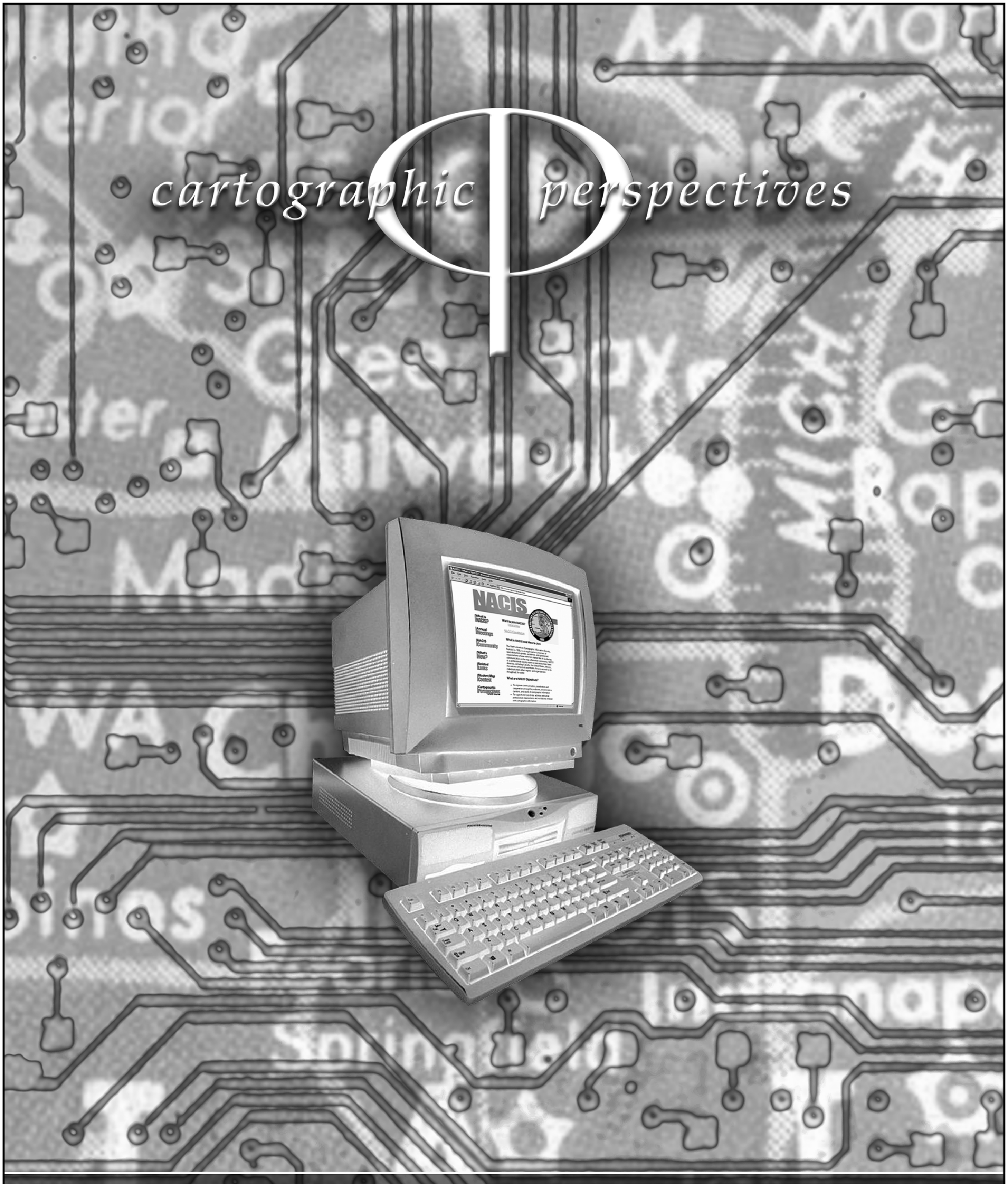
cartographic perspectives



Journal of the North American Cartographic Information Society
Number 39, Spring 2001

journal of the North American Cartographic Information Society

cartographic perspectives

Number 39, Spring 2001

in this issue

(continued on page 3)

Letter from the Editor

Dear Members of NACIS

Issue #38 of *Cartographic Perspectives* (CP) that was distributed at the end of 2001 proved to inspire some lively discussion that included some fairly diverse opinions. In particular was the column *The Map Library's Future* by Peter Keller that put forth some ideas on the future role of map libraries as they move increasing toward managing digital holdings. We had so many requests from non-NACIS members for a copy of the column, that we posted Dr. Keller's paper on the NACIS web site! A response to this article is in the works, and I hope to have this response, as well as additional thoughts from Dr. Keller, in a future issue of CP. It is a goal of this editorial board to seek and publish articles and columns that foster these sorts of discussions of diverse ideas. It is rewarding as an editor to bring about elevated heart rates in a group of typically tranquil cartographers!

(continued on page 3)

Editor
Scott M. Freundschuh
Department of Geography
University of Minnesota
Duluth, MN 55812
(218) 726-6226
fax: (218) 726-6386
sfreunds@d.umn.edu

cartographic perspectives

journal of the
North American Cartographic Information Society

ISSN 1048-9085
Cartographic Perspectives is published triannually

Assistant Editor
James R. Anderson, Jr.
FREAC
Florida State University
Tallahassee, FL 32306-2641
(850) 644-2883
fax: (850) 644-7360
janderson@admin.fsu.edu

Cartographic Techniques Editor
Charlie Frye
ESRI
380 New York Street
Redlands, CA 92373
(909) 793-2853
cfrye@esri.com

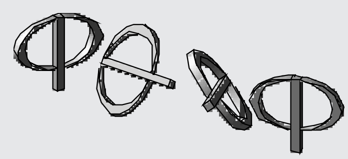
Map Library Bulletin Board Editor
Melissa Lamont
Data Library, McLean Laboratory
Woods Hole Oceanographic
Institution
WHOI Mail Stop 8
Woods Hole, MA 02543
(508)289-3396 fax: (508)457-2183
mlamont@whoi.edu

Book Review Editor
Ren Vasiliev
Department of Geography
SUNY @ Geneseo
Geneseo, NY 14454
(585) 245-5297
vasiliev@geneseo.edu

Essay Section Editor
Matthew McGranaghan
Department of Geography
445 Social Sciences Building
University of Hawaii at Manoa
Honolulu, HI 96822
(808) 956-7092
matt@uhunix2.its.hawaii.edu

Online Mapping Editor
Jeremy W. Crampton
Dept. of Anthropology & Geography
Georgia State University
Atlanta, GA 30303
(404) 651-1763
jcrampton@gsu.edu

about the cover



"The cover design was created by Lou Cross. Lou is a cartographer and graphic artist with the Florida Resources and Environmental Analysis Center at The Florida State University.

(Table of Contents continued)

Issue # 39 of CP has come to fruition. I am happy to report that issue #40, which will be our color issue for this series, is right on the heels of 39. The editorial board of CP has been quite busy the past 8 months. CP has experienced an increase in article submissions that will ultimately place the Journal on track for publication in 2002 and the beginning of 2003. I have relied heavily upon the editorial board for many timely reviews, and have worked closely with authors to facilitate editing of manuscripts for publication.

The current issue of *CP* has three fairly diverse papers. The first is a manuscript titled *The Map Library's Emerging Role in the Dissemination of Cartographic Information on the Internet.* This paper lays out for the reader the many issues surrounding the management and dissemination of digital data by map libraries, and provides a real-world model of how a library might approach this task. The second paper is very much a theoretical piece titled *Feeling it Out: The Use of Haptic Visualization for Exploratory Geographical Analysis.* This manuscript adds to the graphic, dynamic and sonic map design elements currently available for map design, a number of haptic or tactile elements that might be used to facilitate the communication of both spatial and non-spatial information. The author provides a framework for how haptic design elements fit into the scheme of map design, and leads us through some possible examples of where these design elements can benefit the map user. Last is a piece titled *Visualizing Change: Using Cartographic Animation to Explore Remotely Sensed Data*. This paper demonstrates how animation can facilitate the visualization of spatial change. All three papers ultimately focus on the end user of spatial information, and discuss how the needs of the map user can be met more effectively.

The next three issues of CP have taken shape rapidly over the past few months. Issue # 40, which will round out the three issues for 2001, will be a color issue that will include two lengthy articles of a more subjective nature. One of the manuscripts delves into the historical use/misuse of color in ethnic mapping. The other manuscript offers us a trip through the poetic maps of Verona. This issue will also include a column from the president of NACIS, and the usual columns included in all issues of CP.

Issue #41 will be the first in the next series for 2002, and will be a guest edited piece by Martin von Wyss and Alex Tate on Practical Cartography. This issue, of course, will be published in color. Issue #42 will include manuscripts on thinking critically in cartography, on participatory mapping for the disabled, and the unique symbology of railway mail service maps of the late 1800's. Issue #42 is shaping up to be a volume on critical issues surrounding the production of modern atlases. This will be a co-edited piece with Scott Bell and myself. As you can see, the editorial board has much work to do by the end of 2002.

What direction will CP go after this year? As always, the editorial board is encouraging the submission of any and all articles in which cartography is the focus. It is important to create a journal that is representative of its readership, and at the same time challenges the readership's comfort level and goes that one step further. I suspect that we will see more papers that focus on the map user, and that employ human subject testing as a means to assess the efficacy of various map designs and mapping technologies. The cartographic literature is sorely lacking in this type of empirical work, and CP can play a significant role in addressing this void. CP can also play a more significant role in leading the discussion of ethics, power and maps. In other words, cause the membership of NACIS to think critically about cartography, and all the ways that maps influence people. The final thought I want to put forward to all of you is that CP can become a multidisciplinary journal, publishing papers by researchers who don't necessarily call themselves cartographers, or even geographers, but whose research has as it's central focus maps and spatial information. Care to share your thoughts?

With warmest regards,

Scott Freundschuh, Editor

The Map Library's Emerging Role in the Dissemination of Cartographic Information on the Internet

Patrick McGlamery
Homer Babbidge Library

Robert G. Cromley
Department of Geography
The University of Connecticut
Storrs, CT 06269

The Internet is allowing a range of cartographic products from images of map documents to numerical databases of cartographic content to be transmitted to a global user community. This technological innovation is forcing map libraries to rethink the manner in which to provide their services since libraries have traditionally had the responsibility for the storage of, and access to, information by society. The functions of a map library that allow a patron to search the holdings, go to the storage location, browse the document, and ultimately copy it in-house or check out the document can now be provided online. This paper describes the efforts and problems of collection development, assessment of user community needs and access policies associated with an internet-based map library.

INTRODUCTION

With the advent of the Internet in the 1990s, a range of cartographic formats from images of map documents to numerical databases of cartographic content can now be transmitted to a global user community. The form and method of this dissemination is of particular concern to libraries that traditionally have had the responsibility for the storage of, and access to, information by society. In 1999, a Mapping Sciences Committee Workshop, "Distributed Geolibraries" described a vision of the future of cartographic information http://cartome.org/distributed-geolibraries.htm#summary:

"A distributed geo-library is a vision for the future. It would permit users to quickly and easily obtain all existing information available about a place that is relevant to a defined need. It is modeled on the operations of a traditional library, updated to a digital networked world, and focused on something that has never been possible in the traditional library: the supply of information in response to a geographically defined need. It would integrate the resources of the Internet and the World Wide Web into a simple mechanism for searching and retrieving information rele-vant to a wide range of problems, including natural disasters, emergencies, community planning, and environmental quality. A geo-library is a digital library filled with geo-information—information associated with a distinct area or footprint on the Earth's surface—and for which the primary search mechanism is place. A geo-library is distributed if its users, services, metadata, and information assets can be integrated among many distinct locations."

"A distributed geo-library is a vision for the future."

The challenge for libraries is to evolve the "operations of a traditional library" from *Library as Institution to Library as Function* by integrating its knowledge base of how collections and users interact.

Libraries are not information producers; a library collects, catalogs, stores and disseminates data but it does not create the data. Traditionally, a library patron enters a facility, and makes a query of the information stored by the library through and organized query system. This used to be a card catalog but now is an On-line Public Access Catalog (OPAC). An OPAC is a relational database that leads the patron through a process of search and discovery to an item on a shelf. The patron can then go to the bookshelf and retrieve the document, browse it in-house, copy it in-house or check out the document.

Historically, libraries have organized the storage of information by media type: books, microfilm, serial publications, maps and other formats. It reflects the economic imperative of storage units, keeping "like with like". Within the media type, such as books or maps, the organization is thematic, but the primary categorization is media type. For example, map libraries typically have held maps in flat and vertical files, folded on shelves, bound into atlases and on micro media. Other cartographic information such as gazetteers is shelved with atlases because they are bound as books even though the information is in a very different form from a map. Regardless of media type or thematic content, the OPAC contains the storage location for each item.

"Increasingly, producers of spatial data are distributing it only as digital images and databases."

Increasingly, producers of spatial data are distributing it only as digital images and databases. In 1990, the U.S. Bureau of the Census stopped printing census tract maps. For the 2000 census the Census is producing these maps as Adobe PDF images via the Internet. This transformation of information from paper to electronic form has required that libraries redesign their information delivery service. Buckland (1992) has argued that since library materials in electronic form lend themselves to remote access and shared use, the assembling of local collections becomes less important. Coordinated collection development and cooperative collections are now more strategic. This concept of coordinated collections underlies most attempts to provide access to cartographic information over the Internet.

USING THE INTERNET FOR MAP LIBRARY FUNCTIONS

Two types of Internet sites involving cartographic information have evolved: 1) sites in which the cartographic information is ancillary to another purpose such as promoting tourism and travel, and 2) sites in which the cartographic information itself is the main topic of interest. Sites in the latter case provide differing sets of functions traditionally associated with a map library. The site may just be the equivalent of an OPAC that enables an Internet patron to search for selected items, or the site may also have stored information that the patron can browse on-line and even download to a local desktop.

The Alexandria Digital Library, http://webclient.alexandria.ucsb.edu/ a part of the University of California Digital Library (UCDL), is a cartographical search engine that queries several of the map libraries cooperating in the UCDL. A user of the website makes queries using a spatial index (a latitude/longitude bounding rectangle). The search engine ascertains the location of holdings regarding the selected place, but the patron can neither browse, copy nor check-out any of these holdings. A descriptive catalog record is provided, however few opportunities for data downloads have been implemented. When data downloads are available, for example to download a Digital Raster Image, those users who are not students, faculty and staff of the University of California system are required to pay a fee.

"The site may . . . enable an Internet patron to search for selected items, or the site may also have stored information that the patron can browse on-line and even download to a local desktop."

The Harvard Geospatial Library (HGL) http://geodesy.harvard.edu/servlet/MainGeodesyMap is a developing cartographical catalog whose goal is to:

> "alleviate the most common challenges users face when they embark upon a geospatial analysis project: finding interesting data, obtaining that data in a useable form, learning to use new data analysis tools, and accessing appropriate computing platforms."

The HGL's user interface is more intuitive than the ADL interface, but it is still basically a catalog which refers the user to a static dataset of information object which might then be downloaded, or not. Although Harvard is a private university, it makes more of its data available to the web-user, then it can reasonably interpret its license agreements to data.

Although the Federal Geographic Data Committee's (FGDC) clearing house program is not a library, it uses library functions in a similar approach.

> "The Geospatial Data Clearinghouse http://130.11.52.184/FGDC-gateway.html is a collection of over 250 spatial data servers, that have digital geographic data primarily for use in Geographic Information Systems (GIS), image processing systems, and other modeling software. These data collections can be searched through a single interface based on their descriptions, or 'metadata'."

The user retrieves the metadata records that describe the spatial data and indicate availability. The metadata indicates to the user where the holdings are and what the mechanisms are for acquiring the spatial data.

ESRI's Geography Network http://www.geographynetwork.com/ is another example of non-libraries offering a library function. The Geography Network is:

"Fundamental to library management is a keen understanding of the user community."

> "a global community of government and commercial data providers who are committed to making geographic content easily accessible… Through the Geography Network, you can access many types of geographic content including live maps, downloadable data, and more advanced services. The Geography Network content is distributed at many locations around the world, providing you access to the latest information available directly from the source."

Fundamental to library management is a keen understanding of the user community. Both ADL and HGL are grounded in the primacy of the user. In comparison, the Geographic Network and FGDC Clearinghouse invite participation from the geospatial data producing communities, aiming to aggregate collections, but they lack that key component of a library—collection building with a special user community in mind. These programs rely on a 'scatter-shot' approach to collection building based upon available data, not on user needs. These approaches differ from the more focused library strategy for map librarians in an age of accessing of machine-readable information. McGlamery (1989) has outlined a 'plan of action' for the information age that focused heavily on: 1) collection development, 2) user community needs, and 3) access policies—the underpinnings of modern library science. The next sections describe how this plan has been implemented in building an Internet-based map library.

THE DEVELOPMENT OF MAGIC WEBSITE

In 1991, the Map and Geographic Information Center (MAGIC) FTP site at the University of Connecticut evolved from that 'plan of action' and the site has not strayed far from those tenets of basic librarianship (after the introduction of HTML the FTP site became a website http://magic.lib.uconn.edu). The basis of the plan for the map librarian's dilemma with respect to machine readable information was to 're-bind'—making odd things fit into a standard collection—public domain spatial databases into formats required by the University of Connecticut's user community. While many agencies are producing digital databases, rarely do they produce data in a geographic and software format that is directly compatible with the needs of most data users. Clarke (1995) has commented that most items of geographic interest seem to lie on the border of two or more map sheets. For example, in Connecticut the basic geography used by most policy and decision makers is that of 169 town municipalities. However, the digital line graph files produced by the U.S. Geological Survey are organized spatially by quadrangles, whereas TIGER line graph files are organized spatially by county. Neither of these geographic units have much utility for most users of Connecticut data.

Therefore, the first stage in the development of a digital collection was establishing the spatial domain and geographic unit analysis within that domain. The map library established the town in addition to the state, county and quadrangle as its basic domains and counties, towns, census tracts and census block groups as the geographic units within the appropriate domains. The 169 towns in Connecticut were extracted from the TIGER line graph files of the eight counties in the state to create census geographies and street coverages. The same towns were extracted by the state Department of Environmental Protection from the DGL files of the 118 quadrangles comprising the state for other features such as hydrography and roads. The files were then projected into Connecticut State Plane NAD 27, the state standard at the time. Finally, the files were converted into the ARC/INFO coverage interchange file format (E00) and MapInfo interchange file format (MIF/MID) from their native formats. The files were zipped, put up on an open FTP site and made available to the public user, retaining their public domain status.

"The first stage in the development of a digital collection was establishing the spatial domain and geographic unit analysis within that domain."

Use of this site now averages 9,000 zipped data files downloaded each month. The data on MAGIC are still primarily of Connecticut and are still in the public domain. Over time, MAGIC has established connections with local producers of state data and there has been strong cooperation and trust in sharing spatial data. State agencies recognize the public's need for high-quality data and the resources required for distributing the data themselves. MAGIC now has over 20,000 files from the U.S. Bureau of the Census, the U.S. Geological Survey, Connecticut's State Departments of Environmental Protection, Transportation, and Public Safety, the National Resources Conservation Service, and the U.S. Fish and Wildlife Service. Towns are also just beginning to provide their data for library distribution.

Although digital databases were the first form of spatial information to be collected and stored on MAGIC, over time map documents and other images were scanned and stored as raster graphic files. The University does not hold the maps that the scanned images represent; most reside in private libraries of libraries far from Connecticut. Through the Internet, MAGIC has been able to build a public collection of Connecticut's cartographic lineage. Recently members of the School of Engineering reference a 1764 survey of the town of Lebanon to a GPS cadastral survey. Faculty and students were surprised to witness the high quality of the surveying done in Connecticut 250 years ago that was completed using only astronomical observations, pencil and paper. Linking the image of the manuscript map alerted the engineers to ancient controls, enabling them to build out their survey. The MAGIC website brought historical data together with current state of the art spatial data for their use.

"Through the Internet, MAGIC has been able to build a public collection of Connecticut's cartographic lineage."

Throughout its existence, profiling the MAGIC user has been an important aspect of maintaining its digital geolibrary. The use of the data, which data are used most, who uses the data, and which level of geography is most used are key bits of information for the collecting librarian. It is simply not enough to passively collect materials, whether they are books, journals, maps or data. Libraries monitor use statistics and assign budgets accordingly. MAGIC has eight years of comprehensive transaction logs that chronicle the use of the collection. Decisions based on this transaction data have directed MAGIC to acquire more statewide data and directly lead to building the collection of historical map images. The image files of historical maps now account for thirty percent of the data accessed from MAGIC.

"In the conversion from paper to digital media, one of the primary gains has been the separation of the storage and display functions of maps."

Although the MAGIC website has expanded its collections considerably in the past decade, it is still basically a site for passively downloading compressed ASCII export files. Vector data have been augmented with image data; digital orthophotography, scanned historical maps and other remotely sensed data. However, even with these additions, some fundamental structural flaws in the data organization emerged. The University research user community's need to search for, discover, view and acquire timely, and historical social science attribute data and associative digital cartographic data has lead to a complementary website for the dissemination of geographically referenced attribute data for Connecticut.

THE DEVELOPMENT OF THE CTDATA WEBSITE

In the conversion from paper to digital media, one of the primary gains has been the separation of the storage and display functions of maps (Marble, 1987). The storage of spatial databases in the vector data model also separated the storage of the geographic base file (GBF) of the spatial entities from their associated attributes. This latter separation forms the basis of the hybrid architecture used by some geographic information systems in which the spatial entities are independently stored in a different module from the non-spatial attributes (Worboys, 1995). This structure is referred to as the geo-relational model when the non-spatial attributes are stored in a relational database that interfaces to the corresponding spatial entities (see Morehouse, 1985; Waugh and Healey, 1987). The geo-relational model is the basis for the organization of many software formats such as ARC/INFO coverages and ARCVIEW shape files.

"When MAGIC built its digital collection of spatial databases, the geo-relational model was the basis for the stored database."

When MAGIC built its digital collection of spatial databases, the geo-relational model was the basis for the stored database. A coverage was created for each theme of data. When building a coverage for each theme, however, the question arises as to what attributes will be included in he relational table associated with the geographic base file. The answer to this question is straightforward for coverages based on continuous field data. For field data, the attribute is assumed to vary continuously over space (Burrough and McDonnell, 1998). The elements of the geographic base file are determined by the spatial distribution of the associated attribute. For example, in vector-based soils coverage the polygon outlines only refer to geography of soil classes and no other attribute. Thus, only one non-spatial attribute is associated with the geographic base file, although many attributes can be included in a table that names the elements or defines spatial relationships to other geographies. The answer to this question is less obvious for coverages based on entity data. For entity data, the object exists independently of the attributes that are used to describe it; many polygon coverages or entity data are merely collection zones for which summary attributes are compiled. For the geography of Connecticut towns, the U. S. Census collected approximately 5000 attributes in the 1990 census in just the STF3A file for population and housing. The same number of attributes exists for the county, tract and block group geographies. In preparing town coverages of population for the MAGIC collection, the small set of basic demographic attributes was preselected for inclusion in every town coverage. Similarly, in preparing town coverages of housing, a small set of housing attributes was also preselected for each coverage.

The result is a duplication of geographies in the collection; in this case the geography of towns, census tracts and block groups is repeated in the population and housing coverages.

The geo-relational model handles this problem by only requiring that the geographic base file contains a unique identifier field that can be used in a relational join operation to attach any associated attribute table. In a collection of coverages, it is only necessary to store each GBF once as long as the associated attribute table has a minimum of attributes that name each object and provide unique identifiers for subsequent joins. The attributes for describing the objects can be stored in separate sites as long as the proper key fields are present. For coverages of true field data, a separate site is not necessary because only one thematic attribute relevant to the coverage should be included in the table for that coverage. For entity data, however, no site existed that could easily provide the attribute information in a proper table format for all of the geographies that are specific to the Connecticut user community needs.

". . . it is only necessary to store each GBF once as long as the associated attribute table has a minimum of attributes that name each object and provide unique identifiers for subsequent joins."

The U. S. Census website provides access to the 1990 census of population and housing and other intercensual population estimates, but is not organized in a relational format. Because census geographies are hierarchically nested, the census website was designed to retrieve the attribute information in a hierarchical manner. Because the geographical hierarchy skips from state to county to tract to block group, a table can only be built for all objects nested within the next higher geographic level. This means that to extract block group attributes for the city of Hartford, fifty separate tables must be extracted (one for each census tract). Extracting tract data is less cumbersome for Connecticut towns because each town is contained in only one county and all of any tracts in one county can be retrieved in one table. However, a user must know the census codes for the tract identifiers associated with any town in order to retrieve just that town's tracts—a situation that rarely occurs within the general user community.

To overcome these problems of duplicating geographic base files as well as simplifying the extraction of Connecticut attribute data, the Map Library partnered with he University of Connecticut's Center for Geographic Information and Analysis (UCCGIA) to develop the Connecticut Data Server (CTDATA) http://ctdata.lib.uconn.edu. Attribute information is extracted from this site by first defining the relevant study area of inquiry. At present, data can be extracted for the entire state, a county, a town, a labor market area (LMA), a regional planning district (RPD), a congressional district, a state service delivery area (SDA), or a tourism district. After the study area is defined, the user then defines the geographic units of resolution—some subdivision of the study area. All of the previous units are subdivisions at the state level as well as census tracts (block groups are in preparation). Towns and census tracts are valid subdivisions also of counties, LMAs, RPDs, SDAs, tourism districts, and congressional districts (towns split among two or more congressional districts are assigned to the district in which the largest portion of the town's population resided in 1990). After the geographic parameters are chosen, the user is then presented with a choice of databases that are relevant to the chosen geography. Once the desired database is selected, the user can select the specific data fields of his/her interest to be prepared in the data table.

"After the geographic parameters are chosen, the user is then presented with a choice of databases that are relevant to the chosen geography."

While data can be extracted from this site for many purposes, it was designed to distribute information about regions within Connecticut at different levels of geographic resolution in a format that could later be linked to geographic data for later use in a geographic information system. Simultaneous to the development of CTDATA, ARCVIEW shape files for each possible geography were prepared for inclusion on the MAGIC site. Each shape file only contained in its attribute table a name field and appropriate key field(s). For towns, more than one key field was included because towns are referenced as minor civil divisions in census geographies, and the state has developed its own identification number for each town. CTDATA has two output formats: a table format for display on the browser, and a comma delimited format that can be saved as a text file (extension .txt) by the browser. The text file that is created can then be imported into ARCVIEW as a table and joined to a compatible geography.

Thematically, the data currently on the system cover U. S. Census population estimates, historic town population counts, employment data, the 1998 town profile series and the 2000 Census Public Law data used in redistricting. Most of these data are at the town level because that is the most important geography for Connecticut. New school district geographies and their associated attribute tables are under present construction. These new data present new problems because school districts change more frequently and are specific only to certain grade levels.

CONCLUSIONS

The process of a networked map library for the dissemination of cartographic information at the University of Connecticut is a constant evolution. The current geo-relational approach between the MAGIC and CTDATA websites is the product of many trials and errors over time. It falls short of the vision of a distributed geolibrary's goal of efficient information storage and use oriented retrieval of cartographic information. The next level of consolidation will involve the movement to a full geodatabase approach in which the GBF information is also stored as attributes of an object in a relational table. The geography of objects would be retrieved based on the selected study area. This would reduce the need to store multiple coverages that have the same basic geographic units, for example, storing both a county coverage and regional planning district coverage of towns when only a geodatabase of towns is necessary.

"A long-term goal (and benefit) of a web-based map library is increasing the awareness within the state of the need for data standards, more metadata descriptions, coordination of production efforts, and proper archiving."

A second limitation of the current system is that the user can only retrieve data from one database in the construction of the attribute table. The U. S. Census' FERRET project is attempting to overcome this problem by allowing users to enter keywords that can be used to search the metadata of many databases for the possible retrieval of data from different databases that can be merged into one table. MAGIC and UCCGIA are working with the U. S. Census to prepare their attribute data sets in the appropriate format for inclusion in the FERRET search engine.

A long-term goal (and benefit) of a web-based map library is increasing the awareness within the state of the need for data standards, more metadata descriptions, coordination of production efforts, and proper archiving. Many agencies lack the capacity for storing historical information and only retain current data. Having a central location such as the MAGIC and CTDATA websites has facilitated regular collection development and satisfied user community needs through standardized access procedures over the Internet.

REFERENCES

Buckland, M., 1992. Redesigning Library Services: A Manifesto. http://sunsite.berkeley.edu/Library/Redesigning/challenge.html

Burrough, P. and R. McDonnell, 1998. *Principles of Geographical Information Systems*. Oxford: Oxford University Press.

Clarke, K., 1995. *Analytical and Computer Cartography*, 2nd Edition. Englewood Cliffs: Prentice Hall.

Marble, D., 1987. The computer and cartography. *The American Cartographer*, 14(2): 101-103.

McGlamery, P., 1989. The librarian's dilemma: A map librarian's access to machine-readable information. *Cartographic Perspectives*, n2:7-13.

Morehouse, S., 1985. ARC/INFO: A geo-relational model for spatial information. *Proceedings of Auto-Carto 7*, 388-397.

Waugh, T. and R. Healey, 1987. The GEOVIEW design. A relational data base approach to geographical data handling. *International Journal of Geographical Information Systems*, 1(2):101-118.

Worboys, M., 1995. *GIS: A Computing Perspective*. London: Taylor and Francis.

Feeling It Out: The Use of Haptic Visualization for Exploratory Geographic Analysis

Amy L. Griffin
Department of Geography
The Pennsylvania State University
302 Walker Building
University Park, PA 16802
alg207@psu.edu

Visualization is often defined as the act or process of making something visible. MacEachren and Ganter (1990) have argued for an expanded definition of cartographic visualization that emphasizes the role of the map-reader's cognitive processes and schemata when creating visual representations. Cartographic visualization in this sense requires both the designer and the user to structure information and identify salient patterns. Processes of pattern identification and structuring are what help to provide insight in exploratory analysis. Pattern identification and information structuring need not, however, be limited to the visual realm. The use of haptic (both tactual and kinesthetic) information for representing geographic phenomena has been given limited attention as a method for exploring data, due to the difficulty of implementing such methods. However, advances in virtual reality technologies may soon make it possible to implement these variables in a system that creates exploratory geographic virtual environments. This paper explores those haptic variables that might be used to create such representations, and develops a haptic variable syntax for the representation of geographic information based on a logical analysis of the physiological properties of haptic sensation.

Keywords: haptics, cartographic representation, exploratory visualization, virtual reality

INTRODUCTION

Visualization is often thought of as the act or process of making something visible. It is a technique used in many disciplines (including geography) to represent objects or concepts that do not necessarily exist in some tangible material form (e.g. fear spaces) or objects whose extent is so large that the human eye cannot inspect them from one vantage point (e.g. the continent of North America). Some scientists have argued that visualization is much more than the creation of visual artifacts; it is also "an act of cognition, a human ability to develop mental representations that allow us to identify patterns and create or impose order." (MacEachren and Ganter, 1990:66)

"Haptic sensations are those sensations that are related to or based upon the sense of touch."

Visualization research, as the label implies, has focused on *visual* representations as a prompt to thinking. In the real world, however, we receive information through multiple sensory channels and can mentally represent our experiences in ways that take advantage of that multisensory experience. This paper focuses on the potential of haptic representation as a complement to visual representation.

Haptic sensations are those sensations that are related to or based upon the sense of touch. There are two primary types of haptic sensation: tactile and kinesthetic. Tactile sensations are those sensations that are perceived when the skin comes into contact with an object. Kinesthetic sensations are those that are mediated by receptors located in muscles and joints, and that are stimulated by bodily movements and tensions. That is, they are based on the forces of resistance we feel as a result of gravity or when we come into contact with an object. Because any postural position (even laying down) requires the compression of some muscles and joints, we constantly perceive kinesthetic information. In contrast, tactile sensations are perceived only when the skin comes into contact with another object.

This paper specifically explores the potential for using haptic sensations to represent and explore geographic phenomena, with particular emphasis on the potential that virtual reality technology offers for implementing haptic sensations. Haptic representations are considered because haptic perception is active and exploratory, making it a particularly intuitive medium for exploring data sets. Haptic representation allows a literal and direct interaction with the data. To support the use of haptic sensation, a haptic variable syntax for creating haptic representations of geographic data is proposed. This syntax was developed by systematic analysis of the physiological properties of haptic perception.

"Haptic representations are considered because haptic perception is active and exploratory, making it a particularly intuitive medium for exploring data sets."

In addition to the potential that virtual environments offer for implementing haptic sensations, they are offered as a medium within which to create haptic representations because they allow the simultaneous use of multiple sensory modalities. This multisensory characteristic of virtual environments may enable users to take advantage of perceptual skills developed in their normal interactions in space and with objects.

The remainder of the paper will review the methods that cartographers have commonly used for representing geospatial information. Then a haptic variable syntax for creating haptic representations is proposed, along with potential applications of haptic sensations for representing geospatial information. Finally, issues associated with using haptic variables to represent geospatial information are discussed.

CARTOGRAPHIC USE OF VISUAL AND NON-VISUAL SENSATIONS

Cartographic Use of Vision

If the cognitive processes by which we make sense of spatial information are similar for different sense modalities, what cartographers have learned about using visual stimuli to represent spatial phenomena can inform our attempts to represent data using other sensory modalities. Several researchers have argued that these processes are similar for vision and touch. A useful starting point is a discussion of Bertin's (1983) visual variable syntax, and the expansion of this syntax by other researchers.

In his cartographic sign-system of visual variables, Bertin (1983) first identified the visual variables available to the information visualization designer (geographic position in the plane, size, value, texture, color, orientation and shape), and then articulated rules for the appropriate use of these variables, based on whether the data to be visualized are nominal, ordinal or quantitative. These rules were based on his logical analysis of the perceptual properties of potential variables rather than on an empirical analysis.[1] In this analysis, Bertin classified visual variables based on whether the symbols are perceived as similar to, or different from each other; as ordered; or as proportional (i.e. the variable's perceptual character). His recommendation was that the perceptual character of the variable should be matched to the character of the data.

". . . what cartographers have learned about using visual stimuli to represent spatial phenomena can inform our attempts to represent data using other sensory modalities."

The dogmatic manner in which Bertin (1983) presented his proposed rule system led several cartographers to criticize and expand upon his system. Drawing upon Bertin's syntax [and on other work by Morrison (1974) and Caivano (1990)], MacEachren (1995) created an expanded visual variable syntax. His visual variables are location, size, crispness, resolution, transparency, color value, color hue, color saturation, texture, orientation, arrangement and shape. Some of the new variables in MacEachren's syntax have been added because of the impact that computer technologies have had on cartography (e.g. saturation; computer graphics programs now allow for separate control of all three color components—hue, value and saturation). Others have been added by dissolving one of Bertin's variables (e.g. texture, which Caivano (1990) split into directionality, size and density). Still others have been developed as part of an effort to study the representation of uncertainty in data (e.g. crispness, resolution and transparency) (MacEachren, 1992). Other changes have involved identifying the three usability levels for each variable; usable/possible/impossible, rather than Bertin's two levels of acceptable/unacceptable.

"Developing cartographic variable syntactics is important because they can increase the potential for consistent interpretation of cartographic representations."

The work of cartographers who have challenged or expanded Bertin's (1983) visual variable syntax has led to a richer understanding of how to match the map designer's objectives with what the map-reader is capable of perceiving. Developing cartographic variable syntactics is important because they can increase the potential for consistent interpretation of cartographic representations. If the relationships between the map symbols and their referents recognized by the cartographer differ from those recognized by the map reader (or different map readers recognize different relationships), the result will be a different (possibly incorrect) interpretation of the map symbols (MacEachren, 1995).

Theories about the logical interrelationships of map symbols and their referents are less well developed for other non-visual symbols than for visual symbols. The following two subsections focus on reviewing what has been hypothesized about non-visual representations of data and how they should be matched to their referents.

Cartographic Use of Sound

Geographers have only rarely considered using non-visual sensations to represent data for normal-vision users. One notable exception to this is Krygier's (1994) work on sound and geographic visualization. Krygier developed a set of sound variables by considering the different elements and characteristics of sound (location, loudness, pitch, register, timbre, duration, rate of change, order and attack/decay) that could be used to represent data and he suggested potential applications for which sound might be particularly useful.

"Theories about the logical interrelationships of map symbols and their referents are less well developed for other non-visual symbols than for visual symbols."

A few geographers have created applications that represent geographic data with sonic variables. Wheless *et al*. (1996) integrated sound into their virtual reality visualization of the Chesapeake Bay ecosystem. They used sound to represent numerically generated salinity data (a change in pitch represented a change in salinity value). By "walking-through" the study area, researchers could hear changes in salinity while seeing the bay's topography, which helped them to interpret links between processes that occur in the bay's physical and biological systems. Fisher (1994) used both a single sound component (pitch) and multiple sound components (pitch, silence and duration) together to represent the classification uncertainty associated with each pixel in a remotely sensed image. The combination variable was designed to use multiple cues to emphasize the classification uncertainty. Although Fisher did not empirically test or experimentally compare his system to other potential systems (e.g. ones using an additional visual variable to represent the classification uncertainty), based on anecdotal evidence, he concluded that users found the system helpful.

"Geographers have only rarely considered using non-visual sensations to represent data for normal-vision users."

Researchers in other disciplines have evaluated the effectiveness of using sound to represent data for several data exploration tasks. Pereverzev *et al*. (1997) found that by listening to an amplified microphone signal, they could identify predicted oscillations in super fluid helium that they could not detect visually. Flowers and Hauer (1995) examined the effectiveness of visual and auditory trend plots at conveying certain data characteristics (function slope, shape and magnitude). They found no significant differences between the ability of subjects to extract information from either the sonic or the visual version of the graph. In a later study, Flowers *et al*. (1997) evaluated their subjects' ability to estimate direction and magnitude of correlation between two data variables from visual and sonic scatter-plots. They found that there were no significant differences between modalities in estimating the magnitude of correlations. Cronly-Dillon *et al*. (1999) developed a system that enabled users to identify the salient shape features (i.e. outlines or edges) of visual images from sonic representations through the deconstruction of one or more sets of features into a sound pattern, and subsequent analysis of the sound patterns individually or in concert. Experimental testing of the system showed that allowing subjects to somehow segment the overall sonic representation facilitated the task of accurately analyzing and identifying the visual target.

As a group, the data sonification studies provide evidence that, for unpracticed users, sound can (at least in some instances) represent data as effectively as vision. The main implication of the study by Cronly-Dillon *et al*. (1999) is that there may be particular methods that map or graph readers can use to analyze images using sound (and perhaps other senses as well) accurately and efficiently; once such methods are identified, users can be trained to employ them. Finally, other studies (Fisher 1994; Wheless *et al*. 1996; Pereverzev *et al*. 1997) suggest that there may be instances (e.g. when visual representation channels are overloaded) in which sound is more effective than vision; however, this assertion has not been systematically tested.

". . . there may be instances in which sound is more effective than vision; however, this assertion has not been systematically tested."

Cartographic Use of Haptics

The success of using sound to represent data raises the question of whether other senses might also be used effectively. Although cartographers have given some attention to the use of haptic sensations for representing geographic data (in the form of Braille maps and other maps for the visually impaired (Weidel, 1983)), their use and potential for normal-vision map readers has not been comprehensively addressed.

The one exception to this is the set of elementary tactile variables that Vasconcellos (1991) developed by translating Bertin's visual variables into a tactile form. However, Vasconcellos did not identify any tactile variables that do not have a direct visual analog (other than, perhaps, elevation)[2]. That is, her variables included only those variables that are perceptible by both vision and touch, such as symbol size, value (e.g. vertical lines portrayed at increasing densities), texture (different textures), shape, and the orientation of symbols. By simply translating Bertin's visual variables, Vasconcellos failed to include any tactile variables that can only be perceived haptically (e.g. temperature, pressure or kinesthetic variables such as resistance or kinesthetic location). She also did not include recommendations for use of those variables she proposed, perhaps assuming that the cartographer would infer them from Bertin's recommendations.

The following haptic variables address these deficiencies because they correspond to the physiological properties of touch and kinesthetics as well as suggesting recommendations for their use. Little if any cartographic research has addressed the potential for using kinesthetic sensations to represent spatial data, nor the utility of tactile sensations in maps for normal-vision map readers.

"Little if any cartographic research has addressed the potential for using kinesthetic sensations to represent spatial data, nor the utility of tactile sensations in maps for normal-vision map readers."

REPRESENTATION OF GEOGRAPHIC PHENOMENA USING HAPTIC SENSATIONS

Identifying and Describing Haptic Sensations

The first step in developing a haptic variable syntax requires identifying potential variables. Haptic perception is based on a combination of cutaneous (skin-derived) and kinesthetic sensations. Skin, the human body's largest sensory organ, is the organ associated with perceptual qualities such as touch, temperature, and pain. The average adult human's skin has a surface area of approximately 1.8 m^2. Its several layers contain the sensory receptors responsible for the perception of touch, temperature and pain. These receptors are the structures that are responsible for translating mechanical, thermal, chemical and electrical energy into neural signals that are processed by the somatosensory area of the parietal lobe of the brain's cortex to produce the sensations of touch (Cholewiak and Collins, 1991: 26).

There are three basic classes of cutaneous receptors: mechanoreceptors, thermoreceptors and nociceptors. Mechanoreceptors respond to skin indentations (pressure), thermoreceptors to temperature change, and nociceptors to several types of intense stimulation such as high pressure, heat and/or burning chemicals (stimuli that may damage the skin). Because it is unlikely that a map reader would want to use painful sensations to represent data, further discussion of receptors is limited to mechanoreceptors and thermoreceptors.

"There are three basic classes of cutaneous receptors: mechanoreceptors, thermoreceptors and nociceptors."

Mechanoreceptors are responsible for four types of haptic sensations: vibration, flutter, buzz and pressure. Bolanowski *et al.* (1988) proposed a four-channel model of cutaneous mechanoreception based on correlations between physiological data and responses from psychophysically defined sensations. He proposed that each of these four sensations arises when a particular type of mechanoreceptor is stimulated.

Thermoreceptors allow us to perceive increasing and decreasing temperature, and can record (perceive) both the overall magnitude of warming or cooling, regardless of the exact spatiotemporal distribution of the thermal stimuli over the skin, as well as localizing high-level stimulation. Thus, skin can be described as having good spatial summation and poor localization capabilities at low levels of thermal intensity and poor spatial summation and good localization capabilities at high levels of thermal intensity. In contrast, vision has good spatial summation and good localization at intermediate ranges of stimulus intensity (e.g. normal daylight conditions), but localization abilities decrease as the stimulus intensity reaches either extreme (e.g. almost total darkness or very bright conditions).

Kinesthetic information is information that is generated about the position, posture and movement of various parts of our bodies as a result of our bodies' interaction with gravity. Because of Earth's gravitational pull, all bodily movements and postures involve tension, compression and twisting forces on our joints, muscles and limbs. The two basic types of kinesthetic sensations are joint position and joint movement. Now that types of haptic sensations have been identified and described, the following subsection proposes a haptic variable syntax.

"A key step in designing any type of spatial data representation is deciding what types of symbolization are most appropriate for the data that are to be represented."

Haptic Variable Syntax

A key step in designing any type of spatial data representation is deciding what types of symbolization are most appropriate for the data that are to be represented. Like vision or audition, the haptic sensations that might be incorporated into a spatial data representation can be decomposed, or separated into a number of different variables. They can be grouped into three primary categories: those derived from touch, those derived from visual analogs, and those derived from kinesthesia.

Several variables can be derived from the physiological possibilities of touch (as described in preceding section), such as *vibration*, *flutter*, *pressure* and *temperature*. Although it could be difficult to strictly separate out one touch variable from others (e.g. if the user touches a surface that is vibrating at a certain frequency, this surface will also have a perceivable temperature), it is possible to maximize the user's attention to one sensation as opposed to another by holding all but one constant. In the example of vibration and temperature, all the vibrating surfaces could be kept at the same temperature, preferably that of the user's skin; the user would then be more likely to attend to the vibratory stimulus.

Other variables can be derived from cartographic visual variables, such as *location*, *size*, *texture/grain*, *shape* (or *form*), *orientation* and *elevation*. What differentiates these variables from those based on the physiological properties of touch is that these variables can be perceived by both vision and touch. Although there have certainly been instances in which some tactile variables, such as temperature, have been visualized for analytical purposes, this usually involves a transformation of a thermal stimulus into a stimulus based on hue or value (a variable we can perceive visually). Some might also argue that it is possible to visually perceive temperature, but it could be argued that this happens only in special cases, such as in the glowing red of iron in a blacksmith's shop. There are many items, such as a plastic container that has been in the microwave for five minutes, whose appearance does not give us any information about its temperature—it could be hot or cool, depending on its material composition and the level of power the microwave was running at.

"A third set of variables is composed of those that do not follow directly from either physiological possibilities or cartographic design."

A third set of variables is composed of those that do not follow directly from either physiological possibilities or cartographic design. What separates these variables from the other two groups is that a movement of, or a change in the user's position, or in the position of a stimulus relative to the user is required in order for the variables to represent information. *Friction* is felt when the hand is moved across or through a surface, *resistance* can be felt when attempting to deform a surface and changes in *kinesthetic location* (location of the hand in relation to the body) can be used to compare data values to one another.

Figure 1 presents a haptic variable syntax that rates the appropriateness of each variable for each data type. This rating is based on a consideration of whether the variable's perceptual characteristics are ordered or differential (i.e. whether differences in the variable's symbolization are quantitative or qualitative). No distinction has been made between ordinal and numerical data because there is little empirical research that articulates a map reader's ability to make accurate quantitative estimations from haptic symbols without a legend referent.

"If the cartographer and the map reader use different map schemata when creating and interpreting maps, the information that the cartographer intended to present and what the map reader interprets from the map symbols may be quite different."

The basic logic behind recommending that certain variables are appropriate or inappropriate for either nominal or ordinal variables is that if a variable that is perceived as ordered is used to represent nominal differences, the map reader may assume that there is also an implied order to the data when in fact, there is not. If the cartographer and the map reader use different map schemata when creating and interpreting maps, the information that the cartographer intended to present and what the map reader interprets from the map symbols may be quite different.

The "possible" category is reserved for those variables that may be able to effectively represent both types of data. For example, texture could represent ordinal data if the same texture pattern was used at different densities (e.g. diagonal hatch-marks like those in Figure 1, depicted with a different number of lines per inch for each ordinal category). However, texture could also be nominal if different pattern arrangements were used to represent different categories (e.g. diagonal hatch-marks and a checked pattern).

These recommendations are a hypothesis, and (like most similar syntactics) need to be empirically tested to verify their validity. One particular point of uncertainty is whether texture/grain and orientation are really

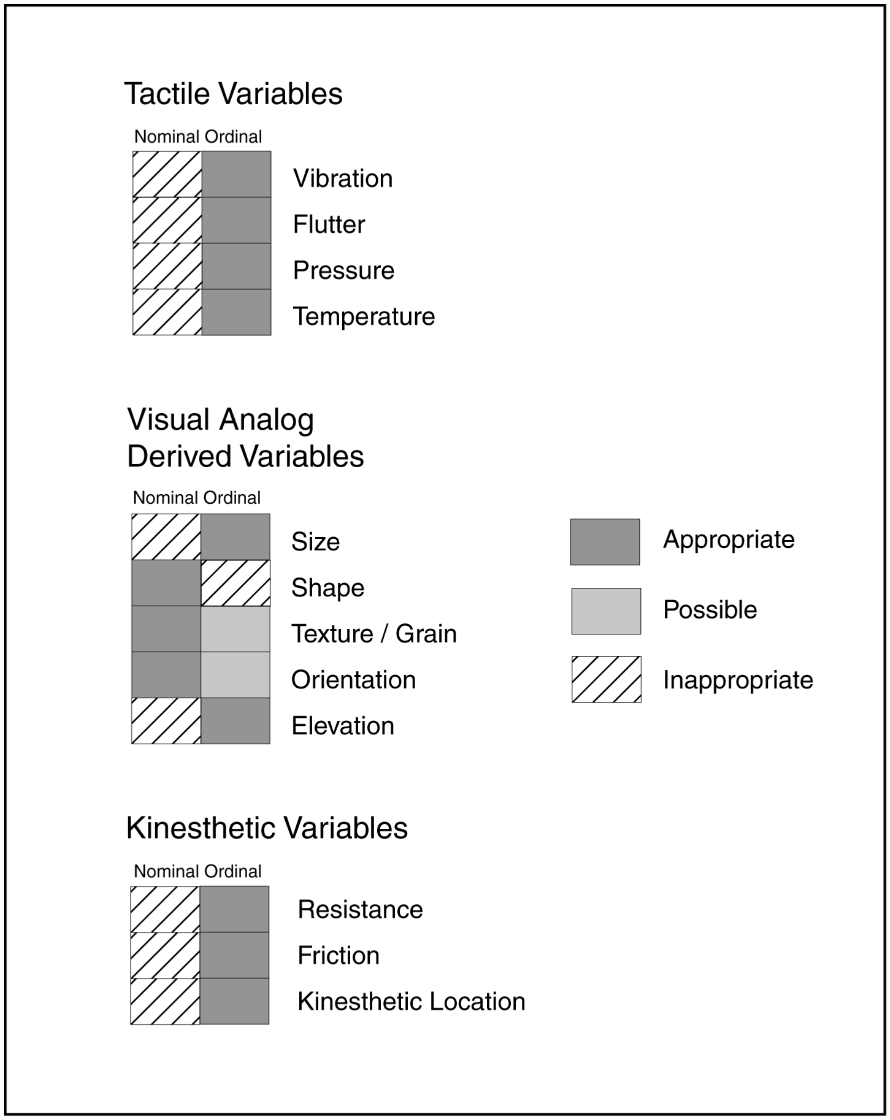


Figure 1. Haptic variable syntax

appropriate for representing both nominal and ordinal data. Future empirical work that monitors and compares the types of errors and mistakes that map readers make when interpreting texture/grain and orientation as nominal or ordinal data may shed some light on this issue. Additional information can be gained in these experiments if map readers are asked to describe both their interpretations, and how they made those interpretations.

"Haptic sensations may be best integrated into spatial data representations by implementing them in virtual reality environments."

Potential Applications of Haptic Variables

Haptic sensations may be best integrated into spatial data representations by implementing them in virtual reality environments. Virtual environments are proposed as a medium within which to create haptic representations because they can simulate real environments; they can be highly interactive; and they allow the simultaneous use of multiple sensory modalities.

Given the potential for virtual environments to simulate real environments while simultaneously allowing users to experience these environments in ways that were previously not possible, the most useful application of haptic sensations in geographic visualizations may be iconic, particularly where it is possible to create an iconic haptic representation but not an iconic visual representation (e.g. resistance is used to represent the density of an air mass at a given location); in iconic representations of phenomena users can draw on their everyday experiences and interactions with the subject matter when making connections between events and/or states of the virtual environment. This may be especially applicable when users are trying to interpret complex outputs of numerical models. For example, the vibration variable might be used to visualize the output of a seismic model that predicts the intensity of shaking due to an earthquake; such visualization might be used to identify unexpected areas of strong shaking. Flutter might be used to represent the output of a model that predicts precipitation over time. Pressure could be used to visualize jet stream wind velocity and location. Imagine an animation of wind over time, in which the user could track the movement of the jet stream while looking at changes in other climatic variables. Temperature might be used to represent water temperature in a river, so that the user could track cold currents through space and time. Resistance could be used to represent measures of pollution; the more polluted an area, the more difficult it might be to walk through an area or move your hand through the area. Friction could be used to visualize terrain roughness, with an increase in friction corresponding to increasingly difficult terrain. The examples mentioned here are just a sample of the ways in which we might expect haptics to be implemented in the (relatively near) future. Current applications are constrained by the available haptic interface technology.

"Current applications are constrained by the available haptic interface technology."

Most current virtual reality systems have limited capabilities for representing the haptic information that we perceive in our everyday experiences. Force-feedback and tactile display devices are often crude, and temperature simulation is not often integrated into force-feedback or tactile devices.[3] Force-feedback devices are often powered by machines that generate and exert relatively small forces on a user when she puts pressure on an object or a surface. Because these forces are then smaller than what the object could withstand in real life, this often allows the user to inappropriately push her finger through a virtual object or surface that would normally be impenetrable to the force a finger can exert. Because there is a high density of mechanoreceptors in the human hand, the resolution of tactile display devices must be quite high in order for the sensations that describe a virtual object to feel the same as they would if the user was touching the real object with his or her bare hand. Improvements in small-scale electronics will allow the construction of denser arrays of tactile stimulators, and improved physical models of object shape and texture will increase the realistic character of haptic representations. Although current haptic representation capabilities do not provide a highly realistic experience, haptic interface technologies are still in the early stages of development and should continue to improve rapidly.

"Tactile display systems can be used for both the hand and other parts of the body."

Haptic interfaces used in VR systems range from devices such as data gloves and data body-suits to computer mice and joysticks that reflect forces back on the user. Force-feedback joysticks or computer mice can be used to portray kinesthetic information, such as resistance and friction, with some also able to portray texture (Minsky and Ouh-young, 1990; Shi and Pai, 1997). Data gloves use fiber optic sensors to detect hand position, and rigid link exoskeletons provide force-feedback (Luecke and Chai 1997).

Tactile display systems can be used for both the hand and other parts of the body. They fall into three categories: shape-changing displays that control the deformation of the skin by applying forces (Monkman, 1992), vibrotactile displays that use an array of vibrating pins placed against the skin (Shimojo *et al*., 1997), and electrotactile displays that use surface electrodes to stimulate the skin (Tan *et al*., 1999).

Because one of the advantages of virtual environments is the literal way in which they allow users to interact with their data, those devices (e.g. joysticks, exoskeletons) which both accept the input of information and display attribute information are of the most interest for haptic representations of geospatial information.

ISSUES IN USING HAPTICS TO REPRESENT GEOSPATIAL DATA

This section describes a number of practical issues that need further consideration before haptic representation systems are implemented: (1) what humans can perceive haptically; (2) how to train map readers to read haptic representations of geospatial data; (3) potential interactions of vision and touch; and (4) the problem of cognitive sensory overload.

Limits of Haptic Perception

An important issue for designers who wish to create haptic representations is what humans *can* perceive haptically. This is a function of the number of receptors available for stimulation as well as of the number of stimulations a receptor can process as individual stimuli within a given period of time. Von Uexküll (1957) suggested a theory of perception based on functional cycles. This theory holds that the stimuli an organism can perceive are based on the organism's needs when interacting with the environment, and that for every perceptual cue the organism receives, there is an effector cue, which prescribes a course of action for the organism. Thus, in Von Uexküll's view, the functional tasks an organism can carry out are decided by the number and arrangement of their receptor cells.

"An important issue for designers who wish to create haptic representations is what humans can *perceive haptically."*

In humans, haptic receptors are not evenly distributed throughout the body. For example, tactual acuity, which can be taken as a measure of the density of receptors in a given part of the body, is much higher for the tip of the index figure than for the back. This makes intuitive sense when you consider that our hands perform more complicated tasks than our backs, and therefore need to receive more precise perceptual cues about their interactions with the environment.

Both time and space are fundamental dimensions of our existence. Without observing a passage of time, observations of change could not exist. Without space, there could not be any relationships between objects or surfaces, nor movement between locations. Based on studies of several organisms, Von Uexküll also proposed that for each organism, time (as the organism experiences it) is divided into a series of moments whose length varies among organisms. The length of a moment is defined as the unit of time in which an indivisible elementary sensation can be perceived. For humans, he notes that one moment is 1/18 of a second (55 milliseconds). That is, if two stimuli reach our receptors less than 1/18 of a second apart, they will be perceived as a single sensation. He provided evidence that the length of this moment (1/18 of a second) holds for vision, sound and touch (Von Uexküll 1957). Other studies, however, have suggested that the length of this moment varies between modalities (i.e. its length depends upon which sensory modality is employed) (White 1963; Eriksen and Collins 1968) as well as on the combination of sensory modalities that are employed in the perceptual task (Dufft and Ulrich 1999). Although the different sensory modalities have different abilities to provide temporal, spatial and intensity information from perceptual stimuli, the input from these various sensory modalities are easily integrated (see more discussion of this below in Section 3.3, Interactions of Vision and Touch).

"Without observing a passage of time, observations of change could not exist. Without space, there could not be any relationships between objects or surfaces, nor movement between locations."

Map Reader Ability to Read Haptic Maps

When research identifies more clearly what haptic representations uses can comprehend, then the efficacy of using such representations to construct knowledge from haptic spatial data representations becomes a central question. Most cartographic research on haptic sensations has focused on their potential utility in maps and graphics for the visually impaired and the blind. This work has addressed two topics: the extent to which tactile maps support spatial cognition in the visually impaired and the psychophysical aspects of reading tactile maps. Much of this literature has examined the use of tactile mobility maps for reference and navigation, rather than thematic maps. Because haptic cartographic research has focused on these issues, less is known about map readers' ability to identify patterns or trends (and thereby construct knowledge) from data represented with haptic symbols than is known about map readers' ability to retrieve a particular piece of information from the map or use the map to solve a particular navigation problem.

"Most cartographic research on haptic sensations has focused on their potential utility in maps and graphics for the visually impaired and the blind."

Several authors have examined the ability of blind or visually impaired subjects to retrieve and synthesize spatial information from tactile maps. When using the sense of touch, the area on a tactile map that can be studied (i.e. that can yield tactile perceptual information) at one moment in time is limited to the size of the surface area of the skin that is applied to the map. Because of this limitation, many stimuli in tactile maps must be perceived sequentially.[4] The tactile map reader must then integrate them into a coherent whole in memory, just as sighted persons must when navigating a large space (containing barriers that prevent seeing it all at once) without the help of a map. Such a synthesis of spatial information may be most easily accomplished when some knowledge of the space's overall structure is available prior to examining the tactile map (Andrews 1983). In sighted persons, viewing a map provides this overall structure; for most visual maps, it is understood that space on the map represents space in the environment (Dodds 1988).

". . . if the map reader's goal is to obtain an overall knowledge of the space, active explorations of spaces should be promoted for haptic visualization users."

Castner (1983) suggested, and Unger *et al*. (1997) demonstrated empirically, that tactile map-learning strategies involving active exploration of maps (e.g. those that relate map elements in space, identify patterns and establish an overall structure) are more successful at promoting knowledge of the overall structure of a space than sequential (route-based) explorations of maps. Unger et al. postulated that this difference exists because the sequential exploration of a map is more likely to prompt the map reader to consider local spatial relationships (i.e. between a feature and adjacent features that also lie on the route) than global spatial relationships (i.e. relationships between non-adjacent features and/or features that do not lie along the route). The implication of Unger *et al's* findings is that if the map reader's goal is to obtain an overall knowledge of the space, active explorations of spaces should be promoted for haptic visualization users. In normal-vision users, however, this may be less important if they can visually extract knowledge of the space's overall structure.

"If map readers cannot differentiate among the symbols used in a map, the map will not be effective."

If map readers cannot differentiate among the symbols used in a map, the map will not be effective. Psychophysical studies of maps attempt to discover how readers interpret different stimuli presented on the map. The results of the few psychophysical studies directed to evaluating the efficacy and appropriateness of particular haptic symbols for representing different types of geographic data provide some useful guidance for creating haptic thematic maps. Thompson (1983) carried out a study to determine whether range-graded graduated point symbols could be used effectively in maps designed for the blind. He found that this symbolization was effective only if a full legend (i.e. a legend that included exemplars of all symbol sizes used in the map) was included. Andrews (1983) performed a similar study with similar results. The conclusion that can be drawn from their results is that map readers are not as good at estimating numerical data values from haptic symbols as they are at matching symbols with values included in the legend. The same conclusion has been reached regarding graduated visual symbols, suggesting that more legend anchors could improve magnitude estimations (Cox 1976). To my knowledge, there have not been any studies that have compared the ability of subjects to judge magnitudes from visual and tactile symbols.

Although cartographic research on the use of haptic sensations for visualizing data has traditionally been directed to visually impaired and blind map readers, the availability of virtual reality technologies is now producing environments within which haptic sensations may be useful in applications for normal vision users. Combining visual and haptic sensations in virtual reality systems may be especially fruitful, particularly in light of research by Unger *et al*. (1997). Virtual reality can provide such an environment, in which vision is used to acquire an understanding of the space's structure, and both vision and haptics are used to explore relationships within this space. Knowledge of a space's overall structure does not necessarily have to be obtained visually. A verbal description of the relative locations of objects within the space could also provide this knowledge. However, Blades *et al*. (1999) have shown that viewing a map of a space is more effective than touch at promoting survey knowledge of that space. Therefore, the implication is that vision should be used for this task in virtual environments.

"Knowledge of a space's overall structure does not necessarily have to be obtained visually."

Interactions of Vision and Touch

Although a purely haptic visualization system might be created for the visually impaired, for sighted users, the main issue is whether a system that employs some combination of modalities has an advantage over a vision-only system. If there is an advantage to using multiple modalities, the next question is how the modalities should be combined.

One particularly important intersensory relation is that between touch and vision. There are four potential relationships between these two modalities:

Vision and touch operate independently, with little or no interaction.
Vision allows for more accurate perception than touch.
Touch allows for more accurate perception than vision.
Vision and touch interact in complex ways (e.g. interference, redundancy, complementarity).

". . . for sighted users, the main issue is whether a system that employs some combination of modalities has an advantage over a vision-only system."

Several researchers have concluded that vision and touch are equally capable of discriminating between textures accurately (Lederman and Abbott 1981; Jones and O'Neill 1985). In a later experiment, Lederman et al. (1986) showed that vision and touch process texture in different ways, which depend on the task at hand. For example, they found that texture is used visually to divide spatial arrays of surfaces into chunks, while touch is used to examine surface properties (e.g. is the surface sharp or smooth?). Heller (1982) found that a combination of the two modalities improved performance in processing texture, and concluded that this was due not to the added visual information related to the texture, but to the ability of vision to help guide the hand in its exploration of the texture.

Warren and Rossano (1991) summarized the literature on the interplay of vision and touch with respect to several other variables, such as tilt, size and length and shape. They found that tactile judgment of tilt, size and length is as accurate as visual judgment, but that tactile judgment of shape is less accurate than visual judgment (for shape). They also found that when subjects were given conflicting information, vision tended to dominate the judgment.

Several authors have noted that the different sensory modalities are more appropriate for different tasks (e.g. touch – texture, vision – spatial location, and audition – temporal rate) because each sense is differently precise for perception of different events (Freides 1974; Welch and Warren 1980); this is presumably because each human sensory system has evolved for different purposes, but may also be reinforced by repeated use of one modality for a particular type of task. Welch and Warren (1980) suggested that this differential precision encourages us to attend more to those senses that are most precise for the task at hand. Because of this specialization, it is necessary to take into account the purpose of the visualization task and its information requirements (e.g. is the information distributed temporally, spatially or spatiotemporally?) when designing visualization systems.

". . . most people with normal-vision have little formal training in interpreting data that are represented only through haptic sensations."

There are three general ways haptics could be implemented in a virtual environment: the representation could consist solely of one data variable represented haptically (only one variable is represented; no other modalities are employed); the representation could consist of a combination of data set variables in which one variable is represented haptically and others are represented using auditory or visual cues; or it could use haptics as a supplement to visual information if one data variable is represented using multiple modalities. Although the first possibility may have important applications for the visually impaired, most people with normal-vision have little formal training in interpreting data that are represented only through haptic sensations. For this reason, it may be most fruitful to create virtual environments in which several data attributes are represented using different modalities, which allows users to concurrently observe the distribution of values of the haptically represented attribute within the context of the values of one or more visually represented attributes, or to represent one attribute redundantly. Cartographers have already shown that, at least for one visual variable combination (size and value), such redundancy (if created through multiple visual cues) significantly improves the accuracy and response time of interpretations made by map readers (Dobson 1983). Although to my knowledge no cartographers have empirically investigated the interactions of multimodal variable integration, some psychological experiments have shown that combinations of visual and auditory stimuli improve task response times (Dufft and Ulrich 1999).

"Haptic information is most often implemented in virtual environments as a supplement to visual images."

Haptic information is most often implemented in virtual environments as a supplement to visual images. Including haptic information creates a more realistic, more completely immersive user-experience. While the use of haptic information to create an experience that more closely matches reality is itself useful, virtual reality technology's most important contribution to scientific and geographic visualization may lie in its ability to represent abstract data with haptics or other sense modes. This could be accomplished by visualizing data that we cannot see in the course of our everyday lives (e.g. air pressure). Because air pressure differences do not normally occur rapidly enough for us to notice them (while standing in one location), and because it is unlikely that we would be able to remember the sensation that a given air pressure produced long enough to travel to a location where the air pressure would feel different, we typically visualize air pressure differences using vision. However, in a virtual environment, both space and time can be compressed, and the magnitude of air pressure differences can be exaggerated, so that when moving from one location to another, there could be a perceptible change in the amount of pressure we feel on our bodies (that corresponds to the change in air pressure in the data set).

Cognitive Sensory Overload and Cartographic Legends

A final important issue in designing haptic representations of geospatial data is that of *cognitive sensory overload*—a condition in which the map reader cannot process all of the information represented in the display, and in which adding more information to the display may actually lead to a decrease in the amount of information the map reader can effectively process. Cartographers are already familiar with this issue in the intramodal case (i.e. within one sense) for vision in a given time period. A map that displays more than two or three attributes with some combination of different visual variables quickly becomes much more difficult for the map reader to interpret. Certainly, we could expect that this difficulty would also extend to haptic variables, and may be even more severe for that case. The difficulties associated with interpreting a visual representation of multiple attributes are at least attenuated to some degree by the semi-permanent nature of the display—the map reader does not have to store as much information in her working memory, as the display itself can help to fulfill this function. A haptic display, on the other hand does not leave a semi-permanent trace to serve as a store of working memory, so we might expect that difficulties in interpreting displays that represent multiple attributes haptically to be even more severe than those for vision. As such, it seems appropriate to restrict the use of haptic variables to the display of one attribute at a time.

"A map that displays more than two or three attributes with some combination of different visual variables quickly becomes much more difficult for the map reader to interpret."

Cognitive sensory overload may also occur intermodally (i.e. between senses). A commonly reported scenario occurs when driving a high-tech car of the future. A study by the Oak Ridge National Laboratory examined how much of a driver's cognitive capacity went to dealing with a cell phone, a forward collision-warning system, a navigation system and an Internet-equipped computer screen while driving, and what portion of their mental capacity was devoted to the task at hand (i.e. driving the car) (ITS America 2001). The scientists found that drivers were better at attending to the multiple devices (often using multiple senses, such as vision and audition) when they could finish one task before dealing with another. The implication this study has for designing visualization systems is that more perceptual cues do not necessarily allow the user to process more information. The amount of information that the user can effectively process is likely to be task-specific (i.e. it may be easier for a user to find anomalies in a multisensory representation than to determine whether a correlation exists between two variables). Therefore, user control of the system is important for helping user's manage the cognitive load associated with integrating and processing data from multisensory perceptual cues.

". . . more perceptual cues do not necessarily allow the user to process more information. The amount of information that the user can effectively process is likely to be task-specific . . ."

We might also expect that in some cases, multisensory perceptual cues will enhance or augment cognition. For example, nurses in the emergency room often rely on changes in the sounds emitted from machines that monitor the patient's status (along with visual cues) to alert them to a patient's deteriorating condition. Without such sonic input, it is likely that a nurse would not be able to effectively monitor the condition of several patients at once. A cartographic scenario in which a similar process could potentially occur might be examined by using Fisher's (1994) vision and sound representation system is using sound to alert a user that a remotely sensed pixel's classification uncertainty has exceeded a user-specified threshold.

We may find that the way we design intermodal representations of geospatial data will have an important effect on whether they produce a condition of cognitive sensory overload in the user. One particular area of concern is in legend design. For example, when a map reader is trying to understand the visual stimuli she sees in a map, she can refer to the legend at any time without losing her place in the mapped distribution, or changing the perceptual stimulus she is attending to. However, with a haptic representation, once the map reader's hand leaves a particular location on the map display, the sensation she feels will also change. Thus, reading the map and referring the legend with the same hand may be very difficult. For this reason, the map reader may use one hand to explore the display and the other as the "legend hand" while exploring haptic representations. The legend could be set to display one reference value or the entire range of values represented in the display, depending on the user's preference and/or the task at hand. Once haptic displays begin to be implemented, it would be useful to design a variety of legends and test their effectiveness for several map reading tasks.

"With a haptic representation, once the map reader's hand leaves a particular location on the map display, the sensation she feels will also change. Thus, reading the map and referring the legend with the same hand may be very difficult."

SUMMARY

The potential for including touch as a channel for geographic visualization, either as a supplement to visual representation or on its own has not yet been widely explored. With advances in virtual reality technology and computing power, more sophisticated representations of data with haptics will be possible. It is important to think carefully about how the various properties of haptic perception can best be applied to representing geographic data, as well as to evaluate their effectiveness in representing geographic data once haptic representation capabilities are implemented in visualization systems. Empirical testing, both of the effectiveness of the proposed haptic variable syntax and of haptic variables themselves (individually and in combination with visual and/or other sense variables) would help to identify areas for their appropriate implementation and application.

REFERENCES

Andrews, S. K. 1983. Spatial cognition through tactual maps. *Proceedings of the First International Symposium on Maps and Graphics for the Visually Handicapped*. 30-40. Washington, D.C.: Association of American Geographers.

Bertin, J. 1983. *Semiology of Graphics: Diagrams, Networks, Maps*. Madison, Wisconsin: University of Wisconsin Press. Translated by William Berg from *Semiologie Graphique* (1967). Paris: Editions Gauthier-Villars.

Blades, M., S. Ungar and C. Spencer. 1999. Map use by adults with visual impairment. *Professional Geographer.* 41(4): 539-53.

Bolanowski, S. J., Jr., G. A. Gescheider, R. T. Verillo and C. M. Checkosky. 1988. Four channels mediate the mechanical aspects of touch. *Journal of the Acoustical Society of America.* 84(5): 1680-94.

Brewer, C. A., A. M. MacEachren, L. W. Pickle and D. Hermann. 1997. Mapping mortality: evaluating color schemes for choropleth maps. *Annals of the Association of American Geographers.* 87(3): 411-38.

Caivano, J. L. 1990. Visual texture as a semiotic system. *Semiotica.* 80(3/4): 239-52.

Castner, H. W. 1983. Tactual maps and graphics: some implications for our study of visual cartographic communication. *Cartographica.* 20(3): 1-16.

Chang, K.-T. 1977. Visual estimation of graduated circles. *Canadian Cartographer.* 14: 130-8.

Cholewiak, R. W. and A. A. Collins. 1991. Sensory and physiological bases of touch. In M. A. Heller and W. Schiff (eds.) *The Psychology of Touch*. Hillsdale: Lawrence Erlbaum Associates, Publishers.

Cox, C. W. 1976. Anchor effects and the estimation of graduated circles and squares. *American Cartographer.* 3: 65-74.

Cronly-Dillon, J., K. Persaud and R. P. F. Gregory. 1999. The perception of visual images encoded in musical form: a study in cross-modality information transfer. *Proceedings of the Royal Society of London, Series B.* 266: 2427-33.

Dobson, M. W. 1983. Visual information processing and cartographic communication: the utility of redundant stimulus dimensions. In D. R. F. Taylor (ed.) *Graphic communication and design in contemporary cartography, Volume 2, Progress in contemporary cartography*. New York, Wiley.

Dodds, A. 1988. Tactile maps and the blind user: perceptual, cognitive and behavioral factors. *Proceedings of the Second International Symposium on Maps and Graphics for Visually Handicapped People*. 30-6. London: University of Nottingham.

Dufft, C. C. and R. Ulrich. 1999. Intersensory facilitation: visual accessory signals can also shorten reaction time. *Zeitschrift für experimentelle Psychologie.* 46(1): 16-27.

Eriksen, C. W. and J. F. Collins. 1968. Sensory traces versus the psychological movement in the temporal organization of form. *Journal of Experimental Psychology.* 77: 376-82.

Fisher, P. 1994. Hearing the reliability in classified remotely sensed images. *Cartography and GIS.* 21(1): 31-6.

Flannery, J. 1971. The relative effectiveness of some common graduated point symbols in the presentation of quantitative data. *Canadian Cartographer.* 8: 96-109.

Flowers, J. H., D. C. Buhman and K. D. Turnage. 1997. Cross-modal equivalence of visual and auditory scatterplots for exploring bivariate data samples. *Human Factors.* 39(3): 341-51.

Flowers, J. H. and T. A. Hauer. 1995. Musical versus visual graphs: Cross-modal equivalence in perception of time series data. *Human Factors.* 37(3): 553-69.

Freides, D. 1974. Human information processing and sensory modality: Crossmodal functions, information complexity, memory and deficit. *Psychological Bulletin.* 81: 284-310.

Heller, M. A. 1982. Visual and tactual texture perception: Intersensory cooperation. *Perception & Psychophysics.* 31: 339-44.

ITS America. 2001. High-tech cars could bring cognitive overload. http://www.itsa.org/ITSNEWS.NSF/a619bd3fc912d6f38525658d00073cd1/4d4a2ccf01557420852569dd00517abe?OpenDocument

Jones, B. and S. O'Neill. 1985. Combining vision and touch in texture perception. *Perception and Psychophysics.* 37: 66-72.

Kimerling, A. J. 1985. The comparison of equal-value gray scales. *American Cartographer.* 12: 132-42.

Krygier, J. 1994. Sound and geographic visualization. In A. M. MacEachren and D. R. F. Taylor (eds.) *Visualization in Modern Cartography*. Oxford, UK: Elsevier.

Lederman, S. J. and S. G. Abbott. 1981. Texture perception: studies of intersensory organization using a discrepancy paradigm and visual vs. tactual psychophysics. *Journal of Experimental Psychology: Human Perception and Performance.* 47: 54-64.

Lederman, S. J., G. Thorne and B. Jones. 1986. Perception of texture by vision and touch: multidimensionality and intersensory integration. *Journal of Experimental Psychology: Human Perception and Performance*. 12: 169-80.

Luecke, G. R. and Y.-H. Chai. 1997. Contact sensation in the synthetic environment using the ISU force reflecting exoskeleton. *IEEE Annual Virtual Reality International Symposium*. 192-8. Albuquerque, NM: IEEE Computer Society Press.

MacEachren, A. M. 1992. Visualizing uncertain information. *Cartographic Perspectives.* 13: 10-19.

MacEachren, A. M. 1995. *How Maps Work*. New York: Guilford Press.

MacEachren, A. M. and J. H. Ganter. 1990. A pattern identification approach to cartographic visualization. *Cartographica.* 27(2): 64-81.

Minsky, M., and M. Ouh-young. 1990. Feeling and seeing: Issues in force display. *Computer Graphics.* 24(2): 235-43.

Monkman, G. J. 1992. An electrorheological tactile display. *Presence.* 1(2): 219-28.

Morrison, J. L. 1974. A theoretical framework for cartographic generalization with the emphasis on the process of symbolization. *International Yearbook of Cartography.* 14: 115-27.

Ottensmeyer, M. P. and K. J. Salisbury. 1997. Hot and cold running VR: Adding thermal stimuli to the haptic experience. *Proceedings of the Second PHANToM User's Workshop*. 34-7. Dedham, MA: Endicott House.

Pereverzev, S. V., A. Loshak, S. Backhaus, J. C. Davis, and R. E. Packard. 1997. Quantum oscillations between two weakly coupled reservoirs of superfluid He-3. *Nature.* 388: 449-451.

Shi, Y. and D. K. Pai. 1997. Haptic display of visual images. *IEEE Annual Virtual Reality International Symposium*. 188-91. Albuquerque, NM: IEEE Computer Society Press.

Shimojo, M., M. Shinohara and Y. Fukui. 1997. Shape identification performance and pin-matrix density in a 3-dimensional tactile display. *IEEE Annual Virtual Reality International Symposium*. 180-7. Albuquerque, NM: IEEE Computer Society Press.

Tan, H. Z., N. I. Durlach, C. M. Reed and W. M. Rabiowitz. 1999. Information transmission with a multifinger tactual display. *Perception & Psychophysics.* 61(6): 993-1008.

Thompson, N. R. 1983. Tactual perception of quantitative point symbols in thematic maps for the blind. *Proceedings of the First International Symposium on Maps and Graphics for the Visually Handicapped*. 103-13. Washington, D.C.: Association of American Geographers.

Ungar, S., M. Blades, and C. Spencer. 1997. Strategies for knowledge acquisition from cartographic maps by blind and visually impaired adults. *The Cartographic Journal.* 34(2): 93-110.

Vasconcellos, R. 1991. Knowing the Amazon through tactual graphics. *Proceedings of the International Cartographic Association*. 206-10. Bournemouth: International Cartographic Association.

Von Uexküll, J. 1957. A stroll through the worlds of animals and men: A picture book of invisible worlds. In C.H. Schiller (ed.) *Instinctive Behavior*. Madison, CT: International Universities Press.

Warren, D. H. and M. J. Rossano. 1991. Intermodality relations: Vision and touch. In M. A. Heller and W. Schiff (eds.) *The Psychology of Touch*. Hillsdale: Lawrence Erlbaum Associates, Publishers.

Weidel, J., Ed. 1983. *Proceedings of the First International Symposium on Maps and Graphics for the Visually Handicapped*. Washington, D.C.: Association of American Geographers.

Welch, R. B. and D. H. Warren. 1980. Immediate perceptual response to intersensory discrepancy. *Psychological Bulletin.* 88: 638-667.

Wheless, G. H., C. M. Lascara, A. Valle-Levinson, D. P. Brutzman, W. Sherman, W. L. Hibbard and B. E. Paul. 1996. Virtual Chesapeake Bay: Interacting with a coupled physical/biological model. *IEEE Computer Graphics and Applications.* 16(4): 52-7.

White, C. 1963. Temporal numerosity and the psychological unit of duration. *Psychological monographs.* 77: 1-37.

NOTES

[1] Empirical work testing some of Bertin's contentions has been undertaken (c.f. studies by Brewer et al. (1997), Flannery (1971), Chang (1977) and Kimerling (1985)).

[2] Elevation can certainly be perceived visually *if* the map reader has access to a 3D representation.

[3] One notable exception to this is the addition of thermal stimuli to the PHANToM haptic interface (Ottensmeyer and Salisbury 1997).

[4] Although visual stimuli in maps are also perceived sequentially, most visual scanning tasks (for most individuals) are probably performed much more quickly than tactile scanning processes because larger chunks of the scene are sensed at once, and vision has greater acuity.

Visualizing Change: Using Cartographic Animation to Explore Remotely-Sensed Data

Mark Harrower
Department of Geography & GeoVISTA Center
The Pennsylvania State University
302 Walker Building
University Park, PA 16802
mah282@psu.edu

This research describes a geovisualization tool that is designed to facilitate exploration of satellite time-series data. Current change-detection techniques are insufficient for the task of representing the complex behaviors and motions of geographic processes because they emphasize the outcomes of change rather than depict the process of change itself. Cartographic animation of satellite data is proposed as a means of visually summarizing the complex behaviors of geographic entities. Animation provides a means for better understanding the complexity of geographic change because it can represent both the state of a geographic system at a given time (i.e. its space-time structure) and the behavior of that system over time (i.e. trends). However, a simple animation of satellite time-series data is often insufficient for this task because it overwhelms the viewer with irrelevant detail or presents data at an inappropriate temporal and spatial resolution. To solve this problem, dynamic temporal and spatial aggregation tools are implemented with the geovisualization system to allow analysts to change the resolution of their data on the fly. These tools provide (1) a means of detecting structures or trends that may be exhibited only at certain scales and (2) a method for smoothing or filtering unwanted noise from the satellite data. This research is grounded in a delineation of the nature of change, and proposes a framework of four kinds of geographic change: location, size/extent, attribute and existence. Each of these kinds of change may be continuous (a process) or discrete (an event).

Keywords: cartographic animation, change-detection, temporal and spatial resolution, data filtering, time series analysis, remote sensing, NDVI

INTRODUCTION

It is has been said that the only constant in the universe is change. This is certainly true of geographic systems, many of which are in a constant state of change. As geographers tackle larger and more complex problems—such as global warming—there has been a shift from studying spatial *patterns* to studying space-time *processes* (Graf and Gober 1992). Advanced statistical and computational modeling have allowed geographers to explore and better understand how geographic systems function. As the kind of phenomena geographers study change, so too does the nature of the maps needed by geographers. One reason that studying geographic processes is challenging is the sheer number of interactions that occur within systems and the enormous range of scales over which those interactions take place (e.g. from the molecule to the globe). Representing these interactions graphically is a significant cartographic challenge. Mapping a static world is difficult enough; mapping a dynamic one introduces new orders of complexity to our cartographic abstractions.

"Advanced statistical and computational modeling have allowed geographers to explore and better understand how geographic systems function."

This paper reports on the potential use of animation as an exploratory visualization tool in change detection research utilizing remotely sensed imagery. To this end, a prototype geovisualization environment has been built to allow users to dynamically control both the spatial and temporal resolution of a raster-based animation. This tool is designed to help users visually explore the effects of changing voxel size on multi-temporal remote sensing data (as used here, a voxel is a two-dimensional pixel with a temporal extent). Such explorations are potentially useful in two ways. First, they may allow users to determine the optimal scale of analysis when working with multi-temporal raster data, and second, they may help users to formulate specific hypotheses about the behavior of geographic entities represented within the data.

Tools that allow users to 'see' patterns and extract meaning from large and complex data sets are increasingly necessary as the volume of data collected by satellites (among other sources) increases rapidly. The data amassed by NASA's *Earth Observing System* (EOS) alone exceeds 1250 GB per day (Meisner et al. 1999). Gahegan (1996 and 2000) notes that information filtering is one of the foundational goals of the emerging field of geocomputation. Innovative geographic and statistical representations, such as linked parallel coordinate plots (Edsall 1999), have already proven successful in this regard. The tool presented in this paper was built with a similar goal in mind: to facilitate exploration of large remotely-sensed data sets and to help filter unnecessary complexity from these data.

". . . information filtering is one of the foundational goals of the emerging field of geocomputation."

Change is one of the fundamental elements of geographic process. The ability to recognize and track changes in complex physical systems is essential to developing an understanding of how these systems work (Yattaw 1999). Many of today's significant research challenges, such as resource management and environmental monitoring, depend upon integrating many kinds of change information collected at a variety of scales. Data collected by satellites is a rich source of spatio-temporal data and meets two necessary conditions for monitoring large-scale geographic phenomenon: (1) it is collected at regular time intervals, and (2) unlike data collected by ground-based observations, it is spatially continuous. In addition, platforms such as Landsat and AVHRR have been operational for over 20 years offering a 'deep' data set both spatially and temporally.

HOW DO WE CONCEPTUALIZE CHANGE?

Representing geographic change on maps requires an understanding of the various ways in which change can be conceptualized and measured. 'Change' is a vague word. A useful definition is "change refers to the fact that an object or phenomenon is altered or transformed into something different through the result of some action or process" (Hornsby and Egenhofer 2000, p. 210). At scales larger than the sub-atomic, change cannot take place without time.

Broadly speaking we can make a distinction between c*ontinuous change* (e.g. stream discharge) and *discrete change* (e.g. change in ownership of a parcel of land). Within these two categories, I propose there are four basic kinds of geographic change: location, shape/size/extent, attribute, and state/existence. These are defined in Table 1 and examples of each are provided. This is an object-oriented worldview, that is, the world is assumed to be composed of identifiable geographic objects such as trees, lakes and thunderstorms which can be distinguished from—and compared to—other objects. We notice a change in location when something moves *relativ*e to another object. In contrast, change in shape/size/extent is self-referential and does not require an external spatial referent, although it does require that we remember previous states against which we can compare the current state (t_1 versus t_2). Not all change requires motion. Change in attribute can occur in stationary objects or fields (i.e. temperature). A change of existence occurs when something is present that wasn't before (or *vice versa*). Change in existence is unlike the others in that it is measured at a nominal level.

"Representing geographic change on maps requires an understanding of the various ways in which change can be conceptualized and measured."

Change in . . .	Example	Level of Measurement
Location	The path of a hurricane	ratio data
Shape/Size/Extent	The areal extent and shape of a hurricane	ratio data
Attribute	Decreasing wind speed	ratio data
State/Existence	Downgraded to tropical storm	nominal data

Table 1. Types of Geographic Change

An important issue is whether cartographic animation is equally good at depicting each of these kinds of change. Furthermore, given that geographic systems usually exhibit multiple kinds of change simultaneously, how do we represent these changes *simultaneously* in an animated map?

CARTOGRAPHIC ANIMATION AND CHANGE DETECTION

Animation as a visualization technique has been widely studied and supported in cartography and geovisualization (Monmonier 1990, Slocum and Egbert 1993, Openshaw et al. 1994, Kraak and MacEachren 1994, Edsall et al. 1997). The idea of using a cartographic animation to *map time with time* is intuitively a good idea. Animations are "a scale model in both space and time" (Monmonier 1990, p. 40) and as such are powerful tools for depicting change information. Almost a decade ago Koussoulakou and Kraak (1992, p. 101) noted, "During the nineties important challenges to cartography will be related to mapping spatial data's multi-dimensional and temporal component. From a cartographic point of view it is necessary to look at the implications of the use of animated maps." However, as a recent research agenda by the ICA Commission on Visualization notes (MacEachren and Kraak 2001), progress during the past decade has been sporadic and many unanswered questions remain regarding the use of animation in geovisualization and the representation of dynamic geographic phenomena.

"The dominant approach in digital remote sensing has been to extract the change information computationally and then visualize the output as a single image, rather than as an animation."

Although a significant amount of research in digital remote sensing over the last 30 years has been directed toward developing robust change detection techniques (Jenson et al. 1997), very little of this work makes use of animation. The dominant approach in digital remote sensing has been to extract the change information computationally and then visualize the output as a single image, rather than as an animation. There are numerous change-detection techniques and according to Sunar (1998) most fall into one of the following categories: (1) classification comparisons, (2) principal components analysis (PCA), (3) image overlay, and (4) image differencing. New techniques continue to appear in the literature and some recent work has assessed the relative merits of the various techniques focusing, in particular, on accuracy and sensitivity (Collins and Woodcock 1996, MacLeod and Congalton 1998, Mas 1999). The popularity of these techniques stems from the fact that they work with a variety of data sets, provide replicable results and off-load much of the work to computers.

"A serious limitation of traditional approaches is their emphasis on measuring the outcomes *of change rather than representing the* process *of change itself."*

A serious limitation of traditional approaches is their emphasis on measuring the *outcomes* of change rather than representing the *process* of change itself. For example, classification comparisons can calculate how many pixels (and hence total area) have changed from wetlands initially (t_1), to farmland subsequently (t_2). This approach says nothing of what happened *between* t_1 to t_2, *how* the sequence of events unfolded, or *why*. Additionally, these techniques focus on only one kind of change: change in attribute (as measured by change in surface reflectance values) making it difficult to characterize motions or rates of change.

In most geographic phenomena change is ongoing (e.g. atmospheric motions, economic trends) and it is difficult to identify a discrete "beginning" and "end" to these processes. Change detection techniques such as image differencing and classification comparison work better with a discrete view of change ("an event," "before and after") than with a continuous view of change ("a process"). Current techniques that emphasize the outcomes of change and ignore the process itself seem insufficient if we wish to describe the behavior of geographic phenomena and their relative motions, or provide a visual summary of temporally-dependent interactions. An animation, it is argued, is a much better tool for depicting and understanding more abstract notions of change—such as the behavior of an El Ninõ—than a single "difference image" derived from two time periods.

"Current techniques that emphasize the outcomes of change and ignore the process itself seem insufficient if we wish to describe the behavior of geographic phenomena and their relative motions, or provide a visual summary of temporally-dependent interactions."

How Animation Can Contribute

Methodologically, this paper proposes a union of the computational rigor of remote sensing with the exploratory power of geovisualization. Geovisualization is fundamentally concerned with leveraging the pattern-recognition and information-extracting abilities of the eye-brain system and giving the user the tools to visualize and explore complex data sets in the hopes of discovering new insights (MacEachren 1995). In the early stages of research, geovisualization can be used to form hypotheses about the behavior of complex geographic systems especially when formal (i.e. testable) hypotheses about those systems are lacking (MacEachren et al. 1992, Hearnshaw and Unwin 1994, Gahegan et al. 2001). Later in the research process, geovisualization may be used to confirm, synthesize, and ultimately present ideas and information (DiBiase 1990). Thus, visualization is potentially helpful in all stages of the knowledge construction process.

Animation is a visual tool that is well-suited to qualitative analysis. Preliminary research has shown that animation can reveal subtle space-time patterns that are not evident in static representations, even to expert users who are highly familiar with the data (MacEachren et al. 1998). As conceived here, animation can be used as an exploratory first step in the change detection process. Because cartographic animation by itself does not generate quantitative data—such as a count of the number of pixels that have changed from wetlands to farmland—it cannot replace numerical/computational techniques. Rather it is a complementary "first look" allowing analysts to *see* what is happening in a data set before performing image analysis.

"Animation is a visual tool that is well-suited to qualitative analysis."

This "first look" may be helpful in two ways. First, it may help to reveal complex behaviors or patterns not evident in static representations or that might be missed with traditional change-detection algorithms. For example, there may be small regions within the imagery that behave atypically, perhaps only during certain time periods, and this insight might get lost in a non-visual approach. Second, animation may be used to establish formal model parameters, such as optimal pixel size, which can lead to better results with traditional change detection techniques. The prototype visualization system presented below is designed to illustrate both of these advantages.

EXAMPLE PROBLEM: SCALE OF ANALYSIS

The are two kinds of scale in multi-temporal satellite imagery. The spatial resolution is determined by the pixel size, which with the current generation of civilian satellites ranges roughly from 1 meter (IKON sensor) to one kilometer (AVHRR sensor). The temporal resolution is determined by the orbital characteristics of the platform, which ranges from continuous with geostationary satellites (e.g. GOES weather satellites), to 18 days (e.g. Landsat). How often a satellite passes over a certain area determines the base sampling rate for change detection research. The more often a satellite surveys a region, the more temporal information is available to the analyst, and the chances of collecting cloud-free imagery are increased which decreases the likelihood of long gaps in the temporal record. Persistent cloud contamination is a serious issue in maritime and tropical regions and temporal and spatial interpolation is often required to fill the gaps (Meisner et al. 1999). In addition to interpolation, raw satellite data can also be aggregated spatially to create larger pixels, and temporally to create temporal averages.

"Scale is a critical and difficult issue to resolve in geographic analysis because scale constrains the questions we can ask and the answers we are likely to generate."

Raw satellite data is often very "noisy" and both spatial and temporal aggregation is necessary to extract a more "stable signature" and eliminate short-term and random fluctuations. The amount of aggregation is related to what the analyst is studying: how large the phenomenon of study is and how quickly it changes. For example, continental-scale landcover studies do not require 1-meter daily imagery. Temporal composites of 10-day (Yang *et al.* 1997), 30-day (Anyamba and Eastman 1996), or even yearly averages (Batista *et al.* 1997) are more appropriate to study long-term surface variations in landcover. Similarly, the spatial resolution of landcover studies is typically fairly coarse (1km to 100 km pixel).

Scale is a critical and difficult issue to resolve in geographic analysis because scale constrains the questions we can ask and the answers we are likely to generate (either visually or numerically). With satellite imagery it is difficult to determine the optimal scale of analysis for a specific research investigation. For example, what is the best pixel size to study the effects of forest fires? What is the optimal sampling frequency for monitoring ocean temperatures? Does it matter what part of the globe is being monitored (e.g. arctic versus tropical)? Does the optimal scale of analysis change throughout the year (e.g. winter to summer)? There are few rules to guide the selection of appropriate pixel size in change-detection research. Choosing the optimal scale of analysis depends largely on experience, convention and the nature of the raw data. One solution presented here is to employ dynamic temporal and spatial filtering tools that allow users to easily change the resolution of their data and view the results.

VOXELVIEWER: A PROTOTYPE VISUALIZATION SYSTEM

The VoxelViewer is a prototype visualization system designed to let analysts explore the effects of temporal and spatial scale in multi-temporal satellite imagery. It is also designed to afford analysts the opportunity to visually explore their data and observe how features change over time and across space. Figure One shows the system interface.

"Choosing the optimal scale of analysis depends largely on experience, convention and the nature of the raw data."

VoxelViewer was built using Macromedia Director 8 multimedia software. This raster-based authoring environment allows for the rapid development of multimedia cartographic tools that integrate maps, sounds, text, and movies. Unlike a GIS-based mapping system, Director is not data-driven and there is no georeferenced database underlying the map. Instead, the various elements of the animation (movie clips, sound files) are created elsewhere and assembled in Director. Director's scripting language *Lingo* is used to coordinate the various elements and determine how the system behaves, for example, when a user clicks on a button. Director gives the cartographer greater flexibility than a typical GIS package in designing the "look and feel" of the system. Building applications in Director is also significantly faster than working in a full programming language

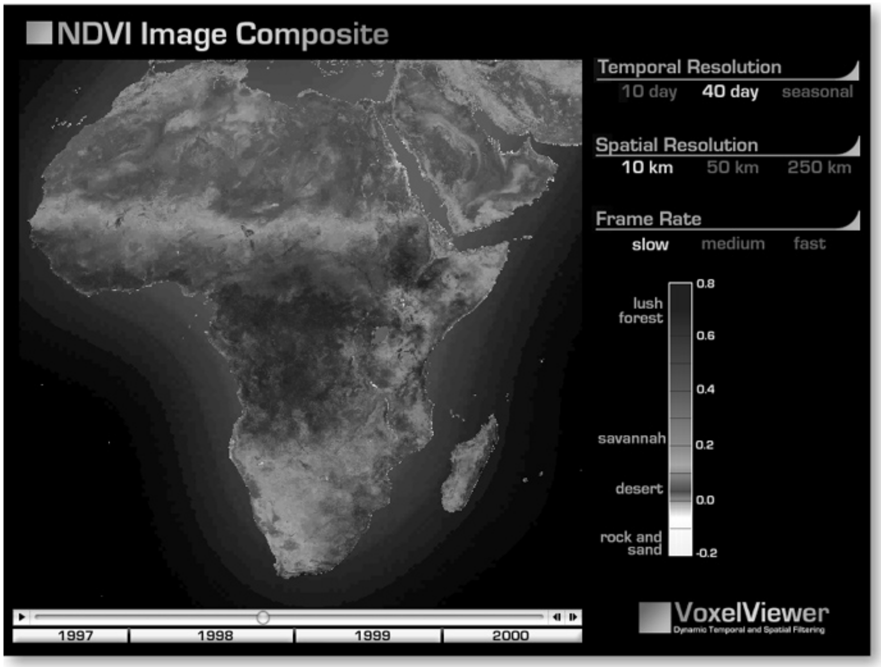


Figure 1. The VoxelViewer interface allows users to watch an animation and control the pace, pixel size, and temporal resolution of the data.

such as Java or Visual Basic because (1) it is at least an order of magnitude less complex and (2) Macromedia includes numerous "libraries" which contain pre-scripted behaviors and graphics (such as roll-over buttons). Lastly, Director creates web-friendly applications which can be viewed by any web browser with the *Shockwave* plug-in (currently estimated to be installed on 95 percent of web browsers) reassuring the designer that their work will be easy to disseminate and viewable by many.

Photoshop 6 was used to storyboard the VoxelViewer and design the various interface components. This raster artwork was imported into Director and used as "cast members" in the animation. The faded ocean halo in each image was created in Photoshop (see Figure One), which was saved as an "action" and used to batch process the remaining images. Approximately one thousand images were created and the powerful batch processing capabilities of Photoshop were an asset in this project. The individual images were converted to QuickTime movies using GraphicConverter 4.0. These files were further compressed and optimized for web-delivery using Media Cleaner 5. The VoxelViewer has a total size of 35MB due to the size and number of raster movies it contains.

"Any time-series satellite data could be used with the VoxelViewer."

The Data

Any time-series satellite data could be used with the VoxelViewer. For demonstration purposes the Normalized Difference Vegetation Index (NDVI) was chosen. The NDVI has become an increasingly popular tool for studying climate variations (Carleton and O'Neal 1995) and changes in landcover characteristics (Ehrlich and Lambin 1996, Liu and Kogan 1996). The NDVI was originally designed for measuring biomass and plant vigor. Common space-borne platforms that can be used to create NDVI images include Landsat TM and MSS, Spot, and AVHRR. Of these, AVHRR is perhaps best suited to long-term surface change studies because of its unparalleled daily global coverage, suitable resolution of 1.1 km at nadir, and an unbroken 20+ year record from the entire fleet of AVHRR satellite. Best of all, the data are available free of charge.

The base data in the VoxelViewer are 10-day cloud free composites with approximately a 10km resolution. These particular data cover the entire continent of Africa over a 3 year period from July 1997 to July 2000 — a sufficiently long sample period to capture both short- and long-term variation. Due to cloud cover it is not possible to study continental-scale phenomena using daily imagery. Instead, cloud-free 10-day NDVI composites are used and represent the finest temporal granularity of the data in the VoxelViewer. These composites are produced by retaining the single highest NDVI value for each location per 10-day period. This ensures that the retained pixels represent surface features because clouds produce low NDVI values and only vegetation produces high NDVI values. The final images use a false color assignment that reflects perceptions of landcover — regions with abundant vegetation are dark green (positive NDVI values), grasslands are light green, and rock and sand are white and gray (negative NDVI values).

"Spatially re-sampling imagery—such as changing 1km pixels to 10 km pixels—is a computationally intensive process."

The images used in the VoxelViewer were retrieved from the Goddard Space Flight Center Earth Sciences Data and Information Services Center Distributed Active Archive Center (DAAC). This organization produces many kinds of free and web-accessible AVHRR products as part of its Global Biosphere Program. Daily and ten-day NDVI products of each continent can be found at http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/BRS_SRVR/avhrrbrs_main.html.

Since the VoxelViewer is a prototype system built in Director 8 there is no real-time interpolation of the raster imagery. Instead, the VoxelViewer gives the impression that the data are interpolated on-the-fly by swapping in the appropriate QuickTime movie. Each frame of every animation had to be created beforehand which is clearly not practical for a functional visualization system. Spatially re-sampling imagery—such as changing 1km pixels to 10 km pixels—is a computationally intensive process. Re-sampling the imagery through time (across frames) makes this task even more demanding. In batch-processing mode, each frame in the VoxelViewer took approximately 5 seconds to be re-sampled on a fast desktop machine. It would be impossible to generate 15 frames-per-second animation rates on anything less than a SGI supercomputer if the imagery had to be read, re-sampled, colored, and rendered on-the-fly. With current desktop hardware this kind of performance is impossible. However, it is likely that at the current rate of CPU development, affordable desktop computers capable of such "supercomputer" feats are not far away. The VoxelViewer is designed as a "proof of concept" for dynamic spatial and temporal resolution tools: do they help analysts, do they compliment current tools, and if so, could such tools be built into future releases of visualization software such as GeoVISTA *Studio* developed at Penn State (http://www.geovistastudio.psu.edu).

"The VoxelViewer is designed as a 'proof of concept' for dynamic spatial and temporal resolution tools . . ."

The Visualization Tools

The VoxelViewer incorporates two kinds of dynamic temporal and spatial filtering tools (Figures Two and Three). These allow users to adjust the pixels size from 10 km to 250 km, and the temporal interval from 10 days to 80 days. Increasing the spatial resolution of the data reduces spatial heterogeneity and creates more stable NDVI signatures. There is an inverse relationship between pixel size and NDVI signature stability: larger pixels are larger spatial samples which average together a greater variety of landcover types. Unfortunately, this decreases the chance of a single pixel representing one landcover type (i.e. the entire pixel is urban). Increasing the temporal resolution has a similar effect. Pixels which are derived from more samples over time reduce shorter-term fluctuations and create smoother looking animations, albeit animations with less temporal resolution. The user is encouraged to download a copy of the VoxelViewer from http://www.geovista.psu.edu/members/harrower/voxelViewer.html

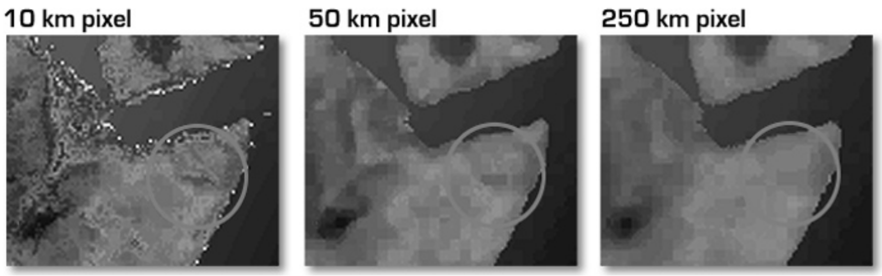


Figure 2. The effect of changing pixel size, or spatial resolution, is apparent with the successive loss of fine details in the Horn of Africa.

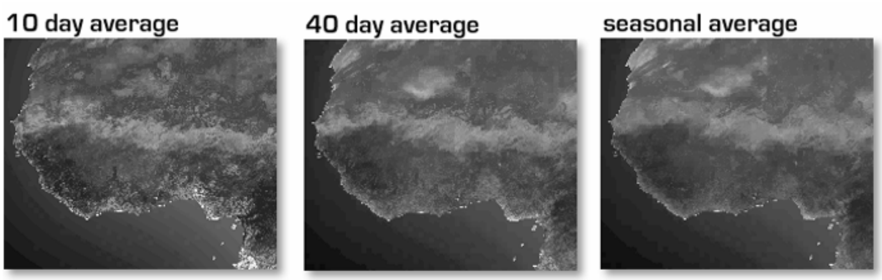


Figure 3. Spatial heterogeneity decreases with temporal aggregation. The ability to filter short-term fluctuations in the NDVI results in smoother looking maps of vegetation.

Interactivity can be enhanced if interface elements provide both visual and audio cues (i.e. simultaneously ‘flash’ and ‘beep’ when pressed). This is important (1) to help distinguish interactive elements (e.g. slider bars) from non-interactive elements (e.g. a color legend); (2) to provide unambiguous feedback to the user that their action (a button press) has initiated a response (load a new movie); and (3) to prevent users from clicking on multiple elements in frustration or ignorance, especially if the system does not respond immediately to all requests. A system that provides immediate responses—even if it is a simple as a “loading data” message—should increase user confidence in a new system.

“Interactivity can be enhanced if interface elements provide both visual and audio cues.”

Previous research (Harrower et al. 2000) has demonstrated the importance of interface elements that provide clear “on” and “off” states. The VoxelViewer relies on a scheme of “grayed-out” buttons for the off state and white buttons for the on state. In addition, the decision was made to display all of the possible spatial, temporal, and tempo choices on the screen at once, arranged in a line under subheadings (Figure One). This approach is favored over pull-down menus because it acts as both an interface and a data legend: the entire range of possible settings is always displayed and the current setting (e.g. 10km) can be compared to the entire range at a glance. By comparison, pull-down menus only communicate the current selection while in their rest state. One advantage of pull-down menus is their smaller footprint in the interface.

Example Insights – Changes in the Sahel

One of the most dynamic features in the imagery of Africa is the region called the Sahel that separates the Sahara Desert to the north from to the south. The Sahel is a semi-arid region that periodically experiences drought causing hardship to the rural poor who live there. The location of the semi-arid transition zone between the Sahara and the forest of central Africa shifts with the seasons, moving north during the monsoon summers and south during the winter. By animating images over many years it is possible to see that the annual migration of this transition zone is different year-to-year, which is related to—at least in part—larger climatic teleconnections (e.g. El Ninõ - Southern Oscillation events). Moreover, the north-south extent of this transition zone varies from year to year, being more compressed in wet years, and less compressed in dry years (Figure Four).

"It is difficult to see this space-time pattern at other resolutions and it would be easy to miss the behavior entirely if not for animation."

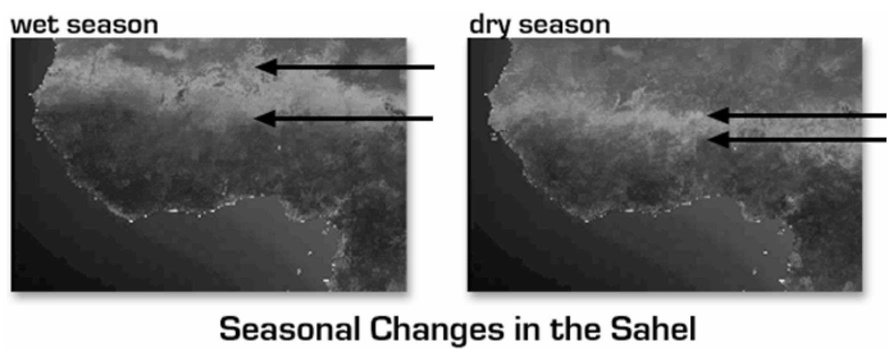


Figure 4. The complex changes of the Sahel region can best be seen in a 15 fps animation loop using 40-day averages with a 10 km pixel. The areal extent and latitudinal position of the upper and lower boundaries of the semi-arid region fluctuate seasonally and yearly.

The motion of this semi-arid transition zone is most vividly depicted at a spatial scale of 10 km and a temporal scale of 40 days, animated at high speed. With this presentation a new behavior emerges. The northern and southern boundaries do not move in unison. Rather, there is a temporal lag in which the southern boundary moves northward first (since the monsoon rains arrive from the south) compressing the region before the northern boundary expands into the desert. The southern boundary is also the first to retreat southward with the onset of the dry season. It is difficult to see this space-time pattern at other resolutions and it would be easy to miss the behavior entirely if not for animation. This demonstrates that some space-time patterns and behaviors are more readily observed at certain spatial and temporal resolutions than others.

". . . perceptual theory and experimental testing indicate that people can both understand and utilize animated graphics."

DISCUSSION

Although this paper does not present the results of formal user testing, perceptual theory and experimental testing indicate that people can both understand and utilize animated graphics. Perceptually, human vision is "hardwired" with special sensors to detect motion (Gregory 1998). Motion, such as that exhibited by the shifting vegetation patterns in Africa, is a powerful visual cue that allows us to identify objects as separate from background and to create perceptual groupings of objects. It stands to reason that because we live and function in a dynamic world, we have the required perceptual and cognitive abilities needed to understand dynamic maps. So what evidence exists to support this belief?

The Conceptual Congruence Hypothesis states that static graphics such as maps should be effective in conveying concepts that are literally or metaphorically spatial, and animated graphics should be effective in conveying concepts that are dynamic (Morrison 2000). In other words, the concept of change is *more cognitively congruent* with an animated map than it is with a static map or a textual description. This sentiment is shared by Blok et al. (1999, p. 140) who state, "In animation, a direct link can be made between the changes of characteristics in world time and their representation in display time…animated mapping thus allows a person to see the data in a *spatial* as well as a *temporal* context." Experimental evidence exists that teaching information about motion (e.g., Newton's laws of motion) with animation leads to better performance than teaching the same information with text or static graphics (Rieber 1990, Hays 1996). Evidence also exists that animation results in better performance on memory-recall tasks as compared to learning from static graphics (Rieber 1990). Animated graphics thus seem better able to communicate concepts of motion and change than static graphics.

"Animated graphics thus seem better able to communicate concepts of motion and change than static graphics."

Within cartography, the effectiveness of animated maps has been demonstrated by Patton and Cammack (1996) who found that sequenced choropleth maps resulted in better map-reading performance among non-experts than traditional static maps, in terms of both speed and accuracy on skill-testing questions. Koussoulakou and Kraak (1992) found that animated maps resulted in faster response times to questions than did static maps, but only when the users could control the animation. These results were supported by Monmonier and Gluck (1994) who noted that viewers are often frustrated by complex changing maps that they cannot control, with the map proceeding too slowly for some tasks and too quickly for others. This frustration has lead most cartographers to recognize the need for some form of user control including at least stop, start, and temporal navigation controls. VoxelViewer incorporates these basic navigational controls in addition to innovative temporal and spatial filtering mechanisms. Interactive animated maps draw viewers "into the map" and allow them to become active participants in the display of the information rather than merely passive observers. It has been demonstrated that animated maps "enhanced" with innovative temporal and spatial controls can lead to more detailed understandings, but only if the participants know *how* and *when* to use those tools (Evans 1997, Harrower et al. 2000). The potential power of animated maps lies in their ability to represent change over time and thus facilitate an understanding of process rather than state.

"The potential power of animated maps lies in their ability to represent change over time and thus facilitate an understanding of process rather than state."

CONCLUSIONS

Change detection is an important area of research relevant to many geographic fields. Current change detection techniques that stress the *outcomes* of change rather than the *process itself* make representing the complex and dynamic behavior of geographic entities difficult. Animation is a tool that is well-suited to representing dynamic phenomena. Animation used as an exploratory geovisualization tool allows users to analyze their data in a qualitative (visual) manner and potentially generate new insights related to motion and space-time patterns. However, animation by itself is insufficient for the task of change detection as the sheer size and complexity of raw satellite imagery would most likely overwhelm the perceptual abilities of the user with random and short-term fluctuations. Tools that allow users to "filter out the noise" are needed. This paper has presented a geovisualization system that can adjust the temporal and spatial resolution of satellite data and perform this data filtering. This system can also be used to determine the optimal spatial and temporal resolution for a given phenomena, region or data set.

REFERENCES

Anyamba, A. and J. R. Eastman. 1996. Inter-annual variability of NDVI over Africa and its relation to El Nino/Southern Oscillation. *International Journal of Remote Sensing*, 17:2533-2548.

Batista, G. T., Y. E. Shimabukuro, and W. T. Lawrence. 1997. The long-term monitoring of vegetation cover in the Amazonian region of northern Brazil using NOAA-AVHRR data. *International Journal of Remote Sensing*, 18:3195-3210.

Blok, C., B. Kobben, T. Cheng, and A. A. Kuterema. 1999. "Visualization of relationships between spatial patterns in time by cartographic animation." *Cartography and Geographic Information Systems* 26(2):139-151.

Carleton, A. M. and M. O'Neal. 1995. Satellite-derived surface climate 'signal' for the Midwest U.S.A. *International Journal of Remote Sensing*, 16:3195-3202.

Collins, J. B. and C. E. Woodcock. 1996. An assessment of several linear change detection techniques for mapping forest mortality using multitemporal Landsat TM data. *Remote Sensing and Environment*, 56:66-77.

DiBiase, D. 1990. Visualization in the Earth Sciences. *Earth and Mineral Sciences* 59(2).

Edsall, R. M., M.-J. Kraak, A. M. MacEachren, and D. J. Peuquet. 1997. Assessing the effectiveness of temporal legends in environmental visualization. *GIS/LIS '97 Cincinnati*, October 28-30, p. 677-685.

Edsall, R. M. 1999. The Dynamic Parallel Coordinate Plot: Visualizing Multivariate Geographic Data. *Proceedings of the 19th International Cartographic Conference*, August 14 – 21, 1999, Ottawa, Canada.

Ehrlich, D. and E. F. Lambin. 1996. Broad scale land-cover classification and inter-annual climatic variability. *International Journal of Remote Sensing*, 17:845-862.

Evans, B. J. 1997. Dynamic display of spatial data-reliability: does it benefit the map user? *Computers and Geosciences* 24(1):1-14.

Gahegan, M. N. 1996. Visualisation strategies for exploratory spatial analysis. Paper presented at *Third International Conference on GIS and Environmental Modeling*, January 21 to January 25, 1996, Santa Fe, New Mexico. http://www.ncgia.ucsb.edu/conf/SANTA_FE_CDROM/sf_papers/gahegan_mark/gahegan.html

Gahegan, M. N. 2000. Tools to support the visual exploration of relationships in geographic data. Paper presented at *Annual Meeting of the Association of American Geographers*, March 2000, Pittsburgh, Pennsylvania.

Gahegan, M. Wachowicz, M. Harrower and T-M. Rhyne. 2001. The Integration of Geographic Visualization with Knowledge Discovery in Databases and Geocomputation. *Cartography and Geographic Information Science*, 28(1):29-44.

Graf, W. L. and P. Gober 1992. "Movements, Cycles, and Systems." In Abler, Marcus, and Olson (Eds.), *Geography's Inner Worlds*, New Jersey: Rutgers University Press. p. 234-254.

Gregory, R. L. 1998. *Eye and Brain: The Psychology of Seeing* (5^{th} ed.). Oxford, U.K.: Oxford University Press.

Harrower, M., A. M. MacEachren, and A. Griffin. 2000. Developing a Geographic Visualization Tool to Support Earth Science Learning, *Cartography and Geographic Information Science*, 27 (4):279-293.

Hays, T. A. 1996. Spatial abilities and the effects of computer animation on short-term and long-term comprehension. *Journal of Educational Computing Research*, 14:139-155.

Hearnshaw, H. M. and D. J. Unwin. 1994. *Visualization in Geographical Information Systems.* Wiley: Chichester, England.

Horsnby, K. and M. Egenhofer. 2000. Identity-based change: a foundation for spatio-temporal knowledge representation. *International Journal of Geographical Information Science,* 14(3):207-224.

Jenson, J. R., D. Cowen, S. Narumalani, and J. Halls. 1997. Principles of change detection using digital remote sensor data. In Star, Estes and McGwire (Eds.) *Integration of Geographic Information Systems and Remote Sensing*, Cambridge: Cambridge University Press. p. 37-54.

Koussoulakou, A. and M.-J. Kraak. 1992. Spatiotemporal maps and cartographic communication. *Cartographic Journal,* 29(2):101-108.

Kraak, M.-J. and A. MacEachren. 1994. Visualization of spatial data's temporal component. *Proceedings of the 17^{th} International Symposium on Spatial Data Handling*, Sept. 5-9, 1994, Edinborough, Scotland.

Liu, W. T. and F. N. Kogan. 1996. Monitoring regional drought using the Vegetation Condition Index. *International Journal of Remote Sensing*, 17:2761-2782.

MacLeod, R. D. and R. G. Congalton. 1998. A quantitative comparison of change-detection algorithms for monitoring eelgrass from remotely sensed data. *Photogrammetry and Remote Sensing*, 64(3):207-216.

MacEachren, A. M., B. P. Buttenfield, J. B. Campbell, D. W. DiBiase, and M. Monmonier. 1992. Visualization. In Abler, Marcus, and Olson (Eds.) *Geography's Inner Worlds*. NJ: Rutgers University Press, p. 99-137

MacEachren, A. M. 1995. *How Maps Work: Representation, Visualization and Design*. New York: Guilford Press.

MacEachren, Alan M., Francis P. Boscoe, Daniel Haug, Linda W. Pickle. 1998. Geographic Visualization: Designing manipulable maps for exploring temporally varying georeferenced statistics. *Proceedings of the IEEE*

Information Visualization Symposium, Research Triangle Park, NC, October 19 – 20, 1998, pp. 87-94

MacEachren, A. M. and M.-J. Kraak. 2001. Research Challenges in Geovisualization. *Cartography and Geographic Information Science*, 28(1):1-11.

Mas, J.-F. 1999. Monitoring land-cover changes: a comparison of change detection techniques. *International Journal of Remote Sensing*, 20(1):139-152

Meisner, R. E., M. Bittner, and S. W. Dech. 1999. Computer animation of remote sensing-based time series data sets. *IEEE Transactions on Geoscience and Remote Sensing*, 37(2):1100-1106.

Monmonier, M. 1990. Strategies for the visualization of geographic time-series data. *Cartographica* 27(1):30-45.

Monmonier, M. and M. Gluck. 1994. Focus groups for design improvement in dynamic cartography. *Cartography and Geographic Information Systems* 21(1):37-47.

Morrison, J. B. 2000. *Does animation facilitate learning? An evaluation of the congruence and equivalence hypotheses*. Doctoral Dissertation, Department of Psychology, Stanford University. 161pp.

Openshaw, S., D. Waugh, and A. Cross. 1994. "Some ideas about the use of map animation as a spatial analysis tool." In Hilary M. Hearnshaw and David J. Unwin (Eds.) *Visualization in Geographic Information Systems*, Wiley: New York. p. 131-138.

Patton, D. K. and R. G. Cammack. 1996. An examination of the effects of task type and map complexity on sequenced and static choropleth maps. In Wood and Keller (Eds.) *Cartographic Design: Theoretical and Practical Perspectives*. New York: John Wiley and Sons. p. 237-252.

Rieber, L. P. 1990. Using computer animated graphics with science instructions with children. *Journal of Educational Psychology*, 82:135-140.

Slocum, T. A. and S. L. Egbert. 1993. Knowledge acquisition from choropleth maps. *Cartography and Geographic Information Systems,* 20(2):83-95.

Sunar, F. 1998. An analysis of changes in a multi-date data set: a case study in the Ikitelli area, Istanbul, Turkey. *International Journal of Remote Sensing*, 19(2):225-235.

Yang, W., L. Yang, and J. W. Merchant. 1997. An assessment of AVHRR/NDVI ecoclimatological relationships in Nebraska, U.S.A. *International Journal of Remote Sensing*, 18:2161-2180.

Yattaw, Nancy J. 1999. Conceptualizing space and time: a classification of geographic movement. *Cartography and Geographic Information Science* 26(2):85-98.

cartographic techniques

Creating TrueType Fonts For Use As Symbols in ArcGIS™

Jaynya W. Richards
Cartography and Symbology Product Specialist
Environmental Systems Research Institute, Inc.
380 New York St
Redlands CA, 92373
Phone: (909) 793-2853
Fax: (909) 307-3067
E-mail: jrichards@esri.com

Introduction

Most organizations need to use iconic symbols of some sort in their documents and maps. These icons may be a widely used standard like the Visa or MasterCard symbols or something custom like an organization's logo. Using these symbols in documents and presentations has often been a problem because the only way to do so was to scan the symbol and use it as a bitmap. Bitmap images offer a trade-off, quality at the expense of performance. For presentations bitmap images are particularly bad because they are often displayed at large sizes and are usually perceived to be of low quality. It is also difficult to publish documents that contain bitmaps due to large file sizes or incompatibilities in the bitmap formats.

In late 1995 ESRI began supporting TrueType fonts as an option for the source for artwork in symbols. By 1997 ESRI had replaced all its bitmap images with TrueType font based symbols in its ArcView product line and had added full support for TrueType fonts in the ArcInfo product line. This was a popular idea as MapInfo Corporation, Caliper Corporation, and Intergraph Corporation also added support for TrueType fonts at or around that same time. The main reason for this migration was to afford mapmakers a higher quality option that was considerably more efficient to work with.

Today ESRI has a large library of standard symbols that are based on TrueType fonts. However, despite this plentitude of symbols, cartographers always seem to want more or slightly different symbols. This article will introduce many of the concepts that pertain to TrueType fonts and the necessary knowledge to create or edit TrueType fonts so they will work with ESRI's ArcGIS products. While that is obviously a product specific direction, the concepts and many of the specific settings will apply to any software that uses TrueType fonts.

Advantages of Symbols that use TrueType Fonts

TrueType fonts as the basis for symbols on a map offer some distinct advantages to cartographers. However, it would be good to note that these advantages really apply to all vector based fonts, for example, OpenType and PostScript fonts. The following are the main advantages to using TrueType fonts as symbols on maps:

1. TrueType fonts are easy to use. Once installed, a TrueType font is accessible to all software applications.
2. Using TrueType fonts generally results in smaller document sizes. Using a TrueType symbol will increase the file size of your document by just a small number of bytes. This is because nothing that is already in the font is redundantly stored in the document. Conversely symbols that are based on bitmap images often require at least one copy of the bitmap to be stored in the document. Some GIS or map making software packages permit symbols to reference external files, but distributing the document file that references these other files can be a frustrating experience.
3. TrueType fonts can be embedded in digitally published documents. As mentioned above, typically GIS and mapping software packages merely reference which characters to use. While efficient, this is not always an effective way to distribute a document because others may not have the same TrueType font available on their computer. Rather than having the software on somebody else's computer substituting another font, a font can be embedded in the document with only a small file size penalty (usually about 100Kb). Embedding can take several forms. ESRI's ArcMap™ application supports embedding in the form of the creation of a PostScript Type 3 font within its EPS (Encapsulated PostScript) and PDF (Portable Document Format) export formats. Only the characters that are actually used get embedded.
4. The graphical quality of a glyph in a TrueType font can be of very high quality. TrueType fonts typically store vector outlines, including parametric definitions for curves that can be scaled to any size with no loss of quality. TrueType fonts also afford the ability to be displayed at any device resolution, i.e., a computer screen or a high-resolution printer with optimal quality. Symbols based on bitmap images cannot scale or adapt to multiple resolutions.
5. Using TrueType fonts often results in work getting done faster. TrueType fonts are handled more efficiently by the operating system for display and output purposes.

A Brief Anatomy of a Font

The definitions of terms and

properties that follow apply to all formats of fonts, not just TrueType.

- Font Family: A font family is a group of fonts that resemble one another, and are visually compatible. One member of the family may be italic, another other bold, another bold and italic, etc. Examples of font family names include Helvetica, New Century Schoolbook, and Times New Roman. Font family names are not restricted to Latin characters. Font families may be grouped into different categories: those with or without serifs, those whose characters are or are not proportionally spaced, those that resemble handwriting, those that are fantasy fonts, etc.
- Typeface or Font: A visually consistent set of characters or glyphs. A font or typeface includes characteristics of style. Typically a font's name includes the family name and the style, for example, Helvetica Bold.
- Font Style: The font style specifies whether the font is normal, bold, italic, etc.
- Font Variant: The font variant indicates whether the font contains normal upper and lower case characters or whether it contains small-caps characters.
- Font Weight: The font weight refers to the boldness or lightness of a font's glyphs.
- Font Size: The font size refers to the size of the font in point units. 72 points equals one standard inch.
- Font Menu Name: This is the name used to access a font in a software application. In the case of Souvenir ™, the Menu Name is the same for all weights of the Font.
- Glyph: A glyph is an individual character within a font.
- Type Spacing: Type is defined by the space around it, whether between letters, words, or lines. Commercially printed text and all the modern digital type used on computers are designed to be spaced proportionally. With proportional spacing, each letter is given just the amount of space it needs to look right and be most legible. Using a proportional font, you can fit much more text on a page than using a fixed-pitch font and improve readability.
- Leading: Leading is the distance between lines of type and is measured in points. During the days of metal type, printers inserted extra strips of lead between long lines of text to make them easier to read. That procedure gave rise to the term "leading."
- Resolution: Characters in TrueType fonts are defined as resolution independent outlines. However, resolution becomes relevant when the image is output to either the screen or a printer at which time the operating system will create the image at the resolution level of the output device. Therefore if you are using a 600 dpi printer the resolution of your character will be 600 dpi.

Creating TrueType Fonts for use with ESRI's ArcGIS Software

TrueType fonts are primarily created using special software packages specifically created for building typefaces. There are several good font editing software packages commercially available. Of these, ESRI uses FontLab by Pyrus North America Ltd. to create its TrueType fonts. FontLab has a relatively easy learning curve while remaining a powerful typography tool.

To create TrueType fonts for use with ESRI's ArcGIS software use these recommended internal font settings:

1. Internal font settings when saving a TrueType font:
   a. Family Name does not begin with the letter "A".
   b. Family Name must match the Menu name.
   c. Family Name cannot conflict with existing installed font names.
   d. Font UPM setting is 1000
   e. Alignment is set to local zones
   f. Set PANOSE Family Kind to Latin Text
   g. IBM identification is set to "No Classification"
   h. Supported Code pages is set to 1252 Latin 1, Character Set to ANSI
   i. All Embedding allowed (for exportability)
2. It is important to use the following ASCII ranges with ESRI's ArcGIS software products: ASCII 33-125, 161-172, 174, 176-180, 182, 184-255.
3. Most TrueType fonts created for use as marker symbols in ESRI's ArcGIS products follow a "symbol" font design. This means the individual characters are not intended to be used in a text document as text, dingbats, or bullets.

Creating glyphs that are intended to overlay in specific ways

The following example will be specific to ESRI's ArcMap software. Unfortunately this example

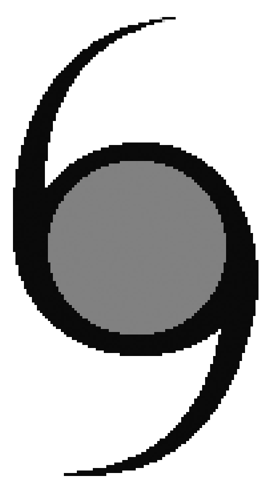


Figure 1

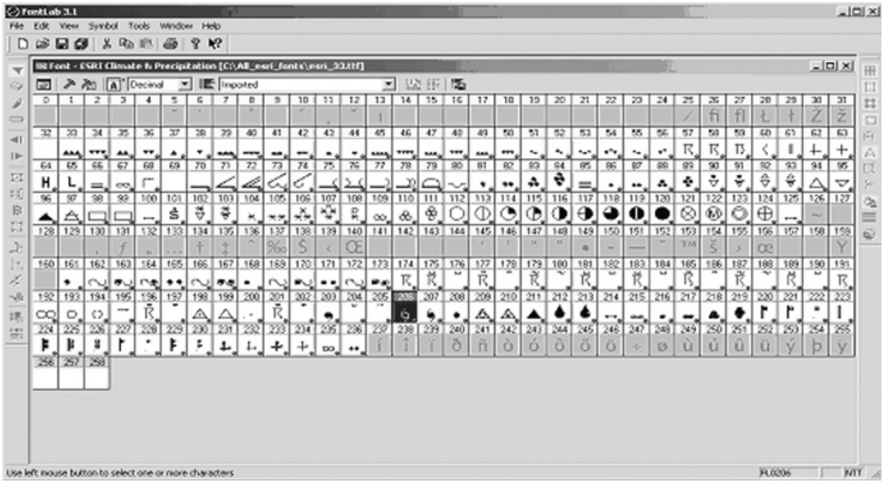


Figure 2

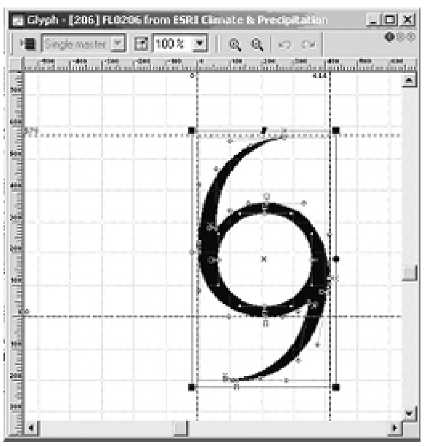


Figure 3

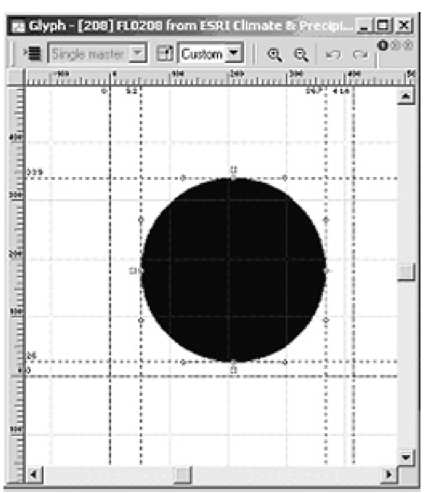


Figure 4

cannot be guaranteed to apply to other software packages, including ArcView GIS and workstation ArcInfo because the settings or metrics that control the positioning of font glyphs can be interpreted and used in several ways.

This example will show how to create two glyphs that will overlay to form a symbol is that used to represent a typhoon or tropical storm (Figure 1). In this case the glyphs are already included in the ESRI font called ESRI Climate & Precipitation (esri_155.ttf). Figure 2 shows what the FontLab application looks like with the ESRI Climate & Precipitation font loaded. The entire contents, all the glyphs, are shown here. The two glyphs that will be used in this example are numbers 206 and 208 (Figures 3 and 4).

Each glyph can be shown in a window that shows the size of the glyph in font units. Notice the baseline extent (distance from lower-left to lower-right) for both glyphs is 414. This is an important dimension for glyphs that are intended to align when overlaid because by keeping each glyph's extent the same you can create artwork in the font creation software that is relative to the centroid (denoted by the "x") allowing it to align when used in ArcMap. If the baseline extent is different, the centroids will not overlap, causing the glyphs to have different centers of rotation.

In order to compare the actual glyph alignment, it is often helpful to select, copy and paste one glyph into another glyph's pattern cell and align the glyphs to check their relative size and fit.

Summary

Hopefully this article has shown that TrueType fonts are a good means for storing artwork for symbols, while affording excellent document publishing and management options. Also, creating and editing TrueType fonts is a task that any cartographer with a modest background in graphics software can readily learn to do. Finally, for more in-depth information, www.truetype.demon.co.uk provides an excellent set of resources for TrueType fonts.

Bibliography

Phillip B. Meggs, *A History of Graphic Design*, Van Nostrand Reinhold, New York, 1983.

Hal Hinderliter, Seybold Seminars 2000, *Fighting Over Fonts*, www.Impresse.com

www.macromedia.com/support/fontographer/ Choose Support and Training, then Fontographer Support Center, Top Tech Notes, and finally in the Tutorial section number 12319.

www.pyrus.com/html/fontlab.html

online mapping

Online Mapping and Critical GIS

Jeremy W. Crampton
Georgia State University

I was recently considering the ques-tion of why we make maps. Or, if you're not actually a prac-ticing car-tographer, why other people think it's worthwhile to make maps and visualize data.[1] Surprising as it may seem, cartography textbooks devote little or no attention to this fundamental question. There is plenty of discussion of *how* to make good maps, and the different types of maps that one could use, such as isarithmic or choroplethic, and what factors to consider, such as scale, projection, or data classification. But these discussions already tend to assume that it is worthwhile to make maps in the first place. Why?

On the face of it this is a strange question—after all the first recorded map dates back nearly 5,000 years and no less an authority than Brian Harley has stated that maps may be more fundamental than writing. And it's true that the textbooks are not completely silent. Some textbooks, especially those that emphasize cartography as visualization—such as Terry Slocum's book (Slocum, 1999, a 2nd edition forthcoming), suggest that maps and scientific graphics help us make sense of numbers. This should easily be apparent to anyone who cares to compare the Atlanta Yellow Pages with a map of businesses in the Atlanta MSA. It will be the map that tells you—at a glance—that businesses agglomerate in the downtown area, the Midtown and Buckhead areas, with scattered centers such as Little Five Points, Virginia Highlands and all the edge cities that make up the Atlanta sprawl. The fact that businesses form clusters is something we might already know from economic geography, but precisely *where* they cluster in Atlanta, how big they are and how they relate to each other, can be quickly seen from the map—or from years of living in Atlanta. (To make it more interesting, you could compare the Gay Yellow Pages or the Korean Yellow Pages to show up Midtown and Buford Highway.)

So why do we want to understand the numbers and the patterns? Just for the sake of it? Perhaps I shouldn't ask a group of professional cartographers this question, but nevertheless how many people in this country come home from work and study maps? No, when we take up a map we do so in the context of an enquiry such as to find alternative routes to work that "beat the traffic" or find out where someone lives. For statistical or thematic mapping the reason is even stronger. I always tell my students that there's no point making a map that has no point…and after the puzzled look is erased they usually look a bit concerned because aren't maps supposed to be neutral? (This is one of the great contradictions of teach-ing cartography: students often come up with excellent topics such as the spread of AIDS or firearm deaths but then seem afraid to tell it powerfully.)

So the question "why make maps" and the answer that it presents numbers clearly is misconceived. The question is really why do we *use* maps?

Here we are on much clearer ground. If we look at why people use maps (rather than tables) it's not because they present the numbers clearly (as the textbooks say) but rather to make decisions and to put decisions into effect. And this has been the case right from the beginning of modern thematic cartography. In other words, thematic maps are inherently a political process. (For my current purposes I will ignore general reference maps although they too are carried out for political reasons.)

A brief look at the history of thematic mapping highlights this point. Thematic maps emerged in the late 18th and early 19th centuries in Europe. France in particular can lay claim to a number of firsts. A French baron, for example, invented the choropleth map in 1826. His name was Charles Dupin (1784–1873) and he already knew the power of "speaking to the eyes" as he put it. Dupin was a member of the Académie des Sciences and later a politician as well as Inspector General of the Génie Maritime. Dupin's choropleth showed the ratio of educated (male) children to the population at large by *département* or region. In fact it was one of the first maps of "moral statistics" which addressed numerous characteristics of populations, such as birth and death rates, crime, early marriages, rapes, houses of ill–repute, attempts to hide abortions and so on. Forty years later Henry Mayhew would make a similar series of maps for England and Wales in his famous book *London labour and the London poor* (4 vols., 1861–2).

Moral statistics were collected, processed and mapped in order to govern the country. In this light it is worth recalling that the origin of the word "statistics" derives from the German *Statistik* or "state–istics". Dupin's goal in making the map was to relate the education of the population to the prosperity and wealth of France—a direct linkage between the health of the population and the health of the state. This link was nuanced by location to such a degree that Dupin's map was instrumental in a discourse of "la France obscure" and "la France éclairée" (unenlightened and enlightened regions of the country). From the start, the modern choropleth map was essential to the state's efforts to evaluate and manage its resources and how these varied across its territory. Statistics, and their graphical depiction in maps, were essential aspects in the state's control and regulation of its population.

Dupin's maps were soon followed by those of D'Angeville (health and wealth choropleths, 1836), Balbi and Guerry (first multivariate crime maps, 1829), Minard (economic maps and great advocate of the study of political economy, whose map of Napoleon's march on Moscow was made famous by Tufte), and the Belgian statistician Adolphe Quetelet, on topics such as education, crime, cholera and disease, the production and transport of goods, sanitation and many other aspects of living conditions (Konvitz, 1987, Robinson, 1967, 1982). At the same time August Comte invented the term "sociology" Quetelet's proselytizing efforts on behalf of statistical science ensured that it would be founded on the idea that social facts are always statistical in nature.

Thematic mapping then was developed not by cartographers, but by social scientists and engineers on behalf of government for political reasons. And there's no doubt, in my opinion, that the same reason applies today: maps are made and used for decision–making and policy formation at many levels from the nation to the business to the individual.

This brings me to online community mapping and "critical GIS." Critical GIS is an emerging field perhaps best thought of as an outgrowth or component of the "GIS and society" debates that were hot in the 1990s (Schuurman, 2000). Critical GIS acknowledges the place of politics in mapping (and, if you excuse the pun, the politics of place in mapping). Critical GIS is not an effort to *insert* politics in cartography and GIS, but to say that mapping is essentially in itself a political act or practice. So critical GIS is not ideological in the same way that propaganda mapping is.

If it seems odd to emphasize the political in mapping, I would argue that there is a far greater danger in failing to do so. When enquiry is not pursued politically it will fail politically. A story about a suburban county near Atlanta illustrates this point. The county school board recently decided to put a disclaimer in their school biology textbooks that states "evolution is a theory, not a fact." No other scientific theories in the science books were similarly highlighted—not even more controversial ones. The move followed a petition signed by 2,000 people, mostly Christian fundamentalists (Griffis, 2002). Science has clearly failed here—but it didn't fail scientifically (evolution is one of the best–proved scientific theories we have) it failed politically. The scientific community should be leading the public debate on this issue, not reacting to it.

It's the same in the mapping community (i.e., cartography and GIS). Maps are already used politically, whether it be for redistricting, enacting the census, risk assessment and inventorying in the face of threats, or making choropleth maps of your population's health in order to govern better. The question is, what kind of political debate and policy goals do we *want* to construct with mapping? Maps are never an end in themselves but are part of our political existence (whether at the national level or the personal level; what is called the "politics of the self"). Online community mapping of the type covered in this column is one example of this. In future columns we will examine more examples of community mapping carried out online.

References

Griffis, K. 2000. Intelligent design? *Creative Loafing*, May 22–28, pp. 35–39.

Konvitz, J.W. 1987. *Cartography in France 1660–1848, Science, Engineering, and Statecraft*. Chicago: University of Chicago Press.

Robinson, A.H. 1982. *Early Thematic Mapping in the History of Cartography*. Chicago: University of Chicago Press.

Schuurman, N. 2000. Trouble in the heartland: GIS and its critics in the 1990s. *Progress in Human Geography*, 24(4), pp. 569–590.

Slocum, T. 1999. *Thematic Cartography and Visualization*. Saddle River, NJ: Prentice–Hall.

[1] Lecture "Why Visualize" given at the Center for Spatially Integrated Social Science (CSISS) workshop on Map Making and Visualization, Santa Barbara, July 2002.

map library bulletin board

University of Colorado at Boulder Map Library

Elisabeth Filar Williams
Map & GIS Librarian

Jerry Crail Johnson Earth Sciences and Map Library
University Libraries 184 UCB
University of Colorado at Boulder
Boulder, CO 80309-0184
303-492-7578
maplib@colorado.edu
http://www-libraries.colorado.edu/ps/map/frontpage.htm

Introduction/Overview

The 11,000 square foot Jerry Crail Johnson Earth Sciences and Map Library is an external branch at the University of Colorado at Boulder (CU) library system. The largest academic and research library in the state of Colorado, CU is also part of the Association of Research Libraries, which is reflected in the university's library holdings. The CU University Libraries consist of a main branch, Norlin, and five specialized branches. The Map Library is a unit on the basement level of the Jerry Crail Johnson Earth Sciences and Map Library, located in the Benson Earth Sciences building. The Benson Earth Sciences building also houses the departments of Geological Sciences and Environmental Studies.

The overall University Libraries' mission is to provide materials, information, and services, to serve as a research resource, and to share these resources as a leader in the national and international library community. The Map Library considers this its mission as well and strives to meet the needs of all its users.

History of the Map Collection

A map collection at CU has been in existence for several decades. CU is a regional depository for the Federal Depository Library Program (FDLP), a program created to allow better public access to United States federal government publications by creating depository libraries. These depository libraries receive materials free of charge and are required to provide access for these resources to the public. Due to this depository program, a map collection began before staff positions were created to manage the collection. The map collection has changed hands and departments over the years. It was a part of the Government Publications department and other divisions with a variety of staff in charge of the collection, usually in addition to their main library duties. For years, the collection – mostly uncataloged – was located in an isolated basement room with limited access in Norlin, the main library. Not only were users unaware of the collection, but it was also difficult to locate. They struggled to use it with little or no trained staff available. Finally, the map collection found a permanent home and staff in January of 1998.

When construction began for the new Earth Sciences Library, Suzanne Larsen, Head of the Earth Sciences Library and a member of the planning team, requested that the map collection find a permanent home with the new earth sciences library. At the same time a position was moved from elsewhere in the library system so that a Map Librarian could be hired to guide the collection. This change was a momentous step for the map collection. Now access would increase dramatically, qualified staff would be available, cataloging could begin to allow better remote access, and a collection development plan could be introduced. A full-time staff position, a Library Technician III, came with the map library to the new site. A half time Library Technician II from the Earth Sciences part of the library branch was shared with the Map Library. At a later date this position was reallocated to full time and more that one half of those hours were designated to the Map Library. Quickly the map collection use began to grow as new users discovered its vast resources. I started as the Map Librarian in August of 1999.

The Earth Sciences and Map Library is named in honor of Jerry Crail Johnson, one of the first women to graduate from Northwestern University with a degree in geology. A gift to the Earth Sciences Library by the Crail-Johnson Foundation was critical to the funding for the construction of the entire building. The Johnson family's deep appreciation for reading and literature and interest in the earth sciences, instilled by their mother, make this a perfect testimonial to her memory.

Map Library Collection

One important aspect to note about the CU Map Collection is that only about 35% is cataloged and searchable in Chinook, the Libraries' database of its resources. Though the University Libraries has a central cataloging department, map cataloging is done in-house in the Map Library. Due to the lack of permanent staff, very few items in the map collection were cataloged in the past. Over the past three years, a tremendous leap in the cataloging of maps at CU has occurred. With several qualified staff and students working hard in the Map Library, most CIA maps, USGS topographic maps, National Geographic Maps, historic urban plans and recently published government depository materials are now searchable in the library catalog. Retrospective cataloging is difficult when new acquisitions also arrive daily, yet the map library staff is driven to make its collection more accessible to all.

Maps

The map collection consists of over 200,000 maps, over 1,000 atlases and reference books, and a growing spatial data collection. The collection primarily consists of publications from United States federal mapping agencies. Some agencies that contribute maps are the U.S. Geological Survey (USGS), Bureau of Land Management, Central Intelligence Agency, U.S. Forest Service, and National Oceanic and Atmospheric Administration. The Map Library houses all current USGS 7.5 minute topographic map series, as well as the 1:100,000, 1:250,000, and several states' county map series. This also includes older editions (from the 1880s – 1960s) of USGS topographic and special mining maps and a set of historic Colorado plat maps. The collection also boasts a complete collection of USGS thematic series maps, a large set of topographic forest service maps, a wide selection of aeronautical charts and resources, a complete collection of current nautical charts, and current road maps for all parts of the world. A large collection of detailed World War II and Cold War era topographic maps of Europe, Russia, Asia and Africa produced by the Army Map Service/Defense Mapping Agency, are especially good for genea-logist's research. There are national and international geologic maps as well. The library has a set of 1:100' maps from the City of Boulder consisting of base, planimetric, water, and sewage type maps. A recent student project involved collecting detailed maps of cities and towns around the state to add to the collection. Historic reproductions of national and international cities have been collected. Now, detailed topographic mapping for other countries are being collected, such as for Britain, Ireland, Canada, Chile, and Mexico.

Monographs

The map collection covers a range of disciplines such as geography, geology, history, architecture, environmental studies, and recreation. There are no "stacks" in the map library; only atlases and reference materials relating to map reading, map projections, place names, geographic dictionaries, and similar resources. The Earth Science collection stacks are physi-cally located in the basement where the Map Library is housed. This collection's resources include the some of the same disciplines as above, as well as paleontology, oceanography, and mineralogy, and often these resources are used along with the map collection resources.

Digital

With the acquisition of a GIS/Map computer, which has a 21" Monitor, DVD/CD-ROM drive, RW CD-ROM drive, 100MB ZIP drive, and an HP 8"x11" or 11"x17" Color Printer, software and digital data collection began. USGS digital raster graphics (DRG) on CD-ROM are available for all of Colorado and for parts of other U.S. states. Digital Orthophotos (DOQ) on CD-ROM are also available for a few parts of U.S. states and soon for the Boulder/Denver region of Colorado. Digital topographic maps for Colo-rado, New Mexico, Arizona, Utah and Wyoming, are available via CD-ROM to view and print on the map library computer. Several pac-kaged GIS data CDs, mainly small scale, have also been added to the collection, as well as some geography department Colorado data and soon some geology department data. The computer is available for map, GIS, or library related usage.

Web site

The Map Library Web site is also considered a valuable resource, both in-house and for non-local patrons. Much of the information about the collection, policies, staff, and projects is located on the Web site. Also added is a "Local Resource" section with links to other CU library holding, other local libraries, and local map vendors. For fun, a Geography Trivia section is also on the Web site.

The key section of the Map Library Web site is "Web Resources." http://www.libraries.colorado.edu/ps/map/links/links.htm The web resources, or web links, are arranged in categories such as "aerial & satellite photos," "Colorado," "federal government resources," "GIS," "maps online (current)," "travel," etc. Once a user selects a category, a page of web links and descriptions are provided, arranged in either geographic or alphabetical order, depending on the category. As frustrating as searching the Web can be, there are incredible resources online. These resource links are used both in house and remotely to provide patrons with well-organized quality map-related Web sites.

Notable acquisitions

Recently the CU Geography De-part-ment offered the Map Library their air photo collection. After the map library donated the few non-Colorado series to other academic libraries, the collection now contains at least 20,000 Colorado air photos. The series are made up of various government agency projects dating anywhere from the 1930s – 1970s. The geography department hopes by having these available in the Map Library, the photos will be managed, made accessible, preserved, and used more frequently. A few series may be unique to this library so preservation and access is key. A few of these sets have been indexed in a variety of ways. An overall consistent way to access the collection is lacking, therefore it is the map library's goal to make these air photos accessible to all. (See Digital Projects for more information)

Collection development

Trying to build a good collection in only a few years is a difficult task. Since most of the focus and the most heavily used resources are local in scope, there is the constant need to acquire the most current resources year after year. In addition, a more current international collection is necessary to support the research of CU's faculty. Requests from patrons, mainly graduate students, professors, and researchers are taken seriously, and purchases have been made because of specific requests.

Circulation

Since maps are a specialized

format, not as easily handled as books, the CU Map Library has is own circulation desk. Though a small branch, with the Earth Sciences Library circulation desk right upstairs, it was decided to have a separate desk for map circulation. Staff and students are trained to work with maps and patrons are given information on handling maps. Most maps circulate except for historic (pre-1950), fragile, or reference maps. Heavily used maps are kept as reference, such as the most recent edition of all USGS Colorado 7.5 minute topographic series. Patrons may check out up to 10 maps for a 2 week loan period. Renewals on maps are also an option. CD-ROMs that are not reference, primarily data CDs such as DRGs, can be checked out for 2 days, also with renewal options.

Admittance

In accordance with the mission of the University Libraries, anyone can visit the Map Library at CU. All materials are open to the public. Those wanting to check out materials must follow the University Libraries patron rules. Any current affiliate of the university (professor, student, etc.) has borrowing privileges. All other public patrons may request a library card only if they are over 18 years old and registered citizens of the state of Colorado.

Users

Most users of the Map Library are students and professors from mapping related fields such as geography, geology, environmental studies, and architecture. The library also sees patrons from disciplines such as, history, anthropology, business, engineering, and other earth science related fields. Every semester orientations to graduate students in Geography and Geology are given. Throughout the semester, many classes visit the map library for an overview of its resources and some stay for a class session, such as an introduction to topographic maps, an overview of GIS and digital data, or even to view and analyze the air photos.

Public users range from CU affiliates, such as from the Institute of Arctic and Alpine Research (INSTAAR) and researchers from private companies and government agencies such as USGS Denver, BLM, etc., to genealogists, Boulder high school students, and other interested users. Many people from around the state of Colorado use these resources when they are in the area, since CU has the largest academic research collection in the state.

Digital Projects

The Colorado air photo project is the main digital project the Map Library is pursuing currently. The goal is to first create a digital index of the entire air photo collection and then scan the collection of air photos. The photos will then be checked out on CD-ROM and/or available online.

Using ESRI's ArcView 3.2, with a Landsat 3-meter resolution image, 1:100,000 DRGs for densely populated areas, and other overlays, shapefiles are being generated for each photo series with an extensive metadata table. The table consists of such fields as landmark, latitude/longitude, date, series number, image condition, county, etc. The objective is to allow patrons to access the collection spatially by clicking a point or boxing a section of the image, or by querying the various fields in the metadata table. The ArcView project can be both used in the library to access the collection and eventually online (hopefully as an ArcIMS server), which will both serve the index online as well as provide the capability to view and download the photos. The library is actively pursing grants to fund labor for the indexing and scanning, as well as buying equipment to scan and serve this project to all.

General Information

The Jerry Crail Johnson Earth Sciences and Map Library is located on the University of Colorado, Boulder campus, to the south of Colorado Avenue across from Folsom Field and at approximately 40° 0' 29" N, 105° 15' 55" W, SE 1/4, Section 31, T1N, R70W. Take a virtual tour: http://www-libraries.colorado.edu/ps/map/vtour/vtour.htm

Reference services are available from trained students at all times, or from staff Monday-Friday 8am-5pm.

The Huxley Map Library Western Washington University

Janet R. Collins
Map Librarian

Huxley College of the Environment
Western Washington University
Bellingham, WA 98225
360-650-3272
jcollins@wwu.edu
http://www.ac.wwu.edu/~maplib

The Huxley Map Library is located in Arntzen Hall 101 on Western's campus. It is one of a handful of map collections in the United States that is administratively and physically separated from the main library. Hours are Monday-Friday from 9-4, Tuesday and Thursday from 9-1, and Wednesday from 6-8. Summer session hours are limited to Monday-Friday from 9-1 as staffing is very limited. During intersessions, the facility is closed. Parking is available by permit from the Visitor Information Center. Please refer to the WWU home page for additional information.

The url is: http://www.wwu.edu

Western Washington University has an enrollment of approximately 12,000 students and offers Bachelor's and Master's degrees in a wide variety of disciplines. The University was initially established as a Normal School, then became a College of Education, then Western Washington State College, and then finally, as a regional University in the 1970s.

The Map Library was established in 1957 within the Department of Geography, in large part due to faculty efforts and the distribution of maps by the Army Map Service. The first Map Curator of the facility, Kathleen Brennan was hired in 1968. Patricia Mayo Simpson, the second Map Curator, was hired in 1971. Depository agreements were established in the 1960's and 1970's with a number of government agencies. The third Map Curator, Dan Turbeville, was hired in 1974. Just prior to his hiring, Gene Hoerauf, then Staff Cartographer, was responsible for the transfer of the collections from "Old Main" into its current location into the then new Arntzen Hall. The first floor location was designed specifically for the Map Library and includes 4200 square feet. Janet Collins was hired as the fourth Map Curator in 1977, and at that time, the collection size included 110,000 map sheets and approximately 200 atlases. In 1992, the Geography Department was administratively transferred from the College of Arts and Sciences into Huxley College of Environmental Studies, where it resides today.

Huxley College has offered an interdisciplinary approach to Environmental Studies since 1970. Specialty areas include Policy, Planning, Education, Geography, Aquatic and Terrestrial Ecology, Chemistry, Toxicology, and Watershed Studies.

The Map Library exists primarily because of the Federal Depository Library Program. We are currently a depository for the U.S. Geological Survey (USGS), National Imagery and Mapping Agency (NIMA), NOAA-National Ocean Service (NOS), Natural Resources Canada-Canada Map Office (NRCan), and the Washington State Department of Natural Resources-Division of Geology (DNR).

Map Library collections include over 241,000 map sheets, 1,000 atlases, 35,000 aerial photographs, 225 cd-roms, and a small collection of globes, reference books, raised relief maps, and satellite imagery. Over ninety-five percent of the collections are post-1900. Historical maps of Whatcom County and surrounding areas are housed in the Center for Pacific Northwest Studies on campus.

The largest of the collections is the USGS collection, numbering over 125,000 maps sheets. Most of those sheets are topographic, however, over 5,000 sheets are geologic maps. The Canadian topographic collection numbers over 26,000 sheets. The Map Library also houses in excess of 12,000 nautical charts produced by NOS and NIMA with worldwide coverage. Like many other map collections throughout the United States, the Map Library benefited from the Army Map Service (AMS), distribution of maps. Most of our coverage at 1:250,000 throughout the world was produced by the AMS.

Our collection of cartographic digital data is growing and housed in two separate areas. Digital data that arrives through the Federal Depository Library Program is housed in the Map Library. Digital data of local and state areas resides downstairs in Arntzen Hall with Gene Hoerauf, Huxley GIS Coordinator and Spatial Analysis Lab Coordinator. Gene meets frequently with local and state folks to share project information and data. An additional GIS Specialist and GIS Faculty member have recently been hired. Huxley College offers a minor in GIS.

The Huxley Spatial Analysis Lab, located downstairs in Arntzen Hall, was funded by Student Technology Fees in 1997 and includes 22 workstations. Facilities also include an 11 x 17 color flatbed scanner, color laserjet printer, and a black & white printer. Each quarter, every WWU student's tuition includes $10 for Student Technology Fees, which are then made available via proposals submitted to University Administrative, Faculty and Student Committees. Instructors in Huxley College and the College of Arts and Sciences utilize the Spatial Analysis Lab for instruction in GIS, Remote Sensing, and Geology.

Perhaps the most valuable and unique collection in the Map Library is our aerial photography collection of Whatcom County. It includes coverage during each decade and dating back to 1943 and is used extensively by faculty and students, and off-campus patrons. We have older coverage of nearby counties and National Forests, but without the significant temporal component. We also house additional limited coverage of the remainder of the State of Washington.

There are very few map libraries in the United States, (less than one-half dozen I believe), that have received Canadian topographic maps on depository. Our depository status with Canada has been largely based on our proximity to the Canadian border (within 20 miles), and our Canadian-American Studies program. The Canadian depository status was due to the efforts of Dr. Robert Monahan, retired Geography Professor. Although the depository status has historically included full coverage of all scales for all of Canada, recent changes in the Canadian depository agreement have restricted U.S. depositories to 1:250,000 scale sheets, special map series, and maps produced for the

National Atlas of Canada. Due to our limited funding, it is unlikely that we will be able to maintain current coverage at 1:50,000 scale for much of Canada.

We also have a large raised relief model, on permanent loan, of the Mt. Baker area. The Mt. Baker area is approximately fifty-five miles east of Bellingham and is best known for its ski area, climbing, and scenic beauty. The model is five feet by six feet and has been recently restored. A new base and interpretive exhibit for the model have been developed with funding provided by a Geography alumnus.

Additional unique collections include WWU Geography master's theses and Environmental Impact Assessments (EIA's) completed by Huxley students.

The Map Library is the repository for cartographic information at WWU and services approximately 42 courses from across campus representing a wide variety of disciplines. In addition, the collection is open to everyone to use, and is used extensively by the local community. Most frequent off campus users include genealogists, consultants, historians, researchers, and government agencies. Handouts are available to assist with use of the collections. Circulation of cartographic materials is limited to classroom presentations. Photocopies are available for a small fee.

Map Library facilities include 4 IBM pc's, a power MAC, an 11 x 17 color flatbed scanner, an 8 1/2 x 14 color flatbed scanner, an HP color laserjet printer, CD tower server, and a wide variety of software packages. Most of the above were provided through Student Technology Fees. WWU holds site licenses, as part of a statewide consortium, for ESRI ArcView and ArcInfo. Light tables, drafting tables, and a Map-O-Graph are also available for patrons.

The budget for acquisitions is virtually non-existent and has required creative solutions to build the collection. Partial solutions have included participation in Library of Congress summer projects, solicitation of donations and maps from likely donors, acquisition of duplicates from other map collections, and purchase of supportive collection material through faculty grants.

A comprehensive collection development policy exists for the Map Library. Very little deselection is accomplished due to the staffing levels. Staffing consists of one full-time map librarian, and during the academic year, student workstudy assistants.

Cataloging of collections does not comply with Library of Congress MARC standards, but utilizes Microsoft Access for databases of holdings. As such, we do not contribute records to OCLC and our holdings are not represented in the Main Library's online catalog. Retrospective conversion of the old card catalog in the Map Library is still underway and will be for quite some time. We are currently working on linking the databases to our web page, and hope to have them available by fall quarter. Staffing, funding, software training, training of student assistants, and space considerations remain the most serious challenges. Like everyone else, we have endless projects.

We are looking forward to cooperative scanning projects with local government agencies and increasing the collection access and increasing the amount of information available through our web

The Map Collection at the University at Stony Brook

David Y. Allen

In many respects the map collection of the University at Stony Brook is typical for a medium-sized academic library. The collection has about 130,000 maps and 600 atlases. Coverage is worldwide in scope, but best for the United States. Our primary clientele is students and faculty at the university, and to a lesser extent the local community. A more detailed description of the collection can be found at our Web site at www.sunysb.edu/library/ldmaps.htm.

Like most map libraries in our situation, we are thinly staffed. There is only one librarian who devotes a sizable portion of his time to maps. The map collection is located in our science and engineering library, and the map librarian receives some backup from other staff in that area. Most of the checking in and filing of maps is done by student assistants. In spite of inadequate staffing, we have taken on some new services. In recent years we have been acquiring aerial photographs, and have moved cautiously into providing some GIS services.

The challenges we face are es-sentially those of running a regional resource. Although we have by far the strongest map collection on Long Island, we are located in a area with several large and distinguished map libraries--most notably the Map Division of the New York Public Library, which is located about fifty miles to our west.

Our collection does have some significant pockets of strength. Although the map collection has been in existence for only about thirty years, some twenty years ago we acquired a long-established collection from another branch of the State University of New York. This gave us a large number of maps of New York State, including many regional and town maps going back to the middle of the nineteenth century. We also inherited a huge nationwide collection of soil surveys. In a recent inventory I found that we have about 1400 soil survey maps antedating 1950.

In collection development we have attempted to build on existing strengths. We have purchased several rare or unique maps of New York, including a copy of Bleau's 1635 map of New Netherland, and a copy of David Burr's 1829 atlas of New York State. Recently we purchased on microfilm a complete set of Sanborn Fire Insurance maps for New York State.

I have found that there is a surprising amount that a library in our position can do to contribute to map librarianship on a statewide and to some extent a national level. Much of what we have accomplished has been done through cooperation with other libraries. Several years ago we played an important role in cooperative preservation projects for old New York State maps and atlases, and we are hoping to do something similar with our soil surveys and 15 minute maps.

We have also been engaged in the digitization of historical maps of New York State. This has been a pet project of mine, since I am interested in the history of cartography, and few of the maps in our collection date from before 1830. Our own digital images have been eclipsed by higher resolution work done elsewhere, and I am trying to take advantage of the work done by others by adding links and explanatory information to their images. As we improve our own capabilities for high-resolution digitization, we may return to the fray with more and better images of historical maps, and possibly of such materials as 15 minute maps and soil maps.

Only a portion of our map collection is cataloged. A by-product of many of my projects is a series of databases in EndNote format, most of which are only available in-house. These include a list of the New York State maps in our Special Collections Department, a list of our soil-surveys published prior to 1950, and a bibliography of New York State maps published prior to 1830. I hope to make at least some of these available on the Web using the Institute for Scientific Information's new product, Reference Web Poster.

book reviews

GIS and Health

Edited by Anthony Gatrell and Markku Löytönen. GISDATA 6. London: Taylor and Francis, 1998. xvii, 212 pp., maps, figures, tables, index. $75.00, hardcover (ISBN 0-7484-07790).

Reviewed by Russell S. Kirby, PhD, MS, FACE
University of Wisconsin-Madison

This book is a collection of essays that were the result of a symposium sponsored by the GISDATA scientific program of the Standing Committee of Social Sciences of the European Science Foundation, held near Helsinki, Finland, in 1996. The sixteen symposium participants were an international group, mostly European with some American participants. The editors have worked with the authors of each chapter to provide a series of essays that are both internally coherent and consistent with a monographic approach.

The primary goal of the book is to explore the opportunities for applying GIS technology and methodology to the domain of health (p. ix). To that end, the editors have structured the essays in two sections, the first dealing with methodological issues and the second describing a series of health applications for GIS. The editors contributed introductory and concluding chapters.

Methodological issues range from the philosophical and theoretical to the specific application of methods to problems in medical geography and spatial epidemiology. Jacquez, for example, chastises users of GIS for health research who adopt the "gee whiz" approach through the use of GIS to transform spatial data into thematic maps which are then utilized to develop hypotheses, preferring instead that the scientific method remain the basis for the development and testing of research hypotheses derived from GIS-based analyses of health concerns. Haining provides a brief discussion of the types of spatial statistical methods; this chapter is far too abbreviated to serve to do more than whet the appetite of the interested reader but the author does provide a useful set of references. Of all the chapters in this book, that by Kulldorff on statistical tests for randomness in spatial epidemiology is most able to stand on its own. Kulldorff reviews the voluminous literature on clustering of health events in space and time, classifies these into four general approaches, evaluates the strengths and weaknesses of each approach, identifies the most useful techniques, and discusses the methodological concerns that remain unresolved. In this reviewer's opinion, Kulldorff's chapter should replace the earlier reviews by Besag and Newell (1991) and Marshall (1991) as a resource for students and researchers seeking a comprehensive introduction to this subject.

Rushton's contribution focuses on methods for improving the spatial aspects of public health surveillance using GIS. Rushton's work will be familiar to many in public health through his summer courses and presentations at national public health meetings, but for others this chapter provides a useful overview of the application and relevance of his methodology. There is a major gap between knowledge and practice in the application of methods for spatial analysis and statistical mapping within the public health community, across the spectrum from local public health agencies to state and national administrative units. Rushton and Haining both note that existing GIS applications are insufficient for health research because they fail to bundle the necessary spatial statistical routines with the automated mapping capabilities. While there is evidence that major vendors are moving to remedy this deficiency, full integration will be hampered by the rapid evolution of biostatistical and spatial statistical methods.

The chapter by Collins focuses on methods for modeling spatial variation in air quality. This chapter is useful in that it describes several competing methodologies (dispersion modeling, kriging, hybrid methods, and spatial regression), identifies their strengths and weaknesses, and compares the statistical results of each using the same dataset. As noted earlier by Kulldorff, similar studies are needed to provide the information necessary to assess the statistical power and robustness of competing statistical methodologies for a number of issues in the fields of spatial epidemiology and medical geography. The final chapter in this section focuses on the opportunities for the analysis of time geography and health using GIS. Löytönen makes a convincing case for resurrecting a set of methods that had their heyday in the 1970s and early 1980s but have rarely been the focus of attention in the field of medical geography and are virtually unknown to epidemiologists and public health researchers. Inevitably, however, the brief chapter provided here serves only to scratch the surface and serious students will need to review the references and other sources.

The remainder of the book focuses on GIS health applications. While readers may find information of interest in the contributions by Trinca and by Braga et al., these chapters focus on describing applications rather than placing the contributions they describe in methodological perspective. López-Abente examines several approaches to the spatial analysis of cancer mortality, while van den Berg shows how population-based health data have been used for small area analysis and point-pattern analysis in western Pomerania. Teppo discusses opportunities for enhancing the analysis of cancer data with GIS, with examples from the Finnish experience. This chapter focuses primarily on data quality and epidemiological issues, rather than on methodological questions in spatial analysis or disease mapping.

Wilkinson et al. provide an overview of applications of GIS in public health. This chapter is limited in scope, and focuses more on environmental epidemiology than on the broader range of public health applications. Fortunately for American readers, the proceedings of the Third National Conference on GIS in Public Health (ATSDR 2000) and two issues of the Journal of Public Health Management and Practice devoted to GIS applications in public health (Richards et al. 1999) more than make up for this deficiency.

Methods for improving small area estimates of health needs through the use of registries or other population-based databases are discussed by Lovett et al. in the final substantive chapter. While American readers may be put off by the chapter's focus on data resources in the United Kingdom, the discussion is actually quite relevant irrespective of national context. Particularly useful are the sections outlining methods for calculating population estimates from patient databases and for applying census estimates to clinical contexts.

Clearly this book is not a comprehensive, all-in-one resource for the student of medical geography or the GIS trainee interested in health applications. However, the book does generally cover the broad range of approaches and methods for applying GIS to questions of health and disease and might serve as a supplemental text for a course in medical geography or as a resource for an advanced GIS seminar. Some critical comments are in order. First, in most chapters the references selected are somewhat limited in their connection to clinical research and population health. As a case in point, although Rushton's chapter is an excellent introduction to geographic approaches to mapping of public health indicators, a reader new to this subject is not directed to the literature on public health surveillance (e.g. Teutsch and Churchill 2000; Wilcox and Marks 1995). While the authors of many chapters are experienced in disease mapping or in environmental epidemiology, practical examples of public health applications are lacking. In the authors' defense, this may be because the real work of public health occurs on a day-to-day basis and rarely appears in peer-reviewed journal form. However, it would be interesting to integrate the concepts and methods discussed here into a public health practice text such as Dever (1997). Finally, this volume contains little material concerning the cartographic aspects of GIS and, therefore, should not be read by those seeking an introduction to geographic information systems in general.

So where does this book sit within the academic literature on geography, GIS, and spatial analysis in health? In my opinion, this book is an interim step, containing several insightful chapters and others that will rarely be accessed five years from now. Those who have access to a large research library would be best advised to read the chapters of interest there, and the rest of us should await a more exhaustive and comprehensive compendium on this subject in the years to come.

References

Agency for Toxic Substances and Disease Registry. *Proceedings of the Third National Conference on GIS in Public Health*. (Atlanta, GA: Agency for Toxic Substances and Disease Registry, 2000); URL:http://www.atsdr.cdc.gov/GIS/conference98/proceedings.

Besag J., Newell J. The detection of clusters in rare diseases. *Journal of the Royal Statistical Society Series A* 1991;154:143-155.

Dever G. E. A. *Improving Outcomes in Public Health Practice: Strategies and Methods.* (Gaithersburg, MD: Aspen Publishers, 1997).

Marshall R. J. A review of methods for the statistical analysis of spatial patterns of disease. *Journal of the Royal Statistical Society Series A* 1991;154:421-441.

Richards TB, Croner CM, Novick LF. Geographic information systems (GIS) for state and local public health practitioners, Part 1 and 2. *J Public Health Manag Pract* 1999 Mar;5(2):73-6; 1999 Jul;5(4):1-6
Teutsch S.M., Churchill R.M., Editors. *Principles and Practice of Public Health Surveillance*, Second Edition. (New York, Oxford University Press, 2000).

Wilcox L.S., Marks J. S., Editors. *From Data to Action: CDC's Public Health Surveillance for Women, Infants, and Children*. (Atlanta, GA: Centers for Disease Control and Prevention, 1995).

The Island of Lost Maps: A True Story of Cartographic Crime

By Miles Harvey. Random House, New York, 2000. 406 pp., illus., notes, index. ISBN 0-375-50551-7 Cloth $24.95

Reviewed by Judith A. Tyner, Ph.D. Professor of Geography, California State University, Long Beach, Long Beach, CA 90840. 562-985-5332; e-mail: jztyner@csulb.edu.

> ". . . in my journalistic travels, as in my personal wanderings, I'm a sucker for detours, back roads, tourist traps, scenic views, and historic landmarks." (p. 136)

The Island of Lost Maps details, on one level, a true story of cartographic crime, the theft of 250 rare maps, worth over one-half million dollars by Gilbert Bland, one of the biggest such thefts known. A reader who is interested solely in this theft and wants an unadorned story of crime, capture, and punishment, may be somewhat frustrated, because Miles Harvey does not follow what he calls "interstate Bland." The reader who enjoys wanderings into history of cartography and exploration, the workings of libraries, and the worlds of map collectors and dealers will enjoy the trip. In this saga of map theft, Harvey cleverly introduces readers to a wide range of topics by intertwining them with the crime story.

In keeping with Harvey's road analogy, the story is actually a quest and is structured much like a quest novel. Harvey is in pursuit of the mind of the aptly named Mr. Bland. Why and how did a teenage car thief, small time unsuccessful crook, Army deserter, with apparently no previous knowledge of or interest in rare maps, become a map thief so convincing that he was able to walk into the rare book rooms of treasure house libraries in the US and Canada, steal maps (using a "shopping list"), and sell them to major map dealers?

Each chapter begins with a narrative that sets the theme. For example, Chapter 2 "Imaginary Creatures," begins with a discussion of the mythical monsters on *mappae mundi*, and the human monstrosities on the 1493 world map in Harman Schedel's *Nuremberg Chronicle*. These, then, are tied to the many imaginary (false) identities that Bland used. The chapter wanders through fictional maps in the Hardy Boys mysteries, the map that Robert Lewis Stevenson used as a base for *Treasure Island*, and the plot of *The Treasure of Sierra Madre*. This literary trick seems forced at times and mildly annoying, such as the unhappy ghost of Lloyd Brown, author of *The Story of Maps*, muttering curses as he hovers above the reading room of the Peabody Library where the crimes were discovered.

Because Harvey is a journalist and not an academic, he gains much of his material through discussions and interviews with experts in a variety of fields. These are effective; readers feel they are in the room with him. Thus, we learn about the world of map dealers through a day trip to a Sotheby auction with "the map mogul" Graham Arader; we watch as the bidding for a copy of Ptolemy's *Geographica* escalates from $100,000 to over $1.2 million. Several hours are spent at the home of "Mr. Atlas," a anonymous, knowledgeable, avid map collector, and at the office of Dr. Werner Muensterberger, psychologist and author of *Collecting: An Unruly Passion*, to understand the obsession for collecting, which after all, fuels the market for antique maps.

The stage is set for Bland's map thefts through a discussion of the problems libraries have maintaining and protecting their collections—the costs of physical repairs to aging buildings, modern security system—and the controversial solutions of "deaccessioning" or selling off a few rare books in order to save others and "breaking books" or gutting them to sell individual maps and illustrations.

Since the book is not aimed solely at the specialist, some knowledge of how maps have been and are made is useful. Harvey details how copper plate maps were made from the 16th through 19th centuries and visits a modern map making firm, the American Map Company, to learn how modern maps are made, and how the transition from manual to computer means is impacting the field.

Cartographic crime, ranging from plagiarism to map theft, is not new. Maps have strategic value in exploration and war, and theft of maps from competitors and enemies has a long history. In Chapter 7, "A Brief History of Cartographic Crime," Harvey chronicles such thefts by Columbus, Magellan, and other early explorers intent on finding a fast route to treasure. Plagiarism of maps also has a long history, and as readers of *Cartographic Perspectives* know, modern mapping companies put copyright markers on their maps to protect themselves from copyright violation. Harvey also summarizes the activities of seven thieves of rare books and maps and the security problems of libraries in this chapter.

The unhappiest chapter, "The Invisible Crime Spree," brings home the tragedy of map theft. Here Harvey details how the University of Washington Special Collections Division acquired Ogilby's 1671 *America* and made it the "poster book" for preservation fund raising. The restorer explains what was involved in restoring and rebinding the book. After five years of effort on the part of librarian and restorer, *America* was made available to library patrons in June of 1995; on October 4, 1995, Bland, the first person to request the book, removed four maps and damaged additional pages when he slashed out the maps. Only three of the maps have been found. Bland's comment on this kind of damage was that the maps could be glued back in.

Harvey is not always complimentary to map dealers, collectors, and librarians and this will rankle some readers. Although he interviewed several dealers, and devotes an entire chapter to Graham Arader, he believes dealers and collectors too often are lax in their search for a map's provenance. Harvey admires librarians, who are usually portrayed favorably, but they are criticized for an "it-can't-happen-in-*my*-library" attitude. This denial is so great that after Bland's capture, some librarians refused to even check if they were missing maps!

The Island of Lost Maps is the office of FBI Special Agent Gray Hill who was responsible for returning the maps to their rightful owners. At the time the book was written, approximately seventy maps remained on the island.

Ultimately, in his search for the inner Bland, Harvey admits failure. Bland refused to meet with him and in their one phone conversation, Bland threatened Harvey with prosecution for stalking if he ever attempted to contact him again. Bland remains a mystery and even in the one photo of Bland in the book, his face cannot be seen. However, in the search for Bland, Harvey learned a great deal about the world of cartographic collecting and dealing and imparts his knowledge to the reader in an entertaining manner. One complaint is that the epilogue is not needed. The story ends nicely with what should be the final chapter "Mr. Bland, I Presume," and in his attempt to give himself closure, Harvey weakens the ending.

Miles Harvey is a frequent contributor to *Outside* magazine, not an academic, a cartographer, or a collector, but he did his research well in his four-year search for Bland. The book is based on standard histories of cartography, as well as interviews with a wide range of specialists: dealers, collectors, librarians, cartographers, historians of cartography, police and the FBI agent responsible for returning the maps. The book is meticulously footnoted and indexed with 40 pages of notes and an 11-page index. Each chapter begins with an illustration that helps set the theme of the chapter. These black and white illustrations are with few exceptions details of maps mentioned in the chapters. Because the page format of the book is small, only 5.5" x 7.25", detail portions are more effective than reductions of entire maps. One of the few illustrations that is not map-related is the aforementioned photograph of Gilbert Bland.

One caveat for anyone trying to find *The Island of Lost Maps* is that you may have a search also. Bookstores seem unsure where to shelve the book. Although the cover indicates "current affairs/travel" it is hardly a travel book. Because of the subtitle: "A True Story of Cartographic Crime," one bookstore displayed it in the true crime section. Because it deals with maps, another store shelved it with earth science. However, it is worth the quest and is, overall, a fascinating story.

nacis news

NACIS FALL BOARD MEETING
Doubletree Downtown Portland
Portland, OR
October 5, 2001

Attending: Jim Anderson, Lou Cross III, Will Fontanez, Adele Haft, Megan Kealy, Gordon

Kennedy, Jeff McMichael, James Meacham, Thomas Patterson, Susan Peschel, Joseph Poracsky, Donna Schenstrom, Jeannine Schonta, Trudy Suchan, Alex Tait, Chris Baruth arrived late.

President Meacham called the meeting to order at 3:40 p.m.

Agenda of Meeting:

1. New Board Members: Introductions
2. Executive Director Transition: Meacham
3. Call for Nominations: Crampton
4. Future NACIS Meeting Sites, 2003 & 2004: Meacham
5. *Cartographic Perspectives* Report; CP Website: Jim Anderson
6. Spring Board Meeting: Meacham
7. NACIS 2002 Meeting Status: Kennedy/Krygier
8. NACIS Website Report: Crampton
9. NACIS-CaGIS: Crampton
10. Other Business

1. New Board Members: Introductions

2. Executive Director Transition: Meacham

How to fill out executive director position to transfer some responsibility to Florida (Lou and Jim Anderson).

Question asked: What does the executive director do?

Chris Baruth: The position evolved over the years. Ron did hotel negotiation; Chris brought the organization's database functions into line–updated accounting and databases to do meeting, membership renewal, *CP* mailing labels, conference registrations, and pay bills. A post office box is maintained in Milwaukee.

Susan P.: The home office in Milwaukee became a repository of organization's knowledge about running the meeting.

Chris does his own programming; he did it to automated tasks. Organization needs to find software to run database

Gordon: non-profit organization software to run organization costs about $400. Organization needs to buy software.

Relational databases are needed to do year-to-year info.

Lou: Reports are needed throughout the year.

Chris: I will produce a list of software function needed for new software. Chris is willing to cleanup his software so others can use his program for the short-term

Jim: Need letter of resignation from Chris, and to appoint Lou.

Chris: Term is 5 years, served two five-year terms, should have be up last year.

Jim: Should the term be from business lunch? The need to transition banking functions to new director.

Lou: Because of the contract with hotel, signing off bill and payments, should term go to a date after meeting?

Susan P.: Hotel in Columbus still needs some attention. Dec. 1st suggested as a date to start new term for Lou.

Motion to end Chris' term October 4, 2001; new director will assume office from that date.

Susan: business office will remain in Milwaukee, incorporated as an organization in Wisconsin. Alex: organization needs to have a permanent address and a registered agent. Chris will continue to be registered agent for organization. The motion passed by all.

Move to thank Chris for his years of service. Motion passed

Chris will announce hospitality suite.

3. Call for Nominations: Crampton

Jeremy Crampton asked for nominations for next year's elections. There was a discussion for which offices needed nominations: Vice President, four board openings, wanted six nominations. Several members' terms will be up in '02 and can be on the board again. Named as nominations: Steven Holloway, Fritz Kesler, Susan Peschel, and Peter Keller.

It was remarked that student members from UGA were not at this meeting

4. Future NACIS Meeting Sites, 2003 & 2004

Jim Meacham made the following remarks: For 2003 we are running late; usually has a site contracted. Possible sites: Orlando will be checked; Baltimore is too expensive at $150/night; Susan Peschel will provide new numbers (based on the last two meeting) for meeting; need about 160 rooms. Alex is not willing to head local arrangements. Annapolis hotel rates are $159/night. Alex will check on rates to Annapolis--airfare will be cheaper than some other cities. The following cities are being considered: Chapel Hill, NC - Jeremy could help here, Greenboro, NC--Pat Gillmartin could help--Elisabeth Nelson, Bolder, CO discussed–would not work out. Aspen, CO was also discussed; Orlando, FL seems best bet for 2003 for a variety of reasons, St. Louis discussed, but no local arrangements. Discussion about local arrangements at either Savannah or Charleston--don't need to tie meeting to a city with a member. Someone needs to travel to these cities to check facilities. 233 members attending Portland meeting.

Duluth, MN was dropped from consideration. Portland, Maine was discussed as a possible future site. Updated list of requirements will be sent to all board members.

Site will need to be selected before spring '02 meeting, most likely this fall.

Dates for next meeting should be first half of October. Travel is a problem in September for US Federal employees because of year-end budgets.

Trudy wants to get future site research time-line tightened to next few weeks.

5. *Cartographic Perspectives* Report; CP Website: Jim Anderson
Jim made some remarks on how to get out issues, 3 issues out within 3 months.

Jeremy/Scott will discuss guest editors. There is a need for more manuscripts from members.

Jeremy asked members who presented paper at meeting to submit it as a manuscript; speaker for tonight banquet to submit something.

Special cartography issue: b&w issue with color cover with color graphics on web.

Color issue plus b&w issues going long are causing cost to soar: 64 pages for binding. Practical cartography issue will be this length.

Manuscripts needed for *CP*. Susan: presenters should do meeting issue.
Jeremy: members don't need to publish.
Lou: announce at banquet to submit manscripts to *CP*.
Trudy: shorter manuscripts are a good thing.

6. Spring Board Meeting: Meacham
A discussion followed about where to have 2002 Spring Board meeting. Chicago has been used in the past, was close to staff in Milwaukee. Atlanta was suggested as new location for meeting. A motion was made to have the meeting in Atlanta, motion passed.

Discussion on date of meeting; a motion on the date of meeting delayed till members can check their schedules for possible dates.

Time for meeting: 9 am Saturday until 5 pm.

7. NACIS 2002 Meeting Status: Kennedy/Krygier
Alex: Practical Cartography Day (PCD) II preconfence planned, will have same setup.

A discussion about PCD should be labeled as pre-conference–this will be kept.

A discussion about number of participant: should it be kept at 40 or 100.

It will be done at 2002; will have to deal with more attendees than 1st thought. Will probably have 80-100 members.
John: Hotel quote will have to be increased from 120 to a more realistic number. A discussion followed about exactly what number of room-nights to get a quote for.

Discussion about space/room configuration of PCD in 2002: 100 to 165 persons

Discussion about lab configuration for workshops: PC or Mac

John K should be a guest at the spring board meeting.

Discussion about getting more local help: ESRI office suggested. Also, student assistants need to be more computer-aware. How many assistants are needed?

8. NACIS Website Report: Crampton
Item: website report:
Jeremy Cramton submitted the following website report:

	10/00	4/11/01	10/01	% Change 10/00–10/01
Disk Space Used	n/a	5%	7%	
Monthly Data Transfer Used	n/a	206 mb	44 mb	
Space Available (100 mb limit)	n/a	95.5 mb	93 mb	
Total Successful Requests (last 7 days)	7,257		10,098	+39.2
Popular directories				
/cp/	20,486		43,359	255
/root/	13,135		18,819	
/Williamsburg/Portland	3,083		6,164	
/contest2000/			1,979	
Requests for pages/day (last 7 days)	197		315	+59.9
Number of distinct files requested	218		234	+7.3
Total Accesses of Homepage from counter			10,645	

There was a discussion about e-mail list or a listserv for NACIS. Chris can personalize e-mail to members.

9. NACIS-CaGIS
Paul Young from CaGIS submitted the following:
Resolution: The members and Board of Directors of the Cartography and Geographic Information Society express their sincere thanks to the North American Cartographic Information Society for allowing us to hold ouor Fall 2001 meeting during the NACIS XXI meeting in Portland, Oregon on October 5th. We look forward to further collaboration between our two organization.

Paul said this is the first step to furthering ties and working together with various members attending the meetings.

10. Other Business
No other business

Motion to adjourn: 5:39 pm

Submitted by:
Jeff McMichael
Secretary, NACIS

2001 Ristow Prize Winners Announced

Each year the Washington Map Society offers the Ristow Prize for cartographic history and map librarianship in honor of Walter W. Ristow, one of the nation's premier map librarians and cartographic authors. Dr. Ristow was for many years head of the Geography and Map Division at the Library of Congress and was founding president of the Society.

The first place winner for 2001 is Dimitris K. Loupis who is a graduate student at the National University at Athens (Greece). His prize winning paper is entitled *Piri Reis's Book on Navigation (Kitab-I Bahriye as a Geography Handbook: Ottoman Efforts to produce an Atlas during the Reign of Sultan Mehmed IV (1648-1687)*. Mr. Loupis's winning entry will be published in the next issue of *The Portolan*. He received a cash award of $500 and membership in the Washington Map Society for the coming year.

Two Honorable Mentions for the excellence of their papers were awarded. Michael Kimaid, a student in the Department of History at Bowling Green State University, submitted a paper *From That Last Point, The Line is Less Exact, The Problem of Cartography Prior to The Louisiana Purchase*. Tine Ningal, student at PNG University of Technology in Papua New Guinea, submitted a paper *A Case Study of Transition from Mental Map to Web Based Mapping in Papua New Guinea for Cartographic Education*. The two students with Honorable Mention will receive membership in the Washington Map Society for the coming year.

New GEOID Model Provides Accurate Elevations
Natural Resources Canada

A new GEOID model and software with the capacity to provide accurate elevations across Canada was released by Natural Resources Canada at the GeoSask2001 conference in Regina.

The Canadian Gravimetric Geoid model (CGG2000) and Canadian Height Transformation Package (GPS-H Package), the latest advance in the Canadian Spatial Reference System (CSRS) allows direct conversion of NAD83 (CSRS) GPS ellipsoidal heights, to the more useful orthometric elevations (heights above mean sea level), referenced to Canada's standard vertical datum, CGVD28. Users will now have the capability, depending on the procedures used, to obtain decimeter-level elevations or better throughout the country.

This capability will result in economic and environmental benefits. Vertical data is used for such applications as water and watershed management, flood-plain mapping and marine safety. It is also used in GPS-based precision farming, for example to control unwanted runoff and stream contamination, and for forestry applications, such as modeling the spread of wild fires. In order to integrate and share this data, it must be based on standardized measurements and referenced to a national infrastructure.

The model and software package are the result of a five-year collaboration with international, federal and provincial agencies, and academic institutions. The CGG2000 model replaces the previously adopted GSD95 model.

Through advances in the CSRS and products such as these, NRCan provides a framework for the greatest possible accuracy for all spatial positioning and makes this framework as accessible as possible to GPS users in Canada. The CSRS system is a fundamental building block for GeoConnections, a federal-provincial partnership for sharing and integrating geospatial data on the Internet.

Avenza ships MAPublisher 5.0 for Illustrator.
Powerful mapmaking software supports Illustrator 10 and Mac OS X

Mississauga, ON, June 17, 2002 - Avenza Systems Inc. announces the release of MAPublisher 5.0 for Adobe Illustrator, mapmaking software to produce quality maps from GIS data. Significant new functionality includes support for Adobe Illustrator 10, Apple Mac OS X and import of MicroStation Design (DGN) files.

"The new features in MAPublisher 5.0 are impressive time savers," said Steve Spindler, owner of BikeMap.com. "Keeping all my workflow in OS X alone made it a worthwhile purchase," he added.

New features in MAPublisher 5.0 for Illustrator

- Adobe Illustrator 10 compatible
- Mac OS X compatible
- MicroStation DGN file import
- Douglas-Peucker Line Simplification
- Plot points in decimal degrees or DMS onto any projected plane
- Convert between DMS and decimal degrees
- Create GeoTiffs and other geo-referenced raster images
- Store map projections in already projected files after import
- 'Sticky' selection menus remember last menu selection
- Automatic Scale bar creation
- Automatic Grid generation in page units
- Simplify Arcs
- Bezier curve creation from GIS data segments
- Bezier curve support during scale transformation, projecting, area and length calculations
- Area drawing tools in map units
- Copy and paste map data between layers
- Automatic grain calculation on data import
- Updated e00 import, now imports all components (anno, pnt, arc, poly)
- Create grids in differing page units
- DGN data automatically attributed level # during import
- Project data to different output map units

More about MAPublisher 5.0 for Illustrator

MAPublisher 5.0 for Illustrator is powerful map production software for creating cartographic-quality maps from GIS data. Developed as a suite of plug-ins for Adobe Illustrator, MAPublisher leverages the superior graphics capabilities of this graphics design software. Avenza also offers MAPublisher for FreeHand – a suite of Xtras for Macromedia Freehand that add mapmaking functionality. MAPublisher 5.0 for Illustrator is available as an upgrade for US$349. New licenses are US$849. Prices include 1 year of maintenance. Full details are available at www.avenza.com.

More about Avenza Systems Inc.

Avenza Systems Inc. is an award winning, privately held corporation that provides cartographers and GIS professionals with powerful software tools for making better maps. In addition to software offerings for Mac and Windows users, the Company offers value-added data sets, product training and consulting services. Visit www.avenza.com for more details.

For further information
Tel: 905-567-2811
Email: info@avenza.com
Web: www.avenza.com

Avenza Announces 2002 MAPublisher Map Competition Winners

Mississauga, ON - July 25, 2002 – Avenza is pleased to announce the winners of the 2002 MAPublisher Map Competition - a competition that showcases the quality and diversity of maps that can be produced with MAPublisher.

"The quality of this year's submissions was terrific," said Ted Florence, president of Avenza Systems Inc. "We congratulate the winners and thank all entrants for their excellent display of cartographic skill using MAPublisher," he added.

Summary of category winners

2002 Best Map Overall - Jana Seta Map Publishers Ltd., for 'Road Atlas of Latvia'.
2002 Best Academic Map Collection - Chris Jessee, IATH University of Virginia for 'Great Bay, Boston'.
2002 Best Academic Map Individual (Tie) - Michael Christensen, Brigham Young University for 'Colorado River Basin'.
2002 Best Academic Map Individual (Tie)- Greg Wolowich, Tim Wykes, Sir Sandford Fleming College for 'Movement of Goods & Services from Canada into Ontario'.
2002 Best General Purpose Map - Tim Parker, Department of Primary Industries, Water & Environment for 'Tasman National Park'.
2002 Best Geologic Map - USGS for 'Geologic Map of the Yucca Mountain Region, Nye County, NV'.
2002 Best Multimedia Map - Jeroen van den Worm, ITC for 'The 1812 Campaign of Napoleon'.
2002 Best Special Purpose Map (Tie) - Rudy Zangari, City of Toronto, for 'Toronto Parks and Trails'.
2002 Best Special Purpose Map (Tie) - Greg Tanaka, Barclay Mapworks Inc. for 'San Mateo & Vicinity'.

2002 Best Thematic Map - Martin Gamache, Boston Redevelopment Authority for 'Fostering Transit Oriented Development in Boston'.

2002 Best Topographic Map - Patrick Dunlavey, Pat Dunlavey Cartographics for 'South Taconic Range'.

2002 Best Transportation Map - Jana Seta Map Publishers Ltd. for 'Road Atlas of Latvia'.

Details of each map, the associated images and notable entries can be found on the company's website at http://www.avenza.com/MPcomp/2002.

The National Map: Topographic Maps for the 21st Century

The U.S. Geological Survey (USGS) is committed to meeting the Nation's needs for current base geographic data and maps. Our vision is that, by working with partners, we will provide the Nation with access to current, accurate, and nationally consistent digital data and topographic maps derived from those data. This synthesis of information, products, and capabilities, ***The National Map***, will be a seamless, continuously maintained set of geographic base information that will serve as a foundation for integrating, sharing, and using other data easily and consistently.

The Nation Needs *The National Map*

Governments depend on a common set of base information that describes the Earth's surface and locates features. They use this information as a tool for economic and community development, land and natural resource management, and health and safety services. Federal functions ranging from emergency management and defense to environmental protection rely on this information. Private industry, nongovernmental organizations, and individual citizens also use the same geographic data. Geographic information underpins an increasingly large part of the Nation's economy.

USGS Role

The most widely known form of geographic base information for the United States is the USGS primary series topographic map. The USGS has produced more than 55,000 unique map sheets and approximately 220,000 digital orthorectified aerial images to cover the Nation. These maps and images are a national treasure, but the average primary series topographic map is 23 years old. Frequent changes on the landscape mean that many of these maps are no longer accurate and complete. The USGS is committed to organizing and leading cooperative activities to ensure that current geographic base information is readily available and useful.

A New Vision

The National Map will provide data about the United States and its territories that others can extend, enhance, and reference as they concentrate on maintaining other data that are unique to their needs. ***The National Map*** will promote cost effectiveness by minimizing the need to find, develop, integrate, and maintain geographic base data each time they are needed.

- Under USGS leadership, ***The National Map*** will provide data and operational capabilities that include the following:

- High-resolution digital orthorectified imagery that will provide some of the feature information content now symbolized on topographic maps.

- High-resolution surface elevation data, including bathymetry, to derive contours for primary series topographic maps and to support production of accurate orthorectified imagery.

- Vector feature data for hydrography, transportation (roads, railways, and waterways), structures, government unit boundaries, and publicly owned lands boundaries.

- Geographic names for physical and cultural features to support the U.S. Board on Geographic Names and other names, such as those for highways and streets.

- Land cover data that classify the land surface into categories such as open water and high-density residential.

Changes affecting ***The National Map*** will be captured in near real time, rather than through cyclical inspection and revision. Currentness will be measured in days and months.

Data will be seamless and consistently classified, enabling users to extract information for irregular geographic areas, such as counties or drainage basins, and to spatially analyze the information. Data resolution and completeness will vary depending on geographic area and need. For example, ***The National Map*** will contain higher resolution elevation data in areas of subtle relief variation, such as river flood plains, to support hydrographic modeling.

Positional accuracy will be sufficient to vertically and logically align features from different data themes. Thus, river course will correspond to land surface slope, and boundaries will align with corresponding features, such as roads or rivers. ***The National Map*** will contain data for many areas that surpass the standards that have been applicable to primary series topographic maps.

All content of ***The National Map*** will be documented by metadata that comply with Federal Geographic Data Committee standards.

Building, Maintenance, and Operations

The initial version of ***The National Map*** will be based primarily on existing available data. As the initial version is improved, emphasis will shift to maintaining data currentness through continuous updating. Potential data sources include State and local governments, private industry, and locally trained and certified volunteers.

Access and Use

The National Map will be accessible through the Internet all day, every day. The data will be in the public domain. Data procured from commercial sources will include unlimited distribution and use rights.

Users will be able to combine data from ***The National Map*** with geographic information available from other organizations, such as cadastral information from the Bureau of Land Management and socioeconomic data from the Bureau of the Census. ***The National Map*** will be a foundation to which all organizations can reference their information, such as land use data, school district boundaries, or wildlife population counts.

The USGS will continue the tradition of the primary series topographic map by providing a standard set of paper topographic maps and digital data products derived from ***The National Map***. Customers will be able to create their own maps by defining a geographic area of interest, selecting unique combinations of data, and printing their maps at home or at kiosks that will be available locally at libraries, recreational suppliers, bookstores, and so on.

Strategies

The USGS will be the (1) guarantor of national data completeness, consistency, and accuracy; (2) organizer of component activities; (3) catalyst and collaborator for partnerships and business relationships; (4) integrator and certifier of data from all sources; (5) data producer and owner when no other source exists; and (6) leader in the development and implementation of national geospatial data standards. A Federal advisory committee will make recommendations on requirements, business processes, technology implementation, and skills development that support ***The National Map*** objectives.

The USGS will proactively seek partnerships and business arrangements with government agencies, the private sector, and other organizations to develop and operate ***The National Map***. USGS staff will be located across the Nation to work directly with staff of other USGS disciplines, partner organizations, private industry, and universities.

Taking advantage of the ongoing convergence of broadband wireless communication, mass data storage, and geolocation capabilities in personal digital devices, the USGS will encourage the participation of organizations and private citizens to serve as a volunteer force for change detection, data compilation and validation.

Vision and Commitment

The National Map is a new perspective on geographic base information. By sharing its vision, the USGS affirms its dedication to refocusing and reinvigorating its efforts to meet the Nation's needs for this critical information. The USGS will consolidate and redefine its component mapping activities and seek creative partnerships to ensure that current, complete, consistent, and accurate information is available and useful to the Nation. It will take sustained commitment to achieve the full goals of ***The National Map*** vision. In the near future, the USGS and its partners will concentrate on improving data and map content and currentness for high priority areas, with emphasis on building long-term partnerships, and on improving data access and dissemination capabilities.

(Taken from USGS Fact Sheet 018-02, February 2002)

INSTRUCTIONS TO AUTHORS

Cartographic Perspectives (*CP*) publishes original articles exemplar of creative and rigorous research in cartography and geographic visualization. Papers accepted for publication must meet the highest standards of scholarship, address important research problems and issues, and appeal to a diverse audience.

The preferred format for submitted manuscripts is a digital MicrosoftWORD document. They can be sent as an email attachment to Scott M. Freundschuh, Editor, at sfreunds@d.umn.edu, or on diskette/zip disk to Scott M. Freundschuh, Editor, *Cartographic Perspectives*, Department of Geography, University of Minnesota, Duluth, Minnesota 55812. If submission of a digital manuscript is not possible, authors can send five analog copies of their manuscript to the editor at the above address. Each manuscript is reviewed by the editor, one or more members of the editorial board, and at least one external reviewer. Items submitted for consideration will not be returned.

Manuscripts should be double-spaced, on one side of the paper, in a 12-point font with proportional spacing and 1-1.5" margins. All parts (abstract, notes, references, tables, and list of figure captions) must be double-spaced and in the same font size. Authors will be required to sign a statement that the manuscript has not been submitted for publication elsewhere and will not be submitted elsewhere until the *CP* editor has reached a decision. Any submitted manuscript must not duplicate substantial portions of previously published material.

Title page. The title serves as the author's invitation to a diverse audience. It should be chosen wisely. The title page should include the full names of the authors and their academic or other professional affiliation.

Abstract. An abstract of 250 words or less should summarize the purpose, methods, and major findings of the paper. Key words should be listed at the end of the abstract.

References. References should be cited parenthetically in the text in this order: author's last name, year of publication, and page number when appropriate. Use the Chicago Manual of Style published by the University of Chicago Press for the correct style for various sources.

Books: Author(s) (last name, first initial, middle initial where appropriate). Year. Book title in Italics. City of publication: publisher name.

Doe, J. 2001. *Citing a book*. Duluth, MN: Northstar Publications.

Articles in Periodicals: Author(s) (last name, first initial, middle initial where appropriate). Year. Title of article. Title of periodical in Italics, volume (number): page numbers.

Doe, J., and Doe, J. 2001. Citing an article in a periodical. *Cartographic Perspectives*, 30:120-129.

Articles in edited volumes: Author(s) (last name, first initial, middle initial where appropriate). Year. Title of article. In (title of edited volume), ed. (editor[s] first initial, middle initial where appropriate, last name), pages. City of publication: publisher's name.

Doe, J.; Doe, J.; and Doe, J. 2001. Citing an article in an edited volume. In *101Ways to Cite and Article*, ed. J. Doe, pp. 120-129. Duluth, MN: Northstar Publications.

The list of references should begin (double-spaced) on a separate sheet immediately after the text and Notes. Entitle the section "References" and list all references alphabetically by the author's last name then chronologically. Provide full, unabbreviated titles of books and periodicals.

Notes. Substantive notes amplify arguments in the text. They should be addressed to a single point in the manuscript. Notes should be numbered sequentially in the text and will appear under the heading "Notes" at the end of the text. They should be typed double-spaced in the same font size as the text (12 point).

Units of Measure. Cartographic Perspectives uses the International System of Units (metric). Other units should be noted in parentheses.

Equations: Equations should be numbered sequentially and parenthetically on the right-hand edge of the text. If special type styles are required, instructions should be provided in the margin adjoining the first case of usage. Authors should carefully distinguish between capital and lower-case letters, Latin and Greek characters, and letters and numerals.

Tables. Tables should be discussed in the text and denoted by call-outs therein, but the meaning of a table should be clear without reading the text. All tables should be typed, double-spaced on separate sheets in the same font size as the text and numbered sequentially with Arabic numerals. Each table should have a descriptive title as well as informational column headings. Titles should accent the relationships or patterns presented in the table.

Illustrations. Maps, graphs, and photos should convey ideas efficiently and tastefully. Graphics should be legible, clean, and clearly referenced by call-outs in the text. Sound principles of design should be employed in the construction of graphic materials, and the results should be visually interesting and attractive. Illustrations should be designed to fit the page and column format of *CP* (insert page size here, and column width here). A fine neatline defining the graphic field is recommended as a visual boundary separating text and graphic. Type should be set using Helvetica where possible, and sizes below 6 point should be avoided.

It is assumed that graphics will be computer generated, and final output will be produced on an image setter as a right-reading, emulsion-down negative. Digital submissions are encouraged. Laser printer copies are acceptable with initial submission of the manuscript for review. Where figures will be photomechanically produced, authors should contact the CP associate editor for guidelines. The CP editor and associate editor will review graphics.

Permissions. If a manuscript incorporates previously published material of substantial extent, the author is obliged to obtain written permission from the holder of the copyright and to bear all costs for the right to use copyrighted materials.

Electronic Submissions. Authors of accepted articles will be asked to submit a digital copy of the final revision in any common software format. CorelWordPerfect or MicrosoftWORD are the preferred word processing formats, and Adobe Illustrator or PhotoShop are the preferred graphic formats.