** Detailed Analysis Results of Spatial Data Resources Organization

**North Carolina State University**
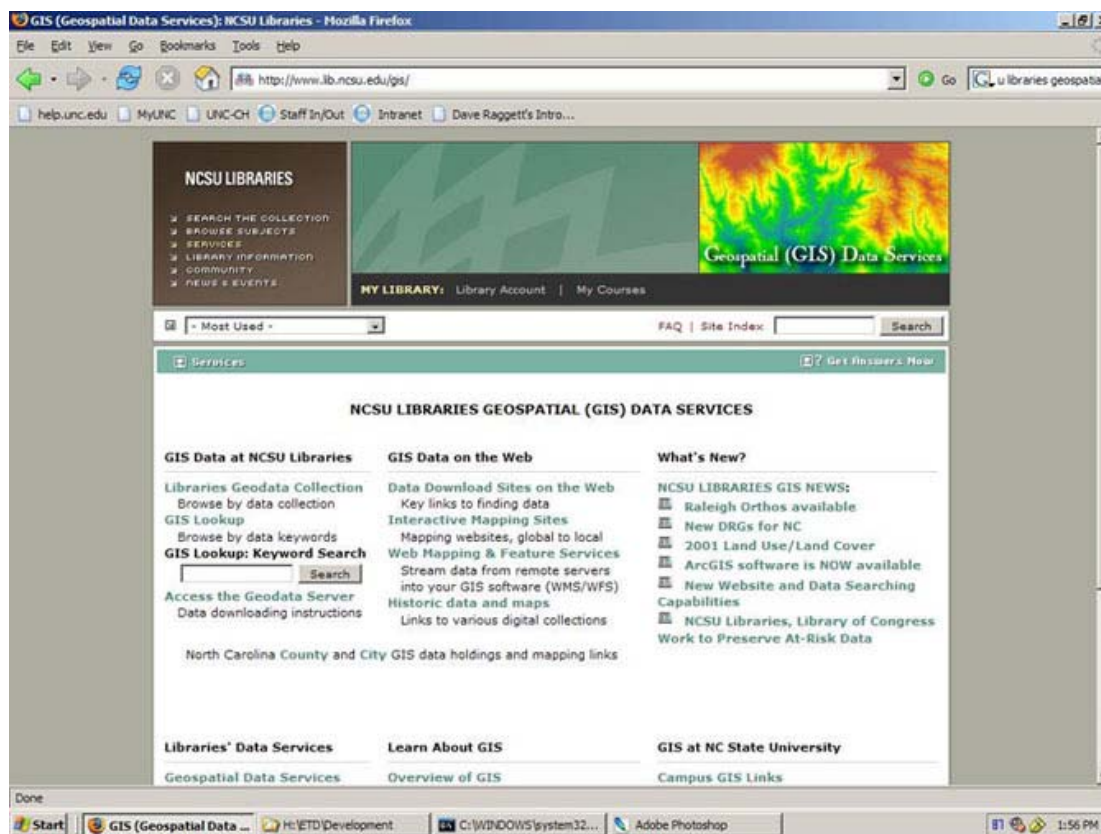


*Figure 1: North Carolina State University Libraries' GIS services website*

The website's information about spatial data is organized under two headings,

"GIS Data NCSU Libraries" and "GIS Data on the Web."



*Figure 2: NCSU's links to spatial data resources*

Under the first heading is a link to the "Libraries Geodata Collection" which contains a list of over 60 data sets organized alphabetically. Each item is identified as an online resource available for download through their Geodata server, a CD-Rom available off-line at the library, or an online resource available through the Web as an NCSU affiliate. Each item is also a link to more and varied information about the data set sometimes including metadata, documentation, download information, format information, etc.

The "GIS Lookup" tool allows users to browse for data thematically using a list of keywords. The results returned by the tool provide the user with metadata and information about accessing the data. Along with the results, the tool gives the users suggested related keywords with which to perform additional searches.

**GIS LOOKUP: THESAURUS A-Z LIST**

Select a term below to find relevant data resources and links to related terms. Links to networked data, metadata, and Web-based mapping utilities are provided. Use available metadata to evaluate and select data resources.

1-9 A B C D E F G H I J K L M N O P Q R S T U V
W X Y Z

**1-9**

1:24000

1:100000

1:250000

3 Digit ZIP Codes

5 Digit ZIP Code Boundaries

5 Digit ZIP Code Centroids

*Figure 3: NCSU's data browsing tool*

Under "GIS Data on the Web" there are four links:

- Data Download Sites on the Web
- Interactive Mapping Sites
- Web Mapping and Feature Service
- Historic Data and Maps

Each of the above links with the exception of "Web Mapping and Feature Service" opens

a Web page containing links to appropriate external website resources along with a brief

description of each resource.  Further, the "Data Download Sites on the Web" Web page

categorizes links by the following headings:

- Global/International Data Sources
- US Data Sources
- NC Data Source
- Local and Regional (NC) Data Source

and similarly, the links on the "Interactive Mapping Sites" Web page are categorized by

the headings:

- Local
- Regional
- State
- National
- Global

**University of Colorado-Boulder**
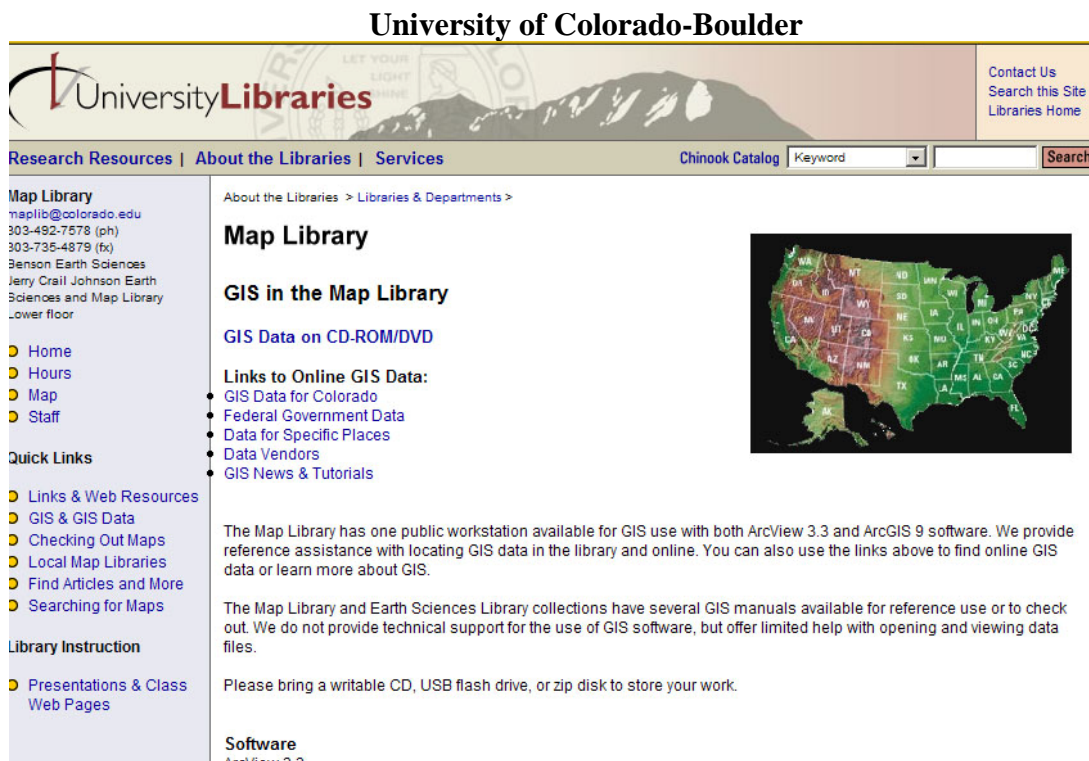


*Figure 4: University of Colorado-Boulder library's GIS services website*

Following the "GIS Data on CD-ROM/DVD" link brings the user to a page

containing a bulleted list of eight brief descriptions of GIS data types or GIS data

resources.  Some of the descriptions describe resources freely available on the internet.

None of the description mentions anything about GIS data on CD-ROM or DVD.  A

sentence at the bottom of the page indicates that federal and state produced GIS data is

available online or on CD-ROM and can be searched for in the University of Colorado-

Boulder's online catalog.   However no guidelines are given for doing such.

The link "Links to Online GIS Data" contains links to GIS data resources

categorized under:

- GIS Data for Colorado
- Federal Government GIS Resources
- GIS Data for Specific Places
- GIS Resources from Vendors
- GIS News, Tutorials & FAQs

All of the links are to external resources available on the Web.

**Princeton University**
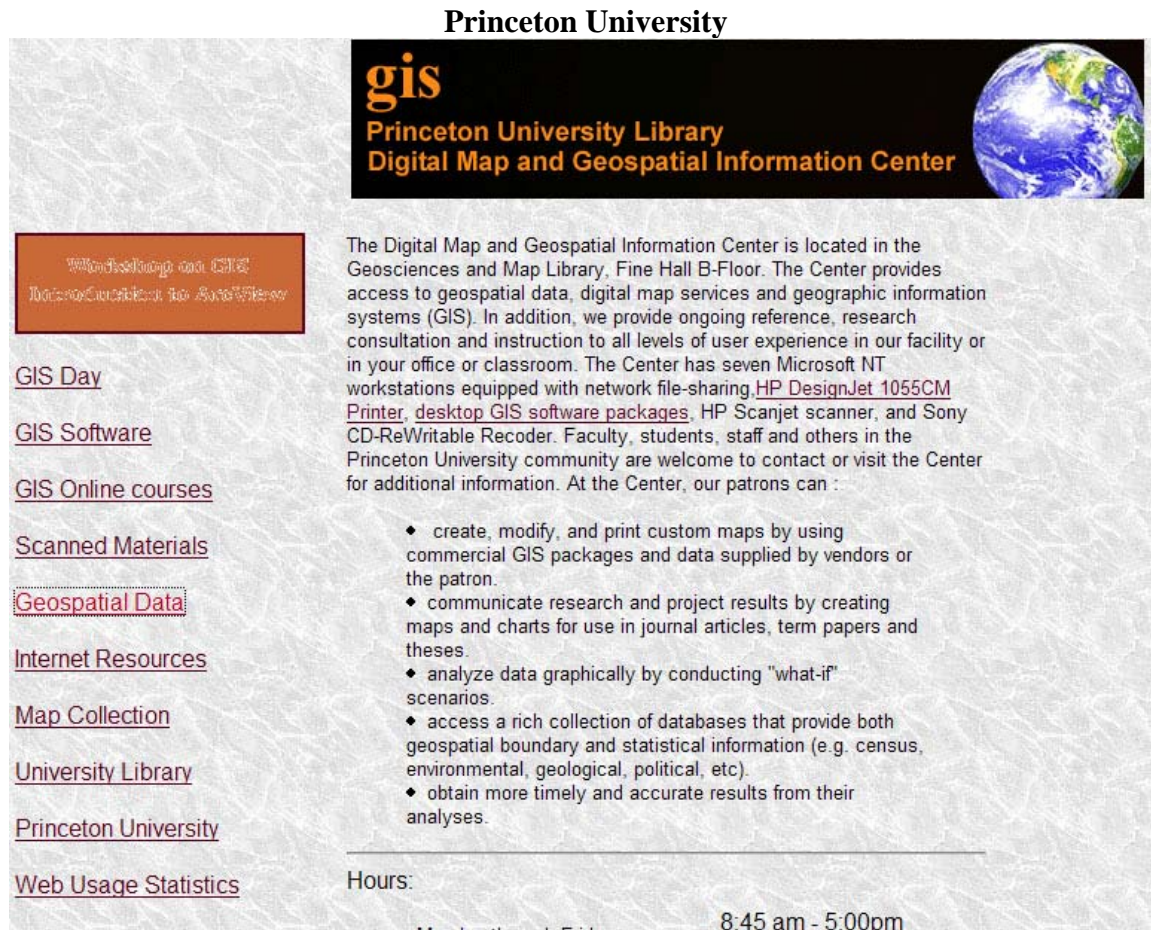


*Figure 5: Princeton University library's GIS services website*

Spatial data resources are found under links labeled "Geospatial Data" and "Internet Resources."

Opening the "Geospatial Data" link presents a page containing fifteen alphabetized links that according to a small paragraph at the top of the page are links to "some of the most commonly used geospatial data." The paragraph also mentions availability of geospatial online through a GIS server, though no link to or further information about the GIS server is present. None of the fifteen links indicate whether the data are part of the library's collection or an internet resource. Each of the fifteen links points to a Web page. Each the fifteen subsequent Web pages present widely varied different information about the data. Some Web pages contain metadata, sample images,

information on the file format, instructions for downloading the data and using it in a GIS application.  Some of the Web pages state that the data is only accessible through a Princeton IP address, but other Web pages contain URLs to websites providing data freely available on the Web.  A couple of the Web pages provide only with further description with no information about accessibility.

Following the "Internet Resources" link opens a Web page containing seven links labeled by geographic regions:

- Africa
- America
- Antarctica
- Asia
- Europe
- Oceania
- Europe
- World

Each of these links opens a Web page containing more links labeled with smaller geographic regions within the original seven previously listed.  These subsequent links are all lead to external URLs pointing to either digital map images or spatial data download websites provided by other academic institutions, federal agencies, non-governmental organization or commercial vendors.

Following up on the mention of a GIS server on the "Geospatial Data" Web page, the author, through the use of Princeton University's site index, located a link to the Princeton University Library's Digital Map and Geospatial Information Center's Metadata Explorer tool.  It uses map browsing technology, similar to the application described by Jankowski and the technology used on the Geography Network website to help users locate spatial data and maps geographically (Jankowski et al., 2001; *Geography network.*2006).  The tool also enables narrowing the search by data content

type and theme. Results offer full metadata viewing when available for a data set.
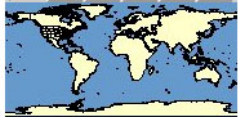


*Figure 6: Princeton's data browsing tool*

**Stanford University**
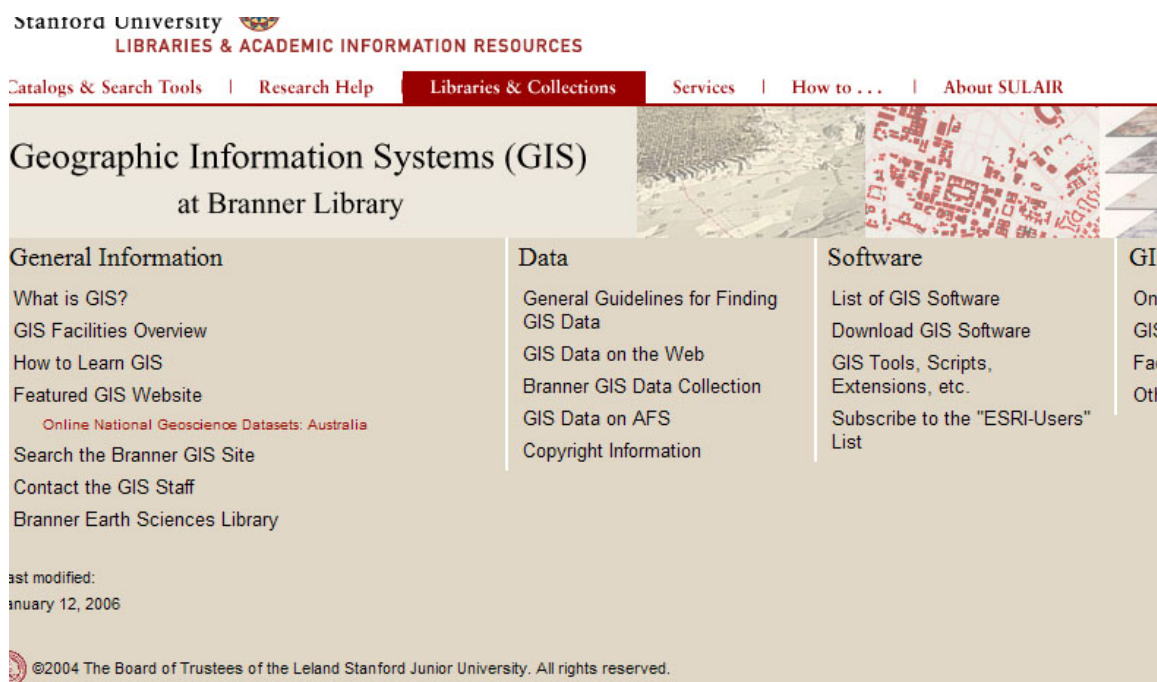


*Figure 7: Stanford University libraries' GIS services website*

The "Geographic Information Systems (GIS) at Branner Library" website contains a heading labeled "Data" under which are four related links labeled:

- Guidelines for Finding GIS Data
- GIS Data on the Web
- Branner GIS Data Collection
- GIS Data on AFS

Following the "Guidelines for Finding GIS Data" link opens a Web page containing step by step instructions for searching the library's online catalog and the Web for spatial data. The Web page also contains considerations for the user to keep in mind once they have located data.

The "GIS Data on the Web" link opens a Web page with lists of links to internet resources categorize by:

- Websites for Digital GIS Data
- National Data Clearinghouses
- San Francisco Bay Area

- State of California
- U.S. by State
- International Data
- Imagery
- Landcover Data
- Miscellaneous

All links on the "GIS Data on the Web" Web page are to external internet websites.

Following the link for "Branner GIS Data Collection" opens a Web page containing information about searching Stanford's online catalog for spatial data followed by links to spatial data sets maintained by the library. The links are organized under six categories:

- Digital Raster Graphics
- Vector Data
- Street Data
- Boundary Data
- Census Data
- Imagery

Following any of the links under the six categories is a page containing a detailed description of the data sets as well as their format (CD-ROM or electronic), their location, and download information if applicable.

The "GIS Data on AFS" link leads to a Web page with information and instructions for Stanford Affiliates about accessing a collection on basemap GIS data located in the university's AFS directory. Brief descriptions of the data are also included on the Web page.

**University of Virginia**



*Figure 8:  University of Virginia library's GIS services website*

On the GEOSTAT website (the University of Virginia's Geospatial and Statistical

Data Center) there is a link labeled "Browse Geospatial Resources."  Following the link

opens a Web page titled, "Digital Maps and Geospatial Data Links."  In the lower half of

the Web page there are four links labeled:

- Virginia Gazetteer Searchable Database
- Subject
- Format
- Geographic Coverage

Mousing over each of the links provides a description of the resources in that category.

*Figure 9: UVA's spatial data resource*

Following the "Virginia Gazetteer Searchable Database" link opens a Web page

displaying information about the Virginia Gazetteer which is a database containing

spatial data holdings for the state of Virginia.  It happens to be housed at UVA's

GEOSTAT Center.  Spatial data holdings fall into five categories and can be searched by

geographic feature (lake, peak, etc.), county, or quadrangle.  The five categories are:

- digital topographic maps
- digital elevation models
- aerial photography
- satellite imagery
- land use data

Search results include accessibility and download information. Only satellite imagery

holdings have UVA restricted access. The tool's search results provide full metadata

viewing and an option to view the actual data, if applicable.

*Figure 10: UVA's data browsing tool for state of Virginia Gazetteer*

The "Subject" link opens a Web page titled "Geographic and Spatial Data by Subject" which contains nine links labeled thusly:

- Aerial Photography/Remote Sensing
- Base Data/General Use
- Demographic
- Environmental
- Historical
- Hydrologic and Water Features
- Planimetric
- Roads/Highways
- Topography/Elevation

Mousing over each of the links provides a description of the resources in that category.

Following each of the above links open a Web page containing a list of links to resources pertaining to the topic. The links are in alphabetical order. Each page includes two small icons that are used to indicate whether the link is to a resource developed outside of UVA and freely available on the Web or the link is to a resource belonging to UVA with access restricted to UVA affiliates.

*Figure 11:  UVA's typical format for spatial data resource links*

The "Format" and "Geographic Coverage" links open to Web pages with the

same layout described in the previous paragraph.  The "Format" link opens a Web page

titled "Geographic and Spatial Data by Format" containing links labeled:

- Electronic Maps
- GIS Data
- Interactive Mappers
- Paper Maps
- Reference Tools
- State Level Distributors and Clearinghouses
- Tabular Data for GIS

The "Geographic Coverage" link opens a Web page titled "Geographic and Spatial Data

by Geographic Coverage"  containing links labeled:

- International
- National
- State
- Virginia

The "Digital Maps and Geospatial Data Links" Web page also contains a section called

"Quick Links to Spatial" containing links labeled:

- Virginia GIS Data
- City/County Planimetric Data
- Aerial Photos for Virginia
- State Level Distributors and Clearinghouses

The Web pages opened by following the above links contain lists of highly used

resources which are subsets of the lists of resources described in the previous paragraphs.

**Washington State University**

The Libraries - Your Information & Resources Gateway

## Washington State University Libraries
## Geographic Information Systems

- Services available through the Washington State University Libraries
- Guide to learning and training opportunities

**Information sources for Geographic Information System**

- Census 2000 Data
- Guide to Finding Books in the Library about GIS
- Guide to General Sources of Information about GIS
- Guide to Geospatial Datasources

*Figure 12: Washington State University Libraries' GIS services website*

The Washington State University Libraries Geographic Information Systems website provides a link to a "Guide to Geospatial Datasources."  Opening the link reveals a Web page containing a long list of over fifty links to resources categorized under the following headings:

- Sources of Data:  Washington
- Sources of Data:  Other Northwest States
- Environment
- United States
- International
- General Directories and Databases for GIS Data

Some of the links are accompanied by brief descriptions.  At first glance, the links appeared to be to external resources freely available on the Web.  However, upon closer inspection, two of the links were to resources owned by WSU.  Following the links opens Web pages containing results windows from the library's online catalog.  Another resource, the state of Washington's Geospatial Data Archive is housed at WSU.  It provides a list of links to spatial data organized by state, counties, and cities.  Most of the

resources are freely accessible.  Resources restricted to WSU affiliates are clearly

marked.