# LTER Information Managers 1996 Annual Meeting Report

## i. Table of Contents

# 1.0. Executive Summary and Action Items (S. Stafford (AND), B. Benson (NTL), D. Henshaw (AND), D. Bolgrien (NTL))

(Action items are italicized with relevant report section noted)

The 1996 LTER Information Managers meeting was held at the Archbold Biological Field Station, Lake Placid, Florida, October 31 - November 3, 1996. Representatives from 16 of the 18 sites were accompanied by Jim Gosz (Chair of the LTER Coordinating Committee), Matt Jones (National Center for Ecological Analysis and Synthesis (NCEAS)), Caroline Bledsoe (research liaison with the Network Office) and Dick Olson (Oak Ridge National Laboratory). McMurdo's new Information Manager, Ken McGwire, was welcomed. Konza Prairie and Hubbard Brook were not represented. Cindy Veen, Hubbard Brook's Information Manager since 1988, died of cancer in January, 1996, and was missed.

The main topic of the meeting was the further development of the LTER Network Information System (NIS) (see **http://lternet.edu/is**). The NIS will facilitate network-scale data retrieval for synthetic research while preserving site-specific data management autonomy. Intersite research groups, such as MODLERS, are already taking advantage of the NIS effort. Jim Gosz stressed that the NIS was an opportunity for LTER to take a leadership role in demonstrating that ecological data can be made available in efficient ways with a net benefit to ourselves and the community.

- *Pursue opportunities at NCEAS for workshops and working groups on elements related to the LTER NIS development. (4.9)*

The bottom-up origin of the NIS, as a distributed rather than centralized system, acknowledges that a single uniform data structure would poorly serve all the sites. It was proposed that the NIS would periodically "harvest" data from sites using site-specific filters. Such harvests might be made to fulfill individual data requests or to maintain Network-scale data sets. Constructing filters is considerable easier than reformatting the data structures of each site. Few LTER data sets have sufficient uniformity to impose network-wide data format standards. Dick Olson offered insights about large distributed information

systems based on his experience with the NASA

Distributed Active Archive Center (DAAC) at Oak Ridge. Prototyping a few key LTER data sets will help refine of the NIS data model. Currently, NIS strategies are being tested on the all-site data catalog, climate data, bibliography (Chinn and Bledsoe 1997), and the X-Roots project.

- *Advance the development and prototyping of an NIS for the LTER scientific research community focusing on a distributed system as compared to the more common centralized archive approach. (2.1)*
- *To accomplish these tasks i.e. refining the data model, prototyping one or more central database storage and search systems, and developing two automated methods for adding catalog entries (one a Web-based and the other a batch-based appraoch), participants will conduct monthly virtual meetings, using the WWW for preparation, with email notification of where to phone, and with a report subsequent to each meeting. Meetings are planned for the second Tuesday of each month at noon eastern time. (3.2.1)*
- *Other activities for the group, or part of the group, may include a visit to ORNL/GCMD to compare their efforts in detail, and a meeting at SEV in March or April. (3.2.1)*
- *Network Office staff will migrate the set of bibliographic text files from each site files into an SQL database (SQL Server) at the Network Office. (3.2.2)*
- *The existing standard formats for exchange of bibliographic data (such as USMARC developed by the Library of Congress; http://lcweb.loc.gov/marc/) will be explored and a proposed plan for maintaining (i.e. updating) the bibliographic database as a "centributed" database will be developed. (3.2.2)*
- *In conjunction with the LTER NIS development, the LTER IM climate data working group will develop a prototype for harvesting climate data from a subgroup of LTER sites to a centralized location. Participating sites will provide a URL for one weather station's daily climate data and will provide required metadata elements. Metadata content requirements will be coordinated with the LTER Climate Committee. (3.2.3)*
- *Plan a climate data workshop including the LTER IM climate data working group, Climate Committee representatives, and climate data users including XROOTS representatives. (3.2.3)*
- *Develop metadata guidelines that would produce a more "publication-like" document which would be peer-reviewed. (3.3.2)*

The implementation of the NIS is especially pressing in light of the recent notice by NFS that

all LTER data be made publicly available in two years. This brief statement from Scot Collins in a letter to the Fall CC meeting was greeted with mixed feelings by the data managers. Every site is actively making data available via the World Wide Web and Internet, but bottlenecks in the migration of data from collection to the Web make a mandated two year turn-around challenging. The Data Managers are formulating recommendations to NSF to help in the transition.

- *Evaluate and make recommendations to NSF on the "2-year data availability concept". Prepare guidelines for NSF to help interpret and implement the "two year rule". Provide suggestions as to the types of data (meteorological data, etc.) that can be made available and provide suitable timelines (after collection, after QA/QC, etc.) for data accessibility. (2.2)*
- *Clarify when the two-year period starts (after the closeout of the award?, what about annual awards?, what about continuing data sets such as core climate and population monitoring studies?). Brian Kloeppel will clarify this with Scott Collins. (4.1)*
- *A working definition of "minimum of restrictions" was not clear due to widely varying data access restrictions at each site. Brian Kloeppel will clarify this with Scott Collins. (4.1)*
- *Clarify when we need to start enforcing this long-standing NSF policy (4.1)*

The diversity, or rather disparity, of data management resources among the sites was also discussed. Jim Gosz argued that current data management resources were barely adequate to manage current data volumes in the fashion expected by NSF. He encouraged data managers to be pro-active in making data management an integral part of the research process. LTER Data Managers are challenged to facilitate the information flow as research themes broaden and budgets remain flat or decline. It is clear that resources are inadequate to manage the expected data volumes of the near future, especially with an increased emphasis on synthetic, cross-site data analyses. It was agreed that the data management capabilities of each site must be surveyed and the collective information management requirements of LTER be presented to the CC and eventually to NSF.

- *Develop proposal to the NCEAS for a working group on these topics, ie., Oracle, NT-SQL, Minimum Standard IM for LTER NIS (C. Wasser, K. Baker, E. Melendez, B. Benson, and S. Stafford). (3.4.3)*
- *Plan a site visit to ORNL to specifically view the NASA DAAC system. (4.5)*
- *Create a survey form to capture the depth of WWW competence across sites. (4.7)*

Outreach to a variety of data management communities was discussed as many LTER data managers prepared for presentations at Eco-Informa '96 Symposium. Opportunities to continue communications with Archbold were discussed. The upcoming Ecological Society of America (ESA) Meeting in August 1997 provides an opportunity for LTER data managers to participate along with members of Biological Field Stations in a proposed two-day Data Management Workshop prior to the ESA meeting.

- *Have PIs at future Information Managers meetings. (4.7)*
- *For future meetings consider meeting at individual sites in lieu of in conjunction with other professional and/or society meetings, having more PI participation, as well as more NSF participation. (5.0)*

Elections were held for new members of the Data Managers' Steering Committee. John Porter (VCR) was elected to a second 3 year term, and Chris Wasser (SGS) was elected for his first 3 year term. Susan Stafford (AND), chair of the committee, thanked Barbara Benson (NTL) for Barbara's dedicated service to the committee. The Archbold Biological Station served as an excellent setting for the meeting. The enthusiasm of its director, Dr. Hilary Swain, and staff was infectious, genuine, and greatly appreciated.

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Table of Contents

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# 2. 0 Introduction and Participants (S. Stafford (AND))

The 1996 LTER Information Managers meeting was held at the Archbold Biological Field Station, Lake Placid, Florida, October 31 - November 3, 1996. Representatives from 16 of the 18 LTER sites were in attendance (App. A ). Site flashes were shared (App. B). Konza Prairie (KNZ) and Hubbard Brook (HBR) were not represented. In addition to individual sites representatives, Jim Gosz, Chair of the LTER Coordinating Committee; Matt Jones, Database and Information Specialist, National Center for Ecological Analysis and Synthesis (NCEAS); Dick Olson, Oak Ridge National Laboratory (ORNL); and Caroline Bledsoe, research liaison with the Network Office fully participated with the LTER IMs to pursue ways of furthering our research collaboration in the future. Jim's Network perspective was insightful and Matt and Dick's participation was most helpful in seeing new opportunities for joint projects and collaboration as we plan for the future. Caroline's work with the All Site Bibliography (Chinn and Bledsoe 1997) and Xroots provided specific examples of the more generic challenges we collectively face creating a Network Information System (NIS). Scientists from Archbold Biological Field Station joined in discussions intermittently throughout the meeting.

2.1. Charge to the Group (S. Stafford (AND))

The 1996 LTER Information Managers Meeting focused on the further development of an LTER Network Information System (NIS). Significant progress on the NIS is critical for the longevity of the LTER Network. Thus, we changed the format of this meeting from previous meetings to help facilitate achieving this goal. We opened with plenary sessions prior to group discussions on major components of the LTER NIS. Break-out groups focused on similar topics to allow "more voices" to be brought into the discussion and thereby add detail and clarification to gain group consensus.

The theme of our meeting was "Putting on Our Bifocals". There are both short-term and long-term issues concerning the development and implementation of an LTER NIS which will affect our "vision". We need to have some usable, short-term accomplishments along with some sustained, long-range planning efforts.

We focused on what we need to be doing and what functionally we need to provide, rather than becoming distracted by resource needs. Potential resources include NCEAS, NSF, San Diego Supercomputer Center (SDSC), and probably other outlets we have yet to discover. In each case, we will need to be creative and innovative in our requests.

*Action Item: Advance the development and prototyping of an LTER NIS for the LTER scientific research community focusing on a distributed system as compared to the more common centralized archive approach.*

2.2 A Call to Action: The Network Perspective (J. Gosz (NET))

One of the significant new developments at NSF with implications for the LTER Network is the two-year data policy statement from Scott Collins. The paragraph that was emailed to Jim Gosz says: "On the issue of data policy, we want all data supported on LTER funding to be available with a minimum of restrictions in two years. This is especially true for the long-term research that

takes place with core LTER funding. Even data that are collected mostly with other NSF money should be available in two years. We are going to urge the ecological community to follow the example of LTER. We can not simply single out the Network for data accessibility. I (Collins) will be raising this issue with panels this week and next, and yet again with Brady (Tom) and Roskoski (Joanne). In the case of short term grants, I would like all data from those grants to be available two years after the close-out of the award. We need encouragement of this policy from the LTER scientists, the National Center for Ecological Analysis and Synthesis, and the Ecological Society of America…."

This policy has many implications that are not spelled out in the NSF memo. LTER awards are 6-year awards and Jim doubts we can get away with not making data available until 2 years after the end of a 6-year award period for a site. We have the opportunity to take a leadership role in the ecological community by demonstrating that site data can be made available to the scientific community in efficient ways with a net benefit to ourselves and the community. Jim also thinks this effort can demonstrate that the community has an ethic of sharing data and the fears about stealing data, etc., are not well founded. The likely result is that more analysis, publication and synthesis will be performed - resulting in better science!

Our challenge is to make the Network Information System work as well as encourage and help the sites with their individual efforts at making their data available. Jim thinks NSF would respond well to our suggestions for the types of data that can be made available at various times (after collection, QA/QC). For example, climate data may be available rapidly, and results from experiments some period (2 years?) after completion. Our recommendations have the possibility of being adopted by the broader scientific community as well. "The devil is in the details!" The recommendation of NSF is general and as we work through this, we will find many situations at variance with a simple statement of "make available in 2 years". We are in the best position to evaluate and make recommendations; and the data managers are the likely people to facilitate this effort.

*Action Item: Evaluate and make recommendations to NSF on the "2-year data availability concept". Prepare guidelines for NSF to help interpret and implement the "two year rule". Provide suggestions as to the types of data (meteorological data, etc.) that can be made available and provide suitable timelines (after collection, after QA/QC, etc.) for data accessibility.*

That also means that the data managers at each site need to be in the decision making process. Jim says, "You need to be at the table! - and working closely with PI's (or become PI's) because the allocation of resources between obtaining data and data management needs will become increasingly difficult."

This data management committee has the respect of the LTER community and NSF. Jim's constructive criticisms for the group were:

1. "You have now been placed in the position of urgency! We need to make rapid progress on a more uniform approach to information management across all sites. The allocation of effort/resources to information management is variable across sites, usually insufficient. This leadership role will require more effort in data management at the site and increased emphasis on the Network Information System.
2. Your group works well together as a result of good people, most of whom have worked together for a long time. You are comfortable with each other and very polite, perhaps too polite from the point of allowing everyone to have his or her way. We are now in a situation where some majority rule is necessary meaning that some may have to conform to the position that will be in the best interest of the Network and scientific community. There were good signs of this happening at this meeting. I suggest we make it happen faster.
3. There is still a fair amount of turnover at these meetings and also among the data managers at sites. Improving the commitment by sites to data management should reduce the turnover (more resources, more time allocated). A more consistent representation at the data management meetings will help you make progress faster.
4. Be Bold!!! We are in a cutting edge situation!! We are unique in the ecological information management world in that we are building a Network Information System from the "bottom up" rather than the "top down" approach of a centralized database (e.g., NCDC). This is an approach that has great benefit because of the diverse situation among the biological field stations, individual research programs of investigators or research teams. Recommendations on how the diversity of approaches can be maintained yet have data available and integrated into a Network Information System would be tremendously valuable to the scientific community."

The current status of the Network Office is that the award to the University of Washington will end in February, 1997 and we anticipate that the new award in the form of a Cooperative Agreement will start at the University of New Mexico at the same time to avoid a gap of funding. The first year of the new award will be a transition year where the functions currently in Seattle will be transferred to Albuquerque. New equipment will be purchased to allow the system to be set up in Albuquerque before it is shut down in Seattle, minimizing a loss of functionality and communication.

Some new people will be hired at Albuquerque in 1997; an Executive Director, publication specialist, administrative assistant,

accountant, and secretarial help. We are working toward moving Rudolf Nottrott and John Vande Castle from Seattle to Albuquerque because of their tremendous value to the Network and knowledge of the Office system. In 1998, we will have the opportunity to hire an additional programmer/computer specialist to help develop the Network Information System. We also will initiate a postdoc position at the San Diego SuperComputer Center that will be dedicated to LTER-SDSC interactions. This person also will have the expertise to help with the Network Information System as well as assist the sites with needs especially suited to the capabilities of the supercomputer center, e.g., massive data archival and management, 3-dimensional modeling. SDSC is currently involved in a proposal that will determine the fate of this center. That decision will be made in 1997 and the status of our interaction with them will then be clear.

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Table of Contents

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# 3.0 LTER NIS Development

3.1 Background (J. Brunt (SEV))

Following last year's meeting Rudolf Nottrott and James Brunt began the development of an LTER NIS planning document. This document has since been through a number of iterations and has been commented on by the information system and data task groups. The document describes existing servers that are maintained by the Network Office, offers the vision of an LTER NIS for the 21st century that was developed at the 1995 LTER IM's Annual Business Meeting in Snowbird, Utah and provides a year-by-year schedule of events to beyond the year 2000. The implementation schedule for 1996 and 1997 is a starting place for this year's information management meeting. A pared down version of this document was used by the LTER Network Office for part of their renewal proposal. These documents are available at: **http://lternet.edu/is.** At this meeting, several steps were initiated to begin the process of implementing various components of the NIS as outlined in the draft document (App. C), including a distributed data catalog, bibliography and climate database.

3.1.1 Expanded vision (J. Brunt (SEV), R. Nottrott (NET))

A major challenge to the U.S. LTER network in the coming decade is the design and implementation of an information system that seamlessly facilitates both cross-site and intra-site data and information exchange. The fundamental philosophy of this effort is "development from a research perspective". The primary function of the LTER NIS will be support of intersite research as well as site research. Therefore, all technical implementations will be driven by this philosophy and research focus. Development of the system will be closely linked to efforts by LTER and collaborating cross-site and synthesis research groups. In addition, development will be made with the recognition that information management systems are always evolving, due both to technological changes and to improvements in our understanding of how scientists most efficiently use information.

An NIS working group has been established to guide and advance the development process of the NIS. In addition, future interdisciplinary task groups composed of scientists from existing intersite or site research groups, information managers, and consultants will provide much of the personnel power necessary to design and implement various components of the system.

The mission of the NIS working group is to design and develop a distributed, LTER-wide information system using a modular approach, while maintaining and building on present functionality. Queries, browsing, and input of datasets and metadata located at multiple sites are essential characteristics for the system to function as an intersite research tool. Platform independence and the capability to present data and information in a consistent fashion, independent of their original format and location, are essential for the system to function in heterogeneous site environments (see App. C: Updated draft document "Developing an LTER Network Information System for the 21st Century").

3.1.2 How the LTER NIS will benefit sites (R. Nottrott (NET))

The main objective of the present and future LTER NIS is to support basic ecological research and science, at both the site and network levels. At the site-level, the NIS needs to support operations such as:

- searching and indexing each individual site data files
- scheduling field crews and equipment
- listing local calendar announcements
- organizing site publications

- oversee data entry.

At the site-level, the NIS should have several areas of emphasis including:

- ability to easily update information in the local system with appropriate security
- move easily between the distributed and local system
- provide high-quality search mechanisms
- maintain a high degree of standardization of variable names and keywords
- employ clearly specified exchange formats
- utilize an easy and direct way to enter and update site data and metadata

An easy and direct way to enter and update site metadata and data in the NIS is crucial because including up-to-date information is critical and ease of use will also facilitate obtaining smaller data sets (e.g. from graduate students).

The NIS has a potential to provide a reference framework for many routine site activities. For example, with an easy way of looking at common metadata within a site, developing keywords and metadata structures across all sites will be greatly simplified. For some sites, this will provide an opportunity to re-organize their own data catalog. Well-organized, complete and consistent on-line data are an essential part of the NIS framework. This reference framework can also be utilized by site personnel to prepare for NSF site reviews. Conversely, it will be a factor considered by future review teams as reviewers endeavor to view and evaluate individual sites from a network perspective.

There is a public relations value of the LTER NIS. The LTER NIS presents a common view and access point to the wider ecological research community domestically as well as the international community world-wide. Any site can point to its role in the greater LTER NIS thus demonstrating the synergy of the LTER network being far more than the sum of its parts.

The critical importance of the LTER NIS for individual sites as a tool for information management dictates that the next steps in the development of the LTER NIS must include improving existing components such that functionality of individual site systems is improved.

3.2 LTER NIS Development activities

There are three elements of the NIS that represent both a broad view of many data sets (through the catalog) and a detailed view of two specific data sets (through the bibliography and climate data). These areas were selected as a testing ground for the NIS development activities. We discuss each in detail below and then provide some summary comments about how the lessons we learn and the experiences we gain can be used to chart the next steps in the NIS development.

3.2.1 Data Catalog (J.Porter (VCR), C.Lehman (CDR), J.Brunt (SEV))

**Overview and Strategies for the Development of the Data Catalog**

An important feature of a LTER NIS is a searchable data catalog which allows researchers to quickly identify and access data sets at all LTER sites. A data catalog currently exists in two forms. First, there is a core dataset catalog which covers core data from each site, but has been in place since before WWW retrieval methods were developed and has not been updated since the initial edition. The second form is a WWW-accessible table compiled by Mike Hartman at NWT LTER (App. D). Although both of these catalogs are useful, they have several deficiencies. The core dataset catalog does not include most of the data currently available on-line at LTER sites. The table is more current, but datasets are restricted to specific categories, and it is not easy to update (updating requires examining the data areas at all 18 LTER sites). Neither catalog provides direct links to actual datasets or metadata.

Four alternatives were discussed for creating an updated catalog. These spanned a range of technical sophistication and functionality, from relatively simple, but with minimum functionality to relatively sophisticated with a high level of functionality. The alternatives were:

1. Add hypertext links to the existing table
    - Advantages: simple.
    - Disadvantages: difficult to update, not searchable, currently does not handle multiple datasets at a site relating to a single topic.
2. Utilize free-text searching capabilities (e.g. WAIS, Harvest) to automatically index metadata on each site's WWW server
    - Advantages: automated update.
    - Disadvantages: only supports free-text searches.

3. Use an existing, non-LTER data catalog (e.g. NASA Global Change Master Directory)
    - Advantages: search engines and input standards already in place.
    - Disadvantages: little opportunity to customize to meet LTER needs.
4. Create a centralized catalog with a distributed interface using a relational database coupled with WWW-based input forms
    - Advantages: supports full range of searches, distributed updates.
    - Disadvantages: requires extensive development, sites must update

The advantages and disadvantages of each of these systems were discussed and a prototype catalog of Type 4 was demonstrated.

**Working Groups on Different Aspects of the Data Catalog Development Effort**

Working groups focused on the competing needs of individual sites and the network for scarce resources and how synergy between the site and network levels might be generated. One group noted that expenditures for database development are very high and involve rapidly evolving processes and technology. They focused on the hierarchy within a network information system. They noted that although individual sites have specific needs and opportunities, they don't need to pass eccentricities up to network level. Development of exchange standards can allow information to be harvested directly from sites. Some components of site information that could be accessed at the network level included the bibliography, personnel directory and the dataset catalog. Search engines developed at the network level could be utilized at individual sites.

Another group focused on identification of "who really is our customer and what goods are we trying to deliver?" and discussed the problem of developing incentives for sites. They noted that development of a network data catalog was an opportunity for some sites to enhance their site data catalog. Another group noted advantages for individual sites in the creation of a framework for metadata and keyword development. They noted that ease of catalog update is extremely important and that this would be facilitated by a clearly specified exchange format.

**Future Activities for the Data Catalog**

During the next year, several participating LTER sites will prototype a refined catalog that uses a web-interface to a relational database. Upper-level metadata (above the attribute level from the 1994 IM report), together with URLs, will reside in a central database for searching, but detailed metadata as well as the data themselves will remain at local sites in site-specific formats. In particular, central metadata will include dataset title, originator, time period of the data, availability, contact, accession codes, citation, spatial domain, keywords, and URLs. Both fields and free text in the metadata will be searchable.

The tasks include (a) refining the data model, (b) prototyping one or more central database storage and search systems, and (c) developing automated methods for adding catalog entries. One metadata entry method will be Web-based and tabular for easy entry information on only a few datasets. The other independent metadata entry method will be batch-based, using ASCII files and keywords, to handle larger-scale entry of information on a group of datasets.

*Action Item: To accomplish these tasks i.e. refining the data model, prototyping one or more central database storage and search systems, and developing two automated methods for adding catalog entries (one a Web-based and the other a batch-based approach), participants will conduct monthly virtual meetings, using the WWW for preparation, with email notification of where to phone, and with a report subsequent to each meeting. Meetings are planned for the second Tuesday of each month at noon eastern time.*

*Action Item: Other activities for the group, or part of the group, may include a visit to ORNL/GCMD to compare their efforts in detail, and a meeting at SEV in March or April.*

The results of this effort should be a broad collection of data from a few sites, with the core datasets from all sites, searchable and accessible by anyone with Web access. Experience here will provide information for further synthesis of the LTER data and for activities in future years.

3.2.2 Bibliography (B.Benson (NTL))

Planned enhancements for the LTER All-Site Bibliography will address the limitations of the existing All-Site Bibliography (Chinn and Bledsoe, 1997). The existing bibliography is currently maintained as a set of text files, one for each site, available through the LTERNet Web server and searchable using gopher and WAIS. Network Office staff will migrate these files into an SQL database (SQL Server) at the Network Office. The SQL database technology will facilitate linking bibliographic information with other components of the NIS such as the data set catalog. WWW interfaces to the SQL database will permit more sophisticated searching.

*Action Item: Network Office staff will migrate the set of bibliographic text files from each site files into an SQL database (SQL Server) at the Network Office*

We will explore existing standards for machine-readable bibliographic information (such as USMARC developed by the Library of Congress; http://lcweb.loc.gov/marc/). A proposed plan for maintaining (i.e. updating) the bibliography database is to have a "centributed" database. The database is maintained and accessed on the SQL Server at the Network Office. However, the information in the database would be updated at the site level and provided to a "harvester" from the Network Office in the standard exchange format. Sites would also be able to retrieve their entries in the central database in the standard exchange format.

*Action Item: The existing standard formats for exchange of bibliographic data (such as USMARC developed by the Library of Congress; http://lcweb.loc.gov/marc/) will be explored and a proposed plan for maintaining (i.e. updating) the bibliographic database as a "centributed" database will be developed.*

3.2.3 Climate Data Project (D.Henshaw (AND), D. Blodgett (BNZ), K.Baker(PAL), B.Benson (NTL))

Background: Climate data is collected at all sites and is typically the most commonly requested data. Synthesis groups have need for ready access to climatic summaries. A standards document developed by the LTER Climate Committee (Greenland 1986) established baseline meteorological measurements to characterize each LTER site and enable intersite comparisons. More recently, the CLIMDES project gathered individual site temperature and precipitation data and created on-line monthly summaries for each site. Additionally, two monthly distribution formats (V-one and V-many) were recommended at an XROOTS workshop in May, 1996. Doug Goodin of the LTER Climate Committee has been charged with revisiting existing standards to determine which new variables should be collected and to extend standards to include data aggregation and exchange.

Project Overview: While the CLIMDES project has satisfied an immediate need for access to monthly site climate data, there are no provisions for maintaining and updating these summaries or satisfying frequent requests for daily data. In conjunction with the LTER NIS development, the LTER DM climate working group will develop a prototype for harvesting climate data from a subgroup of LTER sites to a centralized location. Applications will be developed to generate the two recommended distribution formats from this centralized database. Climate variable content will be daily min., max., mean air temperature, and daily precipitation. A database of metadata for every collection station will be established, with metadata content requirements coordinated with the Climate Committee.

Project Rationale: The LTER Information Management Committee decided to prototype a dynamic system for providing current and comparable summary data from multiple sites. Every site maintains daily climate data. It will benefit all to have one set of centralized applications to produce monthly distribution formats from the daily data than for every site to write these applications locally. This prototype will initially involve a few selected LTER sites but will be scaleable to all LTER sites and will be easily modified if necessary to meet LTER Climate Committee requirements. The XROOTS project has also described (see Section 4.4) a need for access to climate data in such a system.

Specifics: Each participating site in the prototype development process will provide climate data files in a standardized daily format (described below). Each site will provide an Internet address (URL) to identify the location of static files or a dynamic script. Daily climate data will be harvested automatically by a central site into a centralized database. Applications programs will produce two monthly distribution reports or formats (V-one, V-many formats described in X-climate Workshop Report) from the daily climate database. Additionally, sites will provide metadata for every participating collection station which will be centralized in a related database.

One suggested daily format is:

SITE STATION DATE VALUE1 FLAG1 VALUE2 FLAG2 VALUE3 FLAG3 VALUE4 FLAG4

where,

SITE is the three letter LTER site code

STATION is that site's name for the weather station

DATE is an 8 character field, yyyymmdd

VALUE1, FLAG1 is mean air temperature and corresponding flag

VALUE2, FLAG2 is maximum air temperature and corresponding flag

VALUE3, FLAG3 is minimum air temperature and corresponding flag

VALUE4, FLAG4 is precipitation and corresponding flag

Recommendations: A workshop involving the Climate Committee, several data managers, and representative database users is recommended. The prototype will be demonstrated at this workshop and provide a baseline for discussion, refinement, and further development. A climate glossary, variable naming conventions, standard metadata sets, and data flag codes will be developed.

*Action Items:*

- *In conjunction with the LTER NIS development, the LTER IM climate data working group will develop a prototype for harvesting climate data from a subgroup of LTER sites to a centralized location. Participating sites will provide a URL for one weather station's daily climate data and will provide required metadata elements. Metadata content requirements will be coordinated with the LTER Climate Committee.*
    1. *LTER DM climate working group representatives will contact the Climate Committee (David Greenland and Doug Goodin) to present this project.*
    2. *Participating sites (BNZ, SEV, VCR, AND, PAL, NTL have volunteered) will formalize the standardized daily format and metadata requirements, provide a URL for one weather station's daily climate data, and will provide required metadata elements.*
    3. *Working group will request climate data flag information from all the LTER sites and use the assembled information to generate a recommendation for handling data flags in the aggregated database.*
    4. *Working group will develop harvesting applications and methods for a central location.*
    5. *Working group will develop applications for producing monthly data distribution formats.*
    6. *Working group will develop a weather station metadata database.*
- *The working group of data managers, Climate Committee representatives, and climate data users including XROOTS representatives, will conduct a climate data workshop.*

3.3 Other Related Issues to NIS Development

3.3.1 Mixed Data Types (D. Olson (ORNL))

During the discussions, several approaches to developing the LTER NIS were proposed to be the best design. And, while the data could be transferred into any one of the approaches, there was acknowledgment that a mixed approach may be best. Three general types of data are described below with their unique characteristics in terms of developing a NIS.

**Field Data:** The traditional LTER experimental process consists of an individual or small team proposing a study, collecting field measurements, publishing results, and generating datasets. The datasets tend to be small, unique, and have a close association with the investigator that collected the data. The metadata can be larger than the data and, when completed, can require a significant portion of the project resources. Rarely are these datasets quickly released to other outside investigators, although often these datasets are readily available to and shared with investigators within a site.

**Monitoring Data:** In contrast to the field data, the baseline conditions, such as meteorology, stream flow, and atmospheric fluxes, are often measured by automated loggers to produce very large datasets. Potentially these types of data are collected at almost every site and have similar structures at each site. There is less identity with an individual investigator and almost every investigator extracts a subset of these data to help interpret their findings. Often these can easily be made available a short time after being recorded (i.e., within one to several months).

**Integrated Data Products:** One of the assumptions is that once all of the field and monitoring data are in a database, then the data will be easily retrievable and immediately usable for cross-site studies. However, several projects were described (e.g., XROOTS, NCEAS workshop on productivity and diversity, MODLERS, etc.) in which a significant joint effort by scientists and data managers is being invested to answer scientific questions about cross-site processes. The experience is that there are always scientific issues to be addressed about the comparability of methods and measurements that must be addressed before the data are integrated for modeling or analysis. And, although this can be a time consuming effort, the process may produce, in addition to results of the cross-site study, an enhanced database consisting of observations from many sites and many investigators. This value-added product may be extremely useful to modelers or others for additional cross-site studies.

In general, the dataset model (maintaining individual datasets as a collection of one or more files) is great for the Field Data, the relational database model (putting all datasets and files into a single database with retrieval capabilities) is better suited for Monitoring Data, and either model could probably be used to manage Integrated Data Products.

3.3.2 Metadata and Acknowledging Data Compilers (D. Olson (ORNL))

One of the most discussed challenges was how to get investigators to release data after they have a reasonable time to review the data and publish their findings as previously mentioned. Scott Collins, NSF, has recently specified within 2 years. Most of the ideas proposed to accomplish this feat consisted of pressure (the big stick) on the investigator. A few discussed possible incentives, such as getting acknowledgment for a well documented dataset as a scientific achievement similar to a publication. The LTER community has an opportunity to promote and implement both types of incentives. The LTER community could also approach NSF to give more recognition for the datasets that they are requiring investigators to produce and to work with editors and publishers to accept citations to databases as a legitimate citation. One of the keys to making this work may be to develop metadata guidelines that would produce a more "publication" looking document and would include a peer review process.

*Action Item: Develop metadata guidelines that would produce a more "publication-like" document which would be peer-reviewed.*

3.4 Longer term view

3.4.1 Synthesis of broad and specific steps (C.Lehman (CDR)

The three components of NIS development -- the catalog, the bibliography, and the climate data -- represent both a broad view of many data sets (through the catalog) and a detailed view of two specific data sets (through the bibliography and climate data). Both the bibliography and the climate data sets are relatively simple. It should be possible to unify them with common formats across sites, though experience so far has shown that even for these data sets, unification is far from trivial. Experience gained with the two specific data sets can be applied to select which data sets are the next candidates for integration across sites in the future.

3.4.2 Long-term vision for an LTER NIS (K. McGwire (MCM))

The ultimate goal of an LTER NIS would be to allow "one stop shopping" access to data from sites throughout the network, thereby facilitating intersite research and the regional assessment of general ecological hypotheses across sites. Such a system should have a user-friendly interface which makes the details of local implementation transparent to users as they access information from a widely distributed number of sites. The methods developed to meet this goal range across a spectrum with one extreme being a "base level" which provides site metadata and pointers to files which meet user queries and at the other end, a "fully integrated" level which extracts only those relevant parameters from site information systems and formats them into consistent sampling frameworks with respect to time, space, and attribute.

Both of these levels require a sophisticated and coordinated data management infrastructure. The fully integrated level would also require significant resources for the exploration of serious scientific and statistical issues regarding interpolation and aggregation strategies. Given the current configuration of the network and allocation of resources, the most reasonable strategy appears to be ensuring that all LTER sites develop or maintain the base level of service with groups of sites working together, i.e. "teaming", to move towards more advanced functionality as resources permit. Teaming between sites is likely to develop based on shared interests with respect to hardware and software implementations.

One of the initial questions to be addressed is the degree of centralization of the required information system(s). While simplifying the job of the information system designer, the centralized approach would impose a number of difficulties on the network information management infrastructure, with three of the potential issues being version control, timeliness of updates, and duplication of efforts. It is not reasonable to expect that each site develop the capability to support cross-site querying capabilities, so it is expected that a single point of entry which allows access to the distributed network would be the most reasonable model for the user interface. The NIS at this point of entry would represent a "layer of indirection" from individual site databases. This approach would allow a high degree of heterogeneity with respect to hardware, software, and database design at the site level, while providing a seamless front-end to the user. Though appearing as a single point of entry from the user's perspective, this software and its associated database could be mirrored at multiple locations, providing redundancy to improve reliability and performance with respect to network access.

While the NIS at this point of entry would be required to query and coordinate responses from multiple site databases, even the base level of service described previously would require that all site information systems support network-based queries. This

would clearly be based on an established standard, with the obvious choice, at this time, being SQL-92. It is also possible that metadata structures could be standardized in order to reduce the burden on the coordinating site for supporting numerous database representations. However this could be problematic, as such an imposition may have unacceptable consequences with respect to site user needs and re-engineering of existing site information systems.

3.4.3 Training (S.Stafford (AND), C. Wasser (SGS), E. Melendez (LUQ), B. Benson (NTL). K. Baker (PAL))

Opportunities were discussed to fund "in-reach" training opportunities within the LTER network as well as set the stage for further development of a strategic plan for the NIS. We identified three workshop/theme development ideas.

- Research Development in IM at each of the LTER sites: An internal assessment
  - Opportunity to educate and train other sites, and provide an assessment of technological status of LTER network.
  - Format: one hour for each site to showcase what we do best at each site.
  - Objective: establish four to five clusters of common approaches and network leadership personnel: Oracle, NT-SQL, MSQL, etc.
  - Product: Establish basis for the minimum standard IM installation for the LTER NIS
  - Audience: report to NSF and the community, may lead to a proposal similar to the minimum standard installation for GIS and R-S.

- Research Development of Web Tools for linking to data

*Action Item: Develop proposal to the NCEAS for a working group on these topics, ie., Oracle, NT-SQL, Minimum Standard IM for LTER NIS (C. Wasser, K. Baker, E. Melendez, B. Benson, and S. Stafford).*

- Gearing up to the NIS: What is the minimum data management standard at every site to support an NIS for long-term ecological research?
  - Formalize report from NCEAS theme development activities above.
  - Have Plenary Session at the '97 Albuquerque LTER sponsored meeting

In terms of funding, we need to rely heavily on a leveraged approach to making our Network dollars go as far as possible. Sources for funding include: EPA, NASA, NCEAS, SDSC, and NSF.

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Table of Contents

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# 4.0 Reports

4.1. Scott Collins Report (B. Kloeppel (CWT))

There was a whole group discussion and information sharing session regarding the statement by Scott Collins at NSF. This announcement was first mentioned by Jim Gosz (see Section 2.2), but because of its implications to the Information Management Community it is worth repeating (email message from Scott Collins to Jim Gosz on 01 October 96). Collins stated, "On the issue of the data policy, we want all data supported on LTER funding to be available with a minimum of restrictions in two years. This is especially true for the long-term research that takes place with core LTER funding. Even data that are collected mostly with other NSF money should be available in two years. We are going to urge the ecological community to follow the example of LTER. We can not simply single out the LTER network for data accessibility. I will be raising this issue with panels this week and next, and yet again with Brady and Roskoski. In the case of short term grants, I would like all data from those grants to be available two years after the close-out of the award. We need encouragement of this policy from the LTER scientists, the National Center for Ecological Analysis and Synthesis (NCEAS), and the Ecological Society of America (ESA). I have discussed the issue with Jim Reichman, and he is supportive. The ESA

will be a challenge."

This statement was discussed and Jim Gosz emphasized that LTER is NOT being singled out, rather that the LTER network is closest to making this long-standing policy a reality. Further discussion resulted in the following action items.

*Action Item: Clarify when the two-year period starts (after the close-out of the award, what about annual awards, what about continuing data sets such as core climate and population monitoring studies). Brian Kloeppel will clarify this with Scott Collins.*

Brian Kloeppel talked with Scott Collins on 03 December 96 and had answers to and further development of these questions. First, Scott noted that ALL data sets need to be placed on-line (timing discussed in next paragraph). These include (a) core data sets including basic meteorological data (air temp, air humidity, precipitation, etc.) (b) other common data such as net primary productivity (NPP), N mineralization, stream and soil chemistry as well as (c) specific data sets such as tree stem respiration, fish productivity, lake sediment core pollen counts, ice core analyses, and other data sets specific to certain LTER sites.

For shorter-term projects (perhaps 1 to 3 years), a two-year time buffer between project data collection completion and data availability is expected. At the end of two years, data is to be made available to the public (see world wide web page accessibility below). For automated longer-term data collections such as meteorological monitoring, it is hoped that data would be available almost immediately since there is little risk of lost publications and the benefit to the community would be quite high.

*Action Item: A working definition of "minimum of restrictions" was not clear due to widely varying data access restrictions at each site. Brian Kloeppel will clarify this with Scott Collins.*

Scott noted that the World-Wide Web (WWW) is definitely the means by which he and others at NSF are suggesting that data be made available to the public. Currently, some LTER data sets are available directly (users can obtain data without having to contact a PI, Data Manager, or other responsible individual). Other sites have data sets with restrictions such as those mentioned above which may delay the data request for days or weeks.

NSF would like to have individuals be able to access data without having to contact individuals (thus eliminating delays). Follow-up communication with the data set PI or data collector is encouraged if questions arise. It is hoped that speedy transmittal of data will increase communication between parties rather than diminish it.

Regarding accountability of available data sets and the analyses resulting from them, LTER sites could (and some do already) have a form which individuals sign noting that the data set needs to be acknowledged and/or gives the original PI the right to review a publication utilizing the data set before the manuscript is submitted for publication. Though this is difficult to enforce, it does give the originating PI a means by which to refute any poorly analyzed conclusions resulting from the shared data set.

Scott Collins also noted that his office receives many requests for data from undergraduate students and instructors who are looking for recent data to utilize in lectures, lab projects, and senior theses. These requests (which usually result in a non-publication item) are frequently referred to LTER WWW sites which have the type of on-line data which fulfills their requests. Therefore, the on-line data does have a demand and is utilized by not only by others research, but by those in education as well.

*Action Item: Clarify when we need to start enforcing this long-standing NSF policy*

Scott Collins noted that some may feel that a huge burden has been dropped on their shoulders to get ALL data on-line now. However, he said that all new projects should be handled with this two-year policy. In the mean time, all site PIs and Data Managers should continue to pull data that is stored in various formats and assimilate it on to their WWW data pages.

The incentive that all sites will have in this regard is that the data accessibility of sites will be evaluated by NSF Review Committees and will continue to play a larger role in the overall results of the Review Committee reports. This data management policy is for ALL NSF funded projects and is not just an extra burden to be placed on LTER sites.

Reaction from the LTER Community

The above clarifications from Scott Collins were distributed to several key site PIs and their reactions were solicited to gain an understanding of the effect on site PI's. Some of the reactions are summarized below. Overall, LTER Scientists and Data Managers have the infrastructure in place (computer servers, web pages, hard drive space, etc.) to make data available as requested by Scott Collins and others at NSF. However, the recent strong encouragement by NSF of a long-standing policy opens some difficult questions.

1) Some site PIs feel that longer-term data collections such as those involving population monitoring and extensive laboratory analyses ought to be given the same two-year buffer between data collection and availability to the public since the person hours needed to collect, analyze, and review data is at least the same if not greater than the effort needed for the shorter-term projects mentioned above. A double-standard for those involved in long-term collections (see Action Item above) is hardly a fair way to enforce this policy.

2) What professional incentive does the large amount of work involved in data set reformatting and web page preparation give to the site PI? This time could easily be spent on their own publications thereby rendering them authored publications and in return furthering their own careers. Also, for those scientists heavily using on-line data, how are collectors of the data able to receive any credit? Does an acknowledgment (if that) warrant the months or years spent on the original data collection and analyses only to have someone else publish a summary of the data with other available data sets?

3) Many LTER scientists are partially (and minimally) funded by LTER NSF funding. They may allocate other research dollars and institution funding sources to accomplish the research objectives for their LTER project. This often includes their own salary which is frequently paid for by other sources. Therefore, why should NSF (with a minority of the contributed funding to complete the project), have such a large, enforcing role on the entire project's data accessibility? This is a particularly difficult question to address network-wide since every site PI handles the funding of their individual research projects differently.

4.2. MODLERS (D.Olson (ORNL))

The **MOD**IS Land Science Team & **L**ong-Term **E**cological **R**esearch Network **S**ynthesis (MODLERS) project brings together investigators, ideas, and data from 14 Long-Term Ecological Research (LTER) Network sites and from the National Aeronautic and Space Administration's (NASA's) MODIS Land (MODLAND) Science Team for the purpose of locally validating Earth Observation System-era global datasets. Using several standardized methods that incorporate extensive ground datasets, ecosystem models, and remotely sensed imagery, each LTER site is developing local maps to show land cover class (LCC), leaf area index (LAI), and aboveground net primary productivity (NPP). This coordinated, multisite, grain-size aggregation exercise will focus on the effects that scaling, from the fine grain to the coarse grain, has on estimates of important biosphere variables for a range of biome conditions.

The MODLERS team held a workshop in May, 1996 to develop a product for the first years activities consisting of a series of papers describing the scientific background, status, and plans for this project. Dick Olson described the information system that is being proposed to support the MODLERS project. While this system is being developed to meet the needs of a specific LTER project, the developers are mostly LTER information managers (Porter, Henshaw, Briggs, Stafford) and it is planned that the LTER NIS and the MODLERS activities will complement each other. The MODLERS project is receiving funding from NASA and there is an expectation that the data will be come readily available, either from a central LTER access point or other data center, such as the ORNL DAAC.

The core component of the information system was conceived to be a set of cross-site scientific-domain working groups (e.g., NPP, LAI, remote sensing, etc.). Each of the working groups would coordinate the development of data associated with the group's particular scientific domain, including decisions about data requirements, data to be compiled, data formats, derived data products, and schedules across the 14 sites. This arrangement can be illustrated as a set of pyramids with the 14 sites and their data at the bottom of each pyramid, data processing in the middle, and the final standardized data set(s) at the peak. The workshop participants stressed the need to provide incentives for individuals to prepare documented datasets to move through the system.

The overall information system would consist of nodes (MODNODEs) for each scientific domain plus a MODCENTRAL node. The MODCENTRAL node would be the primary entrance to MODNET. It would include access control, project information, data query, data archive, and other functionality. The system is envisioned to be Web based and accessible through one or more of the popular browsers using an html-type interface to the data and information.

The group leader for each scientific-domain working group, or MODCZAR, will provide scientific and technical leadership. MODCZARs would play a critical role in the development of datasets and data products for each working group. They would be in a position to identify the critical data resource needs and quality assurance criteria because of their domain expertise. Equally important, as a leader in the MODLERS project, they would have the prestige needed to encourage other MODLERS participants to fully collaborate in the development of datasets, documentation, and data products. MODCZARs would ensure that the multisite data for their node was either entered into the MODNET database or made accessible in standardized formats within the overall project schedule. However, the MODCZARs might not have the technical expertise in information management to fully implement the data compilation efforts. For this reason, one or more technically oriented partners (computer wizards or MODWIZs) for each MODCZAR may be required. The resulting partnership would ensure scientific credibility, computer efficiency, and timeliness, with the MODCZAR providing guidance and clout whereas the MODWIZ(s) provides expertise in database tools and networking. In addition, the MODLERS project leader (MODARCH) would provide overall direction and coordination among the groups and sites.

The tentative scientific-domain working groups include:

- MODNPP - coordination of net primary production (NPP) data and maps;
- MODLAI - coordination of leaf area index (LAI) data and maps;
- MODLCC - coordination of land cover class (LCC) maps and validation;
- MODTECH - coordination of remote sensing data with appropriate calibrations;
- MODSITE - coordination of intersite comparison methodologies;
- MODSPACE - coordination of spatial aggregation; and
- MODDATA - coordination of overall database development.

4.3. Bibliography (C.Bledsoe (NET))

The All Site Bibliography Project, initiated by Caroline Bledsoe and Harvey Chinn in 1992, now has more than 12,000 entries from all 18 sites and is available via the Internet (**http://lternet.edu/biblio/**). The project was successful only with the extensive help of all the Information Managers from the 18 LTER Sites. The project is described in a recent article in BioScience (Chinn, H. and C.Bledsoe. 1997. Internet access to ecological information -- the US LTER All-Site Bibliography Project). The paper is also available on the Internet (**http://www2.aibs.org/aibs/bioscience/vol47/jan.97.comp/jan.97.computer.html**).

Caroline Bledsoe described the development of the project, emphasizing the value of such a pilot project for the lessons learned about combining information from all sites. A number of these lessons are discussed in the BioScience article. For example, the current bibliography, managed by the LTER Network office staff in Seattle WA, is a static document since there are no mechanisms or support to add to the bibliography or to obtain updates from sites. This issue of "updating" is a critical issue for the All Site Bibliography (ASB) and for many other potential Network files, documents, and databases. A second example is the issue of standards - standard formats for bibliographic references, standard abbreviations, standard "rules" for which documents are included, etc. Both of these issues are relevant to future LTER Network efforts to compile information.

Bledsoe also emphasized the distinction between a "Centralized" and a "Distributed" system for the locations of computerized networked information, such as a bibliographic database. She suggested that a hybrid "Centributed" system might be ideal. In the centributed system, there is a central file which is updated periodically from individual files maintained at the sites. Thus, sites maintain control of their own data and are responsible for updating and accuracy. However, the centralized version can be used for searches and obviates the problem of requiring a search of all individual sites, any one of which might be temporarily unavailable.

Bledsoe urged the LTER Information Managers to consider the options and to recommend to the LTER Coordinating Committee that a centributed All Site Bibliography be developed. Bledsoe would like to work with the Information Managers on such a project, which would involve testing a centributed system with files on NT Servers supporting SQL searches at several sites. If the test was successful, then Bledsoe suggested that the ASB should be moved from its current file structure into a relational database (such as Microsoft's MS Access or Visual-FoxPro, both of which support SQL queries). This project would be a test of the developing LTER NIS.

*Note: Section 3.2.2 describes the IM Committee Action Items related to the All-Site Bibliography.*

The following diagram outlines these ideas:

LTER Network Information System

All-Site Bibliography ---------- 18 individual site copies of

| bibliographies

|

All-Site Personnel Directory ---------- 18 individual site copies of ...

|

|

All-Site Core Data Set Catalog ---------- 18 individual site copies of...

|

|

All-Site..... ---------- 18 individual site copies of.....

(other datasets being developed;

e.g. climate data, soils data, biodiversity data)

4.4. X-Roots (C.Bledsoe (NET))

Relevant URL's: (1) this report in expanded form (**http://lternet.edu/im/xroots/aclim.htm**);

(2) X-Roots home page (**http://lternet.edu/about/research/syn_01.htm**); (3) Climate Committee standards document (**http://lternet.edu/im/climate/standard86.htm**).

Bledsoe proposed to work with the Data Managers in organizing a small LTER meeting called "LTER Climate Data/Metadata Standards Meeting". This meeting would define climate data standards and would develop standard formats for LTER Climate Distribution Datasets. This meeting would involve about 12 persons, including: (a) 3-4 Climate scientists (e.g. Doug Goodin, David Greenland); (b) 3-4 Data Managers (e.g. Nottrott, Henshaw, etc.); ( c) 3-4 Modelers/users of climate data (e.g. Harmon from LIDET project, Bledsoe from X-Roots project, several modelers from LTER). The meeting could be sponsored by the LTER Network and the Information Management Committee and held in the Summer/Fall of 1997, possibly at the network Office in Albuquerque or the SEV field station nearby (cost effective). Funding of about $5,000 for travel, etc. would be sought from appropriate sources, including NSF and the LTER Network Office, and LTER sites would be asked to support travel of participants from their sites.

Bledsoe asked the Data Managers to consider this request and to let her know if they are interested in collaborating. The background for the above request is summarized below.

Bledsoe described a current NSF-funded project called X-Roots and it's activities in locating data, including plant root data, climate data and soils data. X-Roots is a cross-site, multi-disciplinary project designed to synthesize existing below-ground plant root biomass data from many sites (LTER and others), together with associated plant, climate and soils data in order to clarify controls on below-ground plant productivity. X-Roots, a three-year project (Sep 1994 -Aug 1997), was funded from a special NSF/DEB competition to enhance intersite and synthetic research, especially in the LTER Network. The project is funded to Caroline Bledsoe at UCDavis and Jordan Hastings at UNV-Reno; Rudolf Nottrott, LTER Data Manager, is a Co-PI.

When X-Roots found it more difficult than expected to obtain climate data in easily usable forms, the project asked for help from several more experienced LTER climate researchers, including David Greenland, Chair - LTER Climate Committee. Email and telephone discussions led to a small mini-workshop -- the X-Roots/LTER Climate Mini-Workshop which was held on May 16-17, 1996 at UC Davis. Workshop co-sponsors were the X-Roots Project (PIs Bledsoe and Hastings; co-PIs Nottrott and Chinn) and the LTER Network Office (subcontract to LTER Research Coordinator Bledsoe). Invited participants were David Greenland (U Oregon), Don Henshaw (AND site) and John Porter (VCR site). Jordan Hastings (MCM site) and Rudolf Nottrott (NET site) also represented those sites, and served as workshop co-organizers.

Workshop participants were involved in two main activities: (1) review of X-Roots progress to date, particularly database and related software development; and (2) deliberation on content and format of LTER climate datasets to facilitate their distribution and use in projects such as X-Roots. To focus the latter activities, participants were asked to prepare and bring climate datasets from their sites to the workshop.

On the workshop's first day, the overall structure of the X-Roots database was described, followed by a demonstration of the X-Roots bibliographic database ("Biblio Cluster") which is used within the project to track data sources. Next, a prototype of the X-Roots measurement database ("Measure Cluster", used to record quantitative data) was presented, utilizing sample data from the KBS site. This was followed by Greenland's discussion of the intersite CLIMDES ("CLIMate DEScription") project, which was funded in the same NSF/DEB special competition as X-Roots).

On the second day, participants discussed desirable content and format for climate datasets; they also explored the current reality of these issues by importing their LTER climate datasets in forms suitable to X-Roots. The workshop wrap up was an extended discussion of data naming conventions, data source tracking, quality control, and metadata issues. Participants talked about the need to update climate datasets, which led to consideration of distributed datasets which would be accessible and on-line and query-able (e.g. SQL Server software, etc.). Finally, participants outlined several action items from the workshop.

The workshop was successful in many ways. A prototype X-Roots database was populated with climate data from five sites (AND, KNZ, MCM, SGS, VCR). X-Roots project members learned how additional site data can be obtained from CLIMDES. Participants also outlined two possible standard formats, V-One (one variable) and V-Many (many variables), for distributing climate data. A decision was made to experiment with updating some of the CLIMDES datasets (current only to 1990); this process will be useful for two reasons: to provide more recent data (e.g. LIDET project's litter bag decomposition studies began in 1990) and to gain experience with processes for updating centrally held data. Another experiment at formal database distribution will be made with the X-Roots bibliography, followed by the LTER All Site Bibliography, with results to be presented to the LTER Data Managers and LTER Principal Investigators at Fall 1996 meetings. Participants are encouraged by the X-Roots/LTER Climate workshop which, beyond serving the immediate needs of X-Roots (and LIDET), may provide valuable lessons for the LTER NIS.

*Note: Section 3.2.3 describes the IM Committee Action Items related to X-Roots/LTER Climate Workshop.*

**X-Roots Workshop Action Items:**

(1) Climate Data Content: Support LTER Climate Committee's recommendations for content of climate data and limited metadata, organized by levels (Level 1=basic, Level 2= advanced, etc.

(2) Storage and Distribution Formats: Encourage LTER sites to adopt two formats for climate datasets, one for local storage, the other for general distribution. Content is standard for both, with local choice for format of storage datasets, but network-choice for format of distribution datasets.

(3) V-One & V-Many Formats: *Recommend two standard World-Wide Web formats (effectively "transfer protocols") for distribution datasets -- V-One and V-Many.

(4) Limited Climate Metadata with Data: *Recommend standardization and inclusion of codes for three critical pieces of metadata in all climate distribution datasets: climate site and station code; month and date code; and data element (a.k.a. "variable") code. For a Diagram of V-One & V-Many, see the workshop report (**http://lternet.edu/im/xroots/aclim.htm**).

(5) Climate Glossary: *Recommend that the LTER Climate Committee develop a standard

glossary for climate data (Web-accessible via LTER Home Page) which would include:

a) climate site and station names (keyed to geographical location, period of record, etc.),

b) data element dictionary (including name, units of measure, calculation methods, etc.),

c) data-quality flags (ways of marking missing data, questionable data, etc.)

d) list of variables by Levels.

(6) Test Updating and Distribution Processes: Ask the X-Roots group and others (e.g. LTER data managers -- AND/Henshaw, SGS/Wasser, VCR/Porter, NET/Nottrott, etc.) to undertake several experiments to update and distribute datasets. First, post-1990 climate data will be updated to CLIMDES for several sites (Henshaw, Nottrott, others). Second, Web-access to climate data using the V-One and V-Many protocols will be tested for CLIMDES from a few sites (Henshaw, Nottrott). Third, formal database distribution aspects of the X-Roots Biblio Cluster (which supports SQL-queries) will be tested with bibliographic entries from several sites (Hastings and Uthiram, an X-Roots summer intern). Finally, Web-enabled SQL-access to the LTER Personnel Directory will be tested, using a portion of the Biblio Cluster (Nottrott).

(7) X-Roots WEB Page: Develop an X-Roots Home Page with access to an X-Roots Glossary, a sample of the Biblio Cluster, and links to preliminary lists of sources of data (root biomass, soils, climate, etc.) (task to be done by X-Roots Group @ UCD).

4.5. ORNL DAAC (D.Olson (ORNL))

The Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) **(http://www-eosdis.ornl.gov)** was described and demonstrated by Dick Olson, ORNL, as an functioning search and order system for environmental data. The ORNL DAAC is one of nine data centers established by NASA's Earth Observing System Data and Information System (EOSDIS) as part of NASA's contribution to the U.S. Global Change Research Program. The DAAC provides biogeochemical dynamics data to the global change research community, policy makers, educators, and the general public. The information includes data from NASA's ground-based research programs and remotely sensed observations, as well as other non-NASA

biogeochemical dynamics data and value-added products relevant to global change research. Most of the other DAACs process and distribute remote sensing data from NASA satellites.

The DAAC has been operational since July, 1994 and has had a staff of about 10 - 12 individuals with a mix of biological and computer backgrounds. The DAAC currently contains over 220 datasets and has a Web-based, a local X-windows, and a system-wide X-windows interfaces. In the context of planning for the LTER NIS, the development and operation of the nine NASA DAACs offers an example of building a large distributed information system and some lessons learned. The development of the current configuration (connected sites with local implementations) and the planning for the next generation system (central implementation), has required extensive meetings, teleconferences, and work. For example, a monthly teleconferences and several workshops have been invested in developing a standard set of keywords for search and order. The set continues to change and recently a decision was made to change again to conform with the GCMD keywords. Another example has been the impact of the Web tools on the system that has significantly changed the system design. The cost of a creating a consistent, multi-site system is very high and very demanding on the developers and the LTER group can learn from this experience.

*Action Item: Plan a site visit to ORNL to specifically view the NASA DAAC system.*

The concept is that the DAAC receives data and metadata from projects and individuals after the data have been reviewed and findings published so that the data can be archived and distributed to a broader group of researchers. Often the getting the data requires reminders and patience--this is a continuing challenge. Approximately 2-4 weeks are required per dataset for reviewing the data and metadata for completeness and consistency, supplementing the documentation, extracting standard keywords, and moving the data into the database. Keywords and other selected metadata are maintained in a Sybase database for searching while the data are stored as ASCII text files. Data and metadata can be requested from the on-line interface or through the user support office as FTP files, diskettes, tapes, or downloaded directly from the Web page.

4.6 Site Capabilities Survey (K. Baker (Pal))

The LTER Site Capabilities is a survey of site specific software tools begun in 1992 (App. E). This survey is updated each year through the collective efforts of the data managers. The summary has been maintained on-line at the network office since 1993. An overview of this information through 1995 was presented at EcoInforma96 (Porter, Nottrott, Baker 1996). The summaries show the diversity of tools available across the sites being used to reach our common goals. The original listing of site information has been converted to tabular format in order to facilitate update as well as to provide visual intersite comparisons. The tabular format also serves as a template for possible internal site specific surveys.

4.7. Site level-information management: Challenges (S. Stafford (AND), B.Benson (NTL))

We had a group discussion of site-level opportunities and challenges. The group discussion focused on six major issues.

- Implications of flat funding

There was discussion of how the flat funding scenario is affecting sites especially in the area of information management. There is a tendency to cut infrastructure although so far sites have cut PI and student salary; however, there is not much room left in this area. Anticipated impacts from a flat funding scenario include less time to archive long-term data, decreased security for data due to less frequent back-ups, more difficulty to fund cross-site synthesis, and a tendency to lose the Network focus as resources are more constrained to site level work.

- Communication with PIs

An area of concern was getting PIs to release their data. Support of the lead PI was viewed as critical. Emphasizing the advantages of data manager's archiving of data sets was also helpful. Having an electronic calendar, especially one on the World Wide Web, has been found to increase communication. Developing home pages for each person range from the ORNL model of providing support for this to the VCR model where the pages are PI-editable.

*Action Item: Have PIs at future Information Managers meetings.*

- Retention of good Information Managers

Retaining LTER Information Managers is very important for longevity and continuity. There is very keen competition for information managers from the nonacademic, commercial community.

- Providing data and metadata

There need to be rewards and recognition carried to the NSF level for meeting expectations in this area. For example, CV's should include a space for data sets documented and made accessible to the wider community. Data products like CD's will help get names out to a wider audience.

- Visibility of Information Management

Two opportunities for increased visibility include papers in peer-review literature and posters and presentations at site and national meetings. At each site, visits from outsiders can provide opportunities to educate site PIs and administrators.

- Training and communication of ideas among Information Managers

A number of different mechanisms were suggested to increase communication and the sharing of expertise among the LTER Information Managers: using email forums and virtual meetings, sharing accounts on other's machines which provides opportunities for learning about one another's systems, creating a centralized library of software functions maintained on the Net, creating supernodes on the Network that can become centralized sites and service servers for the rest of the network, producing an electronic version of Databits.

*Action Item: Create a survey form to capture the depth of WWW competence across sites. (Eda Melendez volunteered to lead this effort.)*

To develop opportunities for training, we wanted to identify topics in the area of WWW and SQL links. It might be desirable to bring additional computer science expertise into the mix, possibly through NCEAS.

The idea of a published volume on information management was discussed. The minimum publication would be a chapter in each of the site Synthesis Volumes or at the maximum, an Oxford Volume dedicated to Information Management (which might be done at NCEAS). It was suggested that such a volume have thematic chapters and address the "why" of IM even more than the "how".

4.8. DATA PUBLICATION (C. Lehman (CDR), J. Porter (VCR))

The central data catalog, to be enhanced this upcoming year, is a form of data publication, but one without much peer review. The idea of publishing data in some new refereed journals, as described in the 1994 Data Management Proceedings, was discussed. A new format for printing small and medium-sized data sets, called PERM1, was described for printed data publication. The PERM1 format attaches redundancy check codes to printed data, making them machine-readable from the paper sheet via OCR scanner with the same kind of reliability we expect from magnetic media. (See the "tools" section of "**http://www.lter.umn.edu**" for details of PERM1).

4.9. NCEAS (M. Jones (NCEAS))

The National Center for Ecological Analysis and Synthesis (NCEAS) was represented by Matt Jones. Current information is available at the URL "**http://www.nceas.ucsb.edu**". He described the status of activities at the NCEAS and opportunities for collaboration and research for LTER groups through the NCEAS. The NCEAS just passed its 1-year anniversary and has been operational for a little over 10 months. During that period they have established a high performance computing infrastructure for use in data management, analysis, and modeling efforts. This infrastructure is supported by a full time computing staff dedicated to facilitating NCEAS sponsored activities.

Research opportunities through the NCEAS are generally structured as Working Groups, Workshops, Postdoctoral fellowships, and Center Sabbatical Fellowships. The Working Groups generally meet for several medium length time periods at the Center and work collaboratively (then and between meetings) on products proposed by the group. Decisions on funding generally are made twice a year through a "Call for Proposals" issued by the Science Advisory Board of the NCEAS.

Data management activities at the Center include the following projects: 1) internal data management; 2) an NSF grant to SDSC/NCEAS/ESA/Bishop for developing a Web-based data management system for ecological, geographical, and systematics data; 3) a web-based database of URLs and associated registry for organization of ecological information on the WWW; 4) a web-based Oracle database for managing a directory of ecological and environmental expertise. Several discussions focused on the utility and tradeoffs associated with using the Oracle Websystem in comparison to template based systems like miniSQL.

The NCEAS has expressed interest in the potential benefit for both LTER and the wider ecological community from collaboration between the data management groups at both organizations.

*Action Item: Pursue opportunities at NCEAS for workshops and working groups on elements related to the NIS development.*

4.10 Eco-Informa (S. Stafford (AND))

This year's LTER IM meeting was held in conjunction with the 4th annual international meeting of Eco-Informa '96: Global Networks for Environmental Information; Bridging the Gap Between Knowledge and Application, Epcot Science and Technology, Lake Buena Vista, Florida, USA. November 4-7, 1996. This was the first time EcoInforma had been held in the US. John Vande Castle (NET) and Susan Stafford (AND) co-chaired a contributed paper session entitled, Managing Long-Term Ecological Information. Five out of six papers were contributed by LTER or LTER-associated scientists. There were also a great number of LTER interactive poster sessions. Many LTER sites were represented by contributed papers or posters. The published proceedings were available at the time of the Symposium. Appendix F provides the Abstracts for Contributed Papers (App. F1) and Posters (App. F2) at Eco-Informa96.

4.11 Science On-line Antarctica Workshop (SOLA) Workshop Report (K. McGwire (MCM))

A workshop entitled Science On-line Antarctica (SOLA) was held in September of 1996 at the Granlibakken resort at Lake Tahoe. The meeting was coordinated by Jordan Hastings, the previous data manager for the McMurdo LTER. The goal of the meeting was to develop an improved understanding of how needs of ecological researchers might be better met by on-line information systems with the capabilities found in geographic information systems (GISs). A diverse group of environmental scientists were gathered for a set of invited presentations and breakout discussions. Invited speakers included:

- John Helly, who described the San Diego Bay Data Access Model,

- Ralph Dubayah, who discussed issues in solar insulation modeling,

- John Caulkins, who presented a method for integrating GIS and the World Wide Web,

- Michael Prentice, PI on the new NSF-funded New Dry Valleys

Mapping Project, and

- Barbara Stauffer of the Smithsonian Forces of Change exhibit.

Group discussions included interdisciplinary breakout groups to discuss the fundamental processes and scales of biological and geophysical interaction with the atmosphere in Taylor Dry Valley. This was interleaved with discipline specific breakout groups who were to discuss the specifics of implementation for topics brought up in the interdisciplinary sections. Discussion addressed issues of the potential communications gap between the ecological research and information science communities, trade-offs in certainty of methods versus economies of scale when processing is performed by an individual scientist versus a data center, indication of the types of processing which scientists might trust to a data center, and the need for integration of multiple data sources. At this time there is a report in preparation summarizing the workshop.

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Table of Contents

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# 5.0. Plans for Future Meetings (S. Stafford (AND))

Three issues were discussed: meeting at sites in lieu of in conjunction with other professional and/or society meetings, having more PI participation, and having more NSF participation. All were thought to have merit. The plans for the 1997 meeting will provide opportunity to do all three.

The 1997 meeting is part of a marathon meeting session planned for August 1997 in conjunction with the ESA meeting in Albuquerque, New Mexico.

The proposed schedule is the following:

Wednesday, August 6 Evening Mixer LTER IM

Thursday, August 7 LTER IM Business Meeting

Friday. August 8 Organization of Biological Field Stations Meeting (OBFS)/Long Term Studies Section(LTSS) Joint Meeting (Contact person: John Porter, James Brunt, Bill Michener)

Saturday, August 9 OBFS/LTSS Meeting

Sunday, August 10 LTER Special Session (with one session on Information Management)

M-Th, August 11-14 ESA Meetings

*Action Item*: *For future meetings consider meeting at individual sites in lieu of in conjunction with other professional and/or society meetings, having more PI participation, and having more NSF participation.*

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Table of Contents

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# 6.0 Election of new DataTask Members (S.Stafford (AND))

Barbara Benson (NTL) and John Porter (VCR) will retire from their current DataTask term on December 31, 1997. By a majority vote, (one vote per site in attendance) Chris Wasser (SGS) was elected to his first 3-year term and John Porter was re-elected to his second 3-year term. On behalf of all Data Taskers and Information Managers, I would like to extend our sincere appreciation and gratitude to Barbara Benson for her contribution and sustained participation on DataTask. As a group, we have truly benefited from Barbara's careful consideration of issues and her nonwavering commitment to democracy within the group. Her philosophy of bringing all voices to the table for input and discussion PRIOR to reaching a decision has enabled us to reach consensus in many areas that looked doubtful from the outset. Barbara's personal and professional ethics and integrity have set a high standard for all of us. Thank You Barbara! As our former DataTaskers can attest (just ask James Brunt!), you never truly "retire" from DataTask so we will look forward to continuing to work with Barbara for a long time to come - in just a less official capacity.

# 7.0 Literature Cited

Chinn, H. and C. Bledsoe. 1997. Internet access to ecological information --- the US LTER All-Site Bibliography Project. Bioscience.

Greenland, D. 1986. Standardized meteorological measurements for Long-Term Ecological Research sites. Bulletin of the Ecological Society of America. 67: 275-277.

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Table of Contents

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# APPENDICES

A. List of Participants

(Note: For e-mail, use the usual LTERnet naming scheme, e.g. dhenshaw@LTERnet.edu.)

AND: Don Henshaw

AND: Susan Stafford

ARC: Jim Laundre

BNZ: Darrell Blodgett

CDR: Clarence Lehman

CWT: Brian Kloeppel

HBR: NONE

HFR: Rich Lent

JRN: John Anderson

KBS: Sandy Halstead

KNZ: NONE

LUQ: Eda Melendez

MCM: Ken McGwire

NCEAS: Matt Jones

NET: Caroline Bledsoe

NET: Rudolf Nottrott

NET: John Vande Castle

NTL: Barbara Benson

NTL: David Bolgrien

NTL: Maryan Stubbs

NWT: Mike Hartman

ORNL: Dick Olson

PAL: Karen Baker

SEV: James Brunt

SEV: Jim Gosz

SGS: Chris Wasser

VCR: John Porter

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Table of Contents

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B. 1996 LTER Site Flashes

**Andrews Experimental Forest (AND): Don Henshaw, Susan Stafford, Gody Spycher**

The most significant event of this past year was the Flood of February, 1996, which resulted in numerous debris slides and debris flows. The flood was triggered by 13 inches of rain on top of 8-10 feet of snow at the higher elevations in the Andrews Forest. Damage estimates exceed one-half million dollars to roads and watershed research facilities including the destruction of the gauging station at watershed #3. Strong research interest in the effects of the flood led to considerable hydrology and

geomorphology activities this past summer and the development of a flood webpage.

The Andrews LTER4 proposal was completed in January and funded. It is clear that the World-Wide Web (WWW) is now a critical component of LTER proposal and site reviews, and that the perception of data management at a site will be largely based on a site's webpages. This review process has awakened our P.I.'s to the importance of the WWW as a means of educating NSF reviewers and the public about our LTER site. The review process also led to some discussion about the Andrews data management site policy with respect to which and when datasets are made publicly available on-line.

Information Access: We have expanded information access on our web homepage (**http://www.fsl.orst.edu/lter**). New additions include pictures and descriptions of the Flood of 1996, the LTER4 proposal, expanded Andrews Forest meteorological and hydrological data and metadata, and most recently a series of research reports on our efforts of regionalization.

Eco-Informa: Susan Stafford will chair a session with John Vande Castle on Managing Long-Term Ecological Information at Eco-Informa '96. Susan will also present a paper with James Brunt and Barbara Benson on Training Information Scientists of the Future. Gody Spycher, Don Henshaw, and Susan from the Andrews collaborated with Judy Cushing and Nalini Nadkarni from the Wind River Crane Research Facility on a poster paper for Eco-Informa devoted to issues of data validation, federation, and migration.

Andrews Information Management: We are looking very seriously at establishing our core LTER databases in Microsoft's SQL Server running on Windows NT. Our data production will remain in FoxPro, but datasets will be archived on SQL Server. Webserver or an equivalent tool will be used for distributing data on the web.

Field Station notes: The Flood of 1996 was an extreme test of our meteorological and hydrological stations and their data access using radio telemetry. During the heavy snowfall of January and the flood of early February, access to these stations went from very limited snowcat access to no access due to road and bridge failures. Fortunately, the stations operated surprisingly well, and we were able to monitor precipitation and critical snow pack water equivalence at the high elevation sites from the Andrews headquarters with radio telemetry, and even from the lab in Corvallis via our netblazer modems.

**Arctic Toolik Lake (ARC): Jim Laundre**

The field season went well this summer. Although we had a cool summer and early August snowfalls almost everyone reported having a successful summer field season. Among the visitors to the field station this year was Mike Ledbetter, Tom Pyle, Doug Siegel-Causey , and Altie Metcalf from the NSF Office of Polar Programs (OPP). Mike Ledbetter is director of the Arctic System Science (ARCSS) Program. The ARCSS Program goals are: to understand the physical, chemical, biological, and social processes of the arctic system that interact with the total earth system and thus contribute to or are influenced by global change, in order to advance the scientific basis for predicting environmental change on a decade to centuries time scale and for formulating policy options in response to the anticipated impacts on humans and societal support systems. Several ARC LTER investigators receive ARCSS and OPP support for projects that extend and compliment the core LTER research goals. The permanent data archive for all components of the ARCSS Program. is the Arctic System Science Data Coordination Center at the National Snow and Ice Data Center (NSIDC), University of Colorado at Boulder.

The upgrading of the Toolik Lake field station is continuing with new phone lines, a storage building, generators, and dorm rooms all slated for the next stage of development. New phone lines made e-mail connections less congested this past season but data transfer will have to wait until Alaskacom upgrades the microwave backbone.

Chris Harvey, who has been responsible for coordinating stream research and organizing the stream data is leaving to go to graduate school at the University of Wisconsin-Madison. Karie Slavik will be taking over for Chris. She was up at Toolik this summer as a summer research assistant and is looking forward to going back.

We are continuing improvements to on-line data access through HTML pages. Currently most of our data can be accessed through the web. We continue to work on getting older datasets organized and on the web as time permits. All newly collected data is checked and put on the web with access restricted to ARC PIs for one year to allow them to verify and correct the data. We presently use a perl script to parse the metadata files into hypertext and create links to the comma delimited data files. Future work calls for refining the script to link other fields in the metadata file to the appropriate data, e.g. PI information, bibliographic references, etc. We are also working on adding the abstracts to our bibliography.

The GIS data covering the LTER ARC Toolik Lake study area and the Kuparuk River watershed to the Arctic Ocean are on-line through the Arctic System Science (ARCSS) Data Coordination Center. Donald (Skip) Walker, INSTAAR, University of Colorado provided the ARC/INFO coverages through ARC LTER and NSF/ARCSS/LAII funds. These files contain information

on vegetation, geomorphology, hydrology, elevation, and geology. ARC/INFO coverage of the Alaska North Slope study site (1:250, 000) and 3 ARC/INFO coverages of the Toolik Lake study site (1:25,000, 1:5000, 1:500) are available via FTP.

**Bonanza Creek (BNZ): Darrell Blodgett**

PEOPLE:

Lead PI Terry Chapin is now the lead PI of the Bonanza Creek LTER site.

Coop Unit: The US Forest Service closed down the Institute of Northern Forestry (INF provided 1/2 the support needed for LTER projects), but established a new co-operative unit between UAF and The Forest Service to continue support of the LTER site.

Mini-Symposium: Bonanza Creek LTER mini-symposium "Past Results and Future Direction"s. held last October 25-26 1996. PI`s and students gave talks on what they were doing, and planned to do in the future. I gave a talk on Data Management Needs and Opportunities. The results of my talk include a renewed push to get data on-line, and the establishment of a data management protocols committee; (trying to get assistance, feedback and ideas for data management, the Web Server etc.) .

ON-LINE DATA:

45 data sets on-line, 46 Projects documented on-line. During the Bonanza Creek LTER mini symposium last week, I displayed a table of who had submitted data sets from the group, as well as information about how many data sets had been submitted in the year since the mid-term review(11). There is now a renewed push to get data on-line, and there should be a lot of new data coming on-line in the next few weeks.

Organization of On-line Data: We reviewed the way the other sites had organized their on-line data and we decided on displaying a category, then the links to the data sets belonging to that particular category. We also determined to convert data sets to comma-delimited ASCII form.

Bibliography on the move: My plan to move our bibliographic information from procite on a PC to something that is accessible through the web has been moved up since the mini symposium. Expect it to be on-line at Bonanza Creek web site in the coming weeks.

HARDWARE:

Sparc Server 3000: We are in the process of upgrading our SparcServer 690 MP to a SparcServer 3000. The SparcServer 3000 is on site but not installed. The upgrade was paid for by other units at UAF who have been sharing and housing our server as well as paying the hardware & software maintenance contracts.

Jukebox: Our Alphatronix optical jukebox died, and is still down due to the cost of repairs. It requires a customer engineer to visit our site the cost of which gets very close to the cost of a new unit.

Disk Drives: We have purchased 2 4 gigabyte drives and 2 3 gigabyte drives to enhance our on-line storage capabilities.

SOFTWARE:

Windows 95: We upgraded many of our users to the Windows 95 operating system. The network support built in to Windows 95 enabled a very user friendly and efficient sharing of network resources.

SAMBA: We are now running Samba on several of our Sun Workstations, and will be running it on our new server when it is brought on-line. Samba is a free for non-commercial use application that runs on UNIX platforms. It allows our windows 95 users to transparently access sun workstation shared resources, and provides UNIX client software to access Windows 95 shared resources. It seems to be more efficient than PCNFS, and definitely less costly. Samba enables backup of user's PC's to a 7 gigabyte tape drive connected to the data management Sun workstation.

MSQL: I had looked at MSQL a while ago, but had decided that because it did not support compound keys, and had limited data types (no date data type) it was not the SQL database to build our data management system around. The key for much of our data would require a compound key of site and date. After John Porter started using it, I decided to take another look at it. I played around with creating and loading tables (not the most efficient, but feasible), and using WWW-MSQL (very simple). I also saw that the next version of MSQL will support compound keys(site,date). The problems with the big database engines, Ingres,

Oracle etc., are Cost, System overhead, and support personnel needed. Our Scientists have enough to do without learning SQL, and we are lacking in support personnel to develop large database applications (user interface, query engines, report generation). It isn't enough just to have data in a database, there must be ways for users to easily retrieve information from it.

SOLARIS: We still only have one of our Sun systems upgraded to Solaris(2.5). Due to the project to upgrade our server to a SparcServer 3000, and the many difficulties in going from SunOs to Solaris, we decided to wait on upgrading our systems. The problem is with legacy hardware, some hardware will be lost in the upgrade of several of the systems.

**Cedar Creek (CDR): Clarence Lehman, Charles Bristow**

This year, the major field studies started in 1994 demonstrated connections between biodiversity and ecosystem functioning (productivity, nutrient retention, disease susceptibility, etc.). This is said to be the first clear field demonstration since Darwin initially suggested such a connection (See Kareiva, *Nature* 379:673-674 and Culotta, *Science* 273:1045-1046 for background; Tilman, Wedin, and Knops, *Nature* 379:718-720 for details). Also, long-term studies on herbivory showed strong indirect connections between herbivory and productivity (Ritchie and Tilman, Ecology 76:2648-2655).

As our biodiversity studies continue, we have expanded our summer field staff to over 50 persons collecting data, weeding, seeding, and so forth, under the direction of Johannes Knops. After two years success with hand-held computers (HP100s) for data gathering in the field, we have this year expanded to more of them (HP200s) and upgraded to a new data gathering program (declare), which is more versatile and easier to use. We also have upgraded to completely new versions of our soil nitrogen program and our weighing program, and have expanded the number of computer-driven scales in use.

After last field season, we established a Cedar Creek web site describing most of our active experiments, and are continuing to expand that. To make it easier to establish relatively regular sets of pages describing the experiments, we developed a set of Unix filters to convert annotated text files to linked HTML pages, eliminating much of the tedium of creating tables and linkages.

For the first time this summer, a Sun computer with local network at the Cedar Creek field station was in use throughout the field season. A new package we write called MIRRIM automatically copies modified files from the campus computers to the field station each night for off-site backup. We also started very-long-term data archiving with a new printed data method called PERM1.

Finally, this fall we are beginning a large-scale experiment on the effects of elevated carbon dioxide on plant functions, hoping to contribute to understanding of future global change. This is supported on the TECO program by DOE, with Peter Reich being the lead PI from the Cedar Creek LTER group.

**Coweeta (CWT): Gil Calabria, Brian Kloeppel, Ned Gardiner**

PEOPLE:

Dave Coleman and James Vose have taken over for Judy Meyer and Wayne Swank as lead PI's.

SITE ANNUAL MEETING:

We had a very exciting annual meeting this year while updating our 30 PI's on the progress of everyone's research. We had about 35 oral presentations and 10 posters presented. Paul Boastad, one of our Co-PI's, also gave us a presentation on GIS resources available to all Coweeta Co-PI's. He also distributed a copy of the Coweeta Vegetation Map developed from over 400 long term vegetation plots at Coweeta. This vegetation map is available on-line.

THE COWEETA ON-LINE DATA SETS PAGE:

This is the heart of the Coweeta Information System. It is here that we have linked raw data and metadata with their respective supporting publications and PI's information. Currently we have 63 data sets publicly available on-line.

We also have a restricted area with all the ongoing research data. This was created to facilitate research communication, and as a tool to gather metadata data and supporting materials. We are currently developing on-line tools to automate QA/QC procedures and generate sas graphic outputs on-the-fly.

NEW DATABASE DESIGN:

At the creation of the Coweeta DM/GIS lab in 1989, we envisioned a Information System (IS) which linked a relational DB

package (in our case Ingres) with an Statistical Tool (SAS) and a GIS tool (ARC/INFO). A lot of energy was spent trying to link these systems using built-in gateway modules. Unfortunately, these gateways did not deliver the magic it promised. So for the past 5 years, the Coweeta Information Management System has dropped the Relational approach (Ingres) and used the SAS engine for both data archival and QA/QC. The GIS layer was linked to the SAS initially with X-emulation tools, and more recently using the web as the front-end.

This approach has been very successful at the site level, but is not very effective when trying to link data from other lter sites. Hence we are now trying to bring the relation approach back, by working with the "new and improved" OpenIngres DB.

DB FRUSTRATIONS:

Again, the Coweeta Information Management Personal have spent an incredible amount of energy trying to work with Ingres "Support" to make sure OpenIngres can interface with both ARC/INFO and SAS directly. This has been a very slow and frustrating process to say the least. Specially since it has taken four different shipments from Computer Associate for us to get the correct binaries and license codes for OpenIngres...Quite a disappointment coming from a company with CA's reputation.

It has been our experience that unless our IMS front-end is a "point- and-click" interface, the PI's will just not use it -- and I don't blame them! And again we've been very disappointed with the current lack of tools provided by CA to integrate OpenIngres with the web..."Tools are on the way", as they say.

We started looking at CA's new Object-Oriented DB product called Jasmine. And although it supports all "multimedia" data types, its web interface would require more programming than our lab would like to develop. (Besides we are not sure we would like to continue our relationship with Computer Associates!)

So, it was with great delight that we found out VA Coast is already using MSQL as their relational DB engine. We have been flirting with MSQL for awhile now. We have seen some limitation, but we were extremely impressed (and excited) with its "simplicity"...At this point it really sounds like music: s-i-m-p-l-i-c-i-t-y!)

NETWORK IMPROVEMENTS:

As of this April, we are no longer using the 800 number provided by the network office to link the Coweeta Hydrologic Laboratory to our facilities at UGA. With funds from both USFS and NSF/LTER, the Coweeta field station has been wired with a fiber-optic backbone, and it is now directly connected to the Internet via a 56Kb-leased line.

As expected, this new network connection has greatly improved the link between Coweeta and UGA. For instance, it has greatly facilitated site-logistics: on-line van and dorm reservation, road condition reports, etc. It also had a tremendous positive impact on data collection, data documentation, and data archival. As already mentioned above, we are busy developing web pages to automate data QA/QC procedures, and display data graphic checks on-the-fly. These tools were just not effective with slow dial-in lines.

GIS EFFORTS:

Our focus for GIS this fall has been to develop a more convenient access point for PIs, students, and the world for Coweeta GIS data. We have made all of our existing map products available to the Coweeta PIs, and we plan to make these available on the main GIS page of our web site as soon as we have completed some internal QA/QC. Look for a revamped GIS page by the first of the year, including many new map products, downloadable postscript versions, a new data request form and interface, and documentation- of research depicted in each map. This should facilitate others' use of our field and GIS data through ease of access. As always, we welcome comments.

**Harvard Forest (HFR): Richard Lent**

SITE NEWS

Harvard Forest hosted a very successful fall LTER Coordinating Committee Meeting, October 2-6, 1996. The meeting featured a science workshop on the topic of Regionalization and Regional Studies at LTER sites. This particular topic was selected for various reasons, including: regional studies are an important part of most LTER programs and the two augmented sites; many important environmental and disturbance processes operate at landscape to regional scales; there is increasing societal need for broad-scale ecological information; and the LTER program has some important approaches and case studies to share with the larger ecological community.

Harvard Forest received a major donation this year in the form of a large farmhouse from the family of Professor R. T. Fisher, the first director of Harvard Forest from 1907-1934. With funds from an NSF Facilities Grant, the Fisher House is currently being extensively renovated. Acquisition of the Fisher House greatly increases our space for student and visitor housing, meetings, and other activities.

Researchers at Harvard Forest are working on an LTER synthesis volume. Development of the book is being aided by its existence on-line, using a password-protected web page accessible primarily to authors and editors. Chapter topics include disturbance processes and forest dynamics; physical and biological setting; environmental and cultural history of New England; forest responses to environmental change and disturbance; legacies of historical change in the modern forest landscape; forest response to natural and experimental manipulations; synthesis, modeling and regional applications; and implications for theory and application.

The 8th annual Harvard Forest Ecology Symposium is scheduled for 4 February 1997. HFR scientists and collaborators have contributed 59 abstracts of research in progress at the Forest. Proceedings from the symposium will be made into a hypertext document and posted on our Web site.

INFORMATION MANAGEMENT

Harvard Forest continues to expand its on-line information system (http://lternet.edu/~rlent/hfrhome.htm). Our on-line data catalog is being reorganized and expanded, with ASCII data files organized by research topic and by investigator and managed via HTML pages. Major research areas that will be represented include meteorological data, GIS layers, retrospective studies, experimental manipulations, forest structure and process, modeling and regionalization, software, comparative cross-site studies, population biology, and biodiversity. We will use our Web site as a critical part of our upcoming LTER site review in June 1997.

In parallel to development of our electronic data catalog, the Harvard Forest Archives have recently been completely renovated. The three-room facility, newly constructed with funding from the National Science Foundation, is housed in a building adjacent to the Shaler Hall headquarters building. One room is a general-purpose workspace including drafting, cartographic, and photocopy facilities as well as a networked computer. A second room is the primary storage area for archival materials, with a third room for storage of materials that are accessed less frequently. An archive facility for research samples, also newly-constructed, is in a room adjacent to the main Archives. Older datasets currently stored as paper files in the Archives are being prioritized for computerization. A database of samples stored in the new sample archive facility is being designed.

**Jornada (JRN): John Anderson and Barbara Nolen**

As we enter the third year of our third funding cycle for the Jornada LTER, we are continuing the expansion of on-line availability of data and site information with the on-going development of our web page and are currently upgrading our server and its capabilities to facilitate expected developments in data query-ability via the Internet. The new server is a Compaq Proliant 1500, Dual 166Mhz Pentium Pro processors, running Novell Netware v4.1. This new server will not only be our WWW server, but also a full FTP server. Other server upgrades include automated tape library system, consisting of Exabyte EXB-10h Library and Cheyenne ArcServer for Netware, Compaq 1500 UPS, and 13GB storage space.

Kevin La Fleur has accepted another position outside the LTER, so we will be advertising for a new information manager directly. John Anderson, site manager, will be representing the Jornada at the '96 Information Manager's Meeting. He has been working closely with Kevin on data management and is looking forward to the experience of the network perspective.

Climate on the Jornada for the past 2 1/2 years can be summarized nicely with a poem by Dr. Vince Gutschick:

*The rain in Spain Falls mainly on the plain On the Jornada There is nada*

But this year's climate has been quite interesting. After a very dry winter and spring (with virtually no annual plants) and 2 1/2 years of drought, the summer rainy season brought a welcome reprieve. We are above the long-term average with over 10" of rain to date on many areas of the Jornada basin. But as is characteristic of our summer convective storms, there still remain areas that are below average in rainfall for the year. However, where the rain has been good there has been excellent response and recovery by both perennial and annual plants. Grass recovery from the drought has been good in areas with above average rainfall, and, as one would expect, medium to poor in areas where rainfall has been more sporadic. So the second verse on Jornada climate becomes

*While the rain in Spain Falls mainly on the plain On the Jornada It falls wherever it wants*

In September 1995, the biannual site publication, "Jornada Trails," was introduced. It is now available at the Jornada LTER web

site, http://jornada.nmsu.edu. Featured in the most recent issue is Dale Gillette, an LTER Senior Investigator at the Jornada, who has this year established a station to provide a long-term record of wind erosion and dust transport just in time for a major dust storm with max. wind gusts clocked at over 120 mph at nearby San Augustin pass. And Curtis Monger, also featured, is looking at soil-geomorphic mapping for revealing patterns, amounts and timing of wind erosion.

Laura Huenneke has begun measurements this year on plant biodiversity sites which "test whether, and how strongly, species composition and diversity control ecosystem-level processes in Chihuahuan desert shrubland." She is also editor to a special edition of 'The New Mexico Journal of Science' which will be a collection of articles dealing with various aspects of the biodiversity of New Mexico.

We are continuing our extensive collaboration efforts with the USDA Jornada Experimental Range.

**Konza Prairie (KNZ): John Briggs**

The Konza Prairie LTER Research Information Management Program (KRIMP) was involved with two major efforts during this past year. The successful renewal of the LTER grant from NSF summarized and synthesized most of the KRIMP database. However, the greatest challenge of the KRIMP centered around assisting Konza Prairie investigators and other scientists in producing the book "Grassland Dynamics: Long-Term Ecological Research in Tallgrass Prairie". This book, a synthesis of the LTER research program on Konza Prairie over the past 13 years, was delivered to Oxford University Press. This inaugural volume of the LTER series was edited by Alan K. Knapp, John M. Briggs, David C. Hartnett and Scott L. Collins.

Both of these exercises were valuable in pointing out strengths and weakness of our current information system. Having over 90% of the Konza Prairie LTER data on-line via the WWW (http://climate.konza.ksu.edu) was a great help to the scientists and greatly aided both efforts. In addition, many investigators felt that having our detailed methods manual on-line and updated bibliography of our site publications were useful. However, it was felt that many more "intermediate products" (i.e. summaries of data sets, SAS code to analyze data sets and sometimes graphs) instead of just "raw" data sets would have assisted investigators even more. Thus, continued developments of these products will be a major focus this year.

Other tasks of the KRIMP included assisting with the Konza Prairie REU program last summer. Activities included setting up computer accounts, helping with software and hardware problems and some information management. It is hoped that these year, a course in information management system can be developed for the REU program. Briggs attended the annual meeting of Data Management for the Chinese Ecosystem Research Network (CERN) from March 29-30, 1996. In addition, he toured a variety of field sites and examined the information management system in place at these sites. The sites visited were very comparable to LTER sites in the U.S. However, internet capabilities are limited across the entire country, when compared to the U.S. It was very obvious that the workshops and trainings the CERN data managers had in the U.S. is being utilized within CERN and possibly across China as well.

**Luquillo (LUQ) : Eda Melendez**

The LUQ LTER host's, the Terrestrial Ecology Division at the Central Administration of the University of Puerto Rico has changed its name and now belongs to a different unit within the University. We are now the INSTITUTE FOR TROPICAL ECOSYSTEM STUDIES (ITES in English, "INSTITUTO PARA EL ESTUDIO DE ECOSISTEMAS TROPICALES" - IEET in Spanish), part or the Natural Science Faculty of the University of Puerto Rico at R¡o Piedras. The University of Puerto Rico is the lead institution in the LUQ LTER project with the collaboration of fifteen mainland universities including Harvard and Yale. The LTER program has provided over $4 million in research funds to the UPR and has resulted in the UPR being recognized as one of the premier sites for ecological research in Latin America.

SCIENCE BYTES

The Luquillo Experimental Forest Long-Term Ecological Research Program began in 1988 with the goal of integrating studies of disturbance regime and forest structure and dynamics with a landscape perspective. Two central research questions addressed 1) the relative importance of different disturbance types within the four tropical rain forest life zones of the LEF and 2) the importance of the biota in restoring ecosystem productivity after disturbance. The long-term monitoring program initiated as part of the Luquillo LTER was critical to the evaluation of immediate and subsequent effects of Hurricane Hugo in 1989. The occurrence of a hurricane soon after the initiation of the LTER program provides an opportunity to study the long-term dynamics of a tropical forest as it recovers from a major disturbance.

Integration of the spatial and temporal patterns of the different disturbances affecting the LEF (tree falls, landslides, hurricanes, and human land use) indicated that even the effects of large disturbances are not homogeneous over the forest landscape. A

strong gradient in damage from Hurricane Hugo occurs from northeast to southwest in the LEF, corresponding to the direction of the strongest winds. However, even in severely disturbed areas, many forest attributes were approaching their pre-hurricane values within four years of the storm. Forest response depended both on the successional status of the site at the time of disturbance and the intensity of disturbance. In many areas, the legacy of past human activities was apparent in forest composition and structure even after Hurricane Hugo.

The long-term experiments and measurements initiated in 1988 will remain the central focus of the Luquillo LTER as it moves into its second six-year phase. Analysis of the dynamics of recovery after the hurricane and its associated landslides and synthesis of the interaction of multiple disturbances continue to be the primary goals of collaborating investigators. New initiatives will concentrate on defining the distinctive characteristics of anthropogenic disturbance and on evaluating the importance of pivotal species in shaping the path of succession. As before, a major emphasis of the Luquillo LTER will be to provide information and ideas for cross-site and network-wide syntheses.

REMOTE SENSING TECHNICAL BYTES

The capabilities of the Remote Sensing and GIS Laboratory have been enhanced by the addition of storage capacity (now at 15 GB) and networking (now with three X terminals and 17 PCs) to the Sun SPARC workstation. We have also upgraded the peripherals attached to the system. In-house spatial data have increased enormously, exceeding the capacity of our on-line storage. We have added island-wide 1993-1995 SPOT imagery, both panchromatic and multispectral, and historical Landsat TM imagery, island-wide from 1984 and of the eastern half of the island from 1989. A Digital Elevation Model (DEM) of the island from 1:250,000 maps has been prepared, and we have completed 1:20,000 DEMs of selected locations. We have obtained the island-wide STATSGO soil associations digital data from the Natural Resources Conservation Service (NRCS), and we have digitized portions of the Soil Survey maps. We have also added digital versions of island-wide lifezones and geology to our holdings as part of the NASA-IRA project. Under this project we have also conducted a number of spatial analyses using Arc/Info, ERDAS, ERDAS-Imagine, and IDRISI software packages. We have ordered a Global Positioning System receiver from Trimble, which will allow us to geo-reference our spatial data with greater precision than currently possible.

One of the major achievements of the lab has been the training of undergraduate and graduate students in the use of image-processing and GIS software and the handling of large spatial data sets. Another is our success in fulfilling our many requests for spatial data in a timely manner. Immediate plans include upgrading of the PCs in the lab to be able to store and process larger data sets, and to take some of the CPU load off the SPARCstation; hiring a systems manager to handle day-to-day running of the SPARC; and upgrading to a newer and more powerful workstation with greater on-line storage capacity. We are also currently making a number of spatial products available on-line through our web page, and a goal is to make as many of the public spatial data sets as possible available to reduce the workload involved in satisfying data requests.

DATA MANAGEMENT BYTES

The DM department has been involved, as usual, in the entry, manipulation and retrieval of data to respond to the local and external requests for data and information. From the period of June 1 1995 to May 31, 1996 we have made 2 data retrievals from other sources and answered a total of 30 data sets retrievals requests (9 data sets retrievals requests from 8 LUQ investigators and collaborators, 2 data sets retrievals requests from LUQ 2 students, 2 external surveys, 17 data sets requests originated by 5 external investigators). From May to present we have made 1 data retrievals from other sources and answered a total of 20 data sets retrievals requests (2 data sets retrievals requests from 1 LUQ investigators and collaborators, 5 data sets retrievals requests from 2 LUQ students, 14 data sets requests originated by 4 external investigators), two thirds of last year's period. We first put some data on the Web in May 1995. It is obvious that the Web is keeping us busier. We are now in the process of restructuring our Home Page, such that we increase substantially the amount of on-line data sets along with their documentation (which is the hardest part to achieve). This is an effort to get prepared for our site review next June.

Data Management was involved in a proposal to enhance the communication and physical facilities at our El Verde Field Station. James Brunt was one of our consultants for the plan that issue this proposal. It was granted by NSF with a $63K for the development of the station's communication system (which at the moment depends on a cellular and a "pony express").

**McMurdo Dry Valley (MCM): Ken McGwire**

The field season has begun and many of the site investigators are currently in the field. The McMurdo Site review will be happening in January of 1997, including a field visit to the Dry Valleys site by the review team.

In April of 1996, Ken McGwire took over as Data Manager for the McMurdo LTER site. The previous data manager, Jordan Hastings, continued on with the project until June of 1996. Ken McGwire's effort in data management has focused on developing

methods for data access through the world-wide web. A Sun Sparc 5 was purchased to provide a centralized file server for scientists at DRI and web-based development activities. Samba was loaded on the Sun, providing transparent network access by PC's using the SMB protocol. Tests included a successful direct connection from the NT Pentium machine at McMurdo. A site web page was developed, with current capabilities including:

- a searchable bibliography
- a tool allowing users direct access to meteorological data from multiple stations/dates
- on-line access to aerial photography through a clickable image map
- access to data and files which were inherited from the previous data manager

Current development efforts are directed at the implementation of an object-oriented site database which will integrate access to all site data and provides:

- a data search interface to datasets based on selection by parameter, date, and location
- interactive maps displaying sampling locations for desired parameters
- refinement of search criteria based on metadata associated with each data submission
- on-demand plots of data meeting user specified criteria
- generation of customized data files and file descriptions for the user to download.

Also, we have almost completed a web-based tool for investigators to generate customized maps for their publication efforts. This latter development uses Arc/Info in a batch mode, but it is likely that this capability will be subsumed into the object oriented database interface sometime in the future. The initial versions of the object oriented database and map tool are expected to be complete in December, with subsequent efforts focused on populating the database.

**Network Office (NET): Rudolf Nottrott**

Last year brought great changes to the Network Office, present and future. There was an open competition for the new Office and the LTER Executive Committee (EXEC) with Jim Gosz as chairman submitted a proposal to NSF on January 30. The EXEC proposal was on behalf of an association of three institutions - the University of New Mexico (UNM), the University of Washington (UW) and the San Diego Super Computer Center (SDSC). The site review for the new Office was conducted on June 7 at UNM in Albuquerque. EXEC won the competition, with some substantial changes to the proposed Office structure and organization, in particular that the main Office functions, including Network Information Management, are to be consolidated at UNM. There will be a 1-year transition period, starting at the beginning of February 1997, during which all operations will be moved to Albuquerque. The Office is now operating with reduced staff (Stephanie Martin has left and Lynne Hendrix is on extended leave), but we have been getting some help from Kathleen Parkhurst at UNM; Kathleen has helped with some logistical support for this Information Management meeting

We have installed a number of new servers in support of IM and electronic communication. The shift to ever more capable and powerful desktop applications is beginning to be apparent in relational database management. We have installed a Windows NT SQL server/Internet server and have begun porting parts of the LTER personnel database to this server. Two experimental interfaces are available at this point, Web interface and ODBC client interface. This technology has the potential to provide a more cost-efficient RDBMS to sites than existing commercial systems such as Oracle and Ingres. At the same time it is a fully functional RDMS with a standard SQL interface. Several sites have experimented w/ Ingres (BNZ, VCR, NET), Oracle (KNZ, NTL), and free software like miniSQL (VCR), and several others (AND, also the XROOTS group) are using SQL systems that can easily be ported to such an inexpensive server. In this environment it is realistic to undertake some test of distributed SQL operations in the coming year.

On the other end of the complexity scale (plain ASCII text), I have tested and demonstrated the feasibility of distributing existing LTER databases on WAIS servers. WAIS servers and bibliography indices were installed at NET and VCR, and at a site affiliated with the ILTER network (OTS, Costa Rica). In addition, an existing WAIS-based bibliography at another ILTER site (ERIN, Australia) was used.

A video conferencing server has been installed at ILTERnet.edu and tested between NET and VCR. While the technology is very promising for cost-effective video conferencing, the available bandwidth of the WAN Internet is presently too slow to support real-time audio. We expect this bottleneck to disappear in the next two years, however.

**North Temperate Lakes (NTL): Barbara Benson, David Bolgrien, Robin Stubbs**

We have made several enhancements to the NTL-LTER home page on the World Wide Web which significantly expand

information access. Links to the on-line data sets are found within the on-line data catalog which also supplies the supporting metadata. As part of our response to requests for biodiversity information, we provided this abstraction of the database as well. In a major new development, several prototypes (meteorological data and the bibliography) are now available on the home page which demonstrate dynamic query capability of the NTL-LTER Oracle database. The http server executes a CGI program, which then creates an HTML input form. The user fills out the HTML form and posts. The program sends the query to the database via a low-level call interface. The program gets back data from the database and formats into HTML for display to the user. The user has the option of selecting a subset of the meteorological data (subsetting by time or parameters), statistical summaries over user-specified intervals, or graphing of selected parameters.

We have performed development for long-term archiving of the NTL-LTER data by creating a script to write the Oracle tables as external text files. We run this script when the past year's data have been loaded into the Oracle database (or whenever we want to create an archive of the database). The files for archive are then written to CD-ROM.

The data management staff conducted a number of data management training workshops. A series designed for graduate students (but also attended by other staff) was modular in format to accommodate diverse needs. Modules included (1) Overview of Data Management and LTER Data Sets, (2) Oracle Data Browser, (3) Internet Tools, (4) Metadata, QC, and Intersite Issues, and 5) GIS and GPS: Techniques to Optimize the Management, Analysis and Distributions of Spatial Data. Workshops were also conducted for the staff at the field station (including Oracle Data Browser and an Introduction to Relational Databases).

The data management staff provided the data management for an international workshop held at Trout Lake Station on lake ice and climate from October 5-12, 1996. The workshop participants contributed data on lake ice phenology and climate which spanned the Northern Hemisphere. Some of the research projects resulting from the workshop include trend analysis, effects of ENSO, and process and empirical models that predict global ice phenology. The experience of managing data for this workshop raised interesting information management issues related to supporting the data needs of ad-hoc research groups. A subcommittee of workshop participants drafted a data protocol which provided a framework for data sharing. We gained insight into standard formats for exchanging data and into methods for dealing with the multiple formats in which the data actually were submitted. The group recognized the necessity of dealing with operational definitions such as defining when the lake is considered frozen (or thawed). The data management staff attempted to anticipate the analysis requirements of the workshop participants in designing flexible data structures for the centralized database and useful derived data sets generated by scripts.

The NTL-LTER site was successful in submitting a renewal proposal to NSF this year and is now starting year one of that funding cycle. The proposal is available on the NTL-LTER home page. Our augmented research theme to integrate social and natural science in the study of north temperate lakes presents a new data management challenge. New data types, such as census records, survey results, and socio-economic indicators, will need to be incorporated into our research program. As part of the augmentation of our site, four new lakes were added to the set of primary study lakes. The lakes are in the Madison area and provide a comparison of agricultural/urban watersheds with the forested watersheds studied in northern Wisconsin. This augmentation has placed additional demands on the data management staff to modify existing processing programs to incorporate new lakes into the database. Also considerable historic data exist for the new lakes and are being integrated into the data management system.

Barbara Benson, David Bolgrien, and Robin Stubbs will present papers/posters at Eco-Informa '96. Barbara will present a poster on the North Temperate Lakes LTER Research Information Management System and is a co-author on a paper to be presented by Susan Stafford on Training Information Scientists of the Future. Robin will present a paper co-authored with Barbara on Query Access to Relational Databases via the World Wide Web. David is presenting a poster on Variations in Landscape Metrics Derived from Multiple Independent Classifications (co-authored by J. Cardille, R. Wynne and J. Chipman).

**Niwot Ridge (NWT): Michael Hartman**

GENERAL ITEMS:

Our field season was "on schedule" this year, although we are still seeing some residual effects of the unusually late and heavy snow season of 1995.

The Mountain Research Station (our field headquarters) celebrated its 75th Anniversary this summer.

PEOPLE:

There have been some dramatic changes in personnel over the last year. The departure of the previous Data Manager (Rick Ingersoll) unfortunately coincided with the graduation and departure of 3/4 of the students working in the Data Management lab.

The fact that things seem to be running smoothly again is a testament to the great job that Rick did in setting up our program. An Ingersoll et al. article describing our program will be appearing in the new "Computers and Biology" department of BioScience in early spring. Hopefully this new department will be a good forum for data management information exchange.

Other personnel changes this year include the hiring of a new director (James Syvitski) for the Institute of Arctic and Alpine Research (INSTAAR), and the creation of a Systems Administrator position for INSTAAR (filled by Todd Edmands).

UPGRADES AND ADDITIONS:

This fall we upgraded our Workstation to a Sun Ultra 140, and added 2 new 4 gigabyte drives. This required that we update our operating system, so we are now running Solaris 2.5. There were some minor glitches along the way, but the transition was fairly smooth thanks to our new Systems Administrator. We also purchased a new P5-133 P.C. for our Data Management lab, as well as a scanner and a color printer.

The "Tundra Lab" on the Niwot Ridge Saddle (our main research site) was wired with power and phone lines during the summer. This will greatly expand the site's scientific capabilities. It is planned to extend the lines to the nearby subnivean shelter as early as possible next spring.

ON-LINE DATA:

We have continued to make more data sets available on-line, and have also continued to expand our web pages (http://culter.colorado.edu:1030). Notably, both our site bibliography and our data sets are now searchable by keyword and investigator via the web, and our bibliography is searchable by year as well. We have also successfully implemented the use of web forms for the collection of metadata.

GEOGRAPHIC DATA:

The Niwot Ridge GIS data have recently been made available in ARC/INFO format via our web server. Metadata for a new high resolution digital elevation model and several orthophotos that were recently donated to NWT LTER are also available now, and we hope to make the data available soon as well (once we find a good way to handle the large volumes).

**Palmer Station (PAL): Karen Baker**

The sixth field season from November 96 to March 97 begins this week at Palmer Station and plans have begun for our fifth annual January cruise. A new satellite link to Palmer station provides two 3-hr windows of Internet connectivity. This new connectivity will change our research effort in several important ways including improved logistic support and more timely help with equipment repair as well as near real time data analysis and archiving. FTP from the field is planned as a daily activity this season. In fact, the addition of a 9GB disk for LTER data storage is timely. This season will be unique in that an NSF sponsored educational activity 'Live from Antarctica' will focus on Palmer Station during the LTER season and cruise. This program creates school curriculum materials and links schools with field researchers. Investigators are currently exploring the possibility of scheduling a visit on the January 97 cruise to visit the British Antarctic Station (BAS) at Rothera, which is South of Palmer Station, in order to co-ordinate with a new time-series effort beginning at the British station this season. A data manager from BAS (Claire Swanson) and from Palmer LTER (Karen Baker) both submitted poster presentations at the Eco Informa Workshop and were able to continue an exchange of Antarctic program information begun by lead scientists over the last year also developed to summarize the seasonal station work and used to report the USAP 9596 season. Data synthesis has been promoted by a summary display of the annual regional data and a temporal panel of variables collected at the inshore stations. The development of protocol descriptions continues. The regionalization, biodiversity and climate cross-site lter activities received support from data management as did some of the papers submitted to the site's synthesis volume due out this year.

An initial analysis of satellite sea ice data using image processing techniques and graphical IDL analysis culminated in calculation of long term means. Yearly, monthly and seasonal ice indexes have been explored as methods to facilitate use of similar quantitative ice timing and magnitude information. Current historical weather records have been synthesized to produce a 22-year monthly mean against which ongoing measurements can be compared. Improvements in instrumentation and documentation have been initiated. The two automatic weather stations have had battery and transmission difficulties so are scheduled for replacement this season.

Our renewal proposal has been accepted. An addendum modification was required adding a new data policy specifying core data to be available publicly in two years in addition to a time table showing data availability. Further, it was required that data be submitted to the National Oceanographic Data Center (NODC). Contact has been initiated with NODC as well as the Joint

Environmental Data Analysis Center (JEDA) for quality control of hydrographic variables and the National office of the Antarctic Data Directory (ADDS) for Antarctic metadata.

The format developed for our cruise reports has become an emerging internal standard for our site and was used for the January96 cruise. A format was also developed to summarize the seasonal station work and used to report the USAP 9596 season. Data synthesis has been promoted by a summary display of the annual regional data and a temporal panel of variables collected at the inshore stations. The development of protocol descriptions continues. The regionalization, biodiversity and climate cross-site lter activities received support from data management as did some of the papers submitted to the site's synthesis volume due out this year.

**Sevilleta (SEV): James Brunt**

Data management continues to be in full swing at the Sevilleta LTER as Sevilleta researchers are preparing for a mid-term review next September by drafting a site synthesis volume. There will be a chapter on information management. Research at the site is focusing on actual-evapotranspiration modelling. Supporting this spatial modelling effort involves developing and tracking many Gigabytes of supporting data layers as well as field work to develop a new vegetation map. In addition, a 13-year bird record for the Sevilleta NWR has been resurrected.

All Sevilleta workstations are being migrated to Solaris 2.5 running CDE. Having a single operating system greatly reduces administration effort expended. The new operating system will support all the existing software as well as a new Oracle server. The Oracle software was acquired through the University of New Mexico's new site license. At the Sevilleta Field Station a new UltraSparc server and 16 Sun workstations have been added that complete the computing center envisioned. In addition, the Sevilleta Field station now supports a GPS community base station and has just completed a DGPS RTCM station that provides real-time correction in the field to within a meter. This system has been a real time-saver in vegetation mapping efforts. The Sevilleta Field Station recently hosted 7 Hungarian and Czech scientists and 6 U.S. data managers in a two-week training workshop that included the refinement of the Michener et. al. (In Press) metadata standards for international use.

Efforts to develop a satellite communication sytem for the Mapimi Biosphere reserve have been going slow because of equipment problems but most have now been solved. The equipment is expected to be permanently installed in January and provide Sevilleta researchers at the site with voice and data communication.

**Short Grass Steppe (SGS): Chris Wasser**

PEOPLE:

Bill Lauenroth and Indy Burke remain as Co-PIs, although they are currently on sabbatical at The Institute of Ecosystem Studies - Millbrook, NY.

SYMPOSIUM:

Last January we held our annual CPER (now SGS) symposium. It was attended by PIs from the site, LTER graduate students, Agricultural Research Service personnel, and local ranchers and farmers. These annual symposiums provide an excellent forum for exchange and communication of ideas and data regarding the shortgrass steppe of northern Colorado. In addition to formal talks, discussion groups and poster presentations made the symposium very interactive and a big success.

ON-LINE DATA:

In the past year getting all of our datafiles on-line has been a major priority. Currently we have 93 datasets available via our newly redesigned web site. In addition, we have metadata available for an additional 95 datasets. This second group of datasets includes tables that are closed to public access or have not been cleaned up for public display. Among these datasets are the 25+ year old files from the International Biome Project years.

In addition to getting the data on the web, we have been working hard at developing an interface which allows visitors to query our database. The initial version of this process has been available since April and appears to be a modest success thus far. Improvements on the way include more flexible searching and on- line graphing capabilities.

In the past year we have also completely redesigned our website. This has been a large undertaking, but it is now much more useful to the people involved with SGS LTER. Our entire personnel directory is now available via our site as is local information for SGS scientists and students. This, however, is just the start, as we are working towards using our web site as the focus for much of the information dissemination and collection that occurs at our site. In the coming year this will be one of our main

goals.

NEW DATABASE DESIGN:

During the past year we moved from storing data as ASCII text files to an Oracle relational database. This process involved getting Oracle up and running, setting up the database design and structure, and combining hundreds of text files into the current 188 Oracle tables. After some initial frustrations, the migration process was relatively painless and we are now comfortable with the new system, which is far superior to the old system.

One significant advantage for us was the fact that Oracle has developed a product called WebServer, which allows for easy connections between the WWW and an Oracle database. We have been using Oracle's WebServer since March to connect our database to the Internet. Using the WebServer product has required learning Oracle's PL/SQL, but it allows us to generate user-friendly forms and tools at our web site.

BIBLIOGRAPHY:

After much reorganization of the way our bibliographic data is stored, we moved our bibliography onto Oracle as well. The entire database is now searchable (author, keyword, and year) via our web site.

GIS:

One focus of our GIS efforts has been to put together a GIS map atlas for more effective communication of our GIS data. Phase 1 has been completed and many of our GIS maps are now available via our web site. Look for more maps to arrive in the coming year.

We are currently in the design phase of deciding how to integrate our GIS system and our database.

OTHER IMPROVEMENTS:

We finally automated our weather data collection by purchasing software from Campbell Scientific (we use their datalogger at the site) and a modem for our office here at CSU. This connection allows us to download weather values daily and update our datalogger program from CSU, rather than visiting the site. This is a huge improvement over the previous method which used a cassette tape recorder!

**Virginia Coastal Reserve (VCR): John Porter**

The past year has been a busy one at the Virginia Coast LTER. One exciting development for the project as a whole is that we are working on designing a new field laboratory. Currently we are occupying rented space in a large, renovated farm house. However, with the growth of the project, space has become increasingly limited. We have therefore obtained permission (and more importantly, funds!) to purchase land and have received a private donation to begin laboratory development. We are hoping that we will be able to have the new lab up and running within the next year.

From and information management perspective, it has also been a very busy year! An important activity has been the development of tools for using WWW-based forms. For example, annual VCR All-Scientists' Meeting research reports are now submitted directly using a WWW form. This has reduced the time needed to compile a final document from months to days as only minimal editing is required. That system uses a generalized PERL script to process text that is "cut-and-pasted" into the form. The text blocks associated with specific fields of a form are inserted into a document template to create a high-quality finished product. A table of contents entry is also automatically generated. The software used to implement this application has subsequently been used for additional meetings, and for the LTER-Wide Regionalization document.

A more sophisticated application is the new VCR Vegetation Database. This uses a low-cost SQL database linked to WWW-forms to allow customized biodiversity queries by researchers, broken down by island and taxon. The new VCR LTER Personnel Directory enlarges on that technology using WWW-forms for both input and output. Users can add or update their own entries. This system was based on a copy of the LTERNET directory that Rudolf Nottrott provided in DBASE format. PERL scripts are used to notify the LTERNET office of changes to personnel entries in the local database. This system has also been used at LUQ and KNZ LTER sites to supplement their own directory efforts.

We have also been working on expanding our scientific databases. In cooperation with The Nature Conservancy, we are producing an electronic database of 22-years of shore and waterbird data from the paper originals. The new database will be linked to GIS databases and used to test landscape-scale hypotheses. Use of GIS at the University of Virginia has reached a

critical point. There are now enough users to support a site-license for ARC/INFO. This means greater flexibility on which computers are used and facilitates more GIS activities at the field lab.

This has also been a busy year for meetings and research activities. Workshops included the MODLERS, Sun Photometer, X-ROOTS climate prototype workshop, and LTER/LMER workshops. The VCR has provided WWW support for the MODLERS and LTER/LMER workshops. We also participated in the training workshop put together by James Brunt at SEV for Hungarian and Czech scientists. For the first time, we (along with Rudolf Nottrott [NET] and Karen Baker [PAL]) presented a poster at the Ecological Society of America meeting that focused on LTER information management efforts. The response was overwhelmingly positive, with interest in both the scientific and technical aspects of information management expressed by people who stopped by the poster.

During the next year, we are undergoing a change in personnel efforts. David L. Richardson, who has been assistant information manager for the last three years is shifting into a graduate student role. Although he will be able to spend less time on WWW development, we are glad that he will still be at UVA while working on his Master's degree.

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Table of Contents

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C. "Developing an LTER Network Information System for the 21st Century": Updated draft document (J. Brunt (SEV), R. Nottrott (NET))

Introduction

The necessity of intersite research has driven the LTER mandate since intersite workshops in the early 1980's. Since then the LTER information managers have been focusing on facilitating this research. Recently, the maturation of environmental information management, and advances in technology provide an impetus to accomplish more effectively the long-standing goal of facilitating intersite research (Stafford, et al. 1994). Although computers have come a long way, the fundamentals of managing research information and developing an appropriate system for management have remained relatively stable. What has changed drastically in the last decade is researcher and community expectations. With the explosion of Internet connectivity and the emergence of the World-Wide Web (WWW), scientists, administrators, and the general public have come to expect greater access to the products of valuable research dollars. The LTER research network has a wealth of long-term data that are being collected by LTER investigators. With the publication of the LTER Catalog of Core Data Sets in 1990, this resource became more widely known within the ecological research community.

LTER Network Information System (1990-1995)

During the same period of time that the office and data managers developed the catalog of core data sets, the work of the LTER Connectivity Committee and by the sites resulted in nearly full Internet connectivity across the LTER Network. This infrastructure foundation for electronic communication and data exchange substantially enhanced the traditional means of networking. Based on this rapidly evolving infrastructure, electronic versions of the Core Dataset Catalog and the LTER Personnel Directory became available to most researchers in 1991. The evolution of those data repositories from hardcopy versions to on-line databases accessible by e-mail, FTP, Gopher, WAIS, SQL and Web information servers reflects the successful use of the latest communications technology in the integration of individual sites into a coherent research network. When the LTER All-Site Bibliography (ASB) was created in 1993, a hardcopy version was no longer considered an economical or even desirable implementation (Chinn and Bledsoe, 1997). Instead, it was implemented as a searchable on-line database from the very beginning. Improved accessibility and ease of use highlighted existing gaps in the LTER information infrastructure. Gopher and Web information servers were installed at LTERnet in 1992/93. In addition, servers were installed subsequently at most sites, simplifying access to information that is widely geographically dispersed. However, queries are still unwieldy. For example, the ASB is on-line and seeing increasing use, but has limitations in the type and number of queries that are possible. In many cases (other than with the Core Dataset Catalog, Bibliography and Personnel Directory), querying what data are available on LTER site information servers requires connections to each of the site servers individually. Many LTER datasets are available via WWW and other network information servers, but it is difficult to analyze and synthesize data from different sites because most site servers return data in different formats. The LTER data managers are committed to building a system that facilitates cross-site data exchange for intersite research, the LTER Network Information System (NIS) for the 21st Century.

Philosophy and Goals of the LTER NIS (1996-2002)

It is worth reiterating the fundamental philosophy of the LTER NIS effort is development from a research perspective. The primary function of the LTER NIS will be support of intersite research, therefore, all technical implementations will be driven by this philosophy. Development of the LTER NIS will be closely linked to efforts by various LTER cross-site and synthesis research groups. Each intersite research effort will include at least one member from the LTER information management group. Initially, intersite research groups will provide the main pool of users of new system functions and they will provide the feedback required for testing. In addition, development will be made with the recognition that information management systems are always evolving, due both to technological changes and to improvements in our understanding of how scientists most efficiently use data. The goals for this development effort are:

**Goal 1: Increase Utility of Existing System**

A basic network information system (NIS) is available to LTER researchers (eg. catalog, personnel directory, bibliography, integrated mail forwarding, and direct links to most site systems). A modular, step-by-step approach to the LTER NIS development will ensure that existing functions will be seamlessly integrated with the future system. With the objective of fulfilling its mission in information management, the Network Office will be responsible for further development of the LTERnet Network Support System to maintain and expand the following core activities:

- LTERnet Information Server with links to site and international servers
- Personnel Directory
- Core Dataset Catalog
- Cross-site Bibliography
- Satellite Imagery Archive
- Electronic Connectivity
- Query and retrieval systems to integrate these functions

**Goal 2: Increase Access and Query Capability of Intersite Data**

**Goal 3: Maintain Local Autonomy**

Research Data Management at U.S. LTER sites is carried out with common objectives in mind, but under a variety of different circumstances and constraints. There are a number of heterogeneous approaches taken to meet research objectives. Meeting standardized goals with a variety of solutions has built strength into this system. This strength needs to be maintained in the development of the LTER NIS.

System Characteristics

The Network Information System working group has developed the following functions for the LTER NIS based on input from the Information Management Committee and researchers in attendance at the Snowbird meeting in 1995. An advanced access and query capability will facilitate:

- a search for data available anywhere in the LTER network,
- combining and analyzing data from different sites,
- answering standard information requests (those requests that occur >80% of the time)
- economically building query systems for specific projects and special information requests
- automatic retrieval of data and documentation
- query, analysis and display tools that are intuitive and user friendly to researchers

In addition, the system should integrate site information systems, not replace them. The envisioned system will be a distributed system using advanced network tools that will ensure the system is useful into the coming decade. For example, network client/server technology is well suited to this application and can be implemented independent of the specific computer platform.

Participation in Standards Development and Organizations

Members of the U.S. LTER Network Information Management Committee are actively participating in developing standards for non-spatial ecological data (Michener et al. 1997). In addition, standards being adopted at the federal level are being closely scrutinized for implementation with the LTER Network (eg. FGDC, NBII, GILS, etc.). Some de facto standards that can help ensure hardware- and software-independent functionality have emerged in this area and would be considered in our design (e.g., ODBC). There are also some recent developments with potentially major implications for the way future network information systems are implemented independently of any specific hardware or software platform. In particular, executable content on Web

servers by the Java language (an open standard for programming on the Web) could be used to package data together with their metadata.

Plan for Development of an LTER-Wide NIS

Design and implementation of the LTER NIS in a modular, step-by-step fashion will require that teams of information specialists accomplish specific system parts in a coordinated way and in a predictable period of time. Such tasks will include implementation of access and retrieval functions for datasets that are standardized in terms of content and apparent format. For example, measurement procedures of net primary productivity can vary considerably among such different ecosystems as lakes (NTL) and forests (AND, LUQ) and deserts (SEV, JRN). Correspondingly the raw data reflecting those measurements may not be comparable. In this case, a team of researchers and information specialists would work with the sites to add to the NIS the capability to access productivity data and metadata in a consistent format with consistent tools from all sites. The development of an LTER NIS will depend on the efforts of many critical players: The LTER Coordinating Committee, site researchers, Network Office Staff, Data/Information Management Committee, and collaborators (e.g., SDSC). These efforts will be focused at a continuing series of workshops that will form the basis for the design, funding, and implementation of an LTER NIS. Annual meetings of the Information Management Committee and the NIS working group will serve to coordinate the effort. NIS task groups composed of researchers, data managers, and occasional consultants will provide the labor necessary to design, fund, and implement various components of the system.

The NIS working group will solicit interest from a couple of intersite research groups and hold workshops to assess researchers needs to determine what works and what does not work. These workshops can be organized in conjunction with workshops that investigate specific intersite research questions, such as climate patterns, biodiversity distribution, litter decomposition processes (LIDET) or hydrology. The CC will determine which areas to cover first and the subjects initially chosen would relate to core areas. The workshops will also address and attempt to resolve outstanding standardization issues that are relevant to how data and information are presented and distributed by the LTER NIS.

Data of interest to the group, such as the Climate Committee will be used by a task group to demonstrate present capabilities. For example, compile a Web page of all climate data available on LTER site servers, download them into spreadsheets or other applications, and graph them. The group will then evaluate the present approach for what works and what doesn't. Why is it insufficient in supporting the group's intersite research? Propose solutions to fix the shortcomings and use positive aspects in other work groups, develop an information model for the data and set a time-table for implementation. The process would then proceed with mechanisms built in for testing and feedback.

**1996**

**Workshops:**

- NIS Working Group
- Data Management Committee

**Goals:**

- Solidify basic design and implementation strategy.
- Solicit participation from intersite and synthesis groups.
- Adopt metadata standards for ecological data.
- Begin development of "distributed" bibliography.
- Continue expansion and utility of existing WWW based system.

**1997**

**Workshops:**

- NIS working group
- NIS task groups (4) (2 research, 1 bibliography, 1 publication)
- Information Management Steering Committee
- Information Management Committee

**Goals:**

- Develop information model for test research groups.

- Submit proposal to implement test group model and query system.
- Begin development of distributed data catalog.
- Continue distribution of bibliography database.
- Continue expansion and utility of existing WWW based system.

**1998**

**Workshops:**

- NIS working group (2)
- NIS task groups (4)
- Data Management Committee / National-International Symposium/Workshop

**Goals:**

- Implement synthesis group's data model and query system.
- Distributed Bibliography on-line.
- Submit proposal to distribute data catalog (and meta-data standards).
- Continue expansion and utility of existing WWW based system.

**1999**

**Workshops:**

- NIS working group
- NIS task groups (4)
- Data Management Steering Committee
- Data Management Committee

**Goals:**

- Thoroughly test synthesis group's system.
- Continue implementation of distributed data catalog.
- Re-evaluate design and implementation strategy.
- Submit proposal to develop, integrate, and distribute additional data components.
- Focus development efforts on refined design and implementation strategy.

**2000**

**Workshops:**

- NIS working group (2)
- NIS task groups (4)
- Data Management Committee / National-International Symposium/Workshop

**Goals:**

- Implement information model and query system for additional research groups
- Distributed data catalog on-line.
- Submit proposal to develop, integrate, and distribute additional data components.
- Solicit feedback on design and implementation.

**2001**

**Workshops:**

- NIS working group
- NIS task groups (4)
- Data Management Steering Committee
- Data Management Committee

**Goals:**

- Continue Implementation of additional data components.
- Submit proposal to extend information system to other networks.

**2002**

**Workshops:**

- NIS working group
- NIS task groups (4)
- Data Management Committee / National-International Symposium/Workshop

**Goals:**

- All major LTER data components on-line.
- Solicit feedback on functionality of entire system

Resources Needed from LTER Network Office

The LTER Network Office will support expansion of the existing NIS and advanced query and information systems which integrate data from the individual site information systems. The Office will support planning activities, aid in coordination of site activities, promote standards development, develop Network data sets, and provide access to software, storage and network resources. The Office funds annual meetings of the Data Managers Working Group where continued development will occur on this important project. The Network Office will fund a lead person for each of the Network Data Sets to work with LTER sites to develop standard formats for access to data in the site information management systems.

Resources Needed from LTER Network Sites

The development of a distributed system will depend upon the readiness of the site to participate but will not exclude the site's information. Sites that do not yet have full capabilities can have their contributions supported by the Office server.

Literature Cited

Chinn, H. and C. Bledsoe. 1997. Internet access to ecological information --- the US LTER All-Site Bibliography Project. Bioscience.

Stafford, Susan G.; Brunt, James W.; Michener, William K. 1994. Integration of scientific information management and ecological research. In: Michener, William K.; Brunt, James W.; Stafford, Susan G., eds. Environmental Information Management and Analysis: Ecosystem to Global Scales. Proceedings of the international symposium. 20-22 May 1993; Albuquerque, NM. 3-19. Bristol, PA, Taylor & Francis.

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Table of Contents

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D. LTER Sites On-line Datasets

Last updated: 23 July 1996 by M. Hartman

The following table summarizes the current availability, through Gopher and the World Wide Web, of documented datasets (i.e., data + metadata) across the LTER Network.

```
DATA SITE(s)

Animals

aboveground invertebrates AND, ARC, BNZ, CWT, KBS, KNZ, SGS

aquatic invertebrates AND, ARC, CWT, KNZ, NTL, PAL, VCR
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arthropods/nematodes AND, CWT, KBS, KNZ, NWT, SEV, SGS

birds AND, BNZ, HFR, JRN, KNZ, PAL, SEV, SGS, VCR

fish AND, ARC, CWT, KNZ, NTL, VCR

amphibians/reptiles AND, JRN, KNZ, SEV, SGS

mammals AND, BNZ, CWT, JRN, KNZ, NWT, PAL, SEV, SGS, VCR

Vegetation

chlorophyll ARC, NTL, PAL

plant chemistry ARC, BNZ, CWT, HBR, HFR, NWT, SGS

plant cover/composition AND, BNZ, CDR, CWT, HBR, HFR, JRN, KBS, KNZ, LUQ, NTL, NWT SEV, SGS, VCR

plant phenology ARC, CWT, HBR, KNZ, SEV, SGS

primary production/biomass AND, ARC, BNZ, CDR, CWT, HBR, HFR, KBS, KNZ, NTL, NWT, SEV SGS, VCR

Biogeochemistry

atmospheric deposition AND, CWT, HBR, KBS, KNZ, LUQ, NWT

decomposition AND, BNZ, CWT, NWT, SGS

fertilization effects ARC, BNZ, CDR, CWT. HFR, KBS, KNZ, NWT

litterfall (chemistry) CWT, HBR, KBS, KNZ, SGS

snow chemistry NWT

soil (water) chemistry ARC, BNZ, CWT, HBR, HFR, KBS, KNZ, NTL, NWT, SGS

surface water quality AND, ARC, CWT, HBR, NTL, NWT

throughfall/streamflow chemistry CWT, HBR, KNZ

trace gas emissions ARC, BNZ, CWT, NWT

physical limnology ARC, NTL

sediment (chemistry) AND, NTL

Environmental Parameters

meteorology/climatology AND, ARC, BNZ, CDR, CWT, HBR, HFR, JRN, KBS, KNZ, LUQ, NTL NWT, PAL, SEV, SGS, VCR

lake ice duration/meltout NTL, NWT

snow ablation/melt AND, NWT

snow physical properties HBR, NWT

soil moisture/water AND, ARC, BNZ, HBR, JRN, KNZ, NWT, SGS

soil temperature AND, ARC, BNZ, HBR, KNZ, KBS, NWT, SGS

stream channel profiles AND

water flow/discharge AND, ARC, CWT, HBR, KNZ, NTL, NWT

Miscellaneous

disturbance effects AND, ARC, BNZ, CDR, CWT, HBR, HFR, KBS, KNZ, NWT, SGS, VCR

fire history AND, KNZ

GIS coverage maps AND, CWT, HBR, HFR, KBS, KNZ, LUQ, SGS, VCR

global positioning systems KBS, VCR

paleoecology NWT, SGS

satellite imagery KBS, KNZ, LUQ, VCR

## E. 1996 LTER Software Survey - Table of Site Capabilities

| plat | software | AND | ARC | BNZ | CDR | SGS | CWT | HBR | HFR | JRN | KBS | KNZ | LUQ | MCM | NET | NTL | NWT | PAL | SEV | VCR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Word processing** | | | | | | | | | | | | | | | | | | | | |
| pc | framemaker | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | KNZ | --- | --- | NET | --- | --- | --- | --- | VCR |
| pc | kedit | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NWT | --- | --- | --- |
| pc | word | AND | ARC | BNZ | CDR | SGS | --- | --- | --- | JRN | KBS | KNZ | LUQ | MCM | --- | NTL | NWT | PAL | SEV | VCR |
| pc | wordperfect | AND | --- | BNZ | CDR | SGS | CWT | HBR | HFR | JRN | --- | KNZ | LUQ | MCM | NET | NTL | NWT | --- | SEV | --- |
| pc | wordstar | --- | --- | --- | --- | --- | --- | --- | --- | JRN | --- | --- | --- | --- | --- | --- | --- | PAL | --- | --- |
| pc | xywrite | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| mac | clariswork | --- | --- | --- | --- | --- | CWT | --- | --- | --- | KBS | --- | --- | MCM | --- | --- | --- | --- | --- | --- |
| mac | framemaker | --- | --- | BNZ | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | VCR |
| mac | word | --- | ARC | --- | --- | --- | CWT | --- | --- | --- | KBS | --- | LUQ | MCM | --- | NTL | NWT | PAL | SEV | VCR |
| unix | framemaker | --- | --- | --- | --- | SGS | CWT | --- | --- | --- | --- | --- | --- | --- | NET | --- | NWT | --- | --- | VCR |
| unix | roff | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | MCM | --- | --- | --- | PAL | --- | --- |
| unix | tex/latex | --- | --- | --- | CDR | --- | --- | --- | --- | --- | --- | --- | --- | MCM | --- | --- | NWT | PAL | SEV | --- |
| unix | wordperfect | --- | --- | --- | --- | SGS | --- | --- | --- | --- | --- | --- | LUQ | MCM | NET | --- | --- | --- | --- | --- |
| **Bibliographic Software** | | | | | | | | | | | | | | | | | | | | |
| pc | citation | --- | --- | --- | --- | --- | CWT | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| pc | endnote | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NTL | NWT | --- | --- | --- |
| pc | inmagic | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NWT | --- | --- | --- |
| pc | papyrus | --- | ARC | --- | --- | --- | --- | --- | HFR | --- | --- | --- | LUQ | --- | --- | --- | --- | PAL | --- | --- |
| pc | procite | AND | --- | BNZ | --- | --- | --- | --- | --- | JRN | KBS | --- | LUQ | MCM | --- | --- | --- | PAL | --- | --- |
| pc | refman | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NWT | PAL | --- |
| pc | wais | --- | --- | --- | --- | --- | CWT | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| pc | wordperfect | --- | --- | --- | CDR | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NWT | --- | --- |
| mac | endnote | --- | --- | --- | --- | --- | --- | --- | --- | --- | KBS | --- | --- | --- | --- | NTL | NWT | PAL | --- | --- |
| unix | bibix | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | PAL | --- |
| unix | bibtex | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | MCM | --- | --- | --- | PAL | SEV | --- |
| unix | local | --- | --- | --- | --- | SGS | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| unix | wais VCR | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | -- |

**Spreadsheets**

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pc | excel VCR | AND | ARC | --- | CDR | SGS | --- | --- | HFR | JRN | KBS | KNZ | --- | MCM | NET | NTL | NWT | PAL | SEV | | |
| pc | lotus --- | --- | --- | --- | CDR | --- | --- | HBR | HFR | JRN | KBS | KNZ | LUQ | MCM | NET | NTL | NWT | --- | --- | | |
| pc | paradox --- | --- | ARC | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | LUQ | --- | --- | --- | --- | --- | --- | --- |
| pc | quatropro --- | AND | ARC | BNZ | CDR | SGS | CWT | --- | HFR | JRN | KBS | KNZ | LUQ | MCM | --- | NTL | NWT | PAL | --- | | |
| pc | stata --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NWT | --- | --- | -- |
| pc | symphony --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NWT | --- | --- | -- |
| mac | clariswork s --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | MCM | --- | --- | --- | --- | --- | -- |
| mac | excel VCR | --- | ARC | BNZ | --- | --- | CWT | --- | --- | --- | --- | --- | --- | LUQ | MCM | --- | NTL | NWT | PAL | --- | |
| mac | kaleidagraph --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NWT | --- | --- | -- |
| unix | 2020 --- | --- | --- | --- | --- | --- | CWT | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | -- |
| unix | asterix --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NWT | --- | --- | -- |
| unix | exclaim/isl --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | -- |
| unix | pccalc --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NWT | --- | --- | -- |

**Statistics**

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pc | excel VCR | --- | --- | --- | --- | --- | --- | --- | --- | JRN | KBS | --- | LUQ | --- | --- | NTL | --- | PAL | SEV | | |
| pc | matlab --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | PAL | --- | |
| pc | pc-ord --- | --- | --- | --- | --- | --- | --- | --- | --- | JRN | --- | --- | LUQ | --- | --- | --- | --- | --- | --- | --- | -- |
| pc | sas VCR | AND | --- | BNZ | --- | --- | CWT | --- | --- | --- | KBS | KNZ | LUQ | --- | --- | NTL | NWT | --- | --- | | |
| pc | sigmaplot VCR | --- | --- | --- | CDR | --- | --- | --- | HFR | --- | --- | --- | LUQ | --- | --- | --- | --- | PAL | --- | | |
| pc | splus --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | MCM | NET | NTL | --- | --- | --- | | |
| pc | stata --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NWT | --- | --- | -- |
| pc | statgraphics --- | AND | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | -- |
| pc | systat --- | AND | ARC | --- | --- | --- | --- | --- | HFR | --- | KBS | --- | LUQ | MCM | NET | NTL | NWT | --- | --- | | |
| mac | cricketgraph --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NTL | NWT | --- | --- | |
| mac | deltagraph --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | KBS | --- | --- | --- | --- | --- | --- | NWT | --- | --- | |
| mac | kaleidagraph --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NWT | --- | --- | -- |
| mac | matlab --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | PAL | --- | |
| mac | powerpoint VCR | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | LUQ | --- | --- | --- | NWT | --- | SEV | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mac | statview | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NTL | NWT | PAL | --- |
| mac | superanova | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NTL | --- | PAL | --- |
| mac | systat | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | KBS | --- | --- | --- | --- | NTL | --- | PAL | --- |
| unix | blss | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NWT | --- | -- |
| unix | cdrlib-inh s | --- | --- | --- | CDR | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | -- |
| unix | idl | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | PAL | -- |
| unix | imsl | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | -- |
| unix | matlab | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NWT | PAL | --- |
| unix | sas | --- | --- | BNZ | CDR | --- | --- | --- | --- | JRN | KBS | KNZ | --- | --- | --- | --- | --- | --- | SEV VCR | |
| unix | splus | AND | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NET | --- | NWT | PAL | --- | |
| unix | spss VCR | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | -- |
| unix | stata | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NWT | --- | -- |
| unix | statistix | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | -- |
| unix | superpaint | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NWT | --- | -- |
| unix | systat | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | LUQ | --- | --- | --- | --- | --- | --- | -- |
| unix | xplot | --- | --- | BNZ | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | -- |
| ibm | bmdp | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | KNZ | --- | --- | --- | --- | --- | --- | --- | -- |
| ibm | sas | --- | --- | --- | --- | --- | --- | --- | --- | JRN | --- | --- | --- | --- | --- | --- | --- | --- | --- | -- |
| ibm | spss | --- | --- | --- | CDR | --- | --- | --- | --- | --- | --- | KNZ | --- | --- | --- | --- | --- | PAL | --- | |
| vms | sas | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | -- |

**Graphics**

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pc | deltagraph | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | KBS | --- | --- | --- | --- | --- | --- | --- | -- |
| pc | canvas | --- | --- | --- | CDR | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | -- |
| pc | excel | AND | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | PAL | --- |
| pc | foxpro | AND | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | -- |
| pc | grhpd prism | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NWT | --- | -- |
| pc | harvard | AND | --- | --- | --- | --- | --- | --- | HFR | --- | --- | --- | --- | --- | --- | NTL | --- | --- | --- | |
| pc | lview | AND | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | LUQ | --- | --- | --- | --- | --- | --- | |
| pc | matlab | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | PAL | -- |
| pc | paradox | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NWT | --- | -- |

| | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| - | --- | | | | | | | | | | | | | | | | | | | | | | |
| pc | quatropro | --- | --- | --- | --- | SGS | --- | --- | --- | JRN | --- | --- | LUQ | MCM | --- | NTL | --- | PAL | --- | --- | | | |
| pc | sas-graph | --- | --- | --- | --- | --- | CWT | --- | --- | --- | --- | KNZ | --- | --- | --- | NTL | --- | --- | SEV | VCR | | | |
| pc | sigmaplot | AND | ARC | --- | CDR | --- | --- | HBR | HFR | --- | KBS | KNZ | LUQ | --- | --- | --- | --- | --- | --- | --- | | | |
| pc | slidewrite | --- | --- | --- | --- | --- | --- | --- | --- | --- | KBS | KNZ | --- | --- | --- | NTL | --- | --- | --- | --- | | | |
| pc | sygraph | --- | --- | --- | --- | --- | --- | --- | HFR | --- | --- | --- | --- | --- | --- | NTL | --- | --- | --- | --- | | | |
| pc | sysgraph | --- | --- | --- | --- | --- | --- | --- | --- | --- | KBS | --- | LUQ | --- | --- | --- | --- | --- | --- | --- | | | |
| pc | tellagraf | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | SEV | --- | | |
| mac | clariswork-s | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | MCM | --- | --- | --- | --- | -- | | | | |
| mac | cricketgraph | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NTL | --- | PAL | --- | | | | |
| mac | deltagraph | --- | --- | --- | --- | --- | --- | --- | --- | --- | KBS | --- | --- | --- | --- | NTL | --- | PAL | --- | | | | |
| mac | excel | --- | --- | --- | --- | --- | --- | --- | --- | --- | KBS | --- | LUQ | --- | --- | NTL | --- | PAL | --- | | | | |
| mac | image | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | -- | | | | |
| mac | macspin | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NTL | --- | --- | -- | | | | |
| mac | matlab | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NTL | --- | PAL | --- | | | | |
| mac | wingz | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | PAL | -- | | | | |
| unix | framemaker | --- | --- | BNZ | --- | SGS | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | VCR | | | | |
| unix | gmt | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | PAL | -- | | | | |
| unix | idl | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | PAL | -- | | | | |
| unix | khoros | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | KNZ | --- | --- | --- | --- | --- | --- | SEV | | | | |
| unix | matlab | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NTL | --- | PAL | --- | | | | |
| unix | temple | --- | --- | --- | --- | SGS | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | -- | | | | |
| unix | sasgraph | --- | --- | --- | CDR | SGS | --- | --- | --- | --- | --- | KNZ | --- | --- | --- | --- | --- | --- | --- | | | | |
| blnk | sdkgraphs-rv | AND | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | -- | | | | |

**Drawing**

| | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pc | adobe-photo | AND | --- | --- | CDR | --- | --- | --- | HFR | JRN | --- | --- | LUQ | --- | --- | --- | --- | --- | --- | | | | |
| pc | aldus-free-ha | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NWT | --- | -- | | | |
| pc | coreldraw | --- | --- | --- | --- | --- | --- | --- | HFR | --- | --- | --- | --- | MCM | --- | --- | NWT | --- | --- | | | | |
| pc | freelance | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | PAL | -- | | | | |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pc | onyx-posters | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NWT | --- | --- | |
| pc | slide | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NWT | --- | --- | |
| pc | superpaint | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | LUQ | --- | --- | --- | --- | --- | --- | |
| pc | view | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | LUQ | --- | --- | --- | --- | --- | --- | |
| mac | aldus-freeha | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NWT | --- | --- | |
| mac | adobe-illust | --- | --- | --- | --- | --- | --- | --- | --- | --- | KBS | --- | --- | --- | --- | --- | --- | --- | --- | |
| mac | adobe-photo | --- | --- | --- | --- | --- | --- | --- | --- | --- | KBS | --- | LUQ | --- | --- | --- | NWT | --- | --- | VCR |
| mac | canvas | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | LUQ | --- | --- | --- | --- | --- | --- | |
| mac | macdraw | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | PAL | --- | |
| mac | superpaint | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NWT | PAL | --- | |
| unix | coredraw | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | MCM | --- | --- | --- | --- | --- | |
| unix | xfig | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NWT | --- | --- | |
| unix | xvgr | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | MCM | --- | --- | NWT | --- | --- | |

**Databases**

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pc | access | --- | --- | --- | --- | SGS | --- | --- | --- | --- | --- | KNZ | --- | --- | --- | --- | --- | PAL | --- | |
| pc | dbase | --- | --- | BNZ | --- | --- | --- | HBR | HFR | --- | --- | KNZ | --- | --- | NET | --- | --- | PAL | --- | VCR |
| pc | foxpro | AND | --- | --- | --- | --- | --- | --- | --- | JRN | --- | --- | --- | MCM | --- | --- | --- | --- | --- | |
| pc | ingres | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NET | --- | --- | --- | --- | |
| pc | oracle | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NTL | --- | --- | --- | |
| pc | paradox | --- | ARC | --- | --- | --- | --- | --- | --- | --- | --- | --- | LUQ | --- | --- | --- | NWT | --- | --- | |
| mac | ingres | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |
| mac | oracle | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |
| unix | arcinfo | --- | --- | --- | --- | --- | CWT | --- | --- | --- | --- | --- | --- | MCM | --- | --- | --- | --- | --- | |
| unix | cdrlib | --- | --- | --- | CDR | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |
| unix | informix | --- | --- | --- | CDR | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |
| unix | ingres | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | MCM | NET | --- | NWT | PAL | --- | |
| unix | kman | --- | --- | --- | CDR | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |
| unix | msql | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | VCR |
| unix | oracle | --- | --- | --- | --- | SGS | --- | --- | --- | --- | --- | KNZ | --- | --- | --- | NTL | --- | --- | SEV | |
| unix | postgres95 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | MCM | --- | --- | --- | --- | --- | |

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| - | --- | | | | | | | | | | | | | | | | | | | | |
| unix | rdb | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| SEV | --- | | | | | | | | | | | | | | | | | | | | |
| unix | sas | --- | --- | --- | CDR | --- | CWT | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| --- | | | | | | | | | | | | | | | | | | | | | |
| unix | sql | --- | --- | --- | CDR | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | -- |
| - | --- | | | | | | | | | | | | | | | | | | | | |
| unix | sybase | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | -- |
| - | --- | | | | | | | | | | | | | | | | | | | | |
| vms | ingres | --- | --- | --- | --- | --- | --- | --- | --- | --- | KBS | --- | --- | --- | --- | --- | --- | --- | --- | --- | -- |
| - | --- | | | | | | | | | | | | | | | | | | | | |

**GIS**

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pc | arcinfo | --- | --- | --- | CDR | SGS | --- | HBR | --- | JRN | KBS | --- | LUQ | MCM | --- | NTL | --- | PAL | --- | | |
| --- | | | | | | | | | | | | | | | | | | | | | |
| pc | arcview | --- | --- | --- | --- | --- | --- | --- | HFR | JRN | --- | --- | --- | MCM | --- | NTL | NWT | PAL | --- | | |
| VCR | | | | | | | | | | | | | | | | | | | | | |
| pc | epp172 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NTL | --- | --- | -- | | |
| - | --- | | | | | | | | | | | | | | | | | | | | |
| pc | erdas | --- | --- | --- | --- | SGS | --- | --- | --- | JRN | --- | --- | LUQ | --- | --- | NTL | --- | --- | --- | | |
| VCR | | | | | | | | | | | | | | | | | | | | | |
| pc | erdas-imag | --- | --- | --- | --- | --- | --- | --- | --- | JRN | --- | --- | --- | --- | NET | NTL | --- | --- | --- | | |
| --- | in | | | | | | | | | | | | | | | | | | | | |
| pc | grass | --- | --- | --- | --- | --- | --- | --- | --- | --- | KBS | --- | --- | --- | --- | --- | --- | --- | -- | | |
| - | --- | | | | | | | | | | | | | | | | | | | | |
| pc | idrisi | --- | ARC | --- | --- | --- | --- | --- | HFR | --- | --- | --- | --- | --- | --- | NTL | NWT | --- | --- | | |
| --- | | | | | | | | | | | | | | | | | | | | | |
| pc | inhouse | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NTL | --- | --- | -- | | |
| - | --- | | | | | | | | | | | | | | | | | | | | |
| pc | khoros | --- | --- | --- | CDR | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | -- | | |
| - | --- | | | | | | | | | | | | | | | | | | | | |
| pc | map | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NTL | --- | --- | -- | | |
| - | --- | | | | | | | | | | | | | | | | | | | | |
| pc | roots | --- | --- | --- | --- | --- | --- | --- | HFR | --- | --- | --- | --- | --- | --- | --- | --- | --- | -- | | |
| - | --- | | | | | | | | | | | | | | | | | | | | |
| mac | arcinfo | --- | --- | BNZ | CDR | SGS | CWT | --- | --- | JRN | KBS | --- | LUQ | MCM | --- | --- | --- | --- | --- | | |
| --- | | | | | | | | | | | | | | | | | | | | | |
| unix | arcinfo | AND | ARC | BNZ | CDR | SGS | CWT | --- | --- | JRN | KBS | --- | LUQ | MCM | NET | NTL | --- | PAL | SEV | | |
| VCR | | | | | | | | | | | | | | | | | | | | | |
| unix | arcview | --- | ARC | --- | --- | SGS | --- | --- | --- | --- | --- | --- | --- | MCM | NET | NTL | NWT | --- | SEV | | |
| --- | | | | | | | | | | | | | | | | | | | | | |
| unix | erdas | AND | --- | --- | --- | --- | CWT | --- | --- | JRN | KBS | --- | --- | --- | --- | NTL | --- | --- | SEV | | |
| VCR | | | | | | | | | | | | | | | | | | | | | |
| unix | erdas-imag | AND | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NTL | --- | --- | SEV | | |
| VCR | in | | | | | | | | | | | | | | | | | | | | |
| unix | (e)las | --- | --- | BNZ | --- | --- | CWT | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | |
| --- | | | | | | | | | | | | | | | | | | | | | |
| unix | ermapper | --- | --- | BNZ | --- | --- | --- | --- | --- | --- | --- | --- | --- | MCM | --- | --- | --- | --- | --- | | |
| --- | | | | | | | | | | | | | | | | | | | | | |
| unix | grass | AND | ARC | --- | --- | SGS | CWT | --- | --- | --- | --- | --- | --- | --- | NET | --- | NWT | --- | SEV | | |
| --- | | | | | | | | | | | | | | | | | | | | | |
| unix | idrisi | --- | --- | --- | --- | --- | CWT | --- | --- | --- | KBS | --- | --- | --- | --- | --- | --- | --- | --- | | |
| --- | | | | | | | | | | | | | | | | | | | | | |
| unix | inhouse | AND | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NTL | --- | --- | --- | | |
| --- | | | | | | | | | | | | | | | | | | | | | |
| unix | khoros | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | |
| SEV | VCR | | | | | | | | | | | | | | | | | | | | |
| unix | sips | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NTL | --- | --- | -- | | |
| - | --- | | | | | | | | | | | | | | | | | | | | |

**Image Processing**

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| unix | envi | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NWT | --- | --- |
| unix | erdas | --- | --- | --- | --- | SGS | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NWT | --- | --- |
| unix | ermapper | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | MCM | --- | --- | --- | --- | --- |
| unix | idl | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NWT | PAL | --- |
| unix | terascan | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | PAL | --- |

**Data Entry**

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pc | c | --- | --- | --- | --- | --- | --- | --- | --- | JRN | --- | --- | --- | MCM | --- | --- | --- | --- | --- | --- |
| pc | clarion | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| pc | dbase | --- | --- | --- | --- | --- | --- | --- | HFR | --- | --- | --- | --- | --- | --- | --- | --- | --- | PAL | --- |
| pc | excel | --- | ARC | --- | CDR | --- | --- | --- | --- | --- | KBS | --- | LUQ | MCM | --- | --- | NWT | PAL | --- | |
| pc | ezentry | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NWT | --- | --- |
| pc | fortran | --- | --- | --- | --- | --- | --- | HBR | --- | JRN | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| pc | foxpro | AND | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| pc | lotus | --- | --- | --- | --- | --- | --- | --- | HFR | JRN | KBS | --- | LUQ | --- | --- | --- | --- | --- | --- | --- |
| pc | paradox-sc ri | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | LUQ | --- | --- | --- | --- | --- | --- | --- |
| pc | quatropro | --- | ARC | --- | --- | --- | --- | --- | --- | JRN | KBS | --- | LUQ | MCM | --- | --- | --- | --- | --- | --- |
| pc | quickbasic | --- | --- | --- | --- | --- | --- | --- | --- | JRN | KBS | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| pc | sas | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| mac | excel | --- | --- | --- | --- | --- | --- | --- | --- | --- | KBS | --- | --- | MCM | --- | NTL | NWT | PAL | --- | |
| mac | lotus | --- | --- | --- | --- | --- | --- | --- | --- | --- | KBS | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| vms | ingres | --- | --- | --- | --- | --- | --- | --- | --- | --- | KBS | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| vms | spreadshee t | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| unix | informix | --- | --- | --- | CDR | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| unix | inhouse | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | KNZ | --- | --- | --- | --- | --- | --- | --- | --- |
| unix | sas | --- | --- | --- | CDR | --- | CWT | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | SEV |
| DG | DGFortran | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| HP | inhouse | --- | --- | --- | CDR | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

**Modeling**

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mac | stella | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NTL | --- | --- | --- |

**Web**

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| web | gopher/srv | --- | --- | --- | CDR | SGS | --- | --- | --- | --- | KBS | --- | LUQ | --- | --- | --- | NTL | NWT | PAL | --- |
| web | netscape/s rv | AND | ARC | BNZ | CDR | SGS | --- | --- | HFR | JRN | KBS | --- | LUQ | MCM | --- | NTL | NWT | PAL | SEV | |
| web | mosaic/srv | AND | ARC | --- | --- | --- | --- | --- | HFR | --- | KBS | --- | --- | MCM | --- | --- | --- | --- | --- | --- |

**Mail**

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pc | ccmail | AND | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| pc | eudora | AND | --- | BNZ | CDR | SGS | --- | --- | HFR | --- | KBS | --- | --- | MCM | --- | NTL | --- | --- | --- | |
| pc | pegases | --- | --- | --- | --- | --- | --- | --- | --- | JRN | --- | --- | LUQ | --- | --- | --- | --- | --- | --- | --- |
| mac | eudora | --- | --- | BNZ | CDR | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NTL | --- | PAL | --- | |
| mac | pathworks VCR | --- | --- | --- | --- | --- | --- | --- | --- | --- | KBS | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| unix | elm | --- | --- | --- | --- | SGS | --- | --- | --- | --- | --- | --- | --- | --- | --- | NTL | --- | --- | --- | |
| unix | emacs | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| unix | pine | --- | ARC | --- | CDR | SGS | --- | --- | HFR | --- | --- | --- | --- | MCM | --- | --- | NWT | --- | SEV | |
| unix | mailx | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| unix | mh | --- | --- | BNZ | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | PAL | --- | |

**Newsreader**

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pc | newsyp | --- | --- | --- | --- | --- | --- | --- | HFR | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| unix | nn | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |
| SEV | --- | | | | | | | | | | | | | | | | | | | |
| unix | rn | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NTL | --- | PAL | --- |

**Revision**

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| unix | rcs | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | PAL | --- |
| unix | scsc | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

**Acquisition**

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pc | erbaboy | --- | --- | --- | CDR | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

**Windows**

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| unix | motif/cde | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| unix | openwindow | --- | --- | BNZ | CDR | SGS | --- | --- | --- | --- | --- | --- | --- | MCM | --- | NTL | --- | --- | --- | |
| unix | xwin | AND | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | MCM | --- | --- | --- | --- | --- | --- |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| unix | tktcl | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| unix | fvwm | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

**Display**

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pc | powerpoint | AND | --- | --- | --- | SGS | --- | --- | --- | JRN | --- | --- | --- | MCM | --- | --- | NWT | --- | --- | --- |
| mac | pagemaker | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NTL | --- | PAL | SEV |
| mac | powerpoint | --- | --- | --- | --- | --- | --- | --- | --- | --- | KBS | --- | --- | --- | --- | --- | NWT | --- | --- | --- |
| pc | trakker | --- | --- | --- | CDR | --- | --- | --- | --- | --- | KBS | --- | --- | --- | --- | --- | NWT | --- | --- | --- |

**Miscellaneous**

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pc | mapviewer | --- | --- | --- | --- | --- | --- | --- | HFR | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| pc | rdl-sims | --- | --- | --- | --- | --- | --- | --- | --- | JRN | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| pc | surfer | --- | --- | --- | --- | --- | --- | --- | HFR | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| dos | declare | --- | --- | --- | CDR | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| dos | soil | --- | --- | --- | CDR | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| dos | weigh | --- | --- | --- | CDR | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| unix | rolodex | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | PAL | --- |
| blnk | blis | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | MCM | --- | --- | --- | --- | --- | --- |
| blnk | cuseeme | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | NET | --- | --- | --- | --- | SEV |
| blnk | geogrphca lc | --- | --- | --- | --- | --- | --- | --- | HFR | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| blnk | mathcad | --- | --- | --- | --- | --- | --- | HBR | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| blnk | reflex | --- | ARC | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| blnk | showme | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| plat | software | AND | ARC | BNZ | CDR | SGS | CWT | HBR | HFR | JRN | KBS | KNZ | LUQ | MCM | NET | NTL | NWT | PAL | SEV |

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Table of Contents

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F. ECO-Informa Program of LTER Participation: Abstracts of presentations and posters presented at Eco-Informa '96, Lake Buena Vista, Florida, 4-7 November 1996.

F1. Contributed Papers: Abstracts (alphabetical listing by title)

### FROM PAPER TO HYPERCUBES: THE LTER DATA STORY

James R. Gosz

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**ABSTRACT**

In the late 1970s, the scientific community identified the need for long term research to more fully understand the dynamic nature of ecological systems. This was near the end of the period of the International Biological Program (IBP) which was unprecedented in terms of developing integrated programs, complex data sets and simulation models to explain complex systems. That need by the community initiated the Long Term Ecological Research (LTER) program that now consists of 18 sites in North America and Antarctica funded by the National Science Foundation. The data management identified by IBP was rarely achieved; however, the difficulty was documented in many ways and now serves as important lessons learned by this community. These lessons have been used by the current LTER community, supplemented by rapid improvements in technology, to allow important solutions to these needs. Differences in the magnitude of data to be managed also has been impressive. Data sets in IBP stored in paper on the order of hundreds of pages per year are now replaced by data sets in terabytes in LTER that would have the volume of hundreds of volumes per year. Initially, the LTER sites focussed on site-based research, however, during the recent decade it has become clear that cross-site comparisons and synthesis of information from many sites and other sources (e.g., National Weather Data Center) are crucial to understanding complex environments at broader scales. Annual data sets from remote sensing from satellites alone will be many times the volume of data from the entire IBP program in the U.S. The science needed at these larger scales led to the need for networking of scientists and sites to facilitate the exchange of data, scientific approaches and information. Exchanging these huge volumes of data multiply the difficulty of managing data sets. Electronic communication has significantly aided this effort and the development of capabilities such as Internet and the World Wide Web allow unprecedented communication and data sharing. While the majority of the environmental science community continues to practice "normal science" that is highly individualistic, unidisciplinary with little use of advanced communication and data management tools, "LTER science" has become cooperative, multidisciplinary, and made critical use of advanced tools. This has not been without cost, however. Increased infrastructure is needed at the site level as well as at the entire Network level to keep a communication system maintained and current with regard to developing technologies. Additional infrastructure also is needed at the scale of the Network to allow management of massive data sets that can be used by the entire network. The net result is a sophisticated organization and ability to make data and information available to the scientists both in the network of LTER sites and to the broader scientific community. Data management now integrates the numerous "small" data sets characteristics of many different types of ecological research with the massive data from remote sensing that requires interfaces with supercomputer centers.

- **QUERY ACCESS TO RELATIONAL DATABASES VIA THE WORLD WIDE WEB**

M. Stubbs and B. J. Benson

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**ABSTRACT**

At the North Temperate Lakes Long-Term Ecological Research site, our centralized relational database is accessible from the Internet. Initially we used Gopher to serve up flat files of data extracted from database tables to Internet users. These files must be maintained separately as the central database is updated. Such files cannot be queried or linked to provide a subset, summary or join of data files. Search and display capabilities are quite limited. We then investigated low cost methods to access our database directly and dynamically via the World Wide Web (WWW). The freeware Perl5 library called Dbperl was tested to provide HTML CGI access to our Oracle7 database. The PGPLOT.pm and CGI.pm Perl5 modules were also essential. We contrast flat file access with the Perl5 interface we developed. Now our Dbperl development enables WWW users to do interactive queries on the fly and provides the current version of the data.

- TOOLS FOR MANAGING ECOLOGICAL DATA

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R.W. Nottrott

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## Karen Baker

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## ABSTRACT

The Long-Term Ecological Research (LTER) Program is a set of 18 ecological research sites and a Network Office funded by the U.S. National Science Foundation. From the inception of the program in 1980, the LTER program has included a strong emphasis on data and information management as a crucial component of long-term research. The diversity of LTER sites (varying from arctic tundra to tropical rain forest), research questions and data collected (varying in size from <1 KB to >300 MB) demands a philosophy and structure which promotes flexibility and development of innovative solutions. This paper will focus on software tools which have become widely used within the LTER network. These include network information servers, geographical information systems, database and statistical packages as well as the myriad of smaller tools which link them together to work as an integrated whole. We will also discuss tools and approaches that we expect to become emergent standards in the future.

- **TRAINING ENVIRONMENTAL INFORMATION MANAGERS OF THE FUTURE**

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B. J. Benson

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**ABSTRACT**

Complex issues confronting scientists and policymakers require interdisciplinary collaboration and synthesis at much larger spatial and temporal scales than are typical in traditional ecological studies. In this complex research environment, all scientists need some background in bio-informatics and computational ecology. Here, we focus on the more intensive training needed for environmental information managers. "Scientific information management" is emerging as a discipline that emphasizes the effective transformation of data into information that is used to address these complex issues. Synthetic, data-intensive projects will be even more common in the future and will require trained information managers who have skills beyond the custodial and archival functions that data managers have had in the past. We outline an environmental information management training program† that will focus on the link between science and technology. Students will complete core curriculum modules offered at the University of New Mexico and Oregon State University and will then do internships at participating Long-Term Ecological

Research sites.

F2. Posters: Abstracts (alphabetical listing by title)

- **DEVELOPMENT OF PALMER LONG-TERM ECOLOGICAL RESEARCH INFORMATION MANAGEMENT**

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**ABSTRACT**

The Palmer Long-Term Ecological Research (LTER) project, established in the fall of 1990, is the seventeenth site in a network of research sites studying ecological processes over seasonal and decadal time scales. Research focuses on the pelagic marine ecosystem in the area West of the Antarctic Peninsula. Such long-term studies require site information to be recorded consistently, archived digitally, and accessed electronically. The Palmer LTER data management model includes a centralized archive and an emphasis on connectivity among participants who are widely distributed geographically. The model promotes a standard vocabulary and structure while accepting a variety of platforms and software.

- **DYNAMIC DATA TRANSFER VIA THE WORLD WIDE WEB:**

**INCREASING YOUR VISITORS' UNDERSTANDING OF ECOLOGICAL DATA**

Chris Wasser

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**ABSTRACT**

Until recently, much of ecological data presentation via the World Wide Web (WWW) has relied on the use of static text files and graphics. The advent of database connectivity tools has given ecological data managers the option of presenting data dynamically. This functionality allows visitors to select the search criteria for the data they are interested in viewing. Most importantly,

this newer, more user-friendly interface allows visitors to view only the data they are interested in - leading to greater comprehension.

Information management professionals in many other fields have embraced dynamic transfers as the key to unlocking the interactive potential of the WWW. The same is true for the communication of scientific data to the scientific community. The shift from static to dynamic data communication represents the >first wave of dynamic thinking in data presentation. Future developments include intelligent searches, on-line graphing capabilities, and other analytic tools.

- **THE LTER NETWORK INFORMATION SYSTEM FOR THE 21ST CENTURY**

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**ABSTRACT**

A major challenge to the U.S. LTER network in the coming decade is the design and implementation of an information system that seamlessly facilitates both cross-site and intra-site data exchange. The LTER information managers have formulated a vision for a network information system (NIS), and an NIS working group has been established to guide and advance the development process. In addition, future interdisciplinary NIS task groups composed of scientists from existing intersite or site research groups, information managers, and consultants will provide much of the personnel power necessary to design and implement various components of the system.

The background for and preliminary results of the NIS working group are presented. The mission of the working group is to design and develop a distributed, LTER-wide information system using a modular approach, while maintaining and building on present functionality. Queries, browsing and input of datasets and metadata located at multiple sites are essential characteristics for the system to function as an intersite research tool. Platform independence and the capability to present data and information in a consistent fashion, independent of their original format and location, are essential for the system to function in heterogeneous site environments. The information to be presented will chronicle the development of the current LTER information system, detail the planning and design of the new system, and highlight the shifts in ecological science that are driving the development and implementation of an LTER Network Information System.

- **THE NORTH TEMPERATE LAKES RESEARCH INFORMATION MANAGEMENT SYSTEM**

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**ABSTRACT**

The North Temperate Lakes Long-Term Ecological Research (NTL-LTER) project has been performing research on the long-term ecology of lakes in Wisconsin since 1981. Data and information management is an integral part of the research. The NTL-LTER data and information system is designed to facilitate interdisciplinary research. From the design of data collection, to incorporation in a centralized database, to analyses, we focus on the linkages among the components of the ecosystems we are studying. Primary goals of the information management system are to (1) create a powerful and accessible environment for the retrieval of information which facilitates linkages among diverse data sets and (2) maintain database integrity. To implement these goals, we have moved our database to a client/server environment to provide researchers with the powerful search and linkage capabilities of a relational database together with end-user query tools for simple, direct access.

- **OPERATIONAL REMOTE SENSING DATA FOR COMPARATIVE ECOLOGICAL RESEARCH: APPLICATION OF ATMOSPHERIC CORRECTION USING AUTOMATED SUN PHOTOMETERS**

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Eric F. Vermote

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**ABSTRACT**

Satellite remote sensing systems offer a standardized data source for ecological research. Atmospheric constituents, primarily aerosols and water vapor prevent use of uncorrected data in many comparative ecological studies. This paper outlines an approach for atmospheric correction of Landsat-Thematic Mapper data using inputs from automated sun photometer instrumentation. These procedures offer an operational method for producing corrected satellite data in a consistent format for ecological research. A standardized approach using a Normalized Difference Vegetation Index (NDVI) is used to demonstrate the results and significance of using the atmospherically corrected satellite data.

## SOLVING PROBLEMS FOR VALIDATION, FEDERATION, AND MIGRATION OF ECOLOGICAL DATABASES

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### ABSTRACT

The H.J. Andrews Long-Term Ecological Research site has supported production and access of ecological data for over 20 years. We have developed a flexible mechanism to generate validation code based on a standard set of metadata. This approach reduces the time required for data production and permits the maintenance of multiple databases. New challenges are migration of existing databases to include new data formats and federation of existing databases for general access. The more constrained environment of the Wind River Canopy Research Facility could be used to examine new distribution technologies and incorporate spatial data into the existing structures. Shared research sites offer incentives to individual researchers to use prescribed protocols and tools, and provide a test bed for solutions to migration and federation problems.

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Table of Contents

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