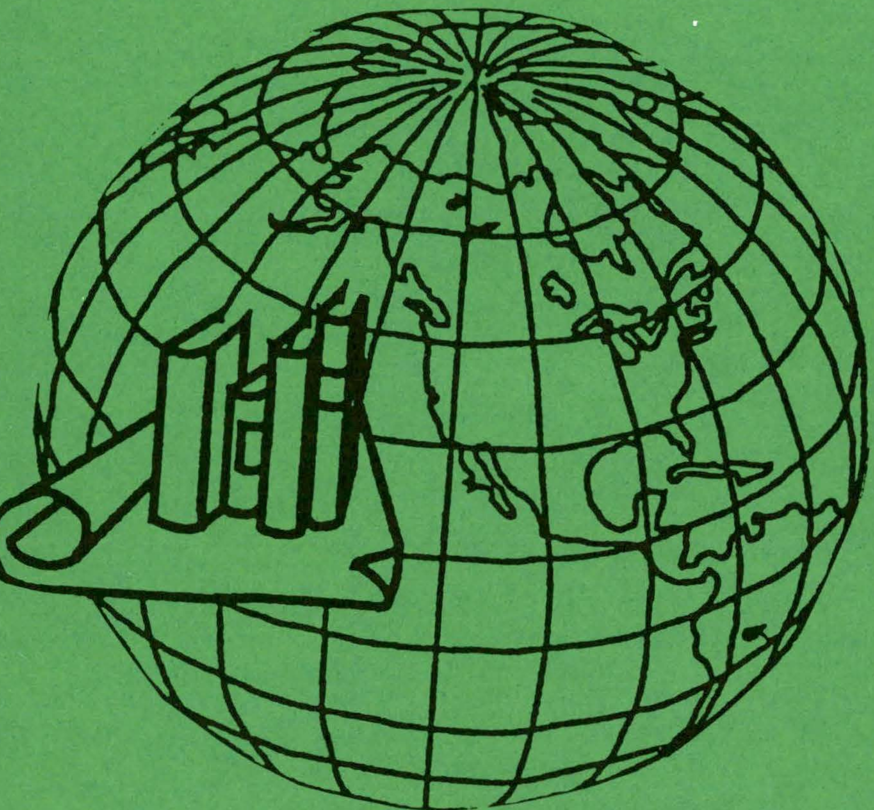
Geoscience Information Society



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CROSSING THE BRIDGE TO THE FUTURE: MANAGING GEOSCIENCE INFORMATION IN THE NEXT DECADE

Edited by
Nancy L. Blair

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Geoscience Information Society Poster Session

PREFACE

The Geoscience Information Society (GIS) is an independent, nonprofit professional society established in 1965 to improve accessing, exchanging, and archiving geoscience information.

Papers published in these proceedings were presented during the 1995 Geological Society of America annual meeting held in New Orleans, Louisiana at three sessions:

l. Invited papers, GIS Symposium : Crossing the Bridge to the Future: Managing Geoscience Information in the Next Decade, November 7, 1995.

2. Contributed papers, GIS Technical Session: Information Technology and Services in the Geosciences, November 7, 1995.

3. Poster presentations, GIS Poster Session, November 8, 1995.

The symposium theme "Crossing the Bridge to the Future" was selected as part of the overall theme of the 1995 GSA annual meeting "Bridging the Gulf". The advent of the Internet and the World Wide Web have brought new customers to the doors of earth science libraries and data repositories and, at the same time, provided our institutions with access to data and information sources far beyond our geographical boundaries. While we are entering a new world of communication, we are also responsible for the preserving the publications of the past. These paper reflect the recent impact of the World Wide Web and how we can relate new communication technologies to our clientele and the archiving of information.

THE GEOSCIENCE INFORMATION PROFESSIONAL IN THE BRAVE NEW INFORMATION WORLD

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Abstract -The world of information is undergoing continuous and dramatic change. This change is dictated by technology, new approaches to research, demands for information, different means of accessing information, and availability of resources. The geoscience information world in the next decade will continue to experience transformational change at an accelerating rate. Several major factors now make personnel costs an essential component of information management. These factors are declining budgets, the reality of constant change, the need for continuous innovation, and a more client-focused approach in the operations of information management.

Professionals possess specialized knowledge and use that knowledge in the service of others. Professionalism is a response to the growing complexity, diversity, and volume of activity in a field and reflects the accumulation of special knowledge to cope with the changes. Information professionals could be called value-added advisors, researchers, analysts, and/or project managers as the future unfolds, no longer keepers and catalogers of documents. The geoscience professional will play a significant role in the crucial activity of shaping context in the geosciences in the next decade.

INTRODUCTION

Information professionals seem to be preoccupied with the future, and spirited discussions continue regarding the ability of an information professional to prosper or even to survive in the brave new information world. An increase in the number of books and articles on future paradigms, changing paradigms, TQM, team-based organizations, and empowerment of the individual is very evident in the literature of our profession and, indeed, these concepts are already being practiced in our work places at least to some degree. As an integral part of the knowledge circle (Figure 1), the new information professional will focus on processes, not products or organizational structures. Interaction with other segments of the knowledge circle will become increasingly important and time-consuming. The new information professional will strive for quantum leaps, not the small incremental changes that have been a part of the past. A client-centered view of the library will be quite different from the more traditional views based on the learned professional craft. A client-centered view balances the cost to the organization and the benefit to the client.

The new geoscience information professional will use information technology in creative ways to cope with the changes. We are already dealing with Geographic Information Systems as well as other new access technologies. Over the years, administrators including, and perhaps especially, university administrators have assumed that automation and/or digitization would reduce the overall costs of operations or even replace the library per se. That has not been the case. Automation and the new access technologies continue to have significant costs associated with them, produce changes in staffing patterns and job assignments, and will continue to be a major catalyst for the future. Crawford and Gorman

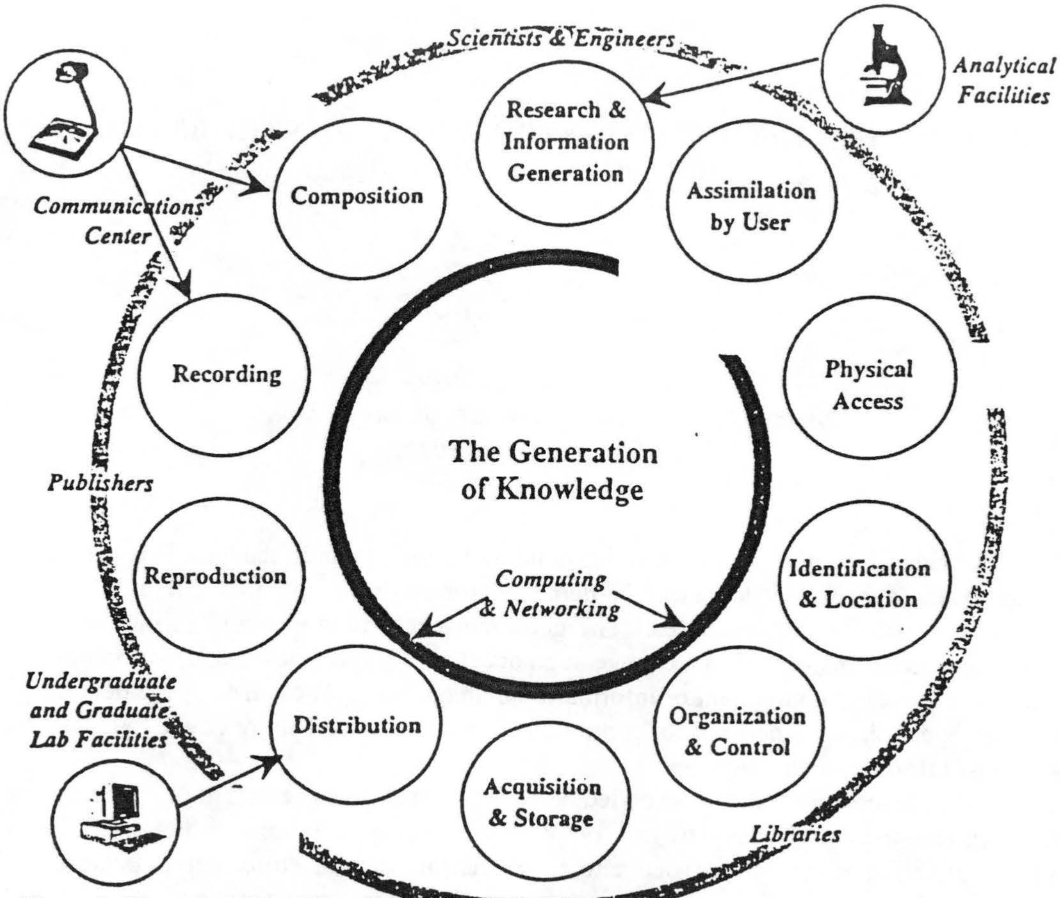

Figure 1. The generation of knowledge, as amended by D. Wilson

(1995) indicate in their book, "Future Libraries: Dreams, Madness and Reality" that new technologies do not usually displace old ones, although they may change how the old technologies are used. When total displacement does occur, it is because the new technology offers a clear advantage. They believe that electronic text does not yet offer clear advantage over print and that the print media will be around for a long time in conjunction with the other technologies. Libraries will, therefore, continue to support many different formats.

Customized information services directed at individual levels will be the demand of the clientele. Information professionals will have a user focus that is so intense the role will be more like a case worker. An emphasis on accountability and evaluation from internal and external sources will probably develop. The information professionals would be responsible for the determination of the cost/benefit of programs, services, and operational activities. The information professional will have a role in end-user training and must be an integral part of the educational process.

There will be a shift from production work to intellectual planning work. All processes will be continuously questioned. Each process cannot have numerous checks and balances, but can have absolute accountability. This involves trust between staff members. It will also mean that one staff member may not be able to substitute for another.

Information technology will influence the transformation of an organization. Organizational charts will look like networks of specialists. Even communication patterns will be shifting from a hierarchical path to a flatter and broader plan as "universal access" alters the location and strength of traditional power centers such as reference or cataloging. Team-based work structures will probably be modus operandi. Herb White (1995b), Distinguished Professor Emeritus of Indiana University, states that team-building can not be a conscious or unconscious search for conformity and mediocrity. It should be the careful selection and hiring of the best people, paying them well, giving them the understanding of what needs to be done, giving them the tools to do what needs to be done, and turning them loose. Voluntarily-formed teams will probably occur as special skills or abilities are needed to solve a problem. The organizational structure will probably require fewer bosses. Individuals should be empowered, evaluated, and rewarded. Incompetent staff members, pleasant or not, should be removed and competent ones, unpleasant or not, should be encouraged. Collaboration with others, not necessarily information professionals, will be necessary.

The new information professional will find it appropriate to be skilled in a subject speciality as well as have a basic computer literacy for electronic resources in a distributed environment. Constant change will be standard operating procedure as the new information world reveals itself. The information professional will be directly involved with assisting users in accessing electronic information resources. Electronic resources will be used as a medium in teaching, learning, and research. The new information professionals will be as comfortable with hardware and software as they have been with the information itself.

EDUCATION OF THE NEW INFORMATION PROFESSIONALS

The implications for the education of information professionals include a broadening of scope and emphasis on practical management and marketing experiences. This may include the study of organizational theory, financial planning, strategic planning, effective communication, hands-on-experience, continuing education for professionals and for the professors, and increased participation in international programs because of the global nature of the new information world. Highly developed interaction and communication skills will be expected. The new information professional's tool chest (to use a business vernacular) will include a proactive approach toward constituencies, a natural flexibility, and responsiveness to diverse service requirements.

Traditional information educational programs will have to undergo restructuring and re-tooling. Recruitment of the best students must be a priority. The first students from the new programs will have a lot to prove. Programs of study and course outlines will be dynamic and not traditional. Tenured faculty may not be as important as adjunct faculty who are practitioners in the information world.

THE INFORMATION ENVIRONMENT

Administrators responsible for hiring will have to be aware of the many different education paths that may be appropriate. The new information professional may have a transcript of class titles such as : Understanding the Information User, Organization of Information, Professional Principles and Ethics, The Information Environment, Management of Information Organizations, The Librarian as Mediator, Information Resources, Information Access and Retrieval, Automated Systems and Software, Collection Management, and Characteristics of Information Agencies. These are class titles from the new University of Denver Library and Information Services program just being started. No longer will course titles such as Cataloging and Classification, Computer-Based Reference Services, Library Mechanization, Science Bibliography, etc., be entry credentials. Practicums, capstone projects, or internships may have more value than other courses. People with diverse educational backgrounds, expectations, and attitudes will be potential clients, and therefore, potential members of library staffs must also have diversity. A library degree may not be the entry credential for employment in the brave new information world.

Expanding the information environment will place new and different demands and constraints on libraries. Missions and goals of libraries will broaden considerably. New technologies will impose new data and behavior requirements and will make possible new demands. The realization of information as a costly commodity will impact all segments of society.

Administrators will determine if their library is pursuing worthwhile goals and is aware of short- and long-term organizational effects. They must recognize and plan for the snowball effect from different service options. Creative tension for staff must be maintained, but not to the point of burnout. Administrators must have the resources available to cope with innovation.

CONCLUSION

This has been an interesting exercise in visualization. I have freely borrowed from Bearman (1984), Cargill (1990), Dewey (1994), and Mason (1990) and an interesting article entitled "Re-engineering the Information Professional". Geoscience information professionals will continue to possess specialized knowledge and the adjustments in preparation of these professionals and practice in the field will be particularly important. Their professionalism will be a proactive response to the growing complexity, diversity, and volume of activity in the geosciences and will reflect the accumulation of special knowledge, skills, and abilities to cope with those changes. As the geoscience community and the geoscience information professional work together, I am confident the geoscience information professional will have a significant part in the crucial activity of shaping context in the geosciences.

REFERENCES CITED

Bearman, Toni Carbo, 1984, The changing role of the information professional: Library Trends, v. 32, no. 3, p.255-260.

Cargill, Jennifer, 1990, Personnel and technology: an opportunity for innovation, *in* Leinbach, Philip E. ,ed., Personnel administration in an automated environment: New York, Haworth Press, p. 31-46.

Crawford, Walt, and Gorman, Michael, 1995, Future libraries: dreams, madness,and reality: Chicago, American Library Association, 198 pp.

Dewey, Barbara, 1994, Personnel costs and patterns in libraries: Library Trends, v. 42, no. 3, p. 537-546.

Mason, Richard O., 1990, What is an information professional?: Journal of Education for Library and Information Science, v. 31, no. 2, p. 122-138.

White Herbert S., 1995a, Library studies or information management--What's in a name?: Library Journal, v. 120, no. 7, p. 51-52.

_______, 1995b, Never mind being innovative and effective -- Just be nice: Library Journal, v. 120, no. 15, p. 47-48.

DIGITAL PRESERVATION: THE PROMISE VS. THE REALITY

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Abstract - Like all books produced during the "brittle paper period" (1850 - present), books on geology are in an advanced state of deterioration. Unlike books in many areas of human knowledge, where systematic microfilming efforts have been made, preservation in geology has been much more limited. Maps and other illustrations that accompany geologic text frequently utilize color coding and/or oversized formats which are not adequately captured on the small frames of black and white microfilm. Some projects have concentrated on individual preservation of volumes and on making photocopies which include copying color maps. However, these efforts do not solve the problem of producing replacement copies that could be widely and inexpensively distributed throughout libraries.

Recent experiments using digital scanning as a preservation technique in geology have produced significantly improved options for widespread distribution of preserved geology books. The experiments are not complete, but are in the final stages, and they suggest that preservation could continue in this direction. The costs are substantially greater than that of preserving plain text.

It is now time for geology librarians to review technological options and to make recommendations on both techniques and priorities that should be followed -- to establish a national preservation program for geology. This proposal must be reviewed by the larger geological research community so there is a clear understanding of and support for preservation goals that can be presented to funding agencies. Considering the high cost and the large amount of literature to be preserved, it would seem prudent to address the issue of alternate preservation schemes that can be utilized when possible.

BACKGROUND

Preservation of the geologic literature has been a subject of concern to geology librarians for many years. Like all books produced since the 1850's, geology books were printed on highly acidic, mass-produced papers. Over time, paper turns yellow and brittle. Eventually the paper crumbles. The problem of decay in the nation's libraries was clearly recognized in the 1960's and over the years there have been massive national, state and private efforts to preserve books.

It is difficult to work in a geology library and not be aware of the problem of preservation. Geologists and students continue using books that are falling apart. Citation studies and other research verify that the historic geologic literature continues to be used by practicing geologists for many more years than is common in most sciences. Much of geology is site specific. Early observations and mapping of areas are frequently used in later studies, both as a basis of studies utilizing new techniques and as a baseline from which change can be determined.

Also, the high percentage of books and journals containing color and oversized illustrations is unique in publishing. Some disciplines such as art history and fields of science such as botany, zoology, and medicine have literatures characterized by close relationships between text and image and therefore in some respects are similar to geology (Commission on

Preservation and Access, 1992). But the literature of these fields rarely includes maps and diagrams printed larger than page size. Not only are many illustrations large, they are also remarkably variable in their actual dimensions even within a single volume.

Color is used for different purposes in geology as well. In art history, the faithful representation of original works of art is extremely important. Botany and zoology illustrations attempt to represent the colors of plants and animals. Geologic illustrations are also used to represent natural colors, in mineralogy, for example. However, far more common is color coding where colors are used to represent complex geologic relationships. The convention of color coding is very much a part of the study and research of geology. Color coding has been used despite the higher costs inherent in the printing process. After a brief hiatus during the 1950's and 1960's, color coding is once more appearing in a surprising number of geologic journals, not only in traditional areas such as stratigraphic mapping, but also in well logging and seismic profiling (Klimley, 1990).

The large geologic illustrations in books are frequently maps. Yet the preservation needs of geologic maps in books differ from the problems most commonly faced in a general map collection. The latter is characterized by large map sheets, single and in series, but not part of books or serials. These maps are stored flat, often as single sheets, and occasionally folded. In contrast the maps in the geologic literature are an integral part of books -- folded three and sometimes four times and tipped into binding or tucked into pockets. These oversized geologic images, already on brittle paper, are subjected to repeated unfolding and refolding and frequently break along the fold lines.

PROBLEMS WITH MICROFILM PRESERVATION

Systematic microfilming has preserved large amounts of printed materials. But for the geologic literature, microfilming has been frustratingly inadequate. Microfilming utilized the most effective techniques for text -- high contrast with black and white film. Almost all black and white and color illustrations -- photographs, line drawings with shading, engravings -- were obliterated by the filming techniques. Film frame size was geared toward the "normal" text pages. The Library of Congress developed standards that called for filming larger than page size images in systematic pieces. The resulting microfilm of geologic books and serials contained oversized images microfilmed in black and white so all color coding was lost, and in sections that were difficult, if not impossible, to reconstruct into facsimiles of the original illustrations.

Possibly as a result of these format problems, the geologic literature has not been filmed by companies such as University Microfilms International (UMI), which in fact has filmed much of the other scientific journal literature. The one area in which filming has been done, geologic dissertations, has been a perennial source of irritation to geology librarians because of the poor filming of maps, photographs, and other illustrations. Academic librarians have also avoided volunteering geologic titles in massive preservation microfilming projects undertaken in their universities.

The central issue is the geology librarian's belief that the images -- color as well as black and white, small on a page of text, enormous, or folded into a pocket -- are integral parts of the geologic information to be conveyed by the book. The necessity of preserving images has not been discussed openly. Meanwhile, the clock runs out on the paper on which the geologic information is printed.

Without an acceptable mechanism for large scale preservation, isolated projects to preserve the geologic literature have focused on conservation of actual books in areas of high importance to individual libraries. In these projects, small groups of books from the geologic literature, central to an institution's primary mission or just in a state of total decay, were preserved as artifacts. Encapsulation of heavily used maps and text was an expensive, not to mention cumbersome, option. Emerging technologies such as the increased availability of color photocopiers were seized upon to provide working copies of dissertations with oversized images.

DIGITAL PRESERVATION

In the 1990's, digital preservation technology emerged as a possible way to retain the relationship between the geologic text and image and preserve the content of the illustrations. The problem of oversized color images proved to be intractable even in the digital world and was separated out for special consideration. Recently completed experiments suggest that, although colors are not reproduced with complete accuracy, digital scanning is adequate to retain the information represented by the colors over the large images (Gertz, 1995). The small, fairly low resolution monitors commonly available make viewing oversized images online nearly impossible. But when digital files are printed on high resolution printers, the good, if not perfect, color representation and high resolution on the resulting prints indicate that the information captured in the scanning process is of acceptable quality.

Efforts to link digital oversized color images to the text and page sized images are underway at the present time. Illustrations, both black and white and color, will be scanned in color as a means of preserving the gray tones of photographs and engravings. Hopes are high that these efforts will be successful. But we are still at the "promise" stage rather than the "reality" stage. The text is not yet reunited with its images and digital preservation is not without other problems. The large images cannot be successfully viewed on most personal computers and can be printed on commonly available color copiers with limited success. The largest maps over 20 inches by 20 inches represent a very small number of the total number of oversized images, but remain an unresolved challenge as the largest of the images. The hope is that personal computers will continue to develop to a point where they can handle the very large files resulting from scanning very large maps. Alternatively the maps may be digitized in sections and "reconstituted" through digital "lacing" or use of a "mosaic" technique.

Despite these reservations, the promise of a technological solution to the geology preservation problem seems closer to a reality than at any time in the past. It is also very clear that the cost is much higher than standard microfilming efforts. Microfilm costs are generally estimated to be $.25 per frame, usually two pages per frame. In the case of one digital preservation project, a vendor charged $75 for scanning one oversized map. Scanning costs could be reduced to under $40 by scanning from color full frame fiche or transparencies, but that does not include the cost of making the fiche or transparency.

The magnitude of the problem of oversized and other images in geologic literature represents a formidable obstacle when the costs of the digital solution are considered. Oversized and other images appear frequently in geologic literature. Twenty-eight early twentieth century numbers of the *New York Museum Service Bulletin* have been used in several projects. An analysis of their text and image content shows that those 28 issues contain more than 6300 pages. There are 539 images embedded in the text, 392 page sized images, and 43 oversized images. Nineteen of the page size images and 36 of the oversized images are in color. The cost of color scanning the 36 oversized color maps alone would be $2700. Simple microfilming of all 6300 pages would be under $800.

NATIONAL PRESERVATION PLAN

There is an old saying: "The longest journey starts with a first step". It now appears that there is a technology, albeit a pricey one, that could solve the problem of preservation of the geologic literature. Perhaps that was the first hurdle to be overcome. The second hurdle is to develop a preservation program statement. Less technically difficult than finding a preservation method, this task requires the literature assessment skills that geology librarians have honed for many years and the review and support of the geology community.

Evaluating preservation alternatives has been done independently by a few individuals. Now it is time for the focus of preservation efforts to change. As the professional organization of geology information specialists, the Geoscience Information Society should develop a long term preservation plan for geology to be validated by the geologic research community, perhaps through an umbrella organization such as the American Geological Institute. This document, developed by knowledgeable information specialists and supported by the researchers in the discipline, will underpin solicitations for funding and support of preservation efforts. A thoughtful national plan is essential in these times of reduced funding opportunities.

The basis of any preservation plan must be discussion among geologic information specialists about goals, assumptions, and the expense of complete preservation of the geologic literature with a realistic eye toward funding possibilities. First, use of digital preservation to capture the images incorporated in geology books is very expensive. If these methods are adopted, more money will have to be spent to preserve a smaller amount of material. Librarians should face this prospect directly. A decision could be made to recommend standard microfilm preservation, saving the geologic text and sacrificing the images. Geologists have also suggested that "only the really important" maps and images should be preserved using color or higher quality techniques. Librarians should be prepared to address both alternatives. Any qualitative selection will add considerable cost to selection in preservation projects and is likely to displease a high percentage of people. If a collective decision is made that text and image must be comprehensively preserved, the rationale must be clearly and convincingly stated.

The literature must be reviewed and decisions made on preservation priorities. This is not going to be an easy task. The Geoscience Information Society is an international organization. Yet what is needed is a plan for the United States where most of the members and many of the sources for preservation funding are located. This does not mean that it is within the interests of American geology libraries to restrict their preservation concerns to American publications. Nor would American preservation funding sources require this. On the other hand, the preservation of international geologic literature is probably an unrealistic goal with which to start.

Even when the directions that preservation efforts should follow seem obvious, they still require clarification. For example, it has been suggested that United States Geological Survey publications have a high preservation priority because of their relevance to geology throughout the United States. Yet when the actual volume and variety of publications published by the USGS is considered, even within that "easy" choice, it is clear that titles will have to be prioritized. The issue of preserving book versus serial literature is one that must be considered.

Once a course of action has been established, opportunities for implementation will open up. It would be possible for consortia of geology libraries to submit a proposal to the National Endowment of the Humanities or to a private foundation. With a plan in hand, individual libraries may be able to advance the preservation progress through local efforts. If state geological publications were to follow the priority of USGS publications, geology librarians might be in a position to encourage inclusion of selected geology titles in state programs. For example, a group of state-produced geology monographs from the 1850's might be included in a state project to scan books relevant to the state from the 19th century. The existence of a national geologic plan would back up the geology librarians' recommendation for inclusion in the project.

Given the very high expense of complete preservation and the rapid destruction of the literature, it is also wise to suggest a fallback position. One possibility would be to recommend preservation of high priority publications in the original form. Geology libraries could take responsibility for titles, perhaps of local significance, and create a master copy by removing, flattening, and encapsulating oversized materials and removing the images and text from public use. If digitization is delayed, a set of publications will exist to be digitized. It is important when libraries undertake "master copy" preservation that this is noted on catalog records in national databases such as OCLC or RLIN so resources for this type of preservation are not wasted.

After years of searching for an appropriate preservation mechanism, the geology library and research community is now faced with breaking new ground in the development of a national preservation program for geology. One excellent model is *A National Preservation Program for Agricultural Literature* written by Nancy E. Gwinn with the assistance of the Advisory Panel on Preservation of the U.S. Agricultural Information Network. This 1993 document consists of 10 points:

1-importance of agricultural literature
2-the need for preservation
3-goal of national preservation program
4-program structure
5-building on past efforts
6-preservation priorities
7-preservation technologies
8-access to preserved literature
9-storage and distribution of archival copy
10-creating a shared commitment for preservation
(Gwinn, 1993)

This plan for the preservation of the agricultural literature includes important points, such as the designation of the National Library of Agriculture as the library of master copy deposit, that have no exact parallel in geology. However, the overall structure of the document is probably similar to that needed for geology. It is also helpful to have a plan that was developed for a science rather than one for the humanities. The preservation plan suggested in this paper is loosely based on the agriculture preservation program

CONCLUSION

Preservation of the historic record is a daunting prospect under the best of circumstances given the volume of material and the speed at which it is deteriorating. In geology, the pressure is on, in great part because of the late start. Librarians may not be able to preserve all of the geologic literature. But with thought, enthusiasm, and new technologies, they can save much of it from being lost forever.

REFERENCES CITED

Commission on Preservation and Access, 1992, Preserving the illustrated text: Washington, D.C., Commission on Preservation and Access, 30 p.

Gertz, Janet, 1995, Oversized color images project, 1994-1995 :Washington, D.C.: Commission on Preservation and Access, 22 p. (URL:http:// www. columbia.edu/ imaging/html/ largemaps/oversized.html)

Gwinn, N.E., 1993, A national preservation program for agricultural literature: Washington, D.C.: U.S. Department of Agriculture Library, 20 p.

Klimley, Susan, 1990, Color representation of geologic data: Episodes, v. 13, no. 3, p.162 -166.

STOCKING THE DIGITAL LIBRARY WITH GEOREFERENCED DATA

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Abstract - Content metadata standards are being developed to describe data sets, information services, and electronic resources for distributed organized collections of digital libraries. These standards are similar in purpose to the library community's MARC format, but extend the scope of description to other attributes. For georeferenced data, the Federal Geographic Data Committee's *Content Standards for Digital Geospatial Data* is the most important metadata standard. This standard is described and related to MARC and other metadata efforts.

INTRODUCTION

Georeferenced information comes in many packages. It includes not only maps and geographic information systems, but also remote sensing images, photographs, census data, biological and earth science data, ecological studies, published articles, papers, and books. It includes all information that is related to a particular geographic place. Retrieval systems that let a user search for data and information related to a particular geographical location are growing in sophistication and are becoming available over Internet connections as well as in locally-held collections. Many of these systems allow searching by both place names and latitude/longitude coordinates. Map-based search interfaces, where a user indicates on a map his/her area of interest, are also becoming available. These search systems compare the user's target area to the spatial descriptions of the information objects in the collections or indexes that are available and return a listing of geographically similar items as well as matching other parameters included in the search. This enhanced access by geospatial characteristics will tap into user needs for such information that were not so evident before the availability of the technology in retrieval systems.

To stock distributed digital libraries with georeferenced data for these systems will require a major effort. Data sets must be described according to standard procedures and formats and coordinated with existing library cataloging practices so that all types of georeferenced information are accessible through a single approach. Library practices and the representation of geographic parameters by indexing and abstracting services will also change as users begin to expect access to information (not only data) by geospatial representation.

The *Content Standards for Digital Geospatial Metadata* by the Federal Geographic Data Committee (FGDC) is the major development in metadata design for geospatial data (Federal Geographic Data Committee, 1995). It is the result of years of consensus building among the participants in the FGDC as part of their overall effort to build the National Spatial Data Infrastructure (NSDI). Its structure will be described in some detail here as well as its relationship to the library community's MARC format and related metadata development efforts.

The federal government has funded six Digital Library Initiatives (DLIs). The focus of these projects is "to dramatically advance the means to collect, store, and organize information in digital forms, and make it available for searching, retrieval and processing via communication networks -- all in user-friendly ways" (Digital Library Initiatives. 1995). These are four-year projects centered at the universities of Illinois, Michigan, Carnegie Mellon, Stanford, and two University of California campuses, Berkeley and Santa Barbara. Each of these projects is building a testbed collection according to its particular project objectives and developing access and delivery technologies for the collection. The testbeds will then be scaled to accommodate more information, more advanced information handling tools, and a greater number of users. Each DLI project is involved in many partnerships with other universities, government agencies, and private companies. The project at Berkeley has a major georeferencing component focused on environmental information (University of California at Berkeley, 1995). The Alexandria Project at Santa Barbara has as its primary focus geospatial data and georeferenced information resources (University of California at Santa Barbara, 1995).

Through these projects and others like them, we are building toward a time when sophisticated queries can be launched to search distributed online resources, including reference materials, scholarly journals, satellite images, video archives, environmental data, and instructional materials of all types. The information sources will reside at hundreds of thousands of geographically remote locations both in electronic and print form. Presenting a coherent view of this varied information, so that users will be able to find these sources by geographic attributes as well as other characteristics, requires a coordinated approach to description through metadata stocked in the digital library.

The goal of this paper is to help bridge the gulf that separates traditional libraries and their collections and services from data centers and their archives and services so that the future digital libraries can provide access to all types of georeferenced data and information that are accessible by both textual attributes and by geospatial parameters. Since readers of this paper are assumed to be more familiar with the library side of information management, the emphasis here is on an introduction to metadata development for data sets.

DEFINITION OF METADATA

"Metadata are 'data about data.' They describe the content, quality, condition and other characteristics of data. Metadata help a person to locate and understand data" (Federal Geographic Data Committee, 1995). Bruce Gritton of the Monterey Bay Aquarium Research Institute described metadata as "a class of data used to describe the content, structure, representation, and context of some well defined data artifact" (Gritton, Bruce, 1995, unpublished White Paper Contribution to First Alexandria Design Review Workshop, September 6-8, 1995, Leesburg, Virginia, 1995). The National Biological Service (NBS) describes metadata this way: "Metadata refers to data that are used to describe a database (e.g., describing the extent of the data, coverage, scale, what methods were used to collect the data, by whom and when the data were collected, etc.). With valid and complete metadata, someone can learn enough about a database (without communicating with the 'owner' of the data) to determine if the data would be of use or interest to them" (National Biological Service, 1995).
Examples of metadata formats are:

- The MARC (Machine-Readable Cataloging) format used by the library community to describe library materials. MARC is an implementation of the National Information

Standards Organization (NISO) Z39.2 standard: *Bibliographic Information Interchange*. MARC includes fields for latitude and longitude coordinate values.

- The Content Standards for Digital Geospatial Metadata developed by the Federal Geographic Data Committee More information about this standard follows in this paper.

- The National Biological Service (NBS) created a content standard for biological metadata and their National Biological Information Infrastructure (NBII) by modifying the FGDC standard (retaining the geospatial data elements). This is an interesting development because it shows the potential for adapting an existing standard for other purposes, but it also raises questions about the coordination structure for these developments. The NBII is an NBS initiative to foster the development of a distributed electronic network of biological data and information maintained by a variety of federal and state government agencies, universities, museums, libraries, and private organizations (National Biological Service, 1995).

- The Directory Interchange Format (DIF) was created by NASA to exchange directory-level information about data sets among information systems and, in particular for the Master Directory, descriptions of worldwide data sets in the earth and space sciences including geospatial parameters. This is an early example of the creation of a metadata format that did not become a widely used standard, but has been a major component of a successful data sharing activity. The DIF format is now being modified to comply with the FGDC Content Standard. For further information, consult the Global Change Master Directory (GCMD) web site at http://gcmd.gsfc.nasa.gov/.

- The Government Information Locator Service (GILS) is a federal initiative to "identify public information resources throughout the U.S. Federal Government, describe the information available in those resources, and provide assistance in obtaining the information. It will consist of a decentralized collection of agency-based information locators and associated information services. U.S. federal agency information resources will be identified in a common way using the specified GILS Core Elements" (Government Information Locator Service, 1995). The GILS Core Elements constitute a metadata record format largely adapted from MARC. It includes data elements for geographic coordinates.

- OCLC and the National Center for Supercomputing Applications (NCSA) convened a meeting in March 1995 for the purpose of addressing and advancing "the state of the art in the development and extension of methods, standards, and protocols to facilitate the description, organization, discovery, and access of network information resources....The primary deliverable from the workshop was a set of thirteen metadata elements called the Dublin Metadata Core Element Set (or Dublin Core) by the workshop participants. The Dublin Core was proposed as the minimum number of metadata elements required to facilitate the discovery of document-like objects in a networked environment such as the Internet." (OCLC/NCSA Metadata Workshop, 1995). One of the thirteen elements is "Coverage" for spatial and temporal description.

METADATA STANDARDS

Why does the development of metadata standards matter?

The reasons are related to long-term interoperability and economics. The library community has a good understanding of the advantages of standard formats for bibliographic data. The MARC format has been the foundation for the sharing of bibliographic records worldwide and of information items (books, articles, etc.) through shared knowledge of the holdings of thousands of libraries. Efforts are being made to describe data set holdings through metadata descriptions in much the same way that bibliographic records describe library materials. Early efforts have been made within particular communities of users and for particular projects. There is a growing awareness that these individual efforts will lead to the isolation of information communities if the proliferation of standards continues. Home-grown metadata formats, if not based on existing standards, result in more problems with importing and exporting information and make the goal of searching across distributed information resources more difficult.

In contrast, a generally accepted metadata format and structure that is adaptable for local purposes will lead to an integrated foundation that will more easily support many user communities and software products to serve many groups and purposes. Well-documented metadata elements are needed to support distributed searching, retrieval, display, and use. The documentation must show how data elements are related to one another and what information is expected to be represented in which data element.

For long term use and deployment of the metadata standards (and there will probably will be more than one), assigned responsibility and formalized mechanisms for maintenance and modification are needed. Without this structure, standards will not be living documents that continue to adjust to newly identified requirements. The case can be made that the USMARC format has been the most successful and most widely used version of MARC because it has a division of the Library of Congress behind it and an active advisory committee (MARBI).

It is important that the metadata records and standards are done correctly the first time because metadata creation is a very expensive process. A full metadata record for a data set will have many data elements describing the source and quality of the data, processing that has been performed on the raw data, instruments that collected the data, format and organization of the data, purpose for which the data was collected, dates of collection, investigators, organizations, etc. But the collection of the data being described is even more expensive and the effort to describe the data in sufficient detail for identification and use by a wide group of users for long-term use is justifiable. No one, however, will be happy having to convert or rewrite metadata later to meet newly discovered interoperability requirements.

THE PURPOSE OF METADA STANDARDS

Metadata represent information objects (documents, data sets, information services, etc.). They are surrogates for more extensive objects. They contain not only extractions from the information objects (intrinsic attributes such as author and title), but also value-added information such as subject description, purpose, and quality (extrinsic attributes). Metadata provide the information needed to determine *accessibility, assess-ability*(fitness for use*)*, *content*, *context*, and *representation* of the data and information.

Accessibility has two aspects. First, the existence of the metadata record 'advertises' and documents the existence of the data. Without this record, the data itself will not be known to exist beyond the group who created the data set. Second, the metadata details the accessibility of the data: who to contact, how to order, any restrictions on access or use, any fees associated with use, etc.

Metadata provide the information needed to *assess* the value of the data set for a particular purpose. Enough information must be provided for a user to make an initial determination about whether or not the data set is likely to be suitable. This covers a broad spectrum of information including date of collection or publication, time period covered, source of the information, accuracy or reliability, level of detail, level of presentation, format of document or data, subject coverage, geographic coverage, etc.

The description of *content* included in metadata covers such information as subject, geographic and temporal coverage, and details of the organization of the data/document.

The description of *context* describes the personal and organizational parties responsible for the data (e.g., authors and their affiliations and corporate sponsors), the purpose of the investigations, the instruments and methodologies used, the known limitations of the data, etc.

The description of *representation* provides information about the structure in which the data is stored or is available.

THE FGDC CONTENT STANDARDS FOR DIGITAL GEOSPATIAL METADATA

The Federal Geographic Data Committee developed a content metadata standard to provide the descriptive structure for representing geospatial data sets through the National Spatial Data Infrastructure. This standard was developed through several years of consultation and discussion within the geographic data community with final approval on June 8, 1994. Federal agencies were directed to use the standard to describe all of their geospatial data by Executive Order 12906 (April 11, 1994) and to make these metadata available to the public through the NSDI.

The FGDC Content Standard is designed to include the information required by a prospective user of the data in order to determine:

- the availability of a geospatial set
- the fitness of a set of geospatial data for an intended use
- the means to access the set of geospatial data
- the requirements to transfer the set of geospatial data successfully.

The Standard does not specify:

- the means to organize the information in a computer system or a data transfer
- how information is transmitted, communicated, or presented to the user.

(Federal Geographic Data Committee, 1995)

In other words, the FGDC Content Standard is not a transfer standard like the MARC record format. It is like MARC in that there are data fields to describe the information object and the resulting record serves as a surrogate for retrieval and evaluation. Neither MARC nor the FGDC Content Standard specifies storage or presentation formats.

The FGDC Content Standard consists of seven main sections plus three supplemental sections that are repeated within the main sections.

The main sections are as follows:

1. Identification Information (subsections shown below)
2. Data Quality Information
   Accuracy and consistency parameters; processing lineage; percentage of cloud cover
3. Spatial Data Organization Information
   Mechanism used to represent spatial data
4. Spatial Reference Information
   Reference frame for, and the means to encode, coordinates in the data set
5. Entity and Attribute Information
   Measured or represented entities in the data set, related attributes and domain values
6. Distribution Information
   Order number or label; order process; digital format; technical requirements; etc.
7. Metadata Reference Information
   Supporting information about data

The supplemental sections are:

a. Citation Information
b. Time Period Information
c. Contact Information

Data elements are organized into compound data elements which are in turn organized into subsections. At each level (primitive data element, compound data elements, and subsections), the FGDC Content Standard identifies whether or not the unit is mandatory, mandatory if applicable, or optional to guide the creation of the record. At the section level, sections 1 and 7 are mandatory and sections 2-6 are optional.

Using Section 1 to illustrate the organization of the Standard: Section 1 has fourteen subsections (1.1 - 1.14):

1.1 Citation (uses Section 8)
1.2 Description: Abstract; Purpose; Supplemental Information
1.3 Time Period of Content: uses Section 9; Currentness Reference
1.4 Status: Progress; Maintenance, and Update Frequency
1.5 Spatial Domain: Bounding Coordinates; Data Set G-Polygon
1.6 Keywords: Theme; Place; Temporal
1.7 Access Constraints
1.8 Use Constraints
1.9 Point of Contact: (uses Section 10)
1.10 Browse Graphic: Browse Graphic File Name; Browse Graphic File Description; Browse Graphic File Type
1.11 Data Set Credit
1.12 Security Information: Security Classification System; Security Classification; Security Handling Description
1.13 Native Data Set Environment
1.14 Cross Reference: (uses Section 8)

Section 8 (Citation) is organized as follows:

8.1 Originator
8.2 Publication Date
8.3 Publication Time
8.4 Originator
8.5 Edition
8.6 Geospatial Data Presentation Form
8.7 Series Information: Series Names; Issue Identification
8.8 Publication Information: Publication Place; Publisher
8.9 Other Citation Details
8.10 Online Linkage
8.11 Larger Work Citation: (repeats the use of Section 8)

The FGDE Content Standard has been mapped to the USMARC format by Elizabeth U. Mangan of the Library of Congress (Mangan, 1995) and the USMARC format has been modified to accommodate all the FGDC data elements (U.S. Library of Congress. USMARC Office, 1995). As noted in the beginning of this paper, the FGDC Content Standard is also being used as the starting point for the development of metadata standards for other research groups. It is also being used by the federally-funded digital library project at the University of Santa Barbara, Alexandria Project, for their testbed of spatial data and information resources.

CONCLUSION

We can envision an Internet-based information system that would meet the needs of the user who is interested in finding and using information relevant to a particular geographic location. This user should be able to use a map interface on a computer monitor to designate the area of interest or use place names associated with the area as well as other parameters to focus retrieval on the information needed. Maps, GIS files, census data, statistics, remote sensing images and aerial photographs, technical reports, articles, conference papers, books, museum artifacts, sample collections, video tapes, etc. should all be identifiable for the geographic region in question. To accomplish this, we need to stock the digital library with spatial descriptions of georeferenced information objects in a consistent manner for all types of information and link place names to spatial representations. Metadata standards development is the mechanism through which we will develop this consistency. For the user's sake, text-based information professionals and data-based information professionals need to coordinate their parallel efforts to represent georeferenced information and be involved in the continuing evolution of these approaches.

REFERENCES CITED

Digital Library Initiatives, 1995, URL: http://www.grainger.uiuc.edu/dli/national.htm (November, 1995) *Provides links to the six digital library initiative projects, November, 1995.*

Federal Geographic Data Committee, 1995, Content standards for digital geospatial metadata workbook: Washington, D.C., Federal Geographic Data Committee, 1 v. *Copies can be obtained via ftp from fgdc.er.usgs.gov in the /var/ftp/pub /metadata directory by the file name or through WWW at: htttp://fgdc.er. usgs.gov/ metaover2.html. Print copies can be ordered from FGDC Secretariat c/o U.S. Geological Survey, 590 National Center, Reston, Virginia 20192; telephone: (703)648-5514; fax: (703)648-5755; or Internet gdc@usgs.gov.*

Government Information Locator Service, 1995, Home page: URL: http://www.usgs.gov:80/gils/ (November, 1995).

Mangan, E.U., 1995, The making of a standard: Information Technology and Libraries, v. 14, no. 2, pp. 99-110.

National Biological Service. Home page. URL: http://www.nbs.gov/nbii/ (November, 1995).

OCLC/NCSA Metadata Workshop, 1995, The essential elements of network object description. URL: http://www.oclc.org: 5046/conferences/metadata/ (November, 1995)

University of California at Berkeley, 1995, An electronic environmental library project. URL: http://elib.cs.berkeley.edu/ (November, 1995)

University of California at Santa Barbara, 1995, Alexandria Digital Library. URL: http://alexandria.sdc.ucsb.edu/ (November, 1995).

U.S. Library of Congress. USMARC Office, 1995, MARBI proposals and discussion papers, 94-17 and 94-17A. URL: http:// marvel.loc.gov (November, 1995) *Look under LC Online Systems, LC MARVEL, Libraries and Publishers, and MARBI Proposals and Discussion Papers, November, 1995.*

GIS ON THE INFORMATION SUPER HIGHWAY (INTERNET)

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Abstract - Internet, a wide network of computers, has facilitated the accessing and sharing of information around the globe. The World Wide Web (WWW) is a protocol on the Internet which allows hypermedia information retrieval. Geographic information systems (GIS) are being widely employed for diversified applications in resources management, geology, and other fields. Purdue University has developed a WWW-based system which facilitates the exchange and dissemination of geographic and geologic information.

GIS data using GRASS (Geographic Resources and Analysis Support Systems), a raster based GIS software, has been made accessible on the Internet. The Web server allows users anywhere on the Internet to manipulate and display the GIS data layers of interest. Additionally, the server supports water resources data for the state of Indiana. Accessibility of GIS on the Internet opens a wide area of information transfer and will enable users to access and share spatial data for various applications.

INTRODUCTION

Geology is a highly integrated science involving and requiring information and expertise from many disciplines to facilitate integrated analysis. Since the 1980's, geologic information has become increasingly data intensive. The changes in the nature and scope of geologic information have been driven in many respects by the changes in technology and the availability of cost effective computers for analysis and storage. Even as the costs of computing have become more reasonable, the costs of acquiring primary data have been rising.

Several areas of research and technology have been developed in recent years which relate directly to data management and geologic information. A significant amount of geologic data is spatially referenced, and thus is best managed by the use of Geographic Information Systems (GIS) technology. GIS was designed to organize, manipulate, and analyze spatial data. Additionally, development on the Internet, specifically, the World Wide Web (WWW, Web or W3) and the Hyper-Text Mark-up Language (HTML) have led to increased interdisciplinary communication. The merging of these two technologies as both a method of data communication and data analysis is a direction which will benefit both researchers and the public.

As the cost of primary research rises, the Web, with its ability to allow remote communication, can be used to stimulate interdepartmental interaction on integrated research projects while avoiding costly duplication of research. Purdue University's response to facilitate data sharing and cooperative research was to create a system where university researchers could communicate and trade information and ideas through the Internet and a local Web site. The theory is that increased communication eliminates the problems which might arise when multiple departments research similar projects. The goal of this paper is to describe the implementation and operation of Purdue's Internet solution to sharing spatial data. Purdue's Web-based systems help eliminate the costs and frustration associated with data duplication and the location of additional primary data sets available both at Purdue and elsewhere. There are three servers which were created at Purdue University specifically to address the aforementioned concerns: the *Indiana Geographic Information Server (INGIS)*, the *Indiana water resources information server (WETnet)* and the *interactive map server*.

IMPLEMENTING A SERVER

There are both *philosophical* and *technical concerns* which must be addressed when implementing a server on the Internet. These two concerns are highly interrelated and, much as technology may drive science in new directions, the philosophy of the server may drive the implementation of the technology.

Philosophical Concerns

There are three basic philosophical issues which must be addressed. The first issue is whether or not the service will be a data repository, a data locator, or a combination of the two. This issue directly relates to the technical concerns or technology which much be provided (a large amount of available disk storage or simple access to the Internet).

The next philosophical issue is based on the type of access which will be granted to the client: 1) the available services and 2) data access. The first concern is whether the client will have limited or unlimited access to the server systems. This relates to whether or not the client needs a password or authorized machine to link to the services or if the services are unrestricted. The services could be limited to subgroups. Again this philosophical concern is directly related to the technology, specifically the software employed to implement the server.

The final issue is one of cost. Is the intended server a free server or do the services provided cost money and require payment for being provided? Commercial servers are becoming more prevalent and universities need to assess whether or not their information will be available outside of the university and, if so, will the public be charged to access it.

Technical Concerns

Four technical concerns must be considered: server type, storage, connectivity of the server, and the look and feel of a server.

The type of server is dictated not only by the available funds, but is also dependent on both the expected traffic to and from the site and the philosophical concern of data repository or data locator. PC-based systems are suitable both for lower traffic and as data locators. The ability to link large data sets to a PC-based system is currently limited by the available operating systems and the availability of viable backup capabilities. Geologic and GIS data sets are often extremely large (GIS data sets can be tens of gigabytes). Mini-computers, often thought of as workstation-based systems, are a moderately priced alternative which can handle moderate traffic and large data sets. UNIX-based workstation systems work well as servers for moderate applications required by systems which have the dual nature of limited data repository and data locator. These systems are not suitable for heavy traffic and running multiple ancillary applications concurrently. Primary use as a data repository or heavy traffic generally requires a larger server. It is beyond the scope of this paper to suggest specific systems, but in general, these guidelines should assist developers and system administrators in correctly establishing the hardware for the server.

The amount of available storage on the system is related not only to the philosophical design of the server but also to the chosen software. As previously mentioned, PC-based systems intrinsically have less available disk space than mini-computers which, in turn, generally have less than mainframe configurations. Greater storage is not always better. The size of a system's hard disks will be directly proportional to the type of usage the system is designed to maintain. Thus data locator systems will need only minimal hard disk space and can often be run very efficiently from a PC-based system. A system which is designed primarily as a data repository and disseminator will work best with a mainframe system which can manipulate and efficiently handle large data transfers and gigabytes of data.

The third primary technical concern is connectivity of the server to the outside world. This area is intimately related to the philosophical concerns dealing with issues of data access and cost. The hardware must be able to communicate efficiently with the outside world, and the outside world (or intended audience) must be able to contact and use the system.

The fourth technical concern is the look and feel of the server. The server will not be of use if it is difficult to access or too difficult to navigate. The specifics of the server's look and feel in some respects is dictated by the HTML daemon under which the server was designed. It is the power of a Web browser to advantageously utilize the multimedia tools such as point and click forms, pictures and sound, or combinations of all the above. Access to forms and image maps has been shown to be an essential tool for Web development, and thus the server must be able to support these forms of HTML protocols which are accessed through what is referred to as Common Gateway Interface (CGI) scripts.

PURDUE UNIVERSITY SERVERS

This section will concentrate on the servers designed and implemented at Purdue University which facilitate data sharing and research collaboration across many of the university's departmental boundaries. These servers were designed to facilitate those faculty, staff, and students working with environmental, geologic, agricultural, and GIS data across the campus.

Indiana Geographic Information Systems Server (INGIS)

The INGIS Server is the backbone of the systems at Purdue University. All of the systems presented in this paper reside on the INGIS machine and are accessible through the INGIS Home page (http://ingis.acn.purdue. edu/). The system chosen was a mid- to small-sized minicomputer system, a SUN SPARC 10. The system is connected directly to the University's Agricultural Computing Network and is accessible directly by staff and students on campus. The system runs with 96 megs of RAM and currently has 16 gigabytes of accessible disk storage. This configuration was chosen not only for its cost efficiency, but also to meet the needs of the philosophical design and mission of the project. Figure l shows the INGIS home page.

The mission of the INGIS server is to aid Purdue University faculty, staff, and students in identifying and accessing GIS data sets, and to provide the GIS facilities to encourage, enhance, and facilitate water and other natural resources research teaching and extension projects. This server was designed as a data locator and repository, storing permanent data sets for ongoing research, teaching and outreach, and enabling transfer and downloading of these data sets. The system was designed to operate free of charge, but with limited access by non-university affiliated researchers. Not all data sets on INGIS are directly accessible to all users. General users can see much of the data, but need to make a formal request to the system maintainer to get a copy of the data set since a great deal of information on the server is only viewable outside of the direct university community.

The server now regularly serves the Purdue County Cooperative Extension Service (CES) and several of the GIS groups within the state government. Although INGIS provides a limited amount of national data, it is primarily designed to provide data at the state and county level for Indiana with a special focus on data usable to the CES agents.

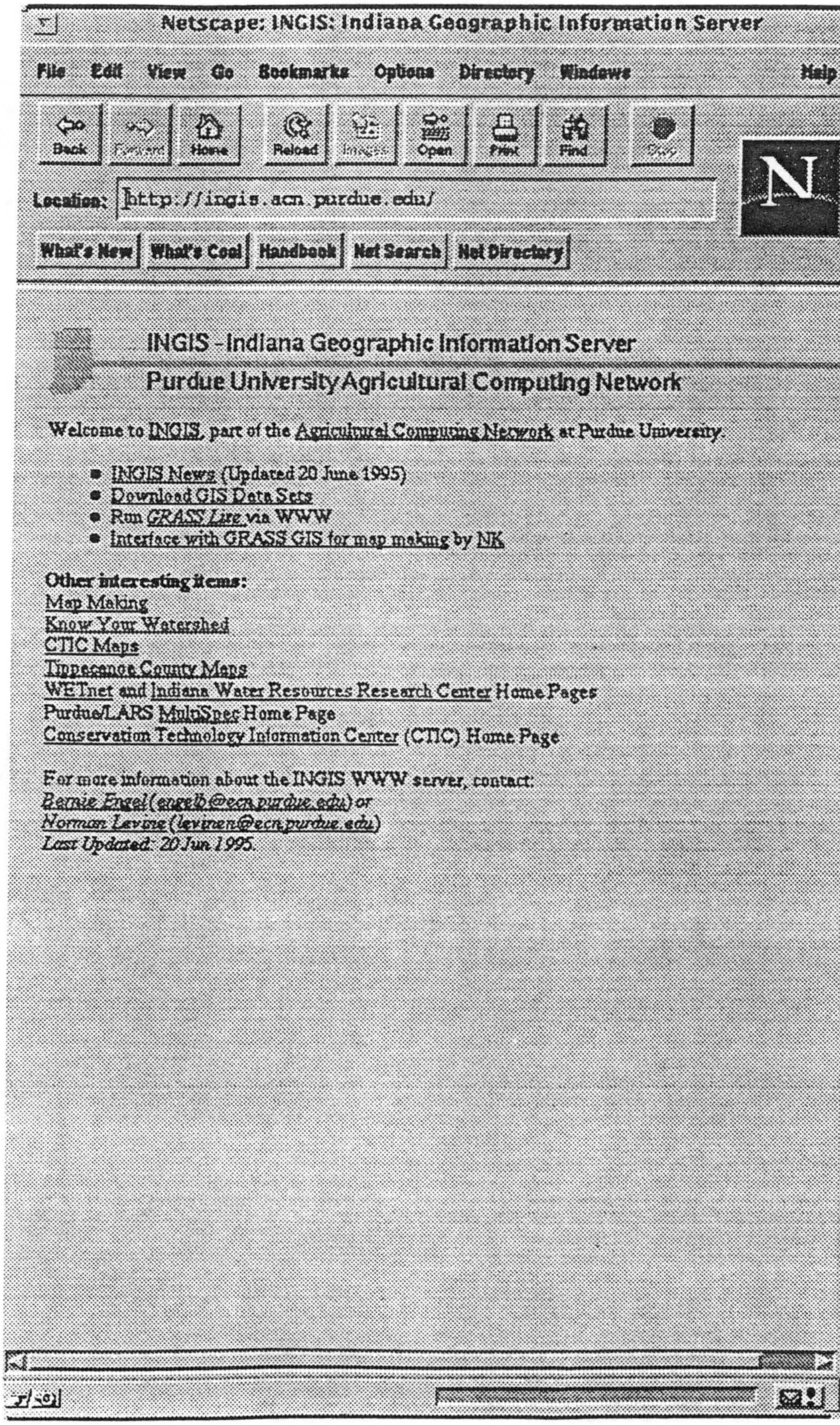

Figure 1: INGIS Home Page

The Indiana Water Resource Server (WETnet)

The WETnet is a second Web server residing on the INGIS server. Thus, the platform descriptions is the same as previously described. The philosophy of this system was different than the INGIS server and the constraints on storage and usage were complementary, therefore the WETnet could reside on the same hardware. The WETnet server is designed to disseminate information about Indiana water resource research and current issues. Primarily a data locator and information server, it points to hypertext links to pertinent documents and other related Web sites. It was designed for use by the general public as well as for university and government personnel. The server is free of charge and the majority of information is accessible to all users. The WETnet server has information relevant to the state of Indiana and links to other similar servers across the country. Figure 2 shows the WETnet home page.

The Interactive Map Server

The WETnet/INGIS Interactive Map Server's goal is to provide a direct visual method of viewing and accessing GIS data collected and in use by the Purdue GIS community. The audience for this server, or more correctly, Web-based visualization tool, is primarily Purdue University faculty, staff, and students, secondarily Purdue Cooperative Extension Service County agents, and finally state agencies (Indiana Department of Environmental Management, Indiana Department of Natural Resources) which are partners with Purdue personnel. The backbone of this system was designed to run on the State Department of Education's Network, thus consideration was given to the accessing of data from K-12 teachers and students in the future. Therefore the system was designed with a philosophy of "simple is best". A Graphical User Interface (GUI) was developed for facilitating data viewing. GUIs are point and click interfaces which allow a relatively inexperienced user to navigate the hidden, complicated, data repository to create maps of features of interest.

Web Based GIS GUI's

Web based GUI's can be presented using region sensitive image maps based on political or natural (e.g. watershed) boundaries. Clients may visually search, locate, and select data of interest. For example, if presented an image map of the United States, suppose that the client selects Indiana. This leads to a county map of Indiana. At this point, the client may select either a database for the entire state or for a particular county. Suppose the client selects Tippecanoe County, Indiana, and no smaller region is defined on the GIS data server. The client would then be given a list of maps available for the county. For the sake of this example, assume that a vector map of streams and a raster map of land use are available. The client could then start GUI for GIS (as a CGI program) and then display these maps or perform a simple analyses. This type of interaction via the Web provides an excellent interface for novice users as well as giving world-wide access to a GIS data server. The elements of such a server necessary for the above example were developed. Implementation of several Web-based GUI's for data access, manipulation, and visualization are described below.

Grass Lite Interface

GRASS (Geographic Resources Analysis Support System) is primarily a raster-based system, originally developed by the U.S. Army Construction Engineering Research Laboratory (USA-CERL). GRASS data sets, comprised of site, vector, and raster data, are arranged by location. Each location can have many map sets or workspaces, usually arranged by themes or file ownership. The PERMANENT map set in GRASS contains the system files defining the geographical extent and the projection information for the location. The end-user typically does not have permission to modify the field in this map set.

GRASS was chosen for this project because

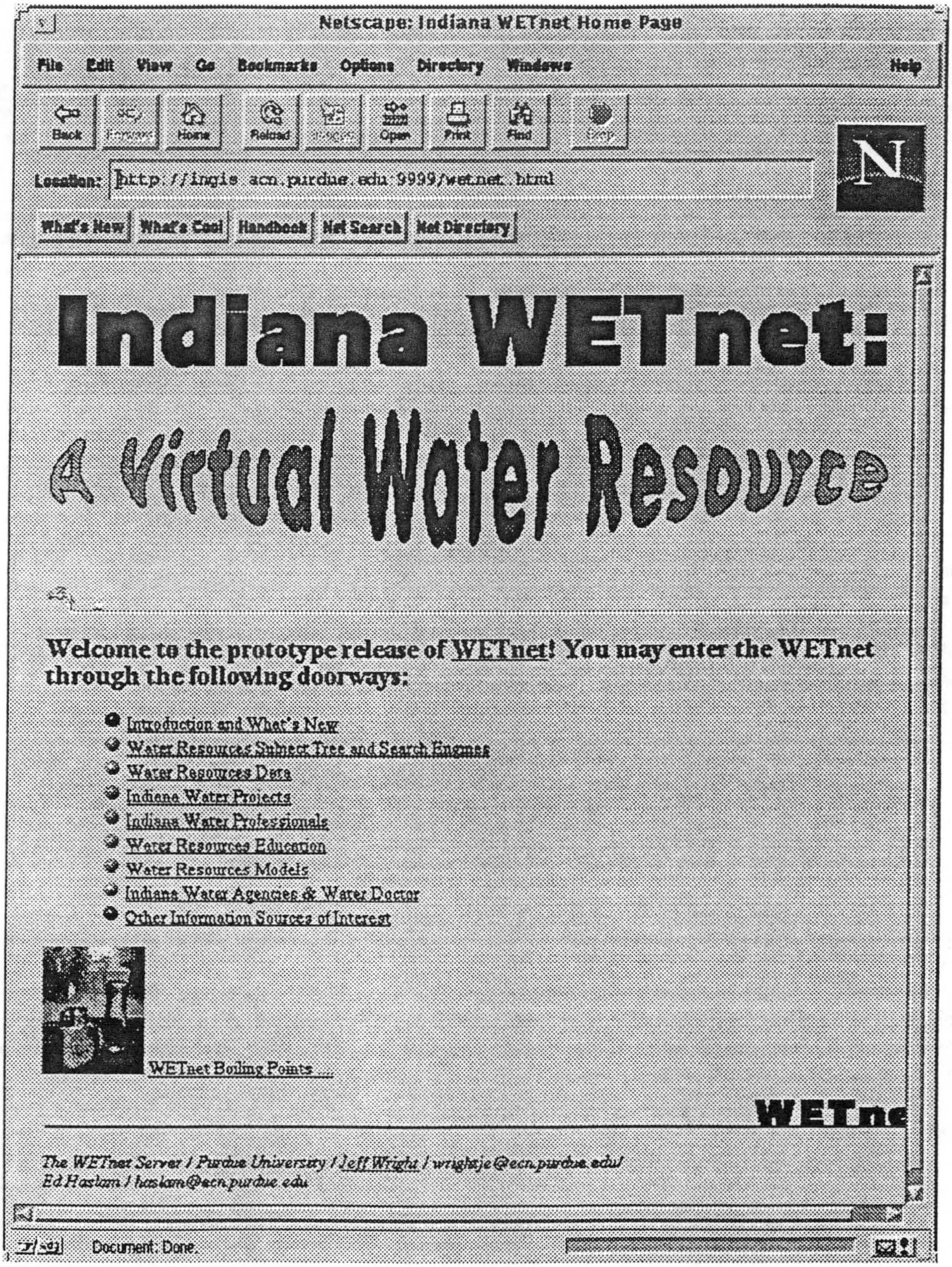

Figure 2. The WETnet Home Page

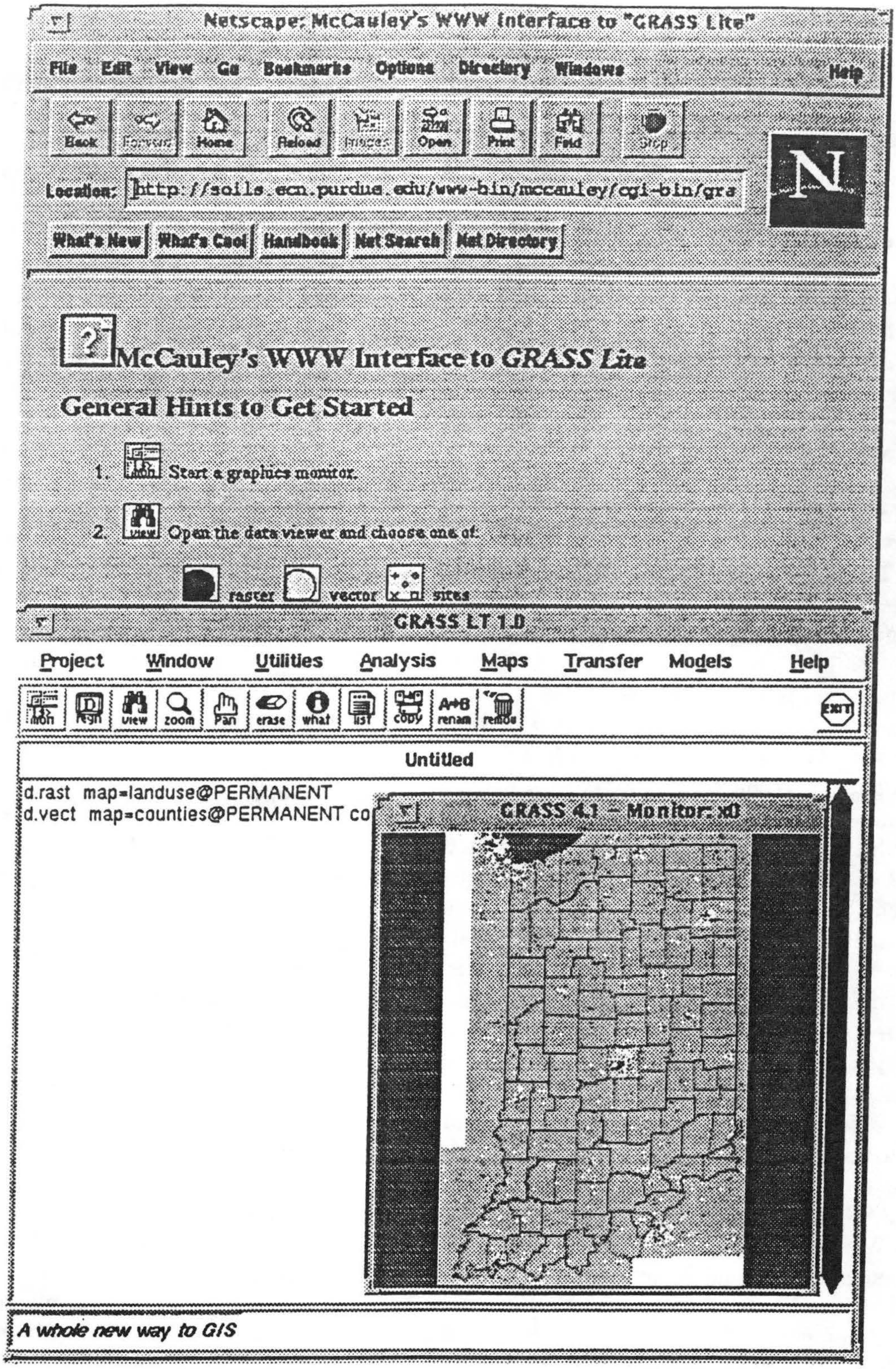

Figure 3 : GRASS Lite session via a WWW session

because of many factors: (1) open file formats (Gardels, 1933 and Ireland, 1995), (2) freely-available source code (which allows for modifications and/or customizations), and (3) lack of licensing restrictions. As a public domain system, a Web server using GRASS does not utilize costly floating licenses that might be associated with commercially available GIS tools. In addition, one of the aims of our GIS/Web project was to redistribute data developed for other teaching, research, and outreach applications which existed in GRASS format. As with similar software systems, graphical user interfaces (GUIs) have been recently developed to allow the user to perform GRASS commands in a graphical and user-friendly environment. GRASS Lite (Zhuang and Engel, 1995) is a GRASS GUI developed by Xin Zhuang of Wyle Laboratories (Arlington, Virginia) using the Tcl/Tk tool kit (Ousterhout, 1994). Tcl/Tk is a native to the X Window System, and is a "vendor-neutral, system-architecture neutral, network-transparent windowing and user interface standard" (Massachusetts Institute of Technology, 1991). Since the X Window System is a network-transparent system, graphical applications can be physically run on the CPU of one machine, but displaced on another machine's monitor (perhaps located on another continent) as long as both machines are on the Internet and are running the X Window System. GRASS Lite requires users to run the X Window System which does not run on PC or Mac architectures without the acquisition of X Windows system software.

Using the Common Gateway Interface, software was developed to make GRASS Lite available on the Internet via the Web. To utilize GRASS Lite for display/analysis of data through the Web, clients page through a series of three documents exchanging information with the server. Each document is created dynamically by a CGI program. The first document uses the FORMS option in the HTML language to allow the user to specify an X Window System display for graphical output. It also instructs the user to allow the server access to their display (using xhost). The next document allows the user to select a GRASS data set (LOCATION). The CGI script was designed to protect the integrity of the data sets as well as the host system. The client is given temporary space in a secure area which is purged at the end of the session. No data from the original database is permanently altered. The final document presented to the user executes GRASS Lite and provides helpful information to begin using the GUI as well as an e-mail address of the maintainer. In addition to map display, this GIS GUI on WWW allows clients to query GRASS databases and perform algebraic manipulations of raster data before downloading data to their own system. Additional functionality may be provided in future version. Figure 3 shows an example GRASS Lite session that was initiated via the WWW.

It should be pointed out that the clients actually access a version of the software that was modified such that obvious security holes have been removed (e.g., any GRASS Lite options that gave users access to the UNIX shell have been disabled). More complete versions of this software are available from the authors (Zhuang and Engel, 1995), but these are not recommended for use via the Web without security-related modifications. The primary limitation of the previous example using GRASS Lite requires users to run the X Window System, which is not readily available to most PC users connecting on the Internet.

GRASS Output in GIF Format

For users who are accessing the Web from PC-based systems or who need only to view data and not perform any types of geographic analyses, a platform-independent display-only system is essential . Because of this, an approach was developed using CGI scripts and the GRASS software to build a display-only system. This system is also accessible from the INGIS URL presented earlier. After selecting the GRASS data set, the LOCATION is posted to a CGI script that reads the available raster, vector and site data

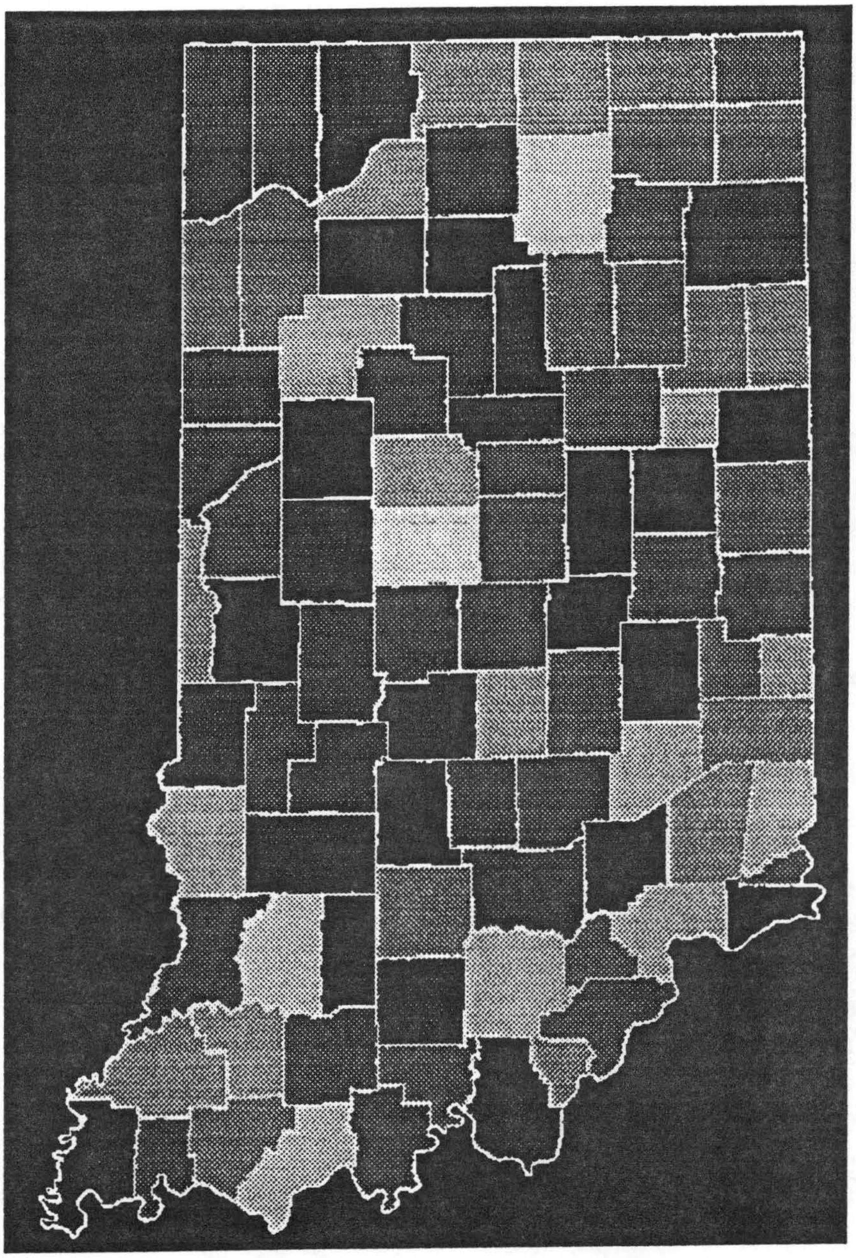

Figure 4: Result of accessing and displaying the Indiana data set county raster map.

layers from an ASCII file and, using point and click forms, creates a HTML document that is sent back to the user's WWW browser. The user has the option to select one raster layer and multiple vector and site layers. The selected data layers, along with the location name, are posted to another gateway script which creates a HTML document that allows the user to select options to compose the final map. The options specified are the functionalities available in ps.map (Carlson, 1994), the PostScript cartographic output program of GRASS. The selected data layers and the corresponding map compositions are sent to another URL which processes the arguments and develops a script file that can be redirected into ps.map. The script reads the PostScript file created and converts it to a format viewable by most Web browsers (a GIF file). The final raster image is displayed in a HTML document as shown in Figure 4.

SUMMARY AND FUTURE DEVELOPMENT

The ability of the World Wide Web to allow hypermedia information retrieval across the network facilitates greater interaction between Purdue University's environmental and GIS communities. The Web-based system supports the exchange and dissemination of geographic and geologic information and thus helps reduce costs associated with primary data collection and development. The Web server allows users anywhere on the Internet to manipulate, analyze, and display the GIS data layers of interest. The accessibility of GIS on the Internet opens a wide area of information transfer and will enable users to access and share data for various applications.

Experience has shown that it is necessary to consider both philosophical and technical constraints on designing and implementing the server. Purdue University's experience has shown that workstation-based systems can handle a wide range of server and system constraints. One must keep in mind that the Internet is a rapidly changing environment and that any server will require modifications to remain viable on the Web. Modifications to Purdue's servers are ongoing in order to meet the needs of the users. The approach described above to create GIF field takes a significant length of time (more than two minutes) and considerable disk space to generate the desired map information and have it returned to the client Web browser (return time depends on the speed of the Internet connection). To overcome this constraint and to reduce the computational load on the server, the GRASS commands that display information have been modified to directly create a file in GIF format. The GIF file can be directly displayed in the client Web browser. A Web form-based interface was written to provide access to this revised version of the GRASS display commands. The user selects the map or maps to be displayed, selects colors to be used, and provides text to be used as titles. This approach reduced the server computation time for creating requested maps by an order of magnitude as compared with the above approach. Additionally, other changes to the data structures and the data transfer tools have been implemented to take advantage of the data downloading capabilities of the Web.

The future development of the two primary services, INGIS and WETnet, is continuing. Two goals have been identified for completion in the foreseeable future. The first is to complete the state wide data locator and directory on the server. This involves linking to other universities and government agencies in the Indiana GIS Alliance and standardizing the methods of data transfer between the participants in the alliance. The second is to improve the functionality of the GIF map viewer. This includes supporting an interface for direct map query and analysis. A goal of the program is to allow more complicated forms of analysis to be run through the Internet.

URLS DISCUSSED AND PLACES OF INTEREST

The INGIS homepage is at http://ingis.acn.purdue.edu/.

WETnet and the interactive map servers can be accessed through the INGIS home page. Additionally the home page will allow users to connect to other pages of interest on GIS, geology, and agriculture on the Web.

REFERENCES CITED

Berners-Lee, Tim, and Connolly, D.W., 1995, Hypertext Markup Language - 2.0, Internet Draft: Cambridge, Mass.: Internet Engineering Task Force(IETF), World Wide Web Consortium (W3C), Massachusetts Institute of Technology, Laboratory for Computer Science, URL: http://www.w3.org/hypertext/WWW/ MarkUp/html-spec/

Carlson, P., 1994, Ps.map: software for cartographic map creation, GRASS 4.1 Reference Manual: Champaign,Ill. : U.S. Army Corps of Engineers, Construction and Engineering Research Laboratories, l v.

Massachusetts Institute of Technology, 1991, The X Window System, version 11, release 5: Cambridge.: MIT, 1 v.

National Center Supercomputing Applications (NCSA), 1995, NCSA httpd 1.4 Software: Urbana-Champaign, Ill.: NCSA, University of Illinois, URL:http://hoohoo.ncsa.uiuc.edu/docs/Overview.html

Ousterhout, J.K., 1994, Tcl and the Tk toolkit : Reading, Mass.: Addison-Wesley, 458 p.

Zhuang, Xin, Engel, B.A., 1995, Tcl/Tk GUI toolkit offers cross-platform application development: GIS World, v. 8, no. 7, p. 58-60.

DATA FOR GIS : THE ESSENTIAL INGREDIENT

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Abstract - A Geographic Information System (GIS) is as valuable as the data it employs. Data sets spanning a variety of disciplines and covering many subjects are available commercially, through federal and local governments, and from research institutions. They are accessible through CD-ROMs, local or consortial servers, and the Internet. The Web is becoming a major supplier of data, but data are not all equally usable to any one individual. Considerations such as hardware, software, and cost are significant. Platforms and formats used to produce or distribute data may be incompatible with that of the user. Utility programs to translate data are often available through the Web, but they are seldom easy to use and may distort data when transferring files. Commercial vendors provide data to meet the specification of any individual at a cost which at times can be high. Some data users feel that data on the Web have minimal use. It is instructive to ask who the users are and for what purpose they are accessing these data: research, instruction, or other?

INTRODUCTION
DATA FOR GIS: THE ESSENTIAL INGREDIENT

The Internet is the Teflon(R) technology. We are constantly advised that: navigation is time consuming; information is unorganized; search and retrieval software is inadequate; access during peak hours is difficult; archiving problems abound; the quality is erratic; Web sites disappear or are not maintained. Yet we continue to load the Internet with information (one recent guess, and guesses are all we have, is that 5000 documents are added daily). Even the for-profit, commercial world has enthusiastically joined despite numerous warnings concerning security and authentication compromises. Maps and numeric data, which are our concern, require much larger storage capacities than text, are slower to transmit, and may compromise accuracy in the decompressing and transferring of files.

Yet we continue to use the World Wide Web, perhaps because of the widely held perception that we are at the threshold of a new age of information which some would call the "electronic library". Many of the problems we identify with the Web appear to belong to the traditional domain of librarianship while others clearly require the contributions of computer scientists to be solved.

Librarians are attacking the problem of organization through traditional standards of controlled vocabulary using Library of Congress Subject Headings. The INFOMINE project, coordinated through University of California, Riverside, for example, permits University of California and Stanford librarians to enter government information available on the Web in a standardized format (University of California, Riverside, 1995). Meanwhile, technology improves continuously. There are projects underway to address the present problems of storage, memory, and bandwidth essential for archiving and distribution of large masses of information on the Internet such as the National Storage Laboratory Project at Lawrence Livermore National Laboratory (Sumpter, 1995). Organizations are developing high capacity servers for their institutions or consortia to access data rapidly on private networks. Demands for electronic access and storage will continue to grow as more material is produced and distributed online, and we will contribute to this growth because data collections and maps are formats that devour space and transmission time. In the traditional printed media environment, expanding building capacity could not keep up with the volumes produced by authors and publishers, and librarians turned to digital storage as a partial solution. It is not clear what technological innovations will be required to accommodate the growing volumes of electronic materials, but we proceed with the confidence that the innovations will occur.

WHAT AND WHERE ARE THE DATA

Data are the essential ingredients of Geographic Information Systems (GIS), and we need to know what data exist and where they are located since collecting and preparing data is staff intensive and expensive. Federal and local government agencies have been major suppliers of U.S. data, including the U.S. Geological Survey (USGS), U.S. National Oceanic and Atmospheric Administration (NOAA), National Aeronautical And Space Administration (NASA), USGS Earth Resources Observation System (EROS) Data Center, Environmental Protection Agency (EPA), and the Bureau of the Census. Commercial vendors often offer government data with value added through reformatting to enable easier use; their fee is for the "investment in time to prepare raw data" [from a personal conversation with a vendor representative]. According to one non-U.S. vendor, data seem to be less available in countries where political security is perceived to be compromised by making data public.

Electronic data storage and distribution is now the preferred medium for the U.S. government. Increasingly more data are being distributed through the Federal Depository Library Program (FDLP) on CD-ROM in preference to paper format and many data sets are finding their way onto the Web. The agenda of the October 1995 meeting of the Depository Library Council was dominated by issues relating to "servicing the public in an electronic FDLP ... the successful transition to a more electronic FDLP... [and] if electronic information is 'free' over the Internet, what would motivate a library to become or continue as a depository?" (O'Mahony e-mail 3 October 1995, Aub: DLC/MEMPHIS:Discussion questions). We might further ask what would motivate the government to continue distributing CD-ROMs, a format whose benefits include ease of accessibility and maintaining in depository libraries.

DATA ON THE WEB

In just the last year, we have seen an extraordinary growth of data distribution on the Internet. There is a new listserver, DISTGIS, distgis@ag.arizona.edu,which addresses distribution issues. The USGS National Geospatial Data Clearinghouse (U.S. Geological Survey, 1995) was established by executive order in April 1994 , and other federal clearinghouses are accessible online. Many state and regional governments have established online GIS data centers (for a listing, see http://library.berkeley.edu:80/UCBGIS/). Some public institutions have established Web sites with listings and links to data (U.S. Geological Survey, 1995a and 1995b), and some have mounted data directly (Merrill, 1995). Individuals have also established Web data sites (Thoen, 1995). Institutional and individual sites may be organized by subject areas or may simply be a list of bookmarks. Indeed it seems that for every site with primary information, there are several sites telling us where it is. Some sites emphasize single subjects (Maidment, 1995); some also contain GIS software and other GIS information. Some Web sites permit registration for e-mail notification of additions and changes which is a convenient feature. Commercial vendors are a good source for customized data according to the platform and format.

GIS maps may be available interactively where the user selects data themes and attributes online with immediate delivery of a map with the desired data layers (Newton, 1995). When data sets are required, they can be categorized and evaluated in several ways:

- *Cost* : They may be free or available for a fee (usually the cost of transfer from non-vendors, with fees sometimes waived for those with data to exchange).
- *Transfer* : In some cases files may be downloaded directly, while in others, data must be requested. In the latter case, files may be provided online or by mail.
- *Format* : There is no single accepted standard for file formats despite the government's use of the Spatial Data Transfer Standard (SDTS). File formats may require specialized translators or may utilize commercial software which Hunt and Joselyn (Hunt, Joselyn 1995) refer to as "software-dependent" data. The latter are the easiest to use and are becoming increasingly the tool for production. With ArcView software, which is used by many libraries, the data easiest to transfer are ArcInfo export files recognized by the extension .e00. Most files are compressed, and many come with conversion information and programs.
- *Metadata* : Information about the structure and requirements of the file should accompany every data set.

USERS

We need to understand the user community to ensure effective data distribution. There seems to be only limited information on users of Web data. Both the USFWS (U.S. Fish & Wildlife, 1995) and MONTANA(Montana State Library , 1995) for example, report about one-fourth of the users of files as "unresolved." Thirty percent of the users of the USFWS files (of which 75% are wetlands GIS data) were from government sites, 20% were from educational sites, and 15% from commercial sites. Commercial and educational sites each accounted for 23% of the identifiable file transfers from MONTANA. The use of the data transferred to educational sites is unclear. A small number of selected faculty (all active participants in GIS projects) contacted in an informal user survey generally felt that data on the Web were being used in academic settings for instruction, but not for research. One faculty member suggested that access figures are misleading, and a better test of research use would be the presence of URL citations in published work.

DATA SHARING

Access to data sets that are not available through a Web search is an issue of considerable importance. The products of university research become available only when published, and even the published material may comprise only a small portion of the total material. The interest in GIS throughout many disciplines makes information exchange difficult even at a single site. At UC Berkeley this fall, for example, there were nine different courses on GIS and many campus labs are involved in GIS research and data production. There are numerous magnetic tapes containing data that might be of widespread interest, but are uncataloged and unavailable even locally. In an attempt to alleviate the local problem, the Berkeley Library formed a task force which included faculty, campus staff, and librarians. A Web site for the GIS Coordinating Task Force (University of California, Berkeley, 1995) was developed to make information available. The Task Force is addressing issues of accessibility of data in academic institutions, and the responsibility of the Library regarding selection, access, archiving, and delivery of data collections. A complementary study is currently underway to examine technical issues associated with facilitating campuswide and public data access, including the feasibility of accessing locally and remotely-mounted GIS software and locally- and remotely-mounted data. Related issues are being considered elsewhere: the BASIN project at the University of Maine, for example, is currently creating a spatial data archive server located in the Engineering Department with data contributions from forestry, geology and wildlife.

Inter-institutional data sharing is a difficult problem. In 1991, Menke and his colleagues (Menke, 1991) at Lamont-Doherty Geological Observatory reported building a view-server system because they "envision a time when an Earth Scientist from any institution will be able to access high-quality data regardless of where it may actually be archived." The view-server would "automate the process of finding out what kind of data [were] available and retrieving them," similar to the Web's role today. In a recent conversation, Menke said that they were successful in the development of the software data environment, i.e., the technical issues, but they were less successful in the social aspects of data sharing. This is disappointing but perhaps not surprising, since there is little incentive for researchers to make data widely available prior to publication. One strategy currently in place to encourage sharing is IRIS/Incorporated Research Institutions for Seismology (University of Washington, 1995), which lends tools to data producers in exchange for data.

While data sharing is one of the most discussed topics in the GIS literature today, our informal survey of faculty suggests many believe sharing is not the real issue. These faculty feel that what is needed is access to metadata which will enable them to identify and locate data.

CONCLUSION : THE FUTURE

It is difficult to predict what the future Web will be, and how it will be used. There is a clear national commitment to the "information superhighway" and online data distribution. We are already seeing the establishment of local and consortial servers, which enhance access, maintenance, and control. Clearly technology is improving continuously, and we can expect more effective identification, retrieval, and management of data through widespread and improved storage and retrieval mechanisms and more user-friendly GIS software. The Open Geodata Interoperability Specification Project (University of California, 1995)), for example, aims to develop a system to enable users "to share a huge networked data space in which all spatial data may be described using a generic model, even though the data may have been produced at different times by unrelated groups using different production systems for different purposes." GIS applications of the future will be routine.

Librarians will continue to be involved in collection development and access to information in the electronic arena. We need to know what data our campus researchers are producing, whether the data are available, and how to access them. Librarians can be effective within their disciplines in promoting local access and sharing because of their traditional interactions with faculty, but the wider issues of data sharing involve considerations that transcend mechanics. There is presently no clear incentive for faculty to make unpublished data available, and there are strong proprietary reasons to keep data private until they have been fully exploited by the collector.

There are emerging issues which we have not addressed here, such as handling of dynamic data and preservation and archiving, and many of the issues touched on here deserve elaboration. What is clear is that GIS data collection and distribution issues are complex and will continue to present new challenges for librarians and those with whom they collaborate.

REFERENCES CITED

Maidment, David, 1995, University of Texas at Austin Department of Civil Engineering: http://www.ce.utexas.edu/prof/maidement/gishydro/home.html

Menke, W., Friberg, P., Lerner-Lam, A., Simpson, D., Bookbinder, R., and Karner, G., 1991, Sharing data over Internet with the Lamont View-Server System: EOS, p. 72 no. 38, p. 409, 413-414.

Merrill, D.W., 1995, Deane Merrill home page: ftp://cedrcd.lbl.gov/data1/ merrill /docs/cdrom/

Montana State Library, 1995, Natural Resource Information System (NRISGIS) : http:\\nris. msl.mt.gov/gis/gis.html

Newton, Glen, 1995, NAISMap WWW-GIS home page: http://ellesmere.ccm.emr.ca/naismap/naismap.html

Sumpter, R.M., 1994, White paper on data management: Livermore, CA, Lawrence Livermore Laboratory, Feb.10, 1994, Version 1.0: http://www. llnl.gov/liv_comp/metadata/papers/whitepaper-draft.html

Thoen, Bill, 1995, Web GIS: toy or tool? resource list: http://www.gisnet.com/gis/webgis.html

U.S. Fish and Wildlife Service, 1995, National Wetlands Inventory: http://www.nwi.fws.gov/

U. S. Geological Survey, 1995, Geologic data: http://www.usgs.gov/data/geologic/index.html

U. S. Geological Survey, 1995 National Spatial Data Infrastructure, National Geospatial Data Clearing House, U.S. Geological Survey node: http://nsdi.usgs. gov/nsdi/products/geologic_data.html

U.S. Geological Survey, 1995, San Francisco Bay Area Regional Database (BARD): http://bard.wr.usgs.gov / index.html

University of California, Berkeley, 1995, GIS Coordinator Task Force: http://www.lib.berkeley.edu/UCBGIS

University of California, Berkeley. Research Program in Environmental Planning and Geographic Information Systems, 1995, OGIS. Open Geodata Interoperability Specification : http://www.regis.berkeley.edu/ogis/ index.html

University of California, Riverside. Library, 1995, INFOMINE : http://lib-www.ucr.edu/Main.html

University of Washington, 1995, IRIS Data Managment Center, SeattleWashington (NRISGIS): http://www. lib.berkeley. edu/UCBGIS

ADDITIONAL REFERENCES

Beard, K., 1995, Digital spatial libraries - a context for engineering and collaboration: Information Technology and Libraries, v. 14 no. 2, p. 79-85.

Bergen, P. F. , 1995, Interactive access to Geographic Information Systems and the World Wide Web: Journal of Academic Librarianship, v. 21 no. 4, p. 303-308.

Cline, N. M., and Adler, P. S. , 1995, GIS and research libraries - one perspective: Information Technology and Libraries, v. 14, no. 2, p. 111-115.

Dibblee, D. W., 1980, Preliminary geologic map of the Hayward quadrangle, Alameda, Costa Counties, California: U.S. Geological Survey Open-File Report 80-540.

Environmental Systems Research Institute, 1994, Smart maps can offer utilities advice: EPRI journal, v. 19 no. 4, p.32

Hunt, L., and Joselyn, M., 1995, Maximizing accessibility to spatially referenced digital data: Journal of Academic Librarianship, v. 21, no. 4, p. 257-265.

Jackson, William, 1995, FEMA systems chief sees big GIS role : Government Computer News, v. 14, no. 14, July 17, 1995, p. 22.

Jones, Jennifer, 1995, Desktop GIS gains popularity: Federal Computer Week, v. 9, no. 3, Feb 6, 1995, p. 34.

Juhl, G. M., 1991, The age of the intelligent super map -- the smart way to manage facilities and people: Business Week, no. 3220, July 1, 1991, p. 69.

Larsgaard, M. L., and Carver, L., 1995, Accessing spatial data online - Project Alexandria: Information Technology and Libraries, v. 14, no. 2, p. 93-97.

Lutz, M., 1995, Making GIS a part of library service - introduction: Information Technology and Libraries, v. 14, no. 2, p.77-78.

Mangan, E. U., 1995, The making of a standard: Information Technology and Libraries, v. 14, no. 2, p. 99-110.

Marshall, Patrick, 1995, Geographical Information Systems: a new look at old data: InfoWorld v. 17, no. 31, p. 68.
McGlamery, P., 1995, Identifying issues and concerns - the University of Case study: Information Technology and Libraries, v. 14, no. 2, p. 116-121.
Menke, W., Friberg, P., Lerner-Lam, A., Simpson, D., Bookbinder, R., and Karner, G., 1991, Sharing data over Internet with the Lamont View-Server System: EOS, p. 72 no. 38, p. 409, 413-414.
National Geodata Policy Forum (lst: 1993: Reston, Va), 1993, National Geodata Policy Forum, present and emerging U.S. policies governing the development, evolution, and use of the national infrastructure, Summary report: U. S. Federal Geographic Data Committee. 26 p.
Perkins, R., 1995, File formats on the Internet: Computers & Geosciences, v. 21, no. 6, p.775-777.
Peuquet, D. J., and Marble, D.F., 1990, Introductory readings in Geographic Information Systems: London; New York, Taylor & Francis, 371 pp.
Ramshaw, R. S., 1995, Geoscience listservers and newsgroups: Computers & Geosciences, v. 21, no. 6, p. 787-790.
Rand, R. Y., 1995, Assisted Search for Knowledge (ASK) - A navigational tool set change data and information: Information Technology and Libraries, v. 14, no. 2, p. 87-91.
Rhind, David, and Connolly, Teresa, 1990, Understanding GIS : the ARC/INFO method: Redlands, CA: Environmental Systems Research Institute. 1 v.
Thoen, B., 1995, Internet resources for the geosciences, with an emphasis on GIS: Computers & Geosciences, v. 21, no. 6, p. 779-86.
U. S. Geological Survey, 1995, Cartographic and digital standard for geologic map information. Draft: U.S. Geological Survey Open-File Report ; 95-525. 1 v.
Zurier, Steve. "GIS and mapping software [buyers guide]: Government Computer News , v. 14, no. 14, p. 71.

SELECTED DATA WEB SITES

http://www.usgs.gov/pubprod/index.html
USGS Data Products

http://www.epa.gov/oppe/spatial.html
EPA GIS Spatial Data Sites

http://www.emtc.nsb.gov:80/http_data /image_maps/national.html
National GIS Data

http://www.ifp.uni-stuttgart.de:80/subject/subject.html
Michael McDermott list of data sites (last update June 1994)

http://www.io.com/~frank/gis.html
Jim Aylward's personal GIS Net sites bookmarks

http://www.ngdc.noaa.gov/mgg/wdcamgg
World Data Center- Marine Geology & Geophysics

http://alexandria.sdc.ucsb.edu/rapid-prototype
Future Digital Spatial Data Library

ftp://ftp.ncdc.noaa.gov/pub/data/inventories/
National Climatic Data Center online data access

http://sun1.cr.usgs.gov/glis/hyper/guide/1_250_lulc
Land Use/Land Cover data files (vegetation, water, natural surface)

http://sun1.cr.usgs.gov/glis/hyper/guide/ecoregions
ECOREGIONS data set (common soils, land use, potential natural vegetation, and landforms).

http://www.epa.gov/docs/grd/forest_inventory/
Forest Land Distribution Data for the United States

http://sun1.cr.usgs.gov/glis/hyper/guide/landsat
The USGS EROS Data Center (Earth's land surface).

http://www.ncg.nrcs.usda.gov/soils/natl_char.html
National Soil Characterization Data

http://sun1.cr.usgs.gov/glis/hyper/guide/world_soi
Zobler World Soils Data Set

ftp://wrgis.wr.usgs.gov/pub/geologic/ca/of95-597/hf_g1.ReadMe
Geologic Map of the Hayward Fault zone, Contra Costa , Alameda, Santa Clara counties, CA

http://www-odp.tamu.edu/~csd/sa_data.html
San Andreas Fault

http://quake.wr.usgs.gov/QUAKES/geodetic/bard/bard.html
Bay Area Regional Deformation network (BARD)

http://www.ncg.nrcs.usda.gov/geocp.html
National Cartography and GIS Center (NCG)

http://sun1.cr.usgs.gov/glis/hyper/guide/gghydro
The Global Hydrographic Data Set (terrain type, stream frequency counts, major drainage basins)

http://nsdi.usgs.gov/nsdi/wais/water/huc2m.HTML
Digital data sets for hydrologic units are available at scales of 1:2,000,000

http://wings.buffalo.edu/geoweb/sources.html
Geographic Data Archive, University of Buffalo

EVALUATING WEB SOURCES FOR THE GEOSCENTIST

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Abstract - The bounty of resources available to the individual geoscientist on the Internet begs the question: what are the really useful sources for the researcher? The authors review and evaluate many Internet sources in the fields of paleontology, geophysics, geohydrology, geochemistry, petrology, petroleum geology and stratigraphy. Findings reflect the broad spectrum of information and the difficulty of establishing standard criteria for evaluation of sources in a resource so young.

INTRODUCTION

The spread of the Internet into our lives is obvious everywhere. Pick up the daily newspaper, *EOS*, *Mining Journal* or almost any other journal and you will see references to the World Wide Web. You can find sites for almost any subject by surfing the Internet, and the hours can quickly disappear while you're doing it. But what are the really useful sources for the individual geoscientist? What can one expect in terms of usefulness? How does one decide what source to use and to add to one's list of bookmarks?

We decided to review the Net offerings in two ways. One was to see what is out there and how the sources fit into the field of earth science. The other was to try to get a feel for what a "good" source is, and in so doing, look at not a few home pages.

We wondered to whom we should address our remarks. While the information and opinions we will share are relevant to all and sundry, the first sections do have more of a Geoscientist focus while the latter parts are targeted at Information Specialists.

Web sites take many forms. Some are sources of information distilled for an audience while others are primarily data repositories. Some are simply filters (lists, if you will) provided for users to get through to other Web sources. Still others are purveyors of mostly trivial information or even useless junk. Some sites are mirrors of other sites. Most, we found, are hybrids. They provide an introduction to the agency's services, provide access to their own data and publications, and links to other related sources. These hybrids tend to be our favorite sites perhaps because the best ones remind us of good reference interviews.

Geoscientists need information in many forms including journal articles, information about article and book locations, data, instructions for authors, conference dates and locations, addresses (electronic or otherwise), phone or fax numbers, information about institutions or companies, tables of contents of journals, laws, policies, maps, images, slides, movies, software, job listings, and ordering information for publications.

Some authors would have you believe that all of this is available on the Internet. In an online announcement of a four-week online workshop entitled *Exploring the Internet*, writer Richard De A'Morelli is quoted as saying, "Virtually all of the knowledge that our civilization has amassed since the dawn of history is accessible on the Internet if you know where to look for it." (Iman, 1996) Although this is more nearly true every day, especially for new documents or new data, this is nothing but hyperbole for published items. While it is easy to find examples of each of these types of information on the Web, the vast majority of current publishing is not yet available in hypertext form, nor is there any reason to think that large sums of money will be spent on mounting retrospective materials any time soon. This is especially true of science and engineering materials from the past. It is still necessary to use the "real" (e.g. non-virtual) library, and probably will be for a long time, especially in our fields, where older material has historically been more important than in other science disciplines.

A quick tour of the Web reveals that the different kinds of organizations of interest to the earth scientist tend to have quite different home pages. They fall into the following loose categories:

- Commercial
- Government agencies
- Societies
- Universities, Libraries, and Other Institutions

COMMERCIAL SITES

Commercial home pages are a good source of information about companies, what they do or sell, stock information, positions available, etc. If you are about to interview with a company, this is a good place to gather information in preparation. If you are seeking information about software produced, you can often retrieve a demonstration file or order a demo disk. Increasingly, you can place orders for a company's products via the Internet. A good example of a commercial page is that of Petroconsultants (http://www.petroconsultants.omnes.net/).

Commercial publishers' pages are a subset of this group, but don't expect much free from commercial publishers. Go to these pages to get information for ordering publications, but very little else. You may find tables of contents, indexes, and sometimes even abstracts, but do not expect to find free journal articles, at least not for long. Commercial publishers exist to make money; they want to make it easy to buy their products. Thus they are setting up Web sites on the Internet. Many publishers now have Internet sites with the tables of contents for the journals they publish as well as information about the monographs they have available for purchase with ordering information.

However, if you are trying to locate a book and you don't know the publisher, don't start cruising the publisher home pages unless you have unlimited time and don't mind spending it. If it is a recent publication, use *Books in Print* (print copy or on CD-ROM) which is not available on the Net. If it is not recent, a government document, or a society publicaiton, try online catalogs such as the Library of Congress (http://lcweb.loc.gov/) or a university library, many of which are available on the Internet. If you still can't find it, try journal indexes - what you want may be an article, not a book.

GOVERNMENT AGENCIES

Government pages are some of the best information sources available. First, profit is not their goal. Second, they are mandated to provide information to the public. It is usually cheaper and more efficient for an agency to provide information via the Web than to distribute paper copies, although it has taken some agencies a while to figure this out. In response to Congressional pressure, the Government Printing Office (GPO) (http://www.access.gpo.gov/su_docs) recently announced that the Depository Library Program will be essentially electronic by

Table 1. Some World Wide Web Sites for Commercial Publishers

• Cambridge Scientific Abstracts	http://www.csa.com
• Blackwell Publishers (Geography, Earth Sciences, Astronomy and Time)	http://www.bookshop.co.uk/WEBSUBJ.EXE?W000:BW:C
• Cambridge University Press (Geography, Earth Sciences, Astronomy and Time)	http://www.bookshop.co.uk/websubj.exe?w000:CU:c
• Oxford University Press	http://www.oup.co.uk/
• Elsevier Scientific Publishers (Earth Sciences)	http://www.elsevier.nl/catalogue/SA2/230/Menu.html
• McGraw-Hill Engineering Catalogue	http://www.cityscape.co.uk/bookshop/cat18.html
• Open University Press	http://www.bookshop.co.uk/OPENUP/opinf.htm
• PennWell Publishers	http://www.lfw.com/0/WWW/pennwell.html
• Reiters Books (Earth Sciences)	http://www.awa.com/reiters/42.html
• Springer Verlag	http://www.springer.de/

by the end of 1998 (Federal Library Depository Program, 1995). Third, they are mandated to collect data which are presumably kept in some usable form. Finally, the amount of data collected tends to be gigantic and far easier to access, store, and use in digital form than on paper or microfiche.

The Planetary Data System home page (http://stardust.jpl.nasa.gov) is a good site with lots of data. Another excellent government Web site, different in style, is designed for focused research information needs: USGS Environmental Research: San Francisco Bay (http://sfbay.wr.usgs.gov). This is not one of those agency pages containing large amounts of data, but is a very good home page from a government agency.

Home pages of important government agencies for providing geological and geophysical data include: National Geophysical Data Center / World Data Center A for Marine Geology and Geophysics (NGDC) (http:// www.ngdc.noaa.gov/mgg/) and the United States Geological Survey (http://www.usgs. gov/USGSHome.html). However, rather than trying to keep track of all of the agency sites, plan to access most federal government pages (including GPO, NGDC, and USGS) via FEDLINK at http://www.fedworld.gov/. A list of state geological survey home pages, as well as those of some non-U.S. surveys, can be found at the Illinois Geological Survey home page (http://denr1.igis.uiuc.edu:/isgsroot/dinos/surveys.html).

SOCIETY SITES

Society pages are a good place to keep up with the news of the organization. You can find information for short courses or other programs, and often links to other sites of interest to members. You can even register for conferences. Some also have indexes of their own publications online. Like commercial publishers' pages, they are frequently good sources for ordering information as well, but they are society-specific. Do not look for American Geophysical Union (AGU) publications on the Geological Society of America (GSA) home page.

Society-specific indexes can be a quick way of locating information about a published item. However, unless you are certain that an item was published by a society, use an established subject index if you have access to one.

The Geological Society of America (GSA) (http://www.aescon.com/geosociety/index.html) has basic membership information, lists of publications, dates of meetings, and abstract forms, as well as an index to GSA journal publications back to 1991 (back to 1972 for its *Bulletin*)(http://www.geosociety.org/pubs / dbquery.html).

The International Union of Crystallographers provides access to the *World Database of Crystallographers*, lists of journals published, and tables of contents back to 1993. You can also find the Union's newsletter as well as postings of available positions (http://www.iucr.ac.uk/).

The Society for Applied Spectroscopy (http://esther.loc.asu.edu/sas/) provides tables of contents and abstracts with an accompanying index, the society's newsletter, plus short course and conference information.

The Society for Mining, Metallurgy and Exploration (http://www.smenet.org/) posts its annual meeting preprints and the table of contents from the latest issue of each of its journals. Career information is also available.

The Society of Exploration Geophysicists (SEG), the European Association of Exploration Geophysicists (EAEG), the Australian Society of Exploration Geophysicists (ASEG) and the Canadian Society of Exploration Geophysicists (CSEG) provide a cumulative index of all four societies' publications, 1936 to date, at SEG's web site (http://sepwww.stanford.edu/seg/ cumindex. html).

You can find links to all the American Geological Institute (AGI) member societies at the AGI site (jei.umd.edu/agi/agi.html).

A list of society Internet pages can be found at http://ww.lib.uwaterloo.ca/society/Webpages. html.

UNIVERSITY, LIBRARY AND OTHER INSTITUTIONS SITES

University and research institution pages vary widely in quality and in content; even library pages are not very consistent. Particularly useful is the online library catalog, mentioned earlier, which helps users locate journals and books at their institution.

The University of California (UC) system library catalog is called Melvyl (http://www.lib. berkeley.edu/Catalogs/). Access to a large number of library catalogs is available via HYTELNET (http://library. usask.ca/hytelnet/), via North Carolina State University's Alcuin home page(http://www.lib.ncsu.edu/staff/morgan / alcuin/wwwed-catalogs.html), and at Berkeley Digital Libraries - Libraries on the Web (http://sunsite.berkeley.edu/Libweb/usa.html). Due to the fluid nature of the Internet, none of these lists is ever complete or up-to-date in all of its references. It is also unlikely that they are identical, so if you are looking for a library catalog that is not at one of these locations, try the others.

University libraries are also using their home pages as access points to databases, online journals, and other sources they have contracted for. You will likely be faced with prompts for passwords to restricted sources on these pages.

LOCATING JOURNAL ARTICLES

The Web site for CARL UnCover (Colorado Alliance of Research Libraries) (http://www-lib. iupui.edu/erefs/carl.html) is a good index of recent journal contents. The online introduction lists 14,000 journal titles indexed from 1988 to the present. UnCover is especially nice because it is free. CARL makes money selling photocopies

Table 2. Selected University Library Catalog Sites With Strong Earth Sciences Collections

California Institute of Technology	http://www.caltech.edu/~libraries
Colorado School of Mines	http://www.mines.edu:8080/library
Columbia University	http://www.cc.columbia.edu/cu/libraries/index.html
Cornell University	http://www.cornell.edu:3002/library/cul.html
Dartmouth College	http://www.dartmouth.edu/~library/
Harvard University	http://www.harvard.edu/home/library.html
Indiana University	http://www.indiana.edu/~libweb/
OhioLINK:Univ. of Ohio, Ohio State, Univ. of Cincinnati	http://www.ohiolink.edu/
Pennsylvania State University	http://psulias.psu.edu/
Stanford University	http://www-sul.stanford.edu/
University of California MELVYL System: UC-Berkeley,UC-Davis, UCLA, Scripps	http://dla.ucop.edu/
University of Illinois	http://www.grainger.uiuc.edu/
University of Texas	http://www.lib.utexas.edu/
University of Washington	http://www.lib.washington.edu/
University of Wisconsin - Madison	http://www.library.wisc.edu/
Yale University	http://www.library.yale.edu/

of the journal articles located in the index.

The Canada Institute for Scientific and Technical Information (CISTI) is also in the business of providing photocopies of journals, books, conference proceedings, and technical reports. The CISTI catalog (http://www.cisti.nrc.ca/cisti/) contains a strong list of earth sciences titles. GEOREF's (http://jei.umd.edu/ agi/dds.html) document delivery service, of course concentrates on providing access to earth sciences documents. If you are an independent geologist, using one of these services may well be the most economical way for you to get copies of articles.

Of course, nothing free on the Internet matches the coverage of major subject indexing services such as GEOREF, INSPEC, and CASOnline. These titles can be found on the Web, but you will not be able to get at them unless your home institution has made arrangements for access.

Stanford is now offering the bibliography *Aquatic Sciences and Fisheries Abstracts* (http://www.marine.stanford.edu/branner/marine.html# ASFA) as a Web site, and is planning to provide several other indexes as well. Stanford students would not be aware of what the database costs the University as they enter through the Stanford Libraries' Web page via a Stanford IP address, although it is expensive for the university just as the paper versions are. An outsider surfing the Stanford website will be denied access.

More and more institutions are following Stanford's lead, loading a database locally and restricting access to their primary clientele. There are drawbacks to this method including a lack of local control over indexing and a perception of delay in indexing. However, this is not the point; while you are complaining about the indexing being slow, the data for the print version is being delivered to a press somewhere in the Midwest. And, honestly, when did any library actually have control over the content of the indexing services it purchased?

The biggest worry that university libraries have about all this is that a vendor will get nervous about its contract and suddenly pull the

Table 3. Geoscience Journals With A Presence On The Web (Journals with articles, abstracts, summaries included)

EEGS Newsletter (Environmental and Engineering Geophysical Soc.)	http://www.esd.ornl.gov/EEGS/newsletter/
Geophysics	http://sepwww.stanford.edu/seg/GEOPHYSICS.html
Journal of Glacial Geology and Geomorphology	http://boris.qub.ac.uk/ggg/index.html
Journal of Seismic Exploration	gopher//jse.tn.tudelft.nl:70/11/JSE
The Leading Edge	http://sepwww.stanford.edu/seg/tle.html
Lunar and Planetary Information Bulletin	http://cass.jsc.nasa.gov/oldnews.html
Terra Nova	http://www.gly.bris.ac.uk/WWW/TerraNova/terranova.html

plug on the campus, cutting off access until the contract is renegotiated. Once you are dependent on a remotely loaded database, this can turn out to be a real problem. Stanford had a problem with this in the early days of Folio's implementation.

As more and more bibliographic databases are available on the Web, you can expect to see a diminution of differences among their search engines, but reading help screens and other online information will always be necessary. Always note the coverage dates and be prepared to notify library staff of problems or use the e-mail link on the home page to notify the owner of trouble.

Regarding coverage dates, be aware that few digital databases are complete online, whether on the Web or not. Most (with the notable exception of GEOREF) contain only the most recent several years' worth of information. All evidence to the contrary, knowledge did not commence at the same time as the Internet, let alone the advent of online databases.

You will notice that we have not mentioned any real journal articles on the Web. Data from government agencies is getting more and more common just as are citations to journals, but finding more than tables of contents, abstracts, and a few issues online is difficult at least in the earth sciences.

You can expect some full-text titles to become available as libraries indicate a willingness to subscribe, but this kind of access is still in its infancy. While not a geoscience journal, the *Journal of Biological Chemistry* (http://www-jbc.stanford.edu/jbc/), is an example of what to expect. *Science* (http://www.aaas.org/science/science.html) and Nature (http://www.nature.com/) represent what we expect to see more of: not true full-text for free but enhanced home pages with a lot of information from the journal, lots of links, but few if any complete papers.

TIPS FOR RESEARCHERS

When searching for information, what broad concepts does a geoscientist need to keep in mind?

√ Scope of information source. What is it? What is it trying to do? When did it begin? What are the dates covered? Was it comprehensive during this time? How current is it?

√ Authoritativeness / authenticity of data. When at all possible, go to the data source or to a more comprehensive source for which authenticity is known.

√ Start with your local information provider - the library, if you have one; this saves you time and money.

√ Read instructions and information on the home page carefully. You will probably save time, and it will lead you to results you need, rather than false drops.

√ Never believe your search results completely, particularly if you get a zero result.

SELECTED INTERNET SITES FOR THE GEOSCIENCES

We have now reached the heart of our paper. We want to discuss our favorite home pages. We spent some time looking around seeing how we would like the information we needed organized, and found, not surprisingly, that the pages we liked tended to be from information agencies such as university libraries and geological survey offices. Since we are information organizers ourselves (desk-top evidence notwithstanding) we looked for information that was easily accessed and well-organized.

When we first discussed doing this presentation, we did not intend to talk about "how we did it good", not only because we get tired of papers like that, but because we had not done it well yet. However, we did realize that we would, in the process, glean some education applicable to our own home page development. We will include as an example one of Stanford's pages which was developed while this investigation was ongoing and benefited from lessons learned. Thus this is not so much "how we did it good" as "how we applied what we learned."

We had hoped to be able to evaluate individual sites by a specific set of criteria, but found that some of those were difficult to quantify such as, the concept of "well- maintained." We think that one of the earmarks of a good Web site is longevity and regular maintenance, but how do you know if something is going to stand the test of time given the Web's brief existence? We think one of the earmarks to look for is how well it is currently maintained. Do you find bad links? Is there an "updated xx/xx/xx"with a recent date indicator on the home page? We think that when authors have produced a solid tool, they will maintain it. At least we hope so.

We also found that design and writing style were frequently at odds with the wish to impart information. We both visited a number of sites profoundly deserving of their "Worst of the Web" designations.

One important thing we discovered was that the best home pages do not just point to Web sources. There is no online version of Dana's *System of Mineralogy*, so point your patrons to the best source, print or digital. Additionally, there are some electronic sources that are not on the Net, but sold only for local mounting. One example is Aleph Enterprises' *Mineral* database sold by subscription to load onto your hard disk. You probably can not establish a link to it through your geochemistry home page, but you certainly should mention it and tell your clients where it is mounted in your library. Anybody surfing your home pages without access to the library will learn that the source exists and can go looking for it closer to home.

We suggest that you design a home page which is full of pertinent information, but not necessarily exhaustive. If you need volcanology information, for instance, outline your local resources and then point to one of the best home pages we've seen, Dartmouth's Electronic Volcano (http://www.dartmouth.edu/pages/rox/ volcanoes/ EvE.html). There is little reason to duplicate those links at your own site even if copying the source code is a snap. Let Barbara DeFelice check those links regularly; just point to her page and let everybody see how useful it is. Another point: exhaustive listings have their place; check out the previously mentioned Illinois State Geological Survey's (http://denr1.igis.uiuc.edu:/ isgsroot/dinos/earthsci_links.html), which is a model of a spare but comprehensive home page. Think of your home pages as the next generation of your "References Sources in xxxx" point-of-use publications. You have never recopied Deer, Howie, and Zussman for a mineralogy hand-out, so do not feel you must now do the equivalent for your home page.

Stanford's geochemistry page (http:// www-marine.stanford.edu/branner/ geochem. html) is a good example of a broad subject information source. It is a pointer to sources, but, by no means, only Web sites. Some sources are print; some locally mounted in a variety of formats: PC-hard drive, mainframe, CD-ROM; some are available to Stanfordians because of site licenses; some are Web-mounted and free to all. Some are primary sources while others are secondary and tertiary which have had value added by manipulation of original data. All reflect the varying nature of source materials in the field.

TIPS FOR DESIGNERS

Now, after all this surfing we have some suggestions for designers. Remember that content should tower over format. If it is vital that large images be in your home page, consider seriously whether they have to be on the first page. Do not make your users sit through a 45-second download (they're not all on high-speed Ethernet connections) before they can see what information they are getting. Placing a thumbnail shot of a larger image is much more helpful to the casual browser. Also, flashy wallpaper that makes text hard to read except in one specific font is not user-friendly design; not to mention that elaborate wallpapers can take forever to load.

Check and update links regularly: this sounds like unnecessary advice, but experience shows that it is not. We especially like those little "new!" and "updated!" flags accompanied by dates, maybe even an "updated" note at the very top of the first page. Everyone has had the experience of selecting a link which was not currently available, but we are always suspicious of links that are regularly unavailable. Your patrons should not have to do your link-checking for you, although you should make it easy for them with an e-mail Webmaster option on every page.

WHAT MAKES FOR A GOOD WEB SITE?

Allowing for the differences in techno-logy, what makes a good web site is the same as for any other information source.

- Clear organization and clear information as to what's included.
- Clear title, source of information. The otherwise useful home page Mediterranean Ocean Database (http://modb.oce.ulg.ac.be/), is sadly lacking this information.
- Real information, not hype.
- Original information. If you are including links to data sources, try to point to the creating agency which most likely will be maintaining and updating its files.
- Search help and/or search examples if the database is included.
- Relevant, working links.
- Evidence of current maintenance.

CONCLUSION

We hope we have provided the reader with useful information. Between the time we presented this paper and the date we submitted it for publication, major changes had taken place in the Internet arena. Staying on top of this constant change is a full-time job, however much fun it can be. Reviewing the Internet is not the same as reviewing a book: everything is in flux, and the design of home pages has become easier and their results more elaborate. Anyone wishing to stay on top of this is making a commitment which their clients (or they themselves) will appreciate. A copy of this article with active links isavailable at: http://www-marine.stanford.edu/ branner/ and at the Geoscience Information Society (GIS) home page: http://www.library.berkeley.edu/ gis).

REFERENCES CITED

Federal Depository Library Program, 1995, The Electronic Federal Depository Library Program transition plan, FY 1996 -FY 1998: Administrative Notes; v. 16, no. 18, p. 3 - 25.

Iman, Steve, 1996, Getting started with Internet-Internet folders: http://www.supomona.edu/ mhr/sciman/folders/fo-gettgstrtd.html (April 30 , 1996).

RETURN OF THE SPIDERWOMAN, OR LIBRARIANS MEET THE WEB

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Abstract - Geoscience information abounds on the Internet and nowhere is it more plentiful than on the World Wide Web where format allows for combinations of text, graphics, color, video and sound. New Web sites appear rapidly and anyone ambitious enough to try to provide pointers to all relevant sites in a particular field faces a daunting task. This is the situation which faced one Web-builder who enlisted the aid of two librarians to help in organizing his collection of interesting Web sites. While this particular Web-builder was keeping up fairly well with the flood of new Web sites, the tidiness of his home page was beginning to suffer. The librarians examined his collection, made various recommendations (discard a few oddball sites, add a bunch of others, etc.), and in the end, developed an entirely new organization for his home page. The process of creating a new design and lessons learned from the collaboration are discussed.

INTRODUCTION

In the beginning, there was but one being in the lower world - Sus'sistinnako, the Spider Woman. Sus'sistinnako cast her web over the water and onto the water-soaked earth. The earth solidified and thus the land was born. It was she who led the people out of the lower world. She who provided the knowledge and instruments to allow the people to emerge and live in the proper way.

Thus goes the tale of the Spider Woman as told by the Sia and other Indians of the American Southwest. The Spider Woman, or Spider Grandmother as she is also called, plays a role in many of the tales of the Pueblo Indians. She frequently appears near an individual's ear in order to give secret advice and assistance. It was in such as role - that of giving behind-the-scenes advice and assistance - that a colleague and I became involved in the redesign of part of a popular Web site.

REDESIGNING A WEB SITE

The College of Earth and Mineral Sciences at Penn State, in common with many other organizations, maintains a Web site (http://www.ems.psu.edu, 1995). This site provides information about the programs and people of the college and acts as a gateway to specialized resources of the college. In addition, it provides links to other Web sites which are relevant to the college's areas of interest - geography, geosciences, meteorology, oceanography, materials sciences, mining, and mineral economics. This area of the site is entitled "Related Web Sites" (http://www.ems.psu.edu/RelatedWebSites.html, 1995) and is the area which we were asked to assist in redesigning.

In the spring of 1995, the Related Web Sites page contained links to over 140 sites, primarily in the earth sciences. General sites such as Yahoo and Carrie's Crazy Quilt were included as were miscellaneous other resources such as Voice of America News. The page was organized as lists of names grouped by the type of access - ftp, telnet, etc. There was little annotation and some dead sites were still listed. Although the page had achieved some recognition as a notable site for earth sciences (Cobb and Lener, 1995), its size was making it unwieldy. The Web builder recognized that he needed a new and more usable organization for the page. This prompted him to approach the college librarian about assisting in the redesign of the page.

He chose the librarian to assist him in the redesign for several reasons. In part, he had been impressed by the work of the University's librarians in the organization of the Libraries' gopher system. He knew the librarian and they had 'talked Internet' before. Finally, he simply needed some help. The college librarian agreed to assist and recommended the inclusion of another librarian in the project, a cataloger, one of the 'super-organizers' of the library world. It turned out to be a very fruitful collaboration.

At the first meeting, the librarians and Web builder discussed the goals, parameters, and time line of the project. The Web builder wanted a design completed prior to the fall semester giving the librarians nearly four months to complete their task. The priorities and purpose of the Web page were discussed. It was agreed that some sites might have to be eliminated or the design narrowed to better accommodate the primary purpose of the page.

Following the meeting, the librarians spent time examining the existing content of the page. They then met to discuss their findings and brainstorm about possible redesigns. It quickly became clear that the team needed to learn more about Web page design issues. Both librarians spent time becoming more familiar with aspects of good Web page design using seminars, a Web-based self study course (Stout and Webster, 1995), and examination of multiple Web sites.

The third meeting took place in a laboratory setting in a room with several microcomputers as well as white boards and markers. The librarians examined multiple Web sites together, sharing their insights into characteristics of sites which worked well or poorly. Nice features were documented and were used in developing a preliminary design.

This preliminary design was then presented to the Web builder. The design was discussed in detail and was revised significantly based upon the discussion. Once again the availability of a chalk board was of great utility. This revised design represented the completion of the work by the librarians.

From start to finish, the project stretched out over a twelve week period. The actual amount of time invested was much less than that amount, however. If necessary, the redesign process could have been accomplished in 4 weeks or less. The Web builder was quite pleased with the suggestions presented. The librarians found the project intellectually stimulating and a pleasant use of their organizational expertise and knowledge.

CONCLUSION

Several useful lessons were learned from the collaboration. The first was to keep focused on the primary purpose of the collaboration, in our case, on *organization* of the page rather than on *content* (although suggestions concerning content were offered and welcomed). We also learned not to become too attached to any one design idea. Many excellent ideas were proposed and rejected by us, and later by the client. Finally, and perhaps most importantly, you must take time to mingle with your clientele otherwise they will not think to ask you to collaborate on projects such as this. Librarians can adopt the attributes of Sus'sistinnako, the Spider Woman; sit near our users' ears, offer advice and assistance, and perhaps, improve the world of the World Wide Web.

REFERENCES CITED

Cobb, F.S. and Lener, E.F., 1995, Internet resources for the earth sciences: College & Research Libraries News, v. 56, no. 5, p. 319-321, 325.

Pennsylvania State University, 1995, Penn State College of Earth and Mineral Sciences: Related Web Sites: http://www.ems.psu.edu/ RelatedWebSites.html

Stout, M.W. and Webster, C.A., 1995, Designing/Structuring text for the World Wide Web: http://ets.cac.psu.edu/presentations/DesigningText/.

INTERNET (WWW) HOME PAGE DESIGN TO IMPROVE THE DISSEMINATION OF GEOSCIENCE INFORMATION

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Abstract - Electronic home pages on the World Wide Web offer an unprecedented opportunity to revolutionize the distribution of and access to geoscience information. Designing these pages, however, can be a challenging task. Among issues considered here are the rationale for creating a home page, content of the page as determined by the interests and information needs of the target audience, design tips and graphics, writing style, and suggestions concerning testing and maintenance of the page and the links. The home page designer must also take into account aesthetics, functionality, and quality assurance.

INTRODUCTION

The World Wide Web (WWW) is a client/server graphical hypertext information system that has become very popular as a system for publishing electronic information. As opposed to the Gopher system, which is linear and relatively inflexible, the Web is interactive providing numerous links to other pages and allowing viewers to see mixed text and graphics on each page.

Client/server systems consist of two separate programs that communicate with each other using a protocol called HyperText Transfer Protocol (HTTP). An information provider such as a company or a university uses a WWW server to make available HyperText Markup Language (HTML) documents, that is, documents which may contain links to other documents and resources on the network, creating a web of interconnected information spanning the Internet. A number of excellent publications on HTML are available (Aronson, 1994; Graham, 1995; Lemay, 1996; Powell, 1995).

The user (reader) uses a Web browser (or client) such as Mosaic, Lynx, or Netscape to access the WWW. Given a Uniform Resource Locator (URL) pointer, the browser:

- accesses the desired document or file
- retrieves the item desired, interpreting the HTML code, and formatting and displaying the document.

This study investigated the design of home pages in the geosciences. The term "home page" may refer only to the page that loads when you start your browser; the term also refers to the collection of linked home page documents available on the home page server. We use the latter, more general, definition.

Unfortunately, home page construction is often haphazard and poorly executed. Many ineffective, incomplete, and unattractive home pages dot the landscape. In this study, we offer some suggestions and ideas which we hope will be useful to those who undertake the design and construction of home pages in the geosciences.

RATIONALE AND CONTENT

The rationale for creating a home page for an organization is straight-forward:

- to provide information (content)
- to facilitate communication
- to advertise and market products and services.

To produce a successful home page one must begin with identifying the purposes in having a page. What does the organization which to accomplish? What are the objectives? To address these questions effectively, one must first identify and target the proposed audience and its needs.

Categories of users which the home page designer may take into account begin with those in the immediate organization and in the larger entity to which the organization belongs. For some organizations concerned about security and firewalls, these may be the only users to be considered as home pages may be restricted to internal access with links to useful sites elsewhere. Falcigno and Green (1995) point out some of the issues in designing home pages for internal versus external use. The present study assumes that users of the home page include similar groups in other locations, the organization's customers, sponsors, and others on the Web.

Users of geoscience home pages will have a variety of needs, which include the following:

- directory information
- overview of the organization or individual
- specifics about the organization and its personnel (research interests) services
- publications and other products
- ordering information
- links to other groups or sources of related information

A careful analysis of the information needs of your users will provide clues to the most appropriate content for the home page. One may, for example, analyze the kinds of information requested (via letters and phone calls) from the organization before the home pages existed. Were there information needs which were not easily met that would be facilitated by a home page? How much directory information (and to what level in the organization) is desirable? What are your organization's most critical and popular services? Which new services do you wish to promote? What other contacts might your users, given their needs, wish to access?

DESIGN TIPS, GRAPHICS, AND STYLE

Before beginning the actual design of a new Web page, the neophyte can benefit enormously by visiting many geoscience sites as a user. Note misleading or confusing aspects, unclear text, tedious features, erroneous instructions, unattractive graphics, and incomplete information. Keep in mind pitfalls to avoid and excellent points to emulate.

Achieving consistent design and an organized logical structure requires careful planning. A menu or hierarchical structure provides an easy, logical approach to organizing Web documents; one can move up for more general information and down for more specific. A linear approach, similar to that of printed documents, is somewhat rigid, but may be useful for putting material online which has a linear structure offline. The most popular and versatile structure for document organization on the Web is a combination of hierarchical and linear (Lemay, 1996).

Storyboarding is a design tool developed in film making which provides an overview of the home page structure indicating which topics go on which pages, the primary links, and a conceptual idea of the graphics and where they will go. Thus, the designer does not have to recall exactly where and how each page fits into the overall presentation (Lemay, 1995).

Linking provides the interactive, hypertext character of the home page. When one browses the Web, clicking on something that is highlighted or underlined takes the reader somewhere else -- to another part of the current home page or to another Web site. Links are created in HTML code by surrounding some text with a hypertext reference anchor or hypertext link. This code contains the URL of the location where you want to take the users when they click on the link

Common sense dictates several design rules for links which, when followed, make the home page easier and more efficient to use:

- Keep the link text as short as possible given that the designer must provide enough description to inform readers what they are linking to; vague links are annoying and waste time.
- Use link menus, which are easier to scan and read than links embedded in text.
- If the designer uses links in the body of the text, make those links natural; avoid the "click here' syndrome.
- Be sure that the home page contains no dead links which take the reader nowhere.
- Avoid something that looks clickable and isn't.

Designers of home pages in the geosciences may be especially tempted to incorporate impressive, detailed graphics, given the numerous possibilities available. However, graphics of unusual geologic sites, colorful minerals, and rugged mountain scenery may take a lot of time to load and are often superfluous. Consider using line art, which compresses nicely and loads faster than complex graphics. Other traps to avoid include the use of garish, unattractive colors or too many colors, poor placement of the text in relation to the accompanying graphic, and suggestions which mislead the reader to expect graphics when only text will be offered. For bandwidth and display purposes, a small image is preferable to a larger one; for example, one recom-mended size is no larger than 35 K (Team Web, 1996). The designer may choose to link the small image to a larger version which the reader can access if desired.

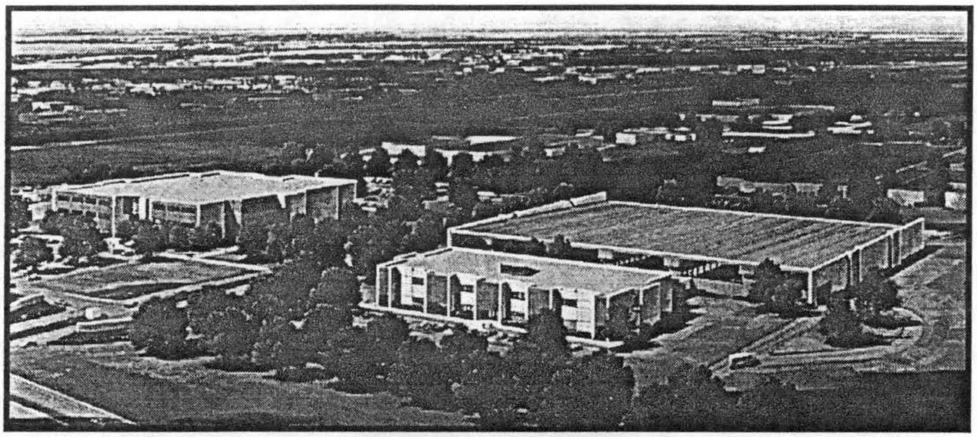
Information provided on the home page should be updated, relevant, factual, and informative. Writing style is critical. Main-taining a professional tone throughout does not allow fluff or hype, incomplete or "under construction" sections, apologies, predictions for future content, or "witty", breezy remarks. Readers appreciate clear, concise text. Use headings, link menus, and lists whenever possible to improve organization and aid in scanning.

Be sure that each page can be accessed and understood independently since users may enter the home page at any level. Do not split topics across pages. If a topic is becoming too large for a single page, consider breaking the content into subtopics which can be treated in separate sections. Provide necessary navigational links to other parts of your home page to ensure clarity and understanding. Revise and rewrite text to improve readability.

The page should be meticulously edited with correct dates, names, and addresses and with no typographical errors. Convenient interactivity throughout the page is critical, for example, no "send us your e-mail address" but rather a "click on e-mail" feature which sends the address automatically. Don't forget to sign and date the page.

An example of the geoscience home page of the two authors illustrates some of the points (Figure 1). The Bureau of Economic Geology (BEG) incorporates:

- an attractive, rapidly-loading graphic
- immediate, clickable access to BEG programs; thus if the reader is interested in a specific program, he or she can proceed immediately to the relevant section.
- a clickable e-mail address which immediately places the reader in e-mail mode to the BEG director.
- a brief, concise description of the Bureau with an incorporated link to the larger entity's home page (The University of Texas at Austin).



What's New at BEG
Oil Research Program
Gas Research Program
Coalbed Methane
Geophysics Program
Environmental Program
Coastal Studies

Hydrogeology Program
Industrial Associates
International Programs
GIS Capabilities
Core Research Facilities
Publications and Products
Services and Staff

Welcome to the Bureau of Economic Geology Home Page

Noel Tyler, Director

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The Bureau of Economic Geology, a major contract-based research unit of The University of Texas at Austin, is one of the oldest and largest geoscience research organizations in the United States. Ongoing research is being conducted in advanced geotechnology; oil and gas discovery and recovery optimization; geophysics; environmental, waste-disposal, and hydrogeologic studies; coastal processes; and coal and mineral resources, both domestically and abroad.

Bureau Research Initiatives

Figure 1. Home Page of the Bureau of Economic Geology

- a second menu of BEG programs so that the reader, having learned more about the Bureau, does not have to return to the first page.
- appropriate links to other relevant institutions.

TESTING

The newly created Web page can be previewed in a browser to examine and correct mistakes, uncover design problems, and check the layout and appropriateness of the links. Web sites should actually be tested for compatibility with different computer systems and with several browsers. Design issues are often simply a matter of preference and can be solved by deciding what looks best in as many browsers as possible.

If you have your own server, you can test the pages by installing them and testing how another user might access them (Fleishman, 1995). Software that checks your pages for coding errors and obsolete links can also be helpful.

UPDATING AND MAINTENANCE

Having created and issued a home page, the Webmaster will need to update it periodically as quality assurance is critical to the credibility of the organization. Frequency of updating depends on the organization and the time-sensitivity of the information presented on the page. Some organizations update their pages daily, whereas others may not need to update for several works. Another common updating plan is to revise selected pages frequently while keeping the main structure and home page intact.

The main point to remember (and to convey to the managers of your organization) is that all home pages need regular maint-enance. An obsolete page reflects poorly on the organization. In addition, Internet-related technology is constantly changing and good sites should utilize these new capabilities appropriately .

Some areas of a home page that may need periodic maintenance include:

- directory or sales information
- significant new content (text and/or graphics)
- anything specified as being "new" or "forthcoming"
- URL's of other organizations
- the date of the last update

PUBLICIZING THE HOME PAGE

Publicize the existence of your page by submitting information about it to several of the popular search engines (Web-Crawler, Excite, etc.) available under "NetSearch" on your Netscape browser. Some search engines will require you to send several keywords to help index the page, while others will do all the indexing for you. Check the search engine periodically to ensure that your announcement appears and that the information is correct.

Also, post articles to relevant news groups, such as sci.geo.petroleum, including the URL, so that the news group readers can click to go right to your page. The article should appear on the news group server within a couple of days.

CONCLUSION

The many poorly designed, out-of-date, and insignificant home pages on the Internet illustrate the widespread opinion, overheard recently by one of the authors, that "Anyone can design a home page -- nothing to it!" Although the mechanics are easy to master, the design of effective, attractive, and relevant home pages is a challenge not to be undertaken lightly.

Determining user needs and specific organizational objectives must precede other aspects of home page design. Visiting dozens of sites as a user (and spending a considerable amount of time at each) is invaluable to the designer, particularly if the sites are similar to the one soon to be under construction. Note convenient and inconvenient features, appearance and loading time of the graphics, use of links, and aesthetics, not necessarily to copy these features but to utilize their advantages in your own design.

When beginning actual design of the page, keep in mind some straight-forward rules. Menus, with their hierarchical approach of general-to-specific, provide a logical approach to organizing Web docu-ments, especially when combined with selected linear structure as appropriate. Links enable the designer to create the interactive, hypertext character of the home page; observing clear and logical rules for designing links avoids user frustration. Graphics should be relevant, quick-loading and attractive. Writing style is critical, as is editing. All pages need periodic maintenance to update content and links and to take advantage of new methods of text and graphics presentation.

Pages should be previewed in several browsers and tested for compatibility with different computer systems. Finally, the page should be publicized through conventional means, such as word-of-mouth and printed sources, and through electronic media such as listserves, search engines, and relevant news groups.

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REFERENCES CITED

Aronson, Larry, 1994, HTML manual of style: Emeryville, CA: Ziff-Davis, 132 p.

Falcigno, Kathleen, and Green, Tim, 1995, HOME page, SWEET HOME page: Database, v. 18, no. 2, p.20-22, 24, 26-28.

Fleishman, Glenn, 1995, Weaving the perfect Web: Adobe Magazine, v. 6, no. 7, p. 69-73.

Graham, I. S., 1995, The HTML sourcebook: Mountain View,CA: SunSoft, 416 p.

Lemay, Laura, 1996, Teach yourself Web publishing with HTML 3.0 in a week (2d ed): Indianapolis, Sams.net, 518 p.

Powell, James, 1995, Spinning the World Wide Web: an HTML primer: Database, v. 18, no. 1, p. 54-59.

Team Web, 1996, Tips on creating graphics, the University of Texas at Austin: http://www.utexas.edu/learn /pub/maps/tips.html.

OTHER USEFUL SOURCES

Cobb, F.S., and Lener, E.F., 1995, Internet resources for the earth sciences: C&RL News, v. 56, no. 5, p.319-325.

Guthery, Scott, 1996, Sci.geo.petroleum. Internet.resources: http//www.slb.com /petr.dir/guthery.html#Companies.

Mills, G.I., 1996, GeoWeb - Gareth I. Mills's Internet geoscience links: http://www.pacificnet.net/ ~gimills/ main.html

Powell, James, 1994, Adventures the World Wide Web; creating a hypertext library information system: Database, v. 17, no. 1, p. 59-60, 62-66.

The University of Texas at Austin, 1996, Team Web publishing guidelines: http://www.utexas.edu/teamweb/ guidelines/

THE CLIMATE FOR WOMEN IN THE EARTH SCIENCES: CHILLY OR WARM?

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Abstract - In the recent substantial discussion of the status of women in science, very little has been said about the standing of women geoscientists. Of note are two short pieces in *EOS* and a few historical accounts of women earth scientists. In general, the focus tends to be on the Big Four sciences: physics, mathematics, chemistry, and biology, while the earth sciences are often ignored. To address this gap, we conducted a survey of women earth scientists and collected data on earth science departments from the American Geological Institute directory.

Our data intends to address the larger questions of which pathways lead women into the geosciences, how women have contributed to the earth sciences, does their work focus in certain research areas, do they pursue a more integrative approach to their research, and how does their teaching impact their research. Our analysis was conducted by a survey sent to 276 women members of the Association of Women Geoscientists, of whom 120 responded. We received responses from a good distribution of women academics, of which 36% were at the assistant professor level, 26% at the associate professor level, and 19% at the full professor level. Thirty-eight percent of the respondents were tenured, while 36% were on the tenure track.

The survey data show that women were attracted to the earth sciences by the interdisciplinary nature of the work and by an interest in nature. The younger women (at the assistant professor level) were also influenced by mentors and an interest in science, whereas the full professors did not indicate that they were influenced by either of the above. This suggests that earth science has become more accessible to the younger generation. This is not to say that our respondents were not frustrated with their work. Most complained of a lack of time for research and stiff competition for funding. Many of our respondents were in dual career couples (at least 80%)and about 505 were in partnerships with other earth scientists. More than 60% of the respondents in a dual career couple reported effects on their career from their couple status, and of these effects, 73% were negative.

ISSUES OF INFORMATION DELIVERY IN GEOSCIENCE LIBRARIES

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Abstract - Delivering information to researchers in the geosciences has become a complex process. Budgetary restraints have made it necessary for library collections to reassess issues of ownership at the same time that more sophisticated technology has made much more information available on demand.

Librarians may choose to utilize traditional consortial agreements such as through interlibrary loan, purchase material through commercial suppliers, provide researchers with access to databases via the Internet, or make available Geographic Information Systems (GIS) which allow researchers to set their own parameters.

This paper will explore some of the positive and negative aspects of the choices available. Results of research conducted in the areas of utilizing commercial document suppliers, increasing efficiency in interlibrary loan, providing information available via the Internet, and preparing for the installation of a GIS laboratory in a library setting will be presented.

DEFINING GEOSCIENCE JOURNAL VALUE: THE ROLE OF UNBOUND USE

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Abstract - Several recent studies have reviewed different methods of measuring geoscience journal use in academic libraries in an effort to determine journal value. Use categories have included check-outs, in-library use, citations by graduate students and faculty, and journals in which these groups publish. Other studies have established a cost-per-use based on journal price divided by various use parameters.

This paper examines unbound issue use as an important component in determining journal value. While this information may be more elusive to capture, it is essential to include in ongoing journal evaluation and serial cancellations. Data for this study was collected during the 1993-94 academic year on unbound geoscience journals held at the University of Washington Libraries. This survey provided data on actual use as well as type of use. Results indicated that browsing table of contents within the library accounted for a significant proportion of unbound journal use. The type of unbound use also varies according to the nature of the journal.

PROCEEDINGS PUBLISHED IN GEOSCIENCE JOURNALS : OCCURRENCE AND USE

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Abstract - The value of conference proceedings is a perennial point of contention. Previous studies of conference proceedings from different disciplines have come to opposite conclusions regarding their worth. As the price of other forms of scientific literature has increased, libraries have had to reduce their acquisition of monographic proceedings. As a result, a greater percentage of their proceedings collections come from those that are received automatically, either in series on standing order or in journals. This study examines the less-studied format, proceedings published in journals. Proceedings are identified in several geoscience journals. Their use is measured with citation analysis. Their citation frequency is compared to that of other articles in the same journals, articles in some monographic proceedings published during the same time period, and proceedings papers published in journal supplements. Also, the relative frequency of citation to these groups is measured from the bibliographies of faculty publications. The results show whether conference papers in journals are used to the same extent as regular journal articles or whether they fit expectations of lower use of proceedings papers.

GEONAMES AND GNULEX --DATABASES OF THE STRATIGRAPHIC NOMENCLATURE OF THE UNITED STATES

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Abstract -- For more than ninety years, the U.S. Geological Survey has maintained a file of the stratigraphic nomenclature of the United States and its possessions. The computerization of this information has been in progress for at least 20 years. This information has recently been released in CD-ROM format.

Two databases have been produced. GEONAMES is an abridged database of all of the stratigraphic units in the U.S. and its possessions. Information on each unit includes the unit name (Santa Margarita), the rank (Formation, Sandstone), the age (middle and late Miocene), and the State in which the unit is located (CA). Additional information may include the lithology and basin in which the unit is located. Multiple entries in each category under the unit name are possible. Searches may be made using any of these categories.

In addition to the information contained in GEONAMES, the GNULEX database contains more detailed information, including location of type (area, locality, section), principal reference (area, locality, section), geologic province, unit thickness, stratigraphic relation (with overlying and underlying units) and method of unit age determination (isotopic or biostratigraphic). The chief drawback to the GNULEX database is that it is incomplete. At present, only about one-third of the units currently names in the western U.S. have been included in it. Progress toward the completion of this database is hampered by insufficient resources at this time for this time- and manpower-intensive project.

Both these databases have been incorporated as part of the Digital Data Series (DDS-6). The minimum system requirements to use these databases with software provided on the CD-ROM are as follows: IBM or compatible computer, 640 kb RAM, DOS version 4.01 or later, CD-ROM drive with ISO 9660 software driver, Microsoft MSCDEX version 2.1 or later, hard disk drive and EGA/VGA color system.

A SYSTEM FOR MONITORING SHORELINE CHANGE WITH GIS: SUNKEN MEADOW SPIT, WELLFLEET BAY WILDLIFE SANCTUARY, CAPE COD, MASSACHUSETTS

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Abstract -- Barrier beach and dune systems provide storm protection and flood control for low lying coastal areas, as well as habitat for a variety of flora and fauna. Human activity and development can adversely affect the natural processes of the barrier island system. Sunken Meadow Spit is a typical barrier beach complex located on the northwestern interior shore of the upper Cape Cod peninsula. Its monitoring has been identified as a management priority because of the influence of anthropogenic forces.

Mathematics, statistics and spatial analysis are essential in monitoring rates of shoreline change over time and problem solving for the defense of areas similar to Sunken Meadow Spit. Geographic analysis software for the personal computer possess these capabilities and are extremely affordable.

The presentation will describe the development of a methodology for the collection and integration of beach profile data into a Geographic Information System for analysis. This will include the establishment of a baseline survey network for field data collection, construction of a spatial database, and the linkage and retrieval of collected profile data into the GIS. A demonstration of database query, spatial analytical and display functions will be featured.

The system will allow Sunken Meadow Spit to be routinely monitored. Data can be consistently acquired and used to examine the extent and causes of shoreline change. The result will be a tool beneficial in the preservation and protection of this barrier beach system.

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