

**Developing “Humane” Interfaces to Data Clearinghouses for Improving the
Delivery of Spatial Information to Marine Resource Managers**

by

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ABSTRACT

Developing “Humane” Interfaces to Data Clearinghouses for Improving the Delivery of Spatial Information to Marine Resource Managers

Web geographic information systems (GISs) and the Internet are now providing the connectivity necessary to support large-scale data access by a wide variety of users, including not just scientific researchers, but also policy-makers and marine resource managers. However, connectivity alone cannot ensure that those who need natural resource information will be able to locate relevant data. Data clearinghouses need to provide user interfaces that help a broad user community understand what spatial data are available, how they can be obtained, and how they should be interpreted.

The Metadata Humane Society project conducted by researchers at Oregon State University combined traditional interface engineering knowledge, scientific research and geographic information science (www.nacse.org/mhs). The researchers wanted to improve access to spatial information by identifying the primary barriers to usability for the National Geospatial Data Clearinghouse (NGDC) interfaces. The project included developing an understanding of the current state of usability among GIS-related Web sites that provide metadata search facilities and identifying promising approaches to “learnability” and navigability that might be exploited in improving the NGDC interfaces. To accomplish these

goals, three types of usability evaluations were performed: initial predictive evaluation of existing sites, user testing of existing NGDC Interface, and a user expectations survey. The evaluations involved actual users from a range of disciplinary backgrounds and user communities, as well different levels of expertise. The project found that different levels of user expertise require distinct subsets of the usability criteria. It is recommended that there be at least two interfaces available for the NGDC addressing different target audiences, and that each interface should focus on certain criteria. To improve the delivery of spatial information to marine resource managers, these recommendations to increase usability should be applied to data clearinghouses such as the Virtual Oregon, Oregon Coast Geospatial Clearinghouse and the Geography Network.

INTRODUCTION

There is a wealth of digital spatial data that can be used by marine resource managers. The spatial extent of regulatory and offshore boundaries aids resource managers with integrated management of ocean resources (Treml, et al. 2002). Accurate boundaries of National Marine Sanctuaries help resource managers address coastal management issues (Killpack et al. 2002). The spatial extent of harmful algae blooms aids resource managers in developing containment strategies (Cole, et al. 2002). On the World Wide Web and the Internet, spatial information is more readily available than ever before and can be used for more effective decision making in marine resource management.

But although Web GISs and the Internet are now providing the connectivity necessary to support large-scale access of spatial data by marine resource managers, connectivity alone cannot ensure usability (Pittman, *et al.* 1998, Fraser and Gluck 1999). Marine resource managers must be provided with sufficient information to locate relevant data and evaluate their likely usefulness before initiating time-consuming download operations (Flewelling and Egenhofer 1999). This is particularly true for repositories as broad and rich as the National Geospatial Data Clearinghouse (NGDC), which encompasses sources from local, state, and federal governments as well as research institutions and private organizations. As with other point-of-entry systems, this user interface provides the only introduction to these data sources that most users will ever see. It will be from such interfaces

that marine resource managers may shape their understanding of what spatial data are available, how they can be obtained, and how they should be interpreted, analyzed and used in decision making.

Because different cognitive processes are involved in conceptualizing geography, the users of spatial data require new approaches to interface design (Downs and Stea 1977, Kuipers 1978, Moran 1981, Egenhofer 1988, Mark 1992, Montello 1993, Wang 1994, and Egenhofer and Mark 1995). The first step in developing interfaces that improve the usefulness of data clearinghouses is knowing more about the characteristics influencing the usability of geospatial metadata. Geospatial data systems are heterogeneous collections of spatial and non-spatial data. Most user interface design tools, on the other hand, deal with uniform representations (predominantly lexical) and typically have focused on popular design components such as menus, panels, and mouse-based manipulation. Geospatial information is comprised of both lexical and graphical information that are closely interrelated. A successful user interface must be able not just to deal with two information modalities, but to provide mechanisms for integrating them into a coherent whole.

How to do this in a general way remains an open research question that cannot be addressed by a single project. But based on previous experience in usability engineering and interface design, a promising approach is to apply usability assessments to aid in developing a much higher degree of interactivity to the interfaces, similar to what Berry (1995) describes in his discussion of "humane

GIS", hence the name of this project, the Metadata "Humane" Society project.

[NOTE: Expand a little on his meaning of "humane" in that user interfaces to GIS operations are made more understandable, easier to use, inviting interaction with the user, thus making them more "humane" to users, especially fledgling users.]

BACKGROUND

Finding digital spatial data and metadata on the Internet and the World

Wide Web can be difficult because they are stored in many forms and systems. A Clearinghouse can provide a standard method for spatial discovery and a unified search capability among distributed sites. The Federal Geographic Data Committee (FGDC) was charged by an executive order in 1994 to establish a National Geospatial Data Clearinghouse (NGDC), a distributed network of geospatial data producers, managers, and users linked electronically (EOP [expand out the "EOP" acronym] 1994). The NGDC has grown to be a distributed collection of over 250 searchable servers through a Web gateway. Each server holds metadata entries whose fields are searchable and can point the user to a URL for direct data download or a information about how data can be ordered.

In 1999, the University Consortium for Geographic Information Science (UCGIS) solicited proposals from individuals at its member institutions to conduct research in the usability of user interfaces to the NGDC, particularly its search and

retrieval interfaces. The research project was to assess the effectiveness of the Clearinghouse's human-computer interface elements for geographic data access and discovery for multiple user communities, to provide guidelines for the selection of methods to better navigate and visualize complex metadata, and to evaluate the access to the Clearinghouse's centralized and distributed metadata repositories that are linked to geospatial data stored in databases.

To this end, researchers at Oregon State University affiliated with the Northwest Alliance for Computational Science and Engineering (NACSE) and the Department of Geosciences were contracted by the FGDC to assess the effectiveness of the NGDC's user interfaces for geographic data access and discovery, from the perspective of several target user communities. The Metadata Humane Society Project reviewed usability aspects of several large clearinghouses that provide metadata in hopes of improving the Clearinghouse's search interfaces. By adjusting the nature and structure of the interfaces to the different user groups, it will be possible to make data clearinghouses responsive to a broader spectrum of user needs. Marine resource managers who are collaborating across networks to share ideas and data will be able to locate and access spatial data that may be spread across many physical locations.

METHODOLOGY

CHARACTERIZATION OF TARGET AUDIENCES

The potential users of environmental geospatial information typically have been characterized as fall into the following groups: geographers, cartographers, public utilities agencies, natural resource managers, scientists, and policy makers. Science educators and students are also important potential users, and the general public is likely to be increasingly interested in geospatial information

Not all of these audiences are of equal importance in the design of the NGDC interfaces. The project identified and prioritized the target user constituencies who use the Clearinghouse interface for geospatial resource discovery and access, characterized the primary targets, and demonstrated how representatives from those groups could be incorporated into user testing activities.

Historically, the top priority for NGDC interfaces has been GIS specialists and government agencies. Scientific researchers who are not GIS specialists, educators, and students have constituted a second-level priority. Business and industry, the general public, commercial data providers, and non-commercial data providers were grouped as a third. Although these priorities represent historical trends in the usage of the NGDC Clearinghouse, they may not reflect the audiences that should actually be supported by the FGDC. Because the clearinghouse provides a key public information resource, the general public may in fact be the FGDC's most important audience.

For the purposes of this project - and the user testing included in the project - the constituencies in the first and second tier were grouped into four target

audiences: GIS specialists, members of government agencies, scientific researchers, and educators and students.

Characteristics of Primary Audiences: Expertise

Each of the four target audiences encompassed a range of individuals with varying levels of expertise. For the purposes of the NGDC interface, users are likely to differ in terms of six dimensions of background skills: Web familiarity, catalog familiarity, map familiarity, metadata familiarity, domain familiarity, and GIS familiarity. Web familiarity is the degree to which users have experience with use of the Web and common Web browser functionality. Catalog familiarity is the degree to which users understand the interactions of a catalog or gateway. Map familiarity is the ability to understand and navigate using maps. Metadata familiarity refers to the degree to which users understand the purpose of metadata, its relationship to data, and standard formats for metadata. Domain familiarity is the degree of knowledge users possess within a disciplinary domain, such as ecology or geology. GIS familiarity is the degree of familiarity with the tools of spatial analysis and modeling.

Metadata familiarity can be further broken down into: (1) an understanding of what metadata is and how it relates to data, what metadata standards are and how they are used, and how metadata clearinghouses can be used (e.g., Wright 2000); (2) the user's familiarity with metadata standards in general, such as the FGDC

standard. This will have impact on how efficiently and effectively user interactions with the NGDC site are.

While it is possible to have various mixes of exposure and experience in all these dimensions, they are not completely independent. It is unlikely, for example, that someone with good GIS familiarity would not also be highly familiar with maps.

In terms of potential NGDC users, the baseline assumed was that they would be comfortable with the Web in general and at least one Web browser in particular. At least some understanding of what catalogs and gateways do was expected, since search engines are a common experience of most Web users. Most would also possess a reasonable level of skill with basic map navigation, including zooming, panning and use of rubber-banding to select map regions, since these are also common features of many Web sites.

The ranges of expertise likely to occur in each of the target audiences, in terms of which are particularly likely to indicate the degree of success a user will have in approaching the site are summarized as follows:

1. GIS specialists are most likely to differ in terms of familiarity with the FGDC standard. While some will be comfortable with it, others will be accustomed to different standards, and a smaller proportion will be unfamiliar with any metadata standards at all.

2. Many members of government agencies, who do not fall under the previous category, will be uncomfortable with the general concept of metadata.

Some will also be unfamiliar with the concept of clearinghouses, but it is assumed that all are aware of portals or gateways. Those who are familiar with metadata standards may have no direct experience using the FGDC standard.

3. Some scientific researchers may have knowledge of metadata and perhaps even clearinghouses, but the majority of these users will be unfamiliar with even their basic concepts. Further, some will be unfamiliar with the notion of gateways.

Although many educators and students will be comfortable with the use of gateways, it is unlikely that many will have significant understanding of how research data is organized and managed. Also, they will be unfamiliar with the metadata and metadata standards used in describing research data.

Characteristics of Primary Targets: User Goals

Each user will approach the NGDC site with particular goals in mind. The ease at which those goals can be met will largely determine the user's overall satisfaction with the NGDC interfaces. While the following descriptions are not exhaustive, they prove a representative sampling of the types of goals likely to be important to each target audience.

GIS specialists are most likely to be seeking data corresponding to some

particular need: theme, location, or time period. At times, however, the most important consideration is to locate data conforming to a particular format or projection, that are suitable for a particular software package, or that contain information or code that might be useful in performing some ancillary function. Different groups of users will be familiar with different sets of terminology, so synonym support will be important.

Government agency employees might share these goals, but also have some that are directly related to the role of their agencies.

Scientific researchers typically seek data that will complement their own research data, that can help to validate their models or hypotheses, or that indicate the usefulness of some method for analysis, interpolation, measurement, etc. They may also be conducting a more general search to learn what kinds of information are available via the Web, and where.

Educators and students are likely to be most interested in identifying sites whose research data is appropriate for use in coursework or student research projects. In some cases, the objective may be simply to identify if such sites exist, rather than to actually access the data.

Finally, for all types of users there will be the need to re-find data or metadata that were located during some previous session.

These example goals were used in structuring the user tasks for the testing activities conducted as part of this project. They also served as the basis for

application of the cognitive walkthrough method for usability evaluation, which was applied at multiple points as revised interfaces were designed and tested.

IDENTIFICATION OF BARRIERS TO USABILITY

To accomplish the goal of identifying the primary barriers to usability for the NGDC interfaces, three types of usability evaluations were performed:

1. *Initial predictive evaluation* of existing sites. The usability engineering team identified those classes of usability problems that are known to be singled out most effectively by usability specialists. The usability specialist tried to predict whether or not a user would have any difficulties.
2. *User testing* of existing NGDC interface: Through verbal protocol exercises, users identified specific usage problems.
3. *User expectations survey*: A survey was distributed to potential users to identify their expectations.

Initial Predictive Evaluation of Existing Sites

An evaluation procedure was used to arrive at an understanding of the current state of usability among typical Web sites devoted to access of GIS metadata, to establish what the primary barriers to usability are, and to identify any

existing approaches that seem promising for improving the usability of the NGDC. Project researchers evaluated the interfaces that had been identified as target sites for this project. In doing so, they approached the evaluation from the point of view of the typical user by assuming various “user roles” and carrying out pre-defined tasks associated with each role.

The search interfaces of the target sites were evaluated by a total of five project researchers. Using three to five evaluators improves the results of expert usability evaluations (Nielsen 1993). Two browsers (Netscape [Note: which version(s) as there are now drastic differences between the older Netscape 4 and Netscape 6 and 7], Internet Explorer 5?) on a total of five operating systems (MS Windows/98, MS Windows/95, MS Windows/NT, Solaris 2.7, IRIX 6.5.11), and several machine/monitor combinations. All trials were conducted using direct network connections to the Internet, with good connectivity, so reports on efficiency indicate the best that a user might expect to see.

Carefully selected evaluation criteria, summarized in the next section, were rated for each site according to the various defined user roles assumed by these specialist during this project phase. Each team member took one or more of the following target user roles in performing the evaluations:

- GIS specialist familiar with the FGDC standard
- GIS specialist familiar with the standards, but not FGDC
- Agency staff experienced with another standard
- Agency staff unfamiliar with the clearinghouse concept

- Agency staff unfamiliar with metadata standards
- Scientific researchers unfamiliar with metadata
- Scientific researchers unfamiliar with the gateway concept

The results of the individual evaluations were combined and analyzed collectively in order to determine the strengths, weaknesses, trends, and recommendations discussed in this report

Criteria Used in Evaluations

Several traditional measures of usability (Jordan 1998, Nielsen 1993) were evaluated in the context of a particular role at a particular site:

- *Explicitness* is the degree to which it is clear how the site should be used. For example, is it clear that results of a query will be metadata rather than the actual data?
- *Compatibility* offers a measure of the degree to which operations fit in with expectations based on the user's real-world experiences. For example, if the user expects that a query always returns data, are metadata queries supported using some other terminology?
- The *effectiveness* of an interface demonstrates the extent to which the user's task can be achieved. An example is whether the user can actually find desirable data or data sources as opposed to finding interesting metadata.

- The site's *efficiency* is the amount of time and/or effort to achieve the user's goal or task. In other words, how many operations, requiring how much typing or pointing, are needed to find the desirable data? A good example is the use of sensible defaults so that the user need specify only a minimal amount of information.
- *Consistency* measures the degree to which similar tasks are performed in similar ways. For example, searching metadata on the basis of location should not be appreciably different from searching on the basis of time span, except for the obvious need to specify a time range in some suitable way. The overall number, type, and ordering of steps should be similar.
- The site's "*learnability*" refers to the capability of an interface to help a novice user learn about its features and usage. One example is selection via lists where items can be recognized rather than having to know a suitable value a priori.
- *Feedback* is the criteria that measures the degree to which user actions are acknowledged with some meaningful response. An example of good feedback would be a "searching" message indicating that a search will take time because it involves going to five different node sites to look for information.
- *Error prevention* measures the degree to which possibilities for error are minimized. For example, having the user select from a list, rather than

typing a word into a field, will eliminate typing errors or inappropriate word choices.

- *Error recovery* measures the degree to which a user can recover quickly and easily from errors. An example of poor error recovery would be a message saying simply "query returned no results"; a good message would point out that inconsistent criteria had been used and would then return the user to the form with fields re-set to the values he/she had previously used.
- The *legibility* of an interface is the ease with which text and other elements can be discerned and comprehended. For example, the use of very small fonts or backgrounds with poor color contrast would make for poor legibility.
- The *visual clarity* criteria rates the degree to which information is organized so that the user knows quickly, and without confusion, how he/she should use it. For example, a web form should make it immediately clear what kind of information is accessible and which fields are really necessary.
- *Prioritization* is the degree to which the most important functionality and information are also the ones most easily accessible to users. One example is having the opening screen be the one supporting the most common type of query.

Potential User Expectations Survey

An expectations survey was implemented in order to understand what potential users might expect to accomplish using the NGDC interfaces, and to identify the models and task structures they are likely to encounter. The survey was distributed at the 2000 Summer Assembly of the UCGIS as the meeting coincided with this stage of the project (cite what you now call Appendix 3, but since this is mentioned in your manuscript before draft appendices 1 and 2, you should rename Appendix 3, Appendix 1 and cite it here, and Appendices 1 and 2 should be changed to Appendices 2 and 3). Fourteen UCGIS participants responded. Questions to a few individuals indicated that they were not responding because they did not know why they would want to use a clearinghouse, which is indicative of the challenges that remain in educating users of the value of metadata and clearinghouses. The responses from the survey were analyzed even though they were low in number, due to time constraints within the time frame of project.

User Testing of Existing NGDC Interface

User testing of the existing NGDC interface was carried out to arrive at an understanding of how users access and apply the existing NGDC interfaces and to identify specific usage problems that should be addressed during interface improvement. All tests were in the form of head-on comparisons of 2 sites, and performed by 11 undergraduate and graduate students in an upper division, introductory GIS class at Oregon State who are active users of clearinghouses. Thus, the subjects can be characterized as those already familiar with GIS

principles and techniques, and with the FGDC standard for metadata. Students were assigned to particular pairs of sites to ensure full coverage. A total of 26 tests were performed, covering 5 of the sites that previous evaluations had identified as “top contenders” as design sources (Appendices 1 and 2; for purposes of task performance comparison, only sites that included the West Coast of the US were considered).

Each student was assigned a series of tasks related to retrieving information associated with a target location. The targets were defined to be a small city in California, Oregon, or Washington, to minimize the effects of subjects' lack of familiarity with the basis for the search.

Test subjects attempted to retrieve information on the basis of place name, mapping regions, and subject keywords. Each student repeated the same steps for both Web sites assigned to him/her. If the search was successful, the student was asked to describe the kinds of information retrieved. If unsuccessful, the reason was recorded. Subjects were also asked to indicate what kind of metadata had been retrieved and how readable it was, the ease with which they were able to learn and use the site, and their impressions on site performance.

After repeating the procedure with the second site, subjects were asked to indicate which of the two sites they preferred, and why.

RESULTS & DISCUSSION

RESULTS OF PREDICTIVE EVALUATION

This summary presents the results of the predictive evaluation of the existing sites identified for analysis. The goal of the evaluation procedure was to arrive at an understanding of the current state of usability among typical Web sites devoted to access of GIS metadata, to establish what the primary barriers to usability were and identify features that support usability. The results of the evaluations are presented by site:

1. CEONet (ceonet.ccrs.nrcan.gc.ca/cs/en/index.html) is the prime discovery and access component of Canada's national spatial data infrastructure initiative. CEONet was designed and built to enable geospatial resource discovery, evaluation and access.

Features that support usability:

- Searching is extremely fast (efficiency).
- The interface is easy to navigate, even for novices (learnability).
- The Earthscape II application for drawing a map as part of the user's search is very nice, especially the cartographic color scheme, the quick refresh rate, and the help button (Figure 1). Also helpful is the fact that the bounding coordinates are filled in automatically based on the map drawn (efficiency, error prevention).

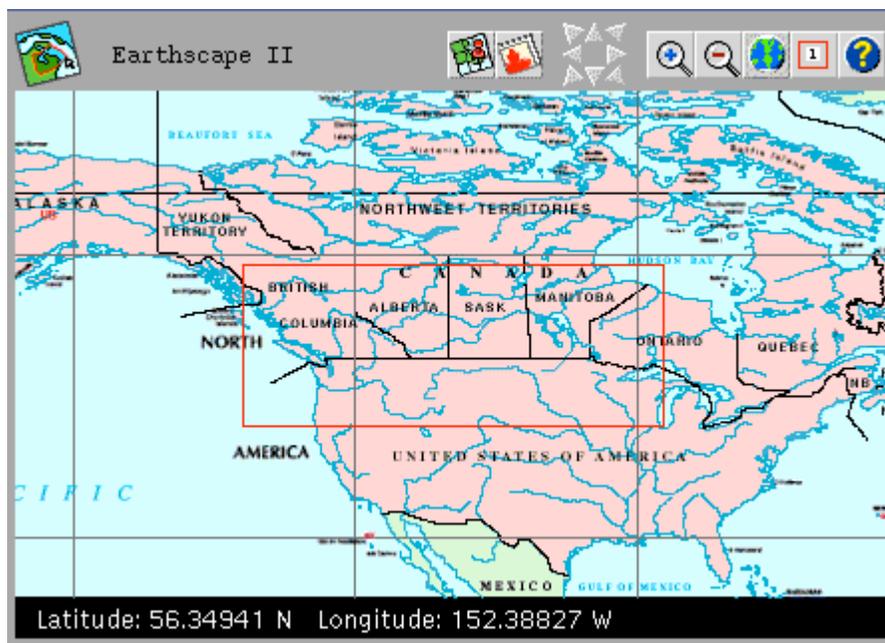


Figure 1: Application used to support map-based searches.
 (from <http://ceonet.ccrs.nrcan.gc.ca/cs/en/index.html>)

- There are several alternate routes for searching: AltaVista-like text search, drop-down list of place names, bounding box on map, textbox for place name (efficiency).
- The ability to search or restrict search by subject and product type is an excellent feature (effectiveness).
- Subject may be selected via a list of items as well as by keyword (efficiency; Figure 2).

CEONET Discover a world of geospatial data, services and expertise

Home Overview Help Feedback Français

Search for data
For example, choose "Ontario" as the Location and "Geology" as the Subject and click the search button.

Location

Subject
Tips: +requires, -excludes, quote to "search for phrase"
 Example: monitor +"air samples" -temperature

Time period

Product type This criteria is only applied to data supplied by Canadian organizations.

Alphabetical list of database names
[A](#) [B](#) [C](#) [D](#) [E](#) [F](#) [G](#) [H](#) [I](#) [J](#) [K](#) [L](#) [M](#) [N](#) [O](#) [P](#) [Q](#) [R](#) [S](#) [T](#) [U](#) [V](#) [W](#) [X](#) [Y](#) [Z](#) [Other](#)

Other lists
[All databases searchable over the Internet](#)

Figure 2: Example from CEONET, showing lists supporting searches based on topic areas and product types.

- The abstracted metadata returned as results are easy to read and are accompanied by a map showing the geographic extent of the data in question, as well as the time period. For more detailed information, the user can click to see the full-blown FGDC-style metadata record (effectiveness; Figure 3).

CEONET Discover a world of geospatial data, services and expertise

Home Overview Help Feedback Français

Aerial Survey Database for Canada

Data provided by **Centre for Topographic Information – Ottawa, ESS / NRCan**

Product type Point, Photo, Remote-sensing data > Airborne, Model, Map > Digital elevation model, Paper, Map, Tabular digital data

Non-digital form Contact distributor for 3-part package. Aerial photographs and diapositives will be mailed. Photogrammetric adjustments can be distributed on CD or via e-mail.

Fees \$100 for first model; then \$25 each for successive models.

Access options Contact the distributor to obtain this data

Further information [See the full description](#)

Abstract

The Aerial Survey Database (ASDB) is a data bank of photogrammetric control points that have been established through the process of aerotriangulation. The primary purpose of this database is to provide a minimum of four points for the compilation of each photogrammetric model contained in a 1:50,000 National Topographic Series (NTS) map sheet. The photogrammetric points can also be transferred to newly acquired aerial photography or satellite imagery and used as control for different derived products such as Digital Elevation Models, Digital Orthophotos, and Digital Perspective Scenes.

The ASDB is divided into blocks; each block consists of several aerial photographs and diapositives covering one or several 1:50,000 NTS map sheets. The blocks are always identified by an alphanumeric code such as "H013" the letters in the code are used to identify the province or region (H=British Columbia), while the numbers indicate the order in which the particular block was completed within the designated area.

The database consists of paper prints of the aerial photographs, along with the corresponding diapositives and the results of the photogrammetric adjustment. The adjustment contains (X,Y,Z) co-ordinates of all photogrammetric points. There are approximately three million points and 250,000 aerial photographs and diapositives in the Aerial Survey Database covering roughly 60 percent of the Canadian landmass.

... for additional information [visit their web site](#)

Purpose

To provide a minimum of four points for the compilation of each photogrammetric model contained in a 1:50,000 National Topographic Series map sheet.

Data coverage

Time period: 1972-01-01 to Present
Blue line indicates geographic extent of data.

Distributor of data

Doug Baker
Centre for Topographic Information (Ottawa), Earth Sciences Sector, Natural Resources Canada
615 Booth Street, Room 750E
Ottawa, Ontario, Canada
K1A 0E9
Phone: +01-613-995-4284
Fax: +01-613-995-4438
Email: DBaker@NRCan.gc.ca

Alain Gagne
Centre for Topographic Information (Ottawa), Earth Sciences Sector, Natural Resources Canada
615 Booth Street, Room 150
Ottawa, Ontario, Canada
K1A 0E9
Phone: +01-613-995-4121

Figure 3: Example from CEONET, showing metadata summary display including geographic extent and time period for data.

- The ability to "refine search" after a successful initial search is a helpful feature (efficiency).
- The user is supplied with helpful messages during remote searches (feedback).

Primary barriers to usability:

- Under Internet Explorer 5, the first response is "page not found." A second click usually works to proceed, but many users would not attempt this. (This is not a problem with Netscape.)

- There are difficulties with the "Alphabetical list of database names" and "Other lists" options at the bottom of the search page. It is unclear whether the user needs to choose from these lists in order to execute a search successfully (visual clarity).
 - Checkboxes are not available for all data sets, and it's not clear why, or whether this is "normal" (consistency).
 - It's difficult to get back to the query screen after searching checked databases (e.g., to change criteria). "Refine" returns to an earlier page, but not to the beginning. To change the data sets searched, the user must return all the way to the home page (efficiency).
 - Error detection appears to be incomplete. For example, when nonsensical values were entered for latitude and longitude, the search was performed without question (error prevention).
 - The term metadata is not mentioned or defined. Consequently, the user may expect to see data but only receive metadata (explicitness.)
 - While most supplementary windows offer a "Close" button, the map window does not (consistency).
2. SEDAC (sedac.ciesin.org), the Socioeconomic Data and Applications Center, is one of the Distributed Active Archive Centers (DAACs) in NASA's Earth Observing System Data and Information System (EOSDIS).

Features that support usability:

- The use of folder-tab selections is a nice feature to distinguish among query elements (prioritization).
- The use of mouse-over messaging helps to expose functionality (visual clarity).
- The query summary panel is a helpful way of indicating what query selections have been made (explicitness).
- Having all database choices appear on one page facilitates selection (visual clarity).
- The availability of a site map assists new users (learnability).

Primary barriers to usability:

- There is slow connection speed and occasional time-outs as problems (efficiency).
- Database choices within each theme are listed in an arbitrary order (compatibility).
- The presentation is offered as if searching for metadata only (compatibility).
- There is poor legibility, especially regarding font size on UNIX (legibility).
- When selecting a region from a map, an accidental slip causes the system to re-set (error recovery).

3. The Master Environmental Library (MEL) (mel.dmsomil/mel-bin/java_query) is a one-stop site for ordering environmental information sponsored by the Defense Modeling and Simulation Office (DMSO). The mission of MEL is to provide direct and timely access to natural environment information, data, and products, wherever they reside.

Features that support usability:

- Selecting a region from the map is simple and attractive (learnability, prioritization)
- The interface is relatively fast (efficiency).
- The availability of images of data helps the user recognize what's available (explicitness).
- Order and description buttons clarify the distinction between obtaining data and metadata (explicitness; Figure 4).

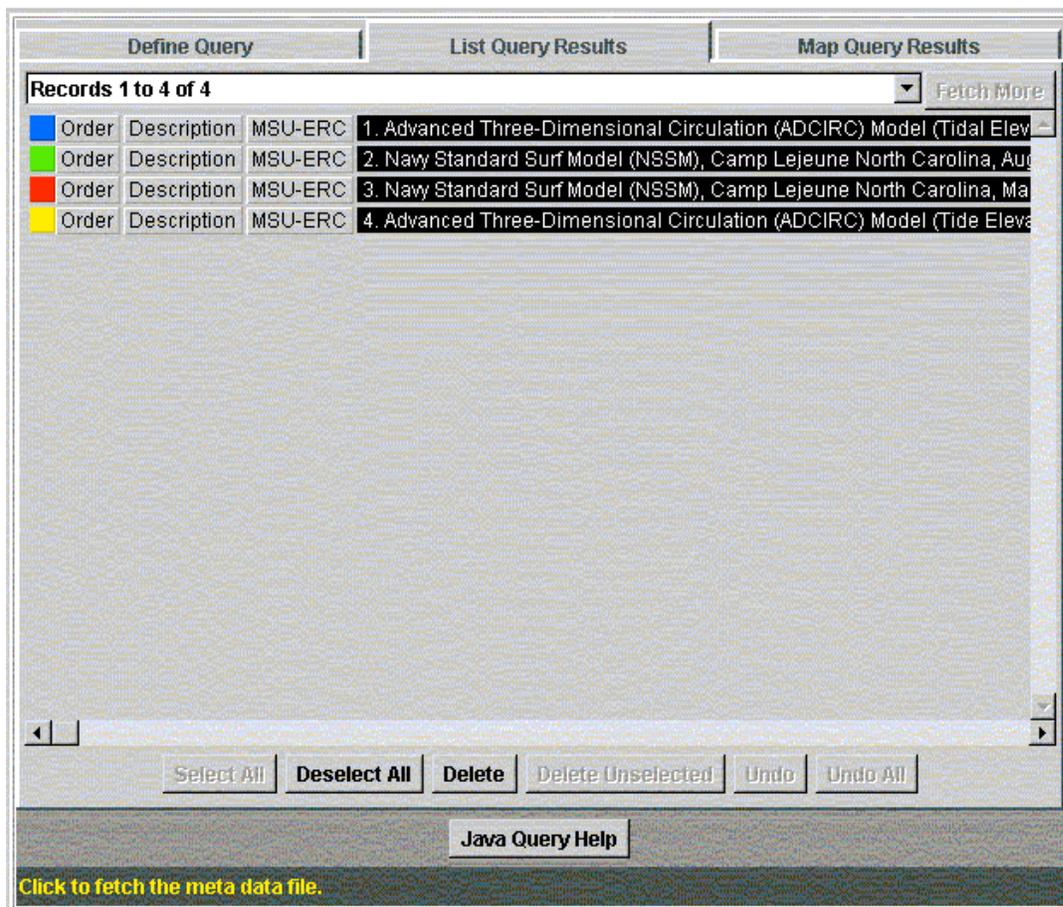


Figure 4: Example from MEL, showing clarity of "view description" vs. "order data" indicators.

- The availability of a tutorial helps new users (learnability).
- The availability of a site map helps new users (learnability).
- Help is available through email, with quick response time (learnability).

Primary barriers to usability:

- Error messages don't provide any guidance to the user; for example "Sorry. Can't query with wraparound ROI!" (error recovery).

- In the HTML version, the user cannot select a keyword via lists, but must know what suitable values are *a priori* (learnability).
- Appearance does not make it clear which fields are needed in performing keyword-based searches (visual clarity).

4. The Australian Spatial Data Directory (ASDD)

(www.environment.gov.au/net/asdd/advanced) is an essential component of the Australian Spatial Data Infrastructure (ASDI). It provides search interfaces to geospatial data set descriptions (metadata) from jurisdictions throughout Australia.

Features that support usability:

- There is good feedback during time-consuming operations (feedback).
- The status screen, which refreshes every few seconds, is a good feature (feedback).
- There are good results from geographical searches (effectiveness).
- Keywords can be selected via lists (learnability).
- Metadata format is in easy-to-understand summary form (clarity; Figure 5).

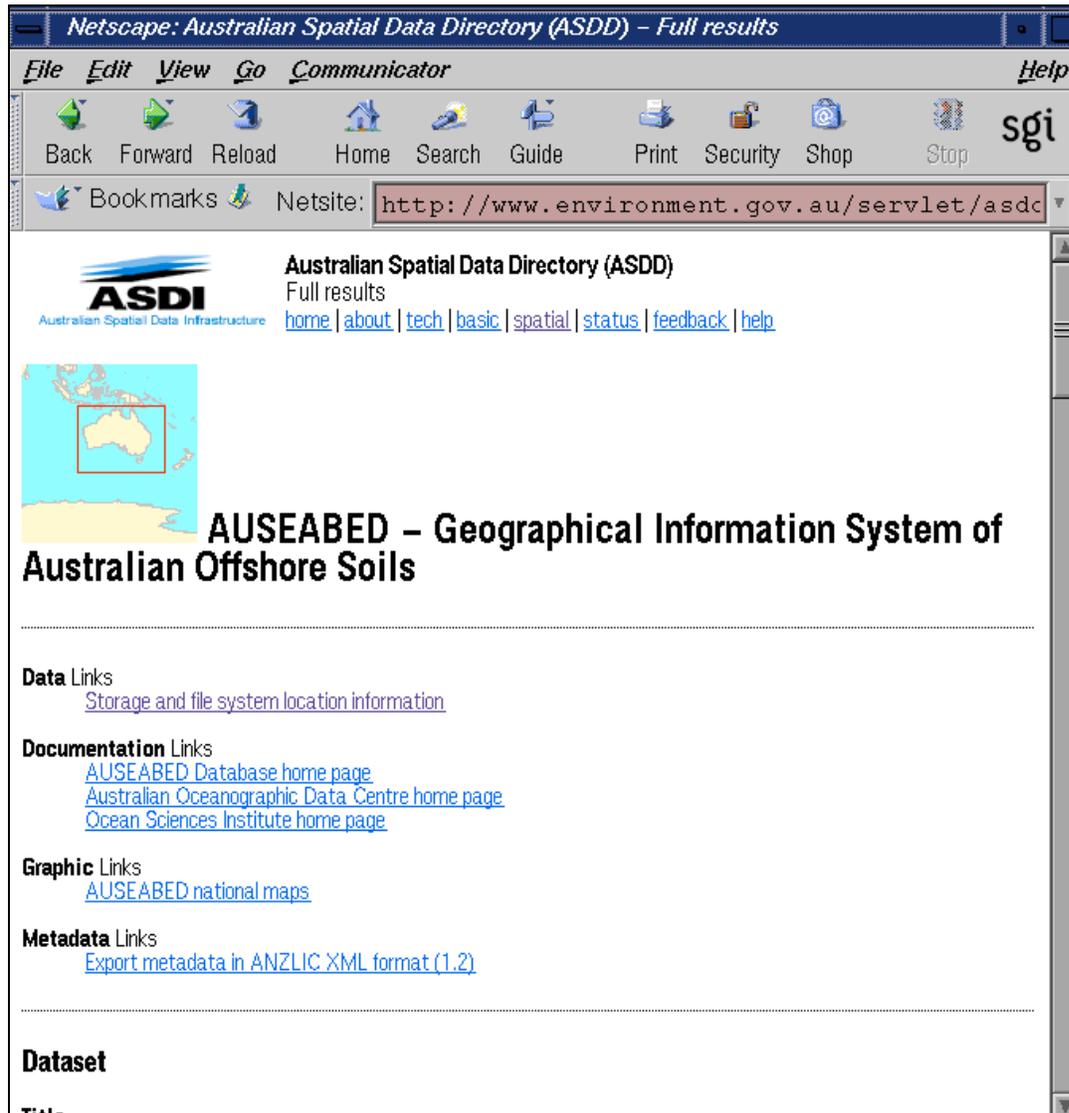


Figure 5: Example from ASDD, showing clarity of metadata summary.

Primary barriers to usability:

- Slow connection speed is discouraging - although it was fast at 2 AM (efficiency).

- Error messages are not helpful, and errors require starting over again (error recovery).
- The use of mouse-over messaging is minimal (visual clarity).
- Color contrast is poor and fonts are small (legibility; Figure 6).

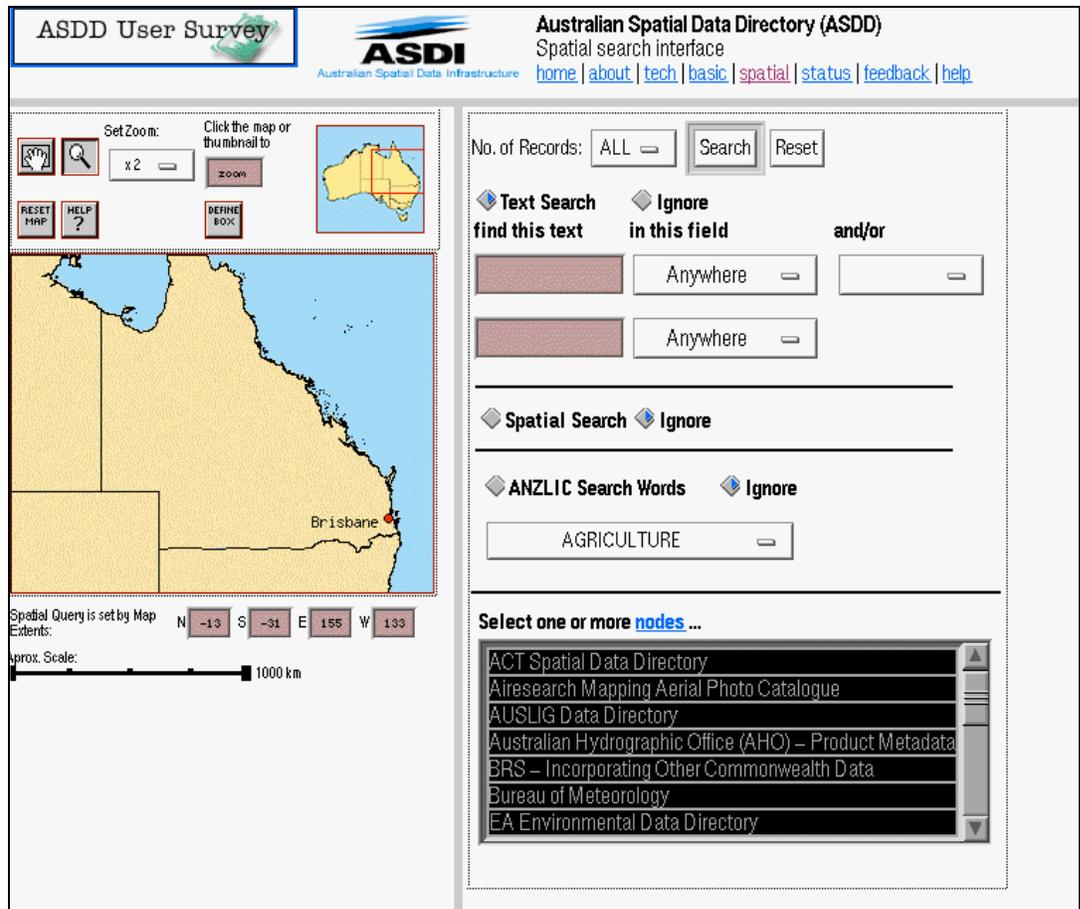


Figure 6: Example from ASDD, showing discrepancies in font sizes (note tiny font in left-hand pane).

5. The Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center for Biogeochemical Dynamics (www-eosdis.ornl.gov) is operated by the

ORNL Environmental Sciences Division as part of NASA's Earth Science Enterprise program.

Features that support usability:

- Ability to search for choice of either data or metadata clarifies expectations (explicitness).
- The ability to select geographic regions via lists is a useful mechanism (efficiency).
- The ability to search on attributes, including investigators (the name of the scientist), sensors, and sources is an advantage (effectiveness). It is also possible to search in iterative steps, gradually narrowing the search (Figure 7).

Bookmarks Location: <http://www-eosdis.ornl.gov/cgi-bin/DAAC/uncgi/sea>

Deepsea-Dawn's Bookmarks Campus Fun/Misc Stuff SGI/Computers

Searching Using Keywords: watershed
 From each list below, select none, one, or more attributes. The results of a successful selection (or combination of selections) will be another screen similar to this one with fewer datasets on it. You may continue this selection refinement until you have listed the desired datasets.

Your Search Resulted In:

4 Projects With **25 Data Sets**

BOREAS FIFE HYDROCLIMATOLOGY DATA RIVDIS	15 MINUTE STREAM FLOW DATA: USGS (FIFE) 30 MINUTE RAINFALL DATA (FIFE) BOREAS CANSIS REGIONAL SOILS DATA IN VECTOR FORMAT BOREAS HYD-04 STANDARD SNOW COURSE DATA BOREAS HYD-05 BEAR TRAP CREEK AND NAMEKUS LAKE WINTER SURFACE FLUX DATA
---	---

(HYDRO CD-ROM Package Not Shown. Order these [Here.](#))

The Data Set Attributes Contain:

31 Investigators, **33 Parameters,**

BAND L. E. BOREAS STAFF SCIENCE BOURBONNIERE RICHARD A. BRIGGS JOHN M. ENGMAN E. TED	BIOMASS DISCHARGE/FLOW EVAPORATION EVAPOTRANSPIRATION HEAT FLUX
--	---

22 Sensors, **and 10 Sources**

ANALYSIS CARBON ANALYZER CLIMATOLOGY DATABASE DIGITIZER EDDY CORRELATION APPARATUS	COMPUTER MODEL FIELD INVESTIGATION GROUND STATION LABORATORY MAPS
--	---

Using My **NEW** Selections Or my selections.

(You must select something for SEARCH to work)
 (You Will Be **Unable To Download Data Set Files** Until You Get The Data Set Count Under 20.)

Figure 7: Interface showing breadth of search criteria and ability to search iteratively (from <http://www-eosdis.ornl.gov>)

- There is good visual clarity (visual clarity).
- The availability of a glossary is a plus (learnability).

Primary barriers to usability:

- Closely related tasks must be performed in slightly different ways; e.g., only some search screens have "Get Data Sets" button (consistency).
- Some screens fail to provide the user with an indication of what operations are possible (explicitness; Figure 8).

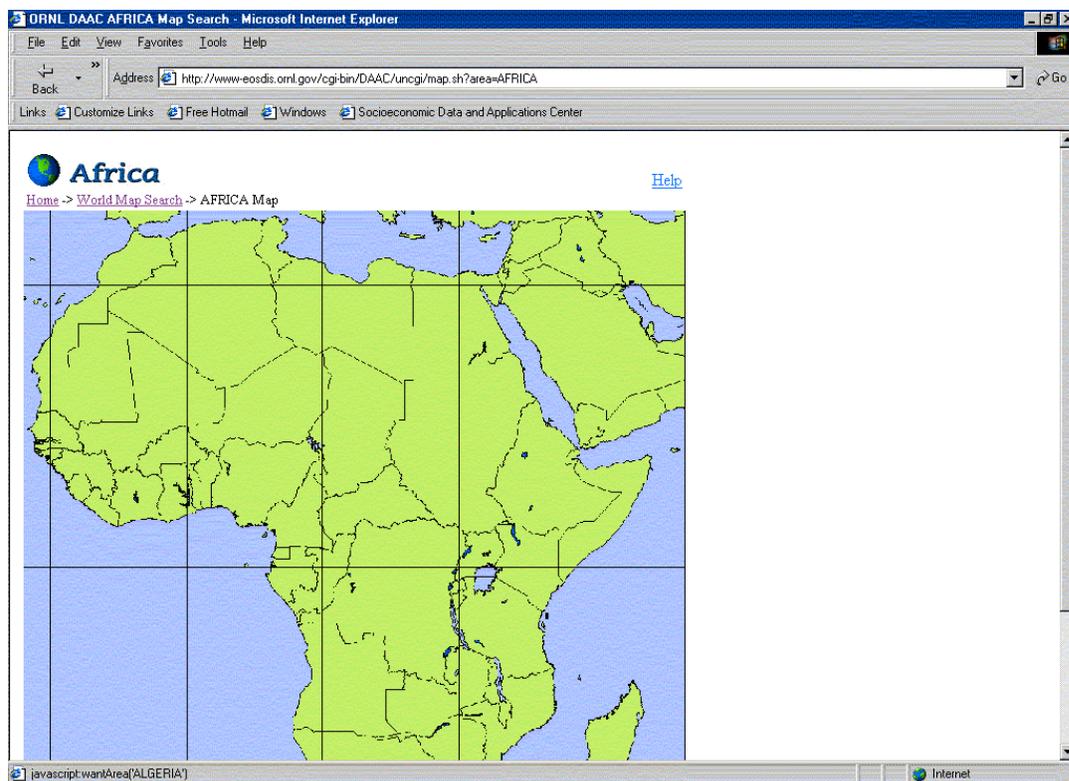


Figure 8: Example from ORNL, showing failure to indicate what user's next step should be.

6. The Ecological Monitoring and Assessment Network (EMAN) (metadata.cciw.ca) is a national network of monitoring and research sites characterized by long term, multi-disciplinary studies. EMAN and its partners contribute to a national data set and metadata library. EMAN is a registered node in the web of NSDI clearinghouses.

Features that support usability:

- There is a good help facility (learnability).
- The multi-lingual (French and English) option is a nice feature (compatibility).

Primary barriers to usability:

- It has an intimidating, long query screen (efficiency).
- The "Clear" button is two screens down (visual clarity).
- It is not clear if one is searching for metadata or data (explicitness).
- Some of the "help" did not work correctly (learnability).

7. The governments of the nations and territories of the wider Caribbean region established the Caribbean Environment Programme (CEP) (www.cep.unep.org) in support of the Cartagena Convention and its Protocols. CEP is a registered node in the web of NSDI clearinghouses.

Features that support usability:

- Two search interfaces are available, one for users not familiar with geographic search engines (learnability).

- Metadata summaries provide a high-level view of data sets, making the data set list easy to browse (Figure 9).

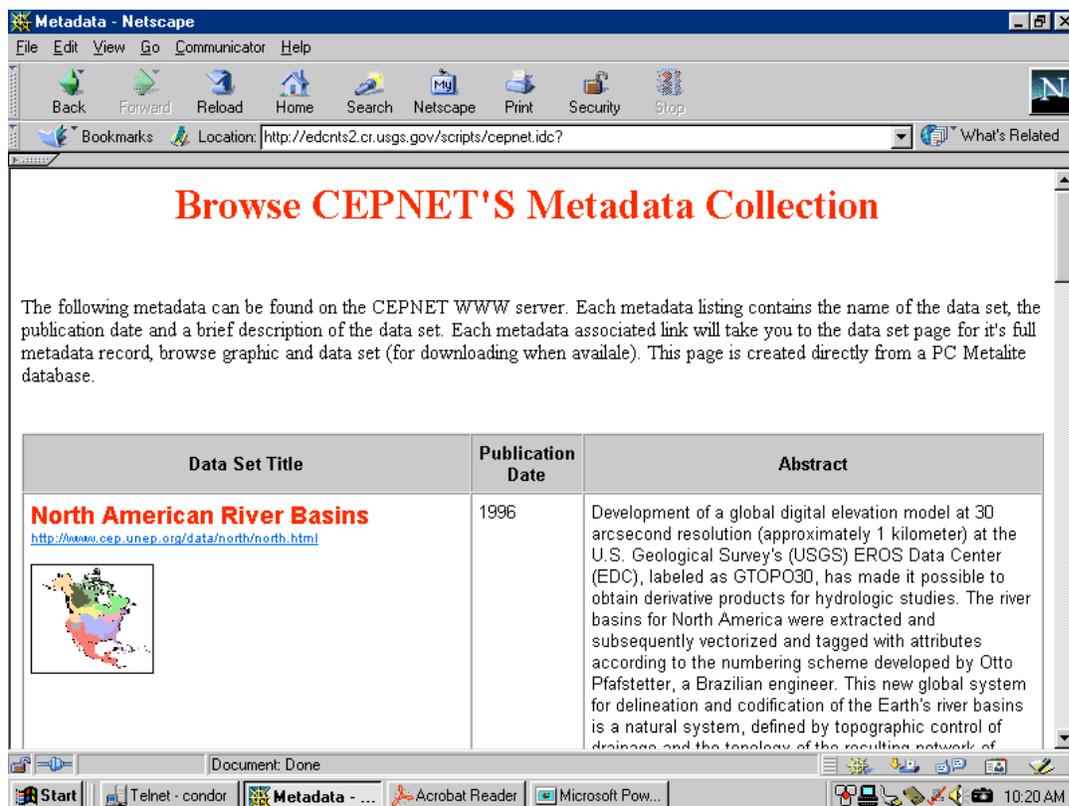


Figure 9: Example from CEP, showing metadata summaries included in data set list, with full metadata available via links.

Promising approaches:

- The availability of time-based searching (although it doesn't seem to actually work) is an important feature.

Primary barriers to usability:

- The basic search and advanced search do not yield results (effectiveness).

- Several "Help" and "Comment" links were not functional (learnability).
- After a search, the user is asked to logout. However, there is no mechanism for returning to the search page to do another (efficiency).
- It is difficult to locate the search engine (prioritization).

8. The Wisconsin Land Information Clearinghouse (WISCLINC)

(badger.state.wi.us/agencies/wlib/sco/pages) is a gateway to geospatial data and metadata, related land and reference information, and the Wisconsin agencies that produce or maintain these items. WISCLINC is a registered node in the web of NSDI clearinghouses.

Features that support usability:

- The collapsible Table of Contents is an effective way to indicate Web site layout (learnability).

Primary barriers to usability:

- The search was ineffective, since it linked to the FGDC custom search -- which wasn't working (effectiveness).
- Error messages were cryptic and did not provide sufficient detail for user to actually contact a responsible party. They were also displayed in such a way that the user could assume a search was still possible (error detection and recovery).

- There's no clear graphical distinction between the icon-button for selecting a WISCLINC versus an FGDC search (visual clarity; Figure 10).

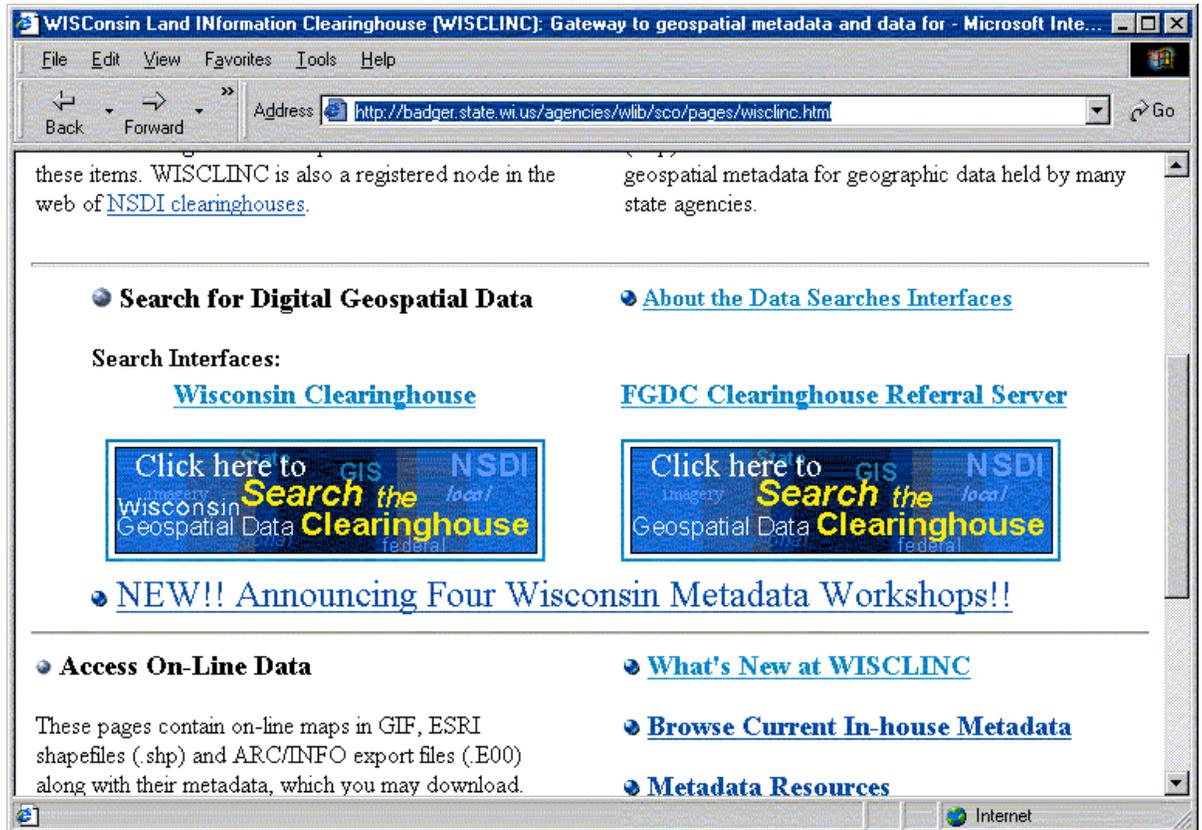


Figure 10: Example from WISCLINC, showing failure to distinguish visibly between local search and FGDC search.

9. The Olympic Coast Clearinghouse (OCC) is an online archive for Olympic Peninsula geospatial and biological information (cathedral.cfr.washington.edu/~chouse/).

Features that support usability:

- When browsing metadata by theme, folders open in the same manner as Microsoft Explorer (compatibility; Figure 11).

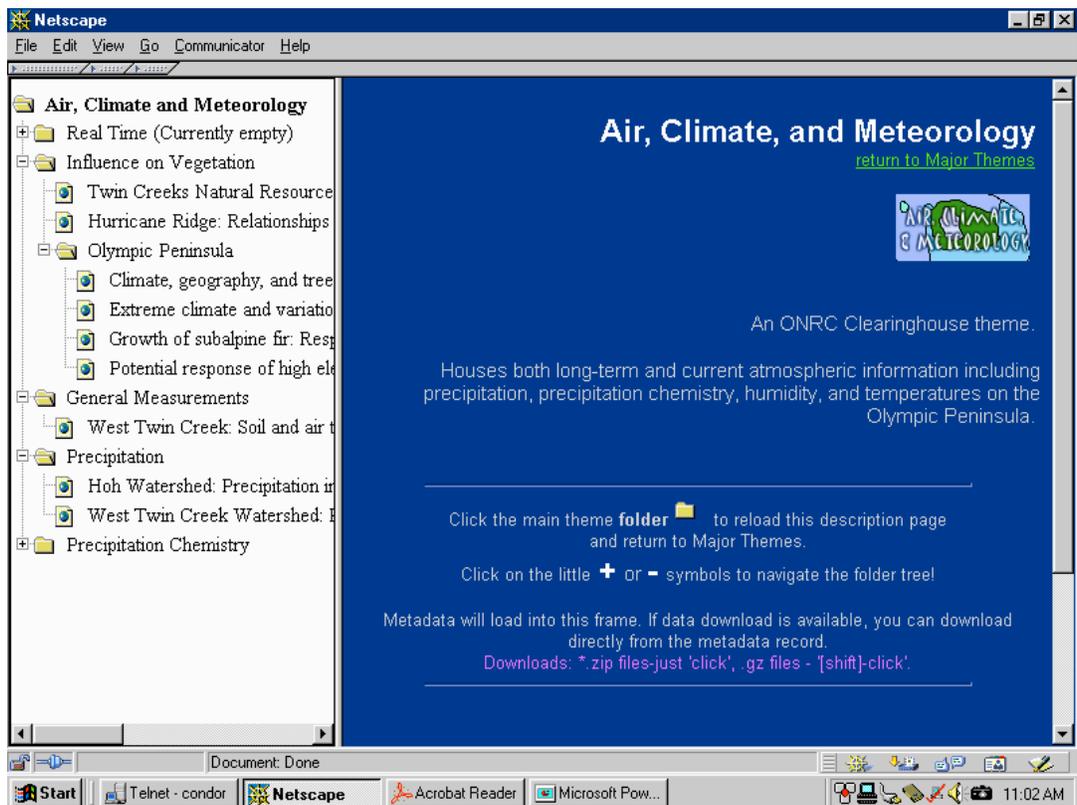


Figure 11: Interface showing use of familiar directory structure metaphor (from <http://cathedral.cfr.washington.edu/~chouse/>)

- It is clear that this is a metadata archive (explicitness).
- The availability of a metadata guide is helpful (visual clarity).

Primary barriers to usability

- Color contrast and font choices make this interface hard to read (legibility; Figure 12).

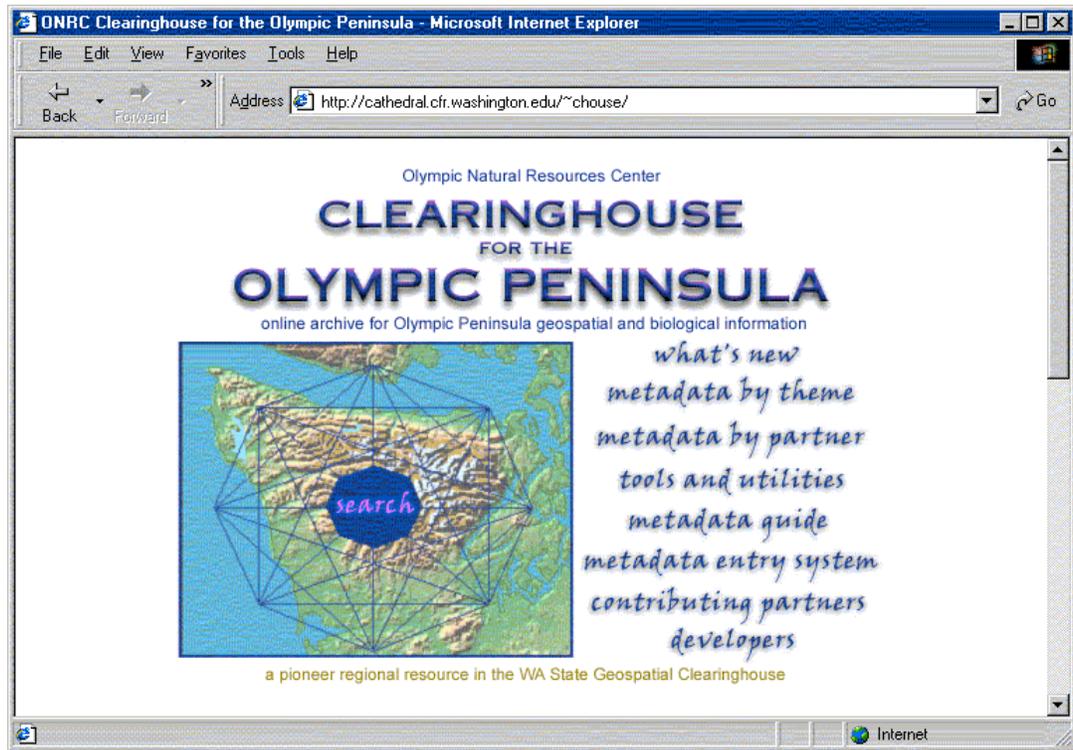


Figure 12

- There is distracting animation (visual clarity).

10. The Cook Inlet Information Management/Monitoring System(CIIMMS) is a for a comprehensive information retrieval system (146.63.13.150/ciimms). It hopes to enable a wide range of users to search, browse, and contribute valuable information about the Cook Inlet watershed and Cook Inlet related projects and activities.

Features that support usability:

- The search showed progress and elapsed time so the user was informed about the activity. This made waiting much easier and more understandable (feedback; Figure 13).

The screenshot shows a Netscape browser window titled "Netscape: CIIMMS Search Status". The browser's address bar shows the URL "http://146.63.13.150/servlet/CIIMMSWBT". Below the browser window, the CIIMMS logo is displayed, followed by the text "COOK INLET INFORMATION MANAGEMENT/MONITORING SYSTEM". A navigation menu includes buttons for HOME, BROWSE, SEARCH, CONTRIBUTE, and FEEDBACK. A red text message reads "Please stand by: Searching.....". Below this, the elapsed time is shown as "Elapsed Time: 0 Minutes and 33 Seconds." A table with three columns: Database, Status, and Result Count, lists the search results for various databases.

Database	Status	Result Count
CIIMMS Local Database	Search Successful	2
CIIMMS Project Database	Search Successful	2
WorldCat (Bibliographic Resources; Test Server)	Search Successful	0
ASGDC (Alaska State Geospatial Data Clearinghouse)	Search Successful	0
AGDC (Alaska Geospatial Data Clearinghouse)	Searching	0
CIIMMS Web Harvest	Search Successful	37

Figure 13: Example from CIIMMS, showing how elapsed time is reported to the user.

Primary barriers to usability:

- The results of a search may take the user to another organization's homepage. This can be very confusing and it is often not the desired outcome (compatibility, explicitness).

- Metadata is often very sparse, which makes it of very little use (effectiveness; Figure 14).

Viewing 1 out of 2 from  CIIMMS Local Database [Next Record](#)

Data Title: Bathymetry - Maj. Contours and Depth Range

Publication Date: 1990

Data Contact(s): Interrain Pacific

Lead Agency: Interrain Pacific

Related Website:

Dataset Description

Dates:

Status:

Access Constraints:

Use Constraints:

Keywords

Keywords

Theme Keyword: Bathymetry
Theme Keyword: Physical Factors
Theme Keyword: Oceanography
Theme Keyword: Bathymetry
Theme Keyword: Depth range
Theme Keyword: Contours

Data Collection

Data Type:

Dataset Metadata:

Figure 14: Example from CIIMMS, showing sparseness of metadata retrieved.

11. The Kansas Data Access and Support Center (DASC) provides a core database that is a collection of various digital spatial information useful for conducting spatial analyses (gisdasc.kgs.ukans.edu).

Features that support usability:

- The use of an expandable menu is a nice addition (prioritization).
- Within the metadata, there is a link to a "data snapshot" or graphical representation of the data (explicitness).
- It is clear whether metadata or data is being searched (visual clarity).
- "Data snapshots" allow the user to see a graphical representation of the data set (effectiveness; Figure 15).

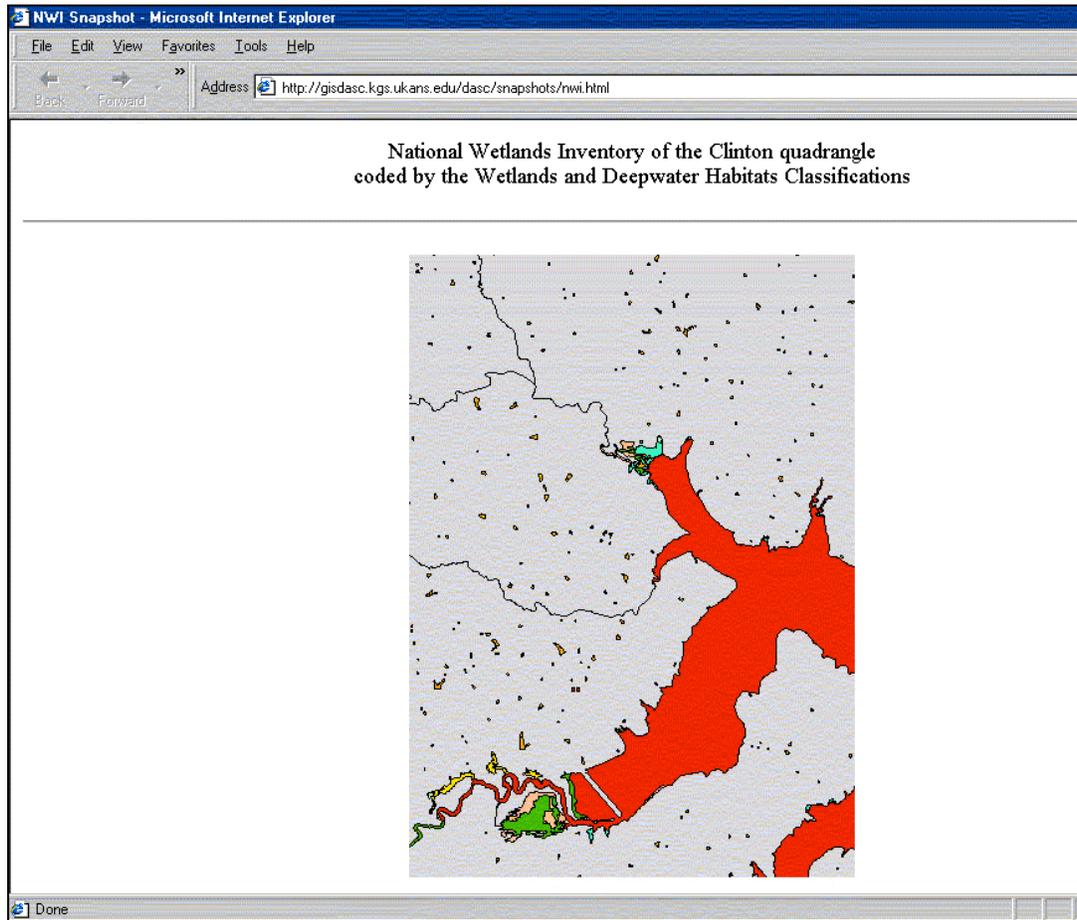


Figure 15: Example from DASC, showing availability of "data snapshot".

Primary barriers to usability:

- The screens do not do a good job of drawing the user's eyes to the most pertinent fields (e.g., the text field for entering search criteria was hard to find (visual clarity)).
- The user must "back out" several pages and reconnect in order to perform a second search (efficiency).

- The advanced search didn't yield any results (effectiveness).
- To perform a location-based search, the user must already know the geography of Kansas; a scrolled list of counties must be used (effectiveness).
- Wording of error messages is overly terse and confusing (error recovery; Figure 16).

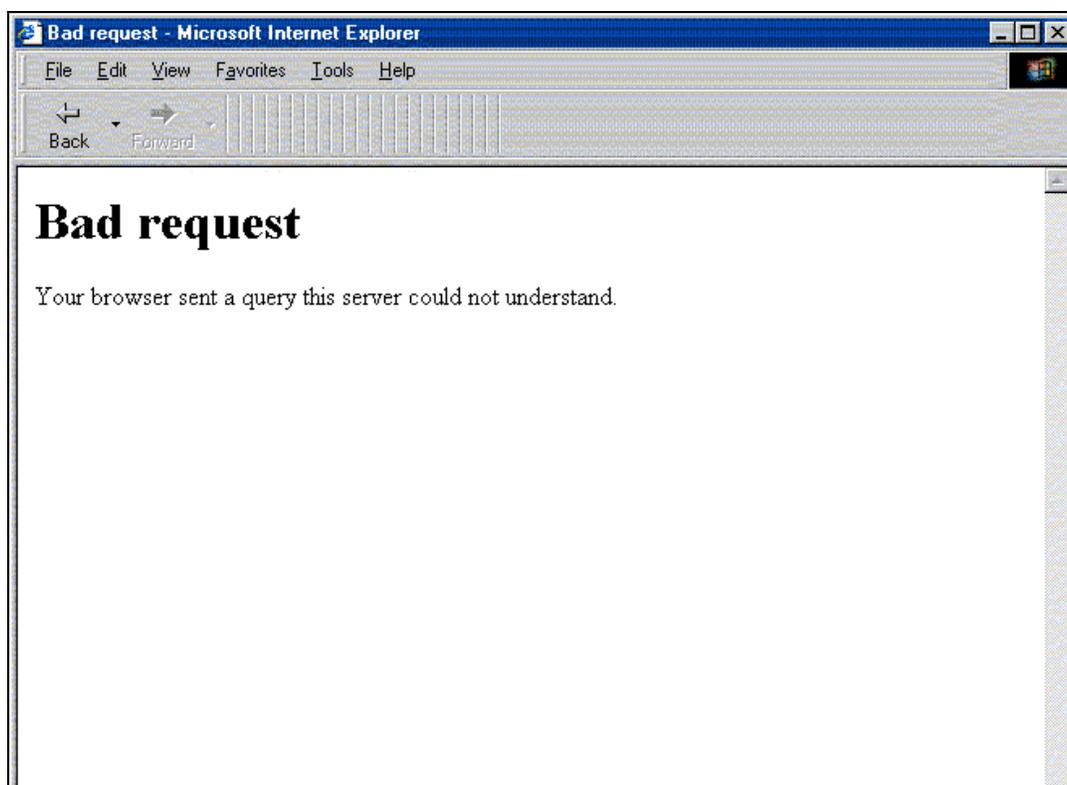


Figure 16: Example from DASC, showing poor quality of error messages.

General Trends

In general, visual clarity characteristics tended to be rated highest for the sites evaluated. That is, information was typically displayed in a manner that made it quick for the user to understand how to proceed. Many sites also were helpful in visually attracting the user's attention directly to the fields that were needed in order to get results.

The team found that efficiency was not a problem in most cases. The exception to this was in cases where there was little or no feedback indicating that work was being performed. Users tend to tolerate a waiting period better when they are being informed that progress is happening towards their desired goals. When no feedback is forthcoming, they lose confidence, often suspecting that the server has gone off-line, that the browser has stalled, etc. It should be noted that high-speed network connections were used in performing the tests; it is to be expected that many users would experience significantly slower access times. In cases where problems with efficiency were explicitly called out, there was trouble with the browser reaching its time-out limit before the server responded, even with a fast network connection.

Overall, the most consistent problem areas were feedback, error recovery, and error prevention, and to a somewhat lesser extent, prioritization. In the area of feedback, as noted above, when the user's actions are not acknowledged with a

reasonable response period, he/she becomes impatient or concerned. Therefore, proper feedback is critical for any operation, which is liable to require more than about 10-20 seconds to complete. Feedback, however, was neglected entirely at many of the sites evaluated.

Both error recovery and error prevention are important helping the user apply his/her time effectively. Failure to prevent errors – and to provide simple mechanisms for undoing the effects of errors – not only slows down the user's progress, but quickly becomes frustrating. For example, if the user can recover quickly from an improper choice of keywords (or if that error can be prevented entirely), he/she can readily move forward to accomplish the intended actions.

In the area of prioritization, it is critical that the most important functionality and associated information be available to the user in a straightforward manner, since users typically respond to what has been presented, rather than searching through a site to determine if other functions are available. Very few of the sites appear to recognize this concept and present the most commonly needed and most useful functions early in the screen traversal process. A significant number of the sites require that the user perform several actions in order to arrive at the screen that offers key functionality.

RESULTS OF USER EXPECTATIONS SURVEY

A sub-population analysis, which identifies sub-populations of respondents and seeks trends in those results, was performed. This portion of the analysis

grouped respondents into two subpopulations, based on whether or not they have visited the NGDC clearinghouse site. Due to the small number of responses, the analysis did not break out individuals who had visited other sites versus those with no experience.

Respondents unfamiliar with the NGDC site indicated that they would likely search on the basis of all three criteria (place, time, and keyword). Those familiar with the site, on the other hand, were more likely to search on the basis of just one criterion, typically keyword. This may reflect what kinds of searches they found effective in the past when using the site.

Across the board, users from both subpopulations indicated that they were more likely to search on the basis of a region at the county level or more specific, rather than a country, state, or other broad geographic area. The most common response, from both subpopulations, was that the target would be selected by rubber-banding an area on a map. Typing in a place name was the second choice; again, this was fairly consistent across subpopulations. It is interesting to note that specification via latitude/longitude was indicated as an important mechanism by every respondent in the second subpopulation, but that only a third of the NGDC-familiar users thought they would specify geographic targets in this way.

Persons unfamiliar with the NGDC site indicated that they would most likely be searching for data from a "recent" time period (i.e., from some past date up to the present time). Those experienced with the NGDC site indicated that the

ability to specify a particular time or to request data from recurring time periods would be equally important.

Respondents from both subpopulations agreed that complete metadata was not as important as the ability to see a list of data sites, ranked by the amount of data present, and a summary of key metadata fields. The list was ranked as most important by users familiar with the NGDC site, while unfamiliar users indicated summaries of metadata fields as their first choice. Members of both subpopulations thought it was more important to see summaries of metadata fields and ranked lists of data sets than complete sets of metadata. Thumbnail sketches of the data were ranked slightly higher by the NGDC-familiar users, perhaps because other users have not seen these and are uncertain of their purpose/value.

NGDC-familiar respondents were clear that they access the clearinghouse primarily when they need to locate new data sites, whereas users without NGDC experience thought they would visit it whenever they wanted new data. This may reflect the fact that NGDC clearinghouse searches are currently much slower than node-based searches – something that unfamiliar users would not know. The NGDC-familiar users added comments like “less and less often does it take me to the data I need” and “only when all my other sources fail.”

Users ranked the importance of efficiency, completeness, feedback (“informative messages that tell you what to try if something goes wrong”), performance (“speed of metadata retrieval”), and comprehensiveness (“how many GIS data sites are covered by the clearinghouse”).

Respondents familiar with the NGDC clearinghouse tended to rank comprehensiveness and search-specification efficiency as the most important, with metadata completeness and feedback as least important. The inexperienced users, on the other hand, often cited metadata completeness as tops, followed by search-specification efficiency, perhaps because they are not really aware of what NGDC metadata includes.

RESULTS OF USER TESTING

User Preferences

Given the critical nature of some of the comments, and the fact that the sites may have altered considerably since our tests were performed, they are referred to here as “Site A,” “Site B,” etc. (The assignment of the letters reflects the order in which comments are made here, and should not be interpreted as corresponding to the list ordering in the last section.) In fact, the nature of the criticisms are more revealing about usability barriers than the specific sites which occasioned the comments.

Site A was the resounding favorite. This site was always preferred over the other, in each head-on comparison where it was included. It received high marks for both usability and metadata readability. Subjects' searches were almost always successful and search results were found to be richer in content than the other sites.

In contrast, Site B did very poorly in the overall rankings. Only once was it preferred over any other site; in that case, it was preferred over Site C because it was considered faster and easier to use. The poor overall rating was associated with complaints about the site not working properly, the site being down, and searches not working. For those few searches that did work, subjects thought the Site B metadata was readable.

Site D was another poorly rated site. Again, it was preferred over another site on only one occasion, when it was being compared with Site E. A major factor was probably the fact that only one subject considered himself completely successful with a search. A couple of other subjects complained about the incomprehensibility of the metadata.

Both Site C and Site E received mixed ratings. They were preferred only approximately half of the time. The two sites got mixed reviews on site usability and metadata readability.

Findings: Subjects' Rationale

Subject responses were further analyzed to establish what general patterns determined why a particular site would be chosen over another. In the majority of the tests (approximately 70%), users preferred a site because they found it easier to use. In particular, they seemed pleased if it was easy to select the location they

were interested in. Other reasons why a site was preferred were better (typically shorter) procedures for selection, and better (more complete) search results.

In general, subjects found few differences in the readability of metadata from different sites. In one instance, metadata returned by Site E was found to be too obscure to be useful. Overall, search speeds appear not to be an issue, at least in the sense that one site is significantly better or worse than the others.

It should be noted that both the place-name and map searches only worked approximately half the time. This fact definitely influenced what subjects thought about the sites, and is consistent with what was observed in other types of usability tests. In particular, the place and map searches typically failed on Site C; on the rare occasion when searches did yield results, the user had good things to say about it. In two tests, Site B was down and could not be evaluated.

Relevant Comments

Subjects provided specific comments relating to the readability of metadata, the general usability of the site, and site performance. Representative examples are provided in Table 1 below. Where the comment is limited to a particular site, its pseudonym is indicated for purposes of comparison.

Table 1. Comments relating to the readability of metadata, the general usability of the site, and site performance

<i>Factor</i>	<i>Typical Comments (and site)</i>
Metadata readability	<ul style="list-style-type: none"> • Perfectly readable, FGDC format • I could not find what each column and row meant at the very beginning (Site D) • It gave me keywords description and abstract of the database - easy to understand (Site B) • For someone not used to looking at large RS data sets, it's a bit of an information overload. But it seems well organized, and I felt even as a novice I was able to get a pretty good sense of what data were available (Site A)
Site usability	<ul style="list-style-type: none"> • Other than the “Draw on a map” function mentioned above, the site was easy to learn and use. The buttons were clearly and accurately labeled (Site A) • The “Attributes Search” screen is difficult to use. Before it would display a database it required me to make a selection in six different parameter areas. If I choose parameters which no database contained, the search resulted in no databases being found. But choices which were not available were listed for each parameter. As a result I had to guess which parameters to choose. Eventually I entered a combination which resulted in a project being selected (Site D) • It takes time to understand the query options. Geographical/spatial search options are limited, and there is no visual display options such as maps, etc. Although otherwise stated, it is not possible to choose 2 servers at a time, unless the servers are close to each other in the list of servers (the ”control” key does not work when the scroll bars have to be used). After a given search some query options go back to default, so the whole query has to be reviewed to make sure all the options are the desired ones (Site C) • This site was fairly easy to learn to use. The map query tool was a bit cumbersome to use in that it took a lot of clicks to zoom in sufficiently to identify a metropolitan area (the SF Bay Area in my case). Also, the map did not show cities or any other geographic features other than land vs. water and state boundaries, which limits its usefulness as an interactive tool. (How do you know where you are?) My

	sense was that the databases searched by this site are geared toward global databases for large-scale applications, for which additional detail in the mapping tool is perhaps unnecessary (Site E)
Site performance	<ul style="list-style-type: none"> • Search speed is satisfactory • Somewhat slow, but not terrible • If request is for more than 10 servers, it can be more than 5 min. which is very frustrating (Site C) • The site had great speed even with eight sources of data. I have a cable modem and the results were back within ten seconds (Site E)

CONCLUSIONS AND RECOMENDATIONS [combine this section with the other CONCLUSION section below, into one section . Otherwise, way too confusing for the reader]

NGDC INTERFACES

This section summarizes the recommendations for the NGDC interfaces, based on the approaches, features, and barriers identified during the usability evaluations. The evaluation team met as a group to discuss not just the ratings, but also their recommendations for which existing interfaces offered the best foundation for the NGDC. By consensus, the following sites were identified as the “top contenders”. (Note that the sites may have been altered since the studies were carried out.)

- CEONet (<http://ceonet.ccrs.nrcan.gc.ca/cs/en/index.html>): The prime discovery and access component of Canada's national spatial data infrastructure initiative.
- SEDAC (<http://sedac.ciesin.org>): The Socioeconomic Data and Applications Center is one of the Distributed Active Archive Centers in NASA's Earth Observing System Data and Information System (EOSDIS).
- MEL (http://mel.dmsomil.com/mel-bin/java_query): The Master Environmental Library is a one-stop site for ordering environmental information sponsored by the Defense Modeling and Simulation Office.
- ASDD (http://www.auslig.gov.au/servlet/asdd_power): The Australian Spatial Data Directory is the component of the Australian Spatial Data Infrastructure that provides search interfaces to geospatial data set descriptions (metadata).
- DAACGD (<http://www-eosdis.ornl.gov>): The Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center for Biogeochemical Dynamics is operated by the ORNL Environmental Sciences Division.

Number and Type of Interfaces Needed

Given that different levels of user expertise require distinct subsets of the usability criteria, it is recommended that there be at least two interfaces available for the NGDC, addressing different target audiences: (1) users unfamiliar with GIS and spatially-based searches; and (2) users already comfortable with searches based on location and geographically-related keywords

It will be necessary to add additional interfaces to reflect users' familiarity with clearinghouses. In fact, it will be important to draw clear distinctions between data and metadata for all levels of users, in order to avoid unpleasant surprises. Similarly, the availability of higher-level summary metadata will be key for all users, even those familiar with the FGDC standard. Therefore separate interfaces based on users' familiarity with the standard is not recommended.

Key Characteristics for NGDC Interfaces

While the relative priorities of features or user support vary from one user class to another, there are certain criteria will be essential for all interfaces and all users. Explicitness, effectiveness, and feedback fall into this category. Assuming that there are two interfaces, as outlined above, it is further noted that non-geospatial users will also require particular support for “learnability”, error

prevention, and prioritization of functionality. The interface for more advanced users should focus instead on efficiency and error recovery as secondary goals.

[Rather than just taking these three at the end, how about putting these sections before the "Conclusions" above, adding an introductory paragraph about why you are including them (i.e., these weren't part of the original MHS study but have been developed since then and are useful to look at with regard to usability and perhaps future improvements to the NGDC. Otherwise, they are just hanging out there by themselves. And in their present position in the paper it also looks to the reader as though these sections are part of your conclusions on the NGDC.

VIRTUAL OREGON

Virtual Oregon is a new data coordination center at Oregon State University. It is being developed as a central place for students, researchers, and resource managers to find data on Oregon natural resources. Virtual Oregon's major strength is that it has a multi-level interface approach, which is favorable as compared to other clearinghouses. The prototype interface is comprised of both lexical and graphical searches.

On one level, the user may use an interactive mapping tool to select data sets from region of interest. The map-based search has features that support usability. For example it is clear that the result of a query will be actual data. The map-based search also has good feedback with a "retrieving data" message

indicating that a search will take time. The primary barrier to usability is in the area of “learnability”. The map-based search interface would benefit from tutorial or explanatory materials that offer quick access to user help (Figure ??).

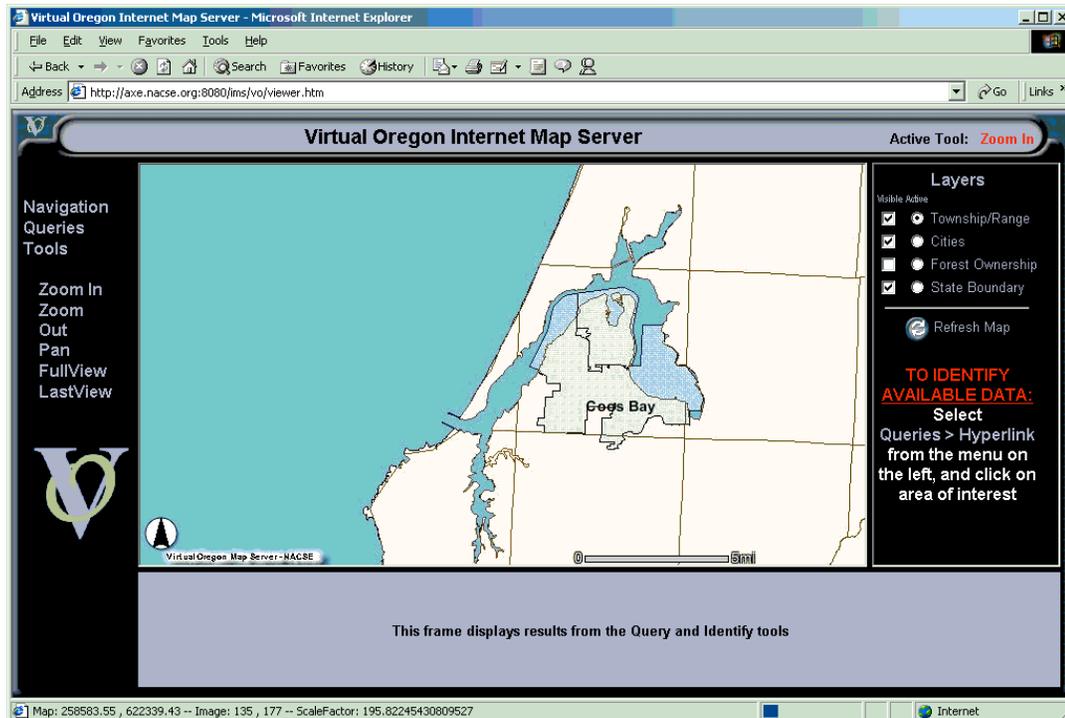


Figure # and caption??

On another level, the user may also search data sets (spatial and non-spatial) and metadata using a text interface. The text based search has features that support usability. It is clear that the result of a query will be metadata and actual data. Having the user select from a list, rather than typing a word into a field, eliminates typing errors or inappropriate word choices. The text search interface would benefit from the availability of tutorial or explanatory materials, although the interface does help a novice user learn about its features and usage through selection via lists

(Figure

??).

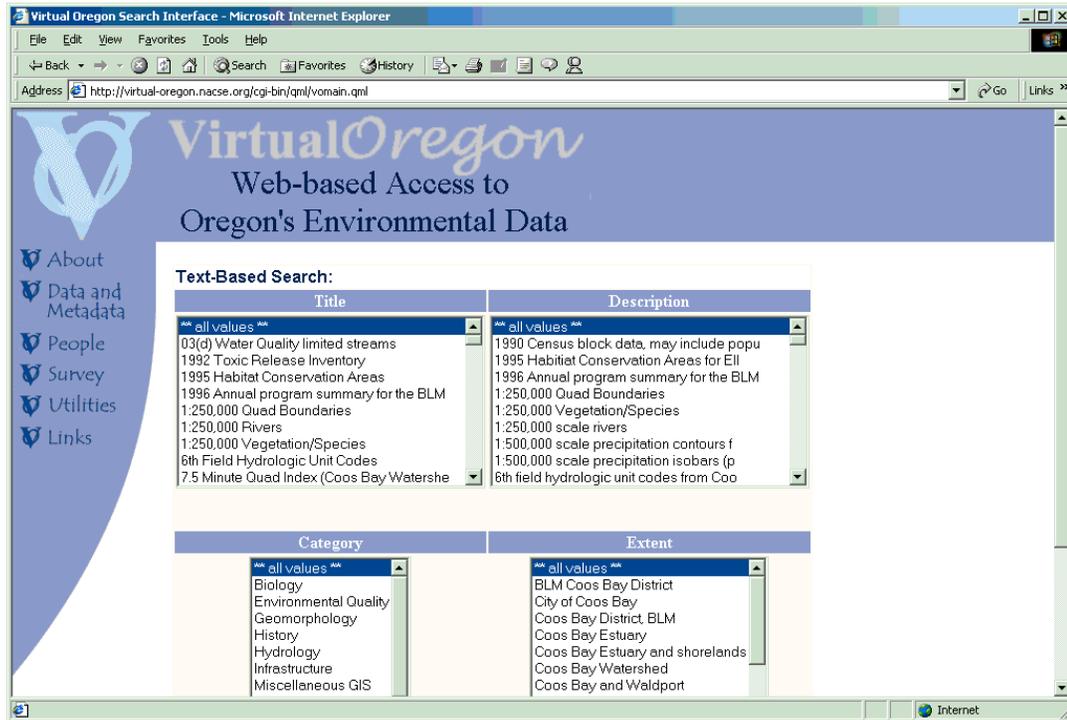


Figure ## and caption??

OREGON COAST GEOSPATIAL CLEARINGHOUSE

The Oregon Coast Geospatial Clearinghouse (OCGC) is a web-based central repository for metadata corresponding to collected data for the Oregon coastal zone, and will soon be the metadata component of the new Oregon Coastal Atlas (www.coastalatlus.net), a web portal in development by the State of Oregon Ocean-Coastal Management Program, Oregon State University, and Ecotrust.

Although the OCGC is now available from the NGDC as a component of the NSDI, the user may also search for the metadata through one of the lists at the OCGC. What is particularly nice about searching for metadata on the OCGC is that it is very obvious what is there and you are given the option to look at a brief abstract as opposed to FGDC compliant metadata, which might be overwhelming for the novice user. Other features that support usability include the site's efficiency. Few operations, requiring not much typing or pointing, are needed to find the desirable metadata.

The screenshot shows a web browser window titled "DEMIS--Dynamic Estuary Management Information System--Coos Bay - Microsoft Internet Explorer". The address bar shows "http://buccaneer.geo.orst.edu/data/demis_data.html". The main content area has a purple header "Data & Metadata" and a sidebar with navigation links. The main content area contains the following text:

The Metadata below are from the
 Dynamic Estuary Management Information System (DEMIS) - Coos Bay Region
 Online linkages to actual data sets contained in metadata records

Metadata from DEMIS include:
[Biological Resources](#)
[Environmental Quality](#)
[Geography](#)
[Hydrology](#)
[Landform](#)
[Landuse and Planning](#)

Actual data sets are available on the [DEMIS Coos Bay CD-ROM](#)

DATA SET	DATA LAYER	METADATA	ABSTRACT
Biological Resources	habsep	FGDC	Brief
	sghabep	FGDC	Brief
	standes	FGDC	Brief
	veg96esf	FGDC	Brief
Environmental Quality	dmdep	FGDC	Brief
	hca95esf	FGDC	Brief
	mitep	FGDC	Brief
	sprmitep	FGDC	Brief
Geography	baseep	FGDC	Brief
	baseep	FGDC	Brief

Figure # and caption?

GEOGRAPHY NETWORK

The Geography Network is a global network of geographic information users and providers maintained by ESRI. The Geography Network has a multi-level interface approach, which is favorable as compared to other clearinghouses. The first level appears to have been designed for the novice user with a simple search on area of interest or keyword available. Although the user cannot select a keyword via lists, but must know what suitable values are *a priori*. This is a barrier to usability. For example if a user enters “marine pollution” as a keyword and he/she will receive no matches, even though there are pollution maps for the ocean in the geography network.

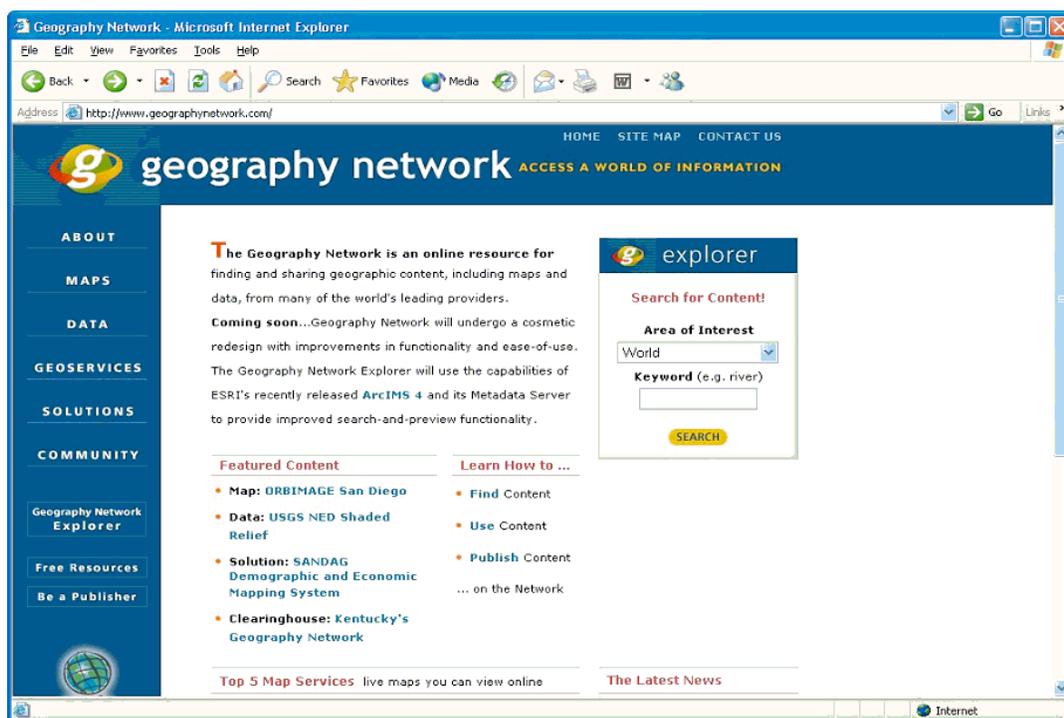


Figure # and caption??

The second level seems aimed towards specialists in geospatial data, although the map search does not show the extent that a user selects or display the boundary coordinates. This second level might be overwhelming if you are not a specialist in geospatial data. A marine resource manager, educator, or student might not know what a map service is, or whether or not they will be obtaining actual data, metadata, or something else. This multilevel approach is helpful but it would be better to have an intermediate level aimed at a user who is neither a novice nor an expert.

The screenshot shows the 'geography network explorer' web application. The interface is divided into two main sections: 'FIND CONTENT' and 'VIEW CONTENT'.

FIND CONTENT Section:

- DEFINE SEARCH AREA:** Includes a search input field with 'World' entered, a 'GO!' button, and a map showing the search area.
- DEFINE SEARCH CRITERIA:** A dropdown menu for 'Type of Content' with options:
 - All Geographic Content
 - All Geographic Content
 - Geographic Services (all)
 - Map Services
 - Data Services
 - GIS Web Services
 - Solutions
 - Geographic Files (all)

VIEW CONTENT Section:

- Search Results:** Records Found: 29
- Summary of Content Found by Search:**

Type of Content	Records
Map Services - Image (ArcIMS)	7
Map Services - Image (WMS)	1
Map Image Files	2
Solutions	5
GIS Web Services	1
Map Data Files	4
Clearinghouses	9
- Map Services - Image (ArcIMS):** back to top
- Publisher:** Arendal kommune
- Content Title:** adressman of Arendal

Figure # and caption

Recently the Geography Network has been undergone redesign with improvements in usability. Now the map search gives the user more feedback and the search criteria makes it clear on whether or not you will receive data or metadata.

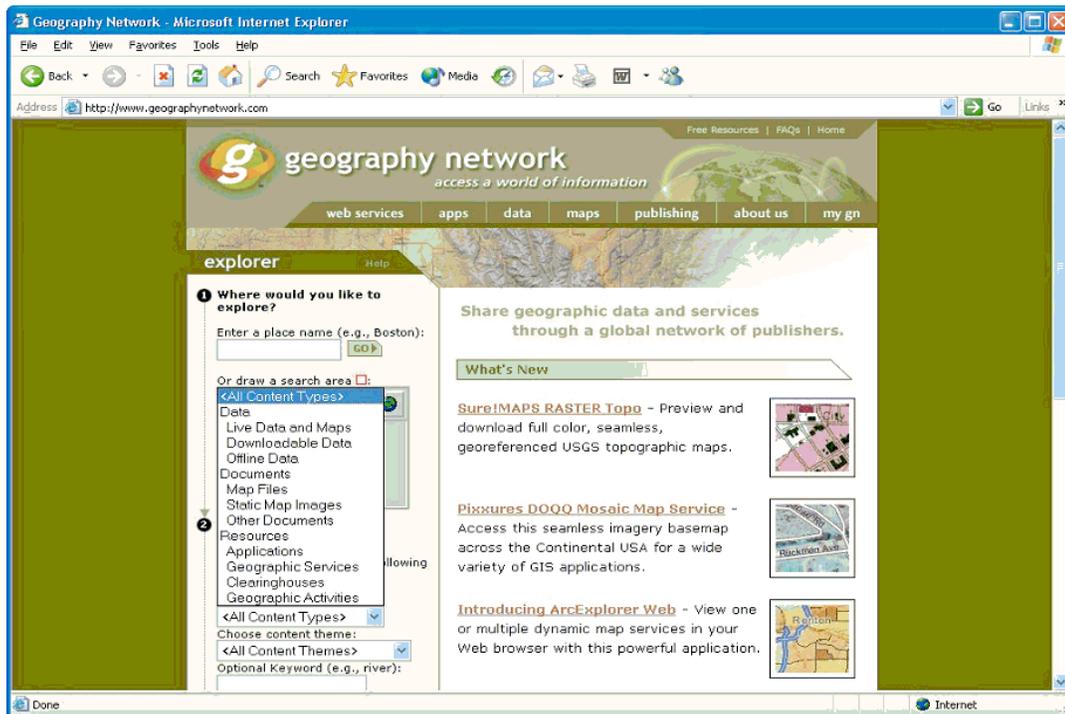


Figure # and caption?

CONCLUSION [fold this section into your other "conclusions and recommendations" section above to make a single section at the end of your paper.

Knowing more about the characteristics influencing the usability of digital spatial metadata and search interfaces is a critical first step in developing interfaces

that improve the accessibility and usefulness of Web-based clearinghouses for marine resource managers. As observed in the findings of this project, lack of usability diminishes the quantity and quality of both metadata and searches for metadata. Usability assessment identifies where these barriers occur and how they might be resolved. The usability attributes that were identified as most important to target user constituencies can be exploited to develop more “humane” interfaces that truly will assist marine resource managers in exploring the availability of digital spatial data.

REFERENCES CITED

- Berry, J. K. 1995. *Spatial Reasoning for Effective GIS*. Fort Collins: GIS World Books.
- Cole, K. B., D. B. Carter, C. Schonder, M. Finkbeiner, and R. E. Seaman. 2002. Finding the green under the sea: The Rehoboth Bay *Ulva* identification project. In *Undersea with GIS*, ed. D. J. Wright. Redlands: ESRI Press, page numbers?.
- Downs, R. and D. Stea, D. 1997. *Maps in Minds: Reflections on Cognitive Mapping*. New York: Harper and Row.
- Egenhofer, M.J. 1988. Designing a user interface for a spatial information system. *GIS/LIS '88 Proceedings Accessing the World* 2:149-161.
- EOP (expand out this acronym). 1994. Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure. Executive Order 12906. *Federal Register* 59:17671-17674.
- Fraser, B. and M. Gluck. 1999. Usability of geospatial metadata or space-time matters. *Bulletin of the American Society of Information Science* 25.
- Flewelling, D.M. and M.J. Egenhofer. 1999. Using digital spatial archives effectively. *Int. J. Geographical Information Science* 13:1-8.
- Jordan, P.W. 1998. *An Introduction to Usability*. Bristol, PA: Taylor & Francis Ltd.
- Killpack, D., A. Hulin, C. Fowler, and M. Treml. 2002. Protected Areas GIS: Bringing GIS to the desktops of the National Estuarine Research Reserves and National Marine Sanctuaries. In *Undersea with GIS*, ed. D. J. Wright. Redlands: ESRI Press, page #s?.
- Kuipers, B. 1978. Modeling spatial knowledge. *Cognitive Science* 2:129-153
- Mark, D. 1992. Spatial metaphors for human-computer interaction. *Fifth International Symposium on Spatial Data Handling* 1:104-112.
- Montello, D. 1993. Scale and multiple psychologies of space. In *Spatial Information Theory: A Theoretical Basis for GIS*, eds. A. Frank, and I. Campari. Lecture Notes in Computer Science.

Moran, T.P. 1981. An applied psychology of the user. *ACM Computing Surveys* 13:1-12.

Nielsen, J. 1993. *Usability Engineering*. San Francisco: Morgan Kaufmann.

Pittman, S.K., F.J. Hanes, M. Newsome and C.M. Pancake. 1998. Multiple database personalities: Facilitating access to research data. In *Proc. 4th Intl. Conf. On Inf. Systems, Analysis and Synthesis*: 200-207.

Treml, E., H. Smillie, K. Cohen, C. Fowler, and R. Neely. 2002. Spatial policy: Georeferencing the legal and statutory framework for integrated regional ocean management. In *Undersea with GIS*, ed. D J. Wright. Redlands: ESRI Press, page #s??.

Wang, F. 1994. Towards a natural language user interface: An approach of fuzzy query. *Int. J. Geographical Information Systems* 8:143-162.

Wright, D., G. Duvall, and B. Ward. 2000. Metadata matters: A national geospatial clearinghouse for the Oregon Coast. In *Proceedings of The Coastal Society 17th International Conference*, Portland, Oregon. <http://dusk.geo.orst.edu/tcs/>