ECOLOGICAL INFORMATICS:

FINDING ANSWERS FOR LONG TERM ECOLOGICAL RESEARCH

Definition of The Issues

Complex issues confronting scientists and policy makers require interdisciplinary collaboration and synthesis at much larger spatial and temporal scales than are typical in traditional ecological studies. Synthetic, data intensive projects will be even more common in the future and require increased access to data and metadata distributed across multiple sites. The major challenge to the LTER information management group is to make information available to ecologists in forms they can locate and use. A plethora of technological tools is available to produce solutions to this challenge. Keeping abreast of the changes in technology and the potential benefits to ecologists while meeting site and network level goals is a challenge in itself. We recognize that this new science and new technology interact to evolve the role of informatics in ecology. In this complex research environment, all scientists need some background in information science and computational ecology. A third challenge to the information managers is to facilitate the development of a new generation of scientists that are "info-literate".

Statement of Purpose

Our goal is to promote ecological science by fostering the synergy of information systems and scientific research.

Vision Statements from 1996

- Pursue information systems development and implementation from the context of ecological research needs
- Conduct information management in a nested context of site, research network, national, and international levels
- Emphasize the timely and effective transformation of data into information and the ease of access to that information
- Ensure the long-term preservation and availability of information
- Ensure appropriate information system development through information management research
- Develop human resources necessary for the continuing evolution of LTER information systems

Pursue information systems development and implementation from the context of ecological research needs: We approach information management from an ecological research perspective, guiding our development by the research uses of the information system and evaluating the system implementation in the light of specific research projects. Information management is an integral part of the LTER research platform, and provides crucial infrastructure for the LTER research enterprise.

Conduct information management in the nested context of site, research network, national, and international levels: Site-oriented agendas must be balanced with broader (network, national, and international) level goals. Network solutions should consider and facilitate local site solutions while local site solutions should take into account the strategic plans developed at the network level.

Emphasize the timely and effective transformation of data into information and the general availability of that information: The LTER community expects us to continually find better ways to access and use existing data to answer increasingly complex questions with minimum difficulty. Meeting these expectations will require new data products and information interfaces. Developers of environmental databases must address many issues including the storage and integration of a variety of data types, a large range of both temporal and spatial scales and sizes, and increasingly sophisticated analytical requirements. Design of any information system must assure data quality, protection, and availability while considering cost and efficiency. While sites independently build information systems to meet their own needs, an information system at the network level may require the development and implementation of standards for LTER.

Ensure the long-term preservation and continual accessibility of information: Long-term research requires a data

management environment that provides for the long-term availability of data and metadata. Preservation implies that appropriate quality control checking has been performed on the data set, and that the associated metadata is sufficient and complete for interpretation of information in the future. Potential users of this information include scientists, academicians, managers, policy makers, as well as the public. Data publication of selected high-quality data sets should be pursued.

Ensure appropriate information system development through information management research: The information management system of the LTER must facilitate current needs, anticipate new technical horizons, and be extensible to new technology and research requirements. Research into new information system technologies must be conducted to ensure appropriate system development for LTER, with external resources cultivated when necessary. The LTER network should provide a testbed for new technological solutions, providing a means for implementation and improvement of the research platform. Publication of innovative implementations of new technology should be explored. Historically, we have explicated the necessary components each site should develop to provide acceptable data management at a site level in support of an operational network of sites, and this role will continue.

Develop human resources necessary for the continuing evolution of LTER information systems: As we move into the 21st century, we must ensure that the intellectual capital in this area exists for the next generation of long-term ecological research. We see a need to continue developing training materials and curricula in the area of information management. The Data Management Committee meetings are essential to maintaining our collective expertise, and other workshops will be necessary as we move toward a network development focus.

Status of LTER Information Science

Data and information management plays an important role at LTER sites and has since the inception. Data managers at LTER sites met formally for the first time in 1988 and have continued to meet annually. The group was established as a standing committee of the LTER coordinating committee in 1996 as demands for network information resources increased. Activities of the group focus on site and network-level data and information management issues.

Information systems designed for Ecology: LTER has pioneered the use of bottom-up and research-driven approaches to informatics. Discipline specific working groups are the key to success in developing a network information system. Information managers form the integrative "glue" that is the interoperability layer of the system. Scientists know data and its uses but do not know the information technology available to them to solve problems. Information managers know information technology but do not understand the subtleties involved in the storage and use of the data. By forming these integrative working groups, bringing together disciplinary specialists with information specialists, strong productive partnerships have been formed to solve real-world issues in ecology.

Distributed informatics laboratory: The LTER Network is a testbed for ecological information management tools and techniques. The breadth of expertise and infrastructure in the LTER network has allowed the distributed testing and evaluation of tools for ecologists without the costs of network level implementation. For example, software is most often designed for to provide business solutions, whether a given package will function as a tool for ecologists is never clear. The "LTER cycle" includes the following:

1. individual sites test different hardware and software approaches
2. successful approaches "ported to" the network and beyond
3. unsuccessful approaches are abandoned

The "LTER cycle" is being successfully demonstrated today as LTER approaches are being used at field stations and research sites around the world. LTER sites have become a distributed laboratory for the testing of informatics solutions.

Back to school: LTER information managers have been sponsoring and contributing to data management training, courses, workshops, and students for almost two decades. These activities have led to the accumulation of experiences and materials that are enabling formalization of a curriculum for next-generation scientists that melds ecology and

informatics.

One-stop shopping: The LTER information system has the goal of providing "one-stop shopping" access to ecological data and metadata. Prototypes of modules for a network information system have been developed that take advantage of the latest in web to database connectivity. These include a streamlined data catalog, site description and personnel database, and a network climate database. These systems take advantage of "centributed" mechanics, which leave the data at the site where it can best be managed while making it accessible through a common interface.

Strategic Plan

Promoting Ecological Science: LTER information managers see the importance of bringing leading edge capabilities in computing, communications, and information science to benefit and drive advances in ecological science. By recognizing that,

- Ecological Information Systems are dynamic, in a continual state of evolution and refinement, and
- Eco-Informatics is an area of active research, as well as a discipline that supports ecological research,

LTER Information Managers are preparing to meet the information challenges of the next century.

- Developing an information system from a research perspective, linking closely to cross-site research groups and collaborating partners, and
- taking advantage of improved tools and computational hardware particularly network technologies where LTER has a history of leadership,

will help to promote ecological science by fostering the synergy of information systems and scientific research.

Striking a balance: Meeting standardized goals employing a variety of site-specific solutions has built strength into the LTER Network. Given that:

- the diversity of science and organizational models at LTER sites demands flexible solutions to site information management challenges, and
- meeting network-level goals requires a minimum level of homogeneity across sites (such as a Minimum Standard Installation for Database Development and Integration),

The strategy is to find solutions that are viable and beneficial at both site and network levels by continuing to draw on the strength in diversity that is an important benefit of the LTER Network.

Training the next generation: LTER information managers have emerged as a training resource for ecological information management. Thus far, successful demonstration of the utility of this program has been through:

- outreach to biological field stations and marine labs
- forging linkages with international LTER programs

The ultimate objective being to establish a formalized curriculum and training that would function as an Ecological Informatics Institute in a distributed environment.

Needs to Achieve Objectives

These ambitious but achievable objectives can be met, but only through the commitment of individuals, sites, and the network.

1. Individuals: the commitment and personal initiative to achieve the goals set forth.
2. Site: continued support for data managers to participate in network activities.
3. Network: continued support of data management working group meetings.

Ultimately, success will rely on the individuals who commit time to the development of publications, proposals, and

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solutions.