Annual Report of the Long Term Ecological Research Network Office (2005-2006)

Introduction

This report describes activities and accomplishments of the LTER Network Office (LNO) during the period March 1, 2005 until February 28, 2006. This report follows the same format used last year to facilitate that committee's evaluation of the LNO. We present information on 1) the priorities of the LNO as described in the LNO Strategic Plan 2) a description of efforts undertaken in response to the Executive Committee's recommendations, 3) a summary of major accomplishments of the LNO during the last year, and 5) a detailed listing of activities in each of the four priority areas.

Priorities

The LNO Strategic Plan establishes four priority areas for the LNO: 1) service to LTER sites, 2) service to the LTER Network, 3) service to NSF, and 4) service to the broader scientific community. The LNO Strategic Plan further provides mechanisms to encourage participation of LTER sites, scientists, and governing bodies in defining the activities that contribute to each priority area. Specifically, the LNO will identify and document key existing and desired services through an annual survey administered to sites. Through the review procedure established in the LTER bylaws, the LNO will work with the LTER Executive and Coordinating Committees to define priority activities in service to sites and the Network. The current list of priority activities is shown in Appendix 1.

Four strategies for future LNO activities are defined in the LNO Strategic Plan: Prioritizing Work, Long Term Growth, Defining Relationships, and Increasing Impact. Actions under each of these four strategies are described in the Strategic Plan, and implementation plans for each action are being developed. The LTER Coordinating Committee approved these strategies and actions in August 2004. The LTER Executive Committee will review strategies and actions annually and suggest revisions or additions.

During 2005-2006, several of the actions proposed in the LNO Strategic Plan were completed. These included:

- Through surveys administered to individuals and sites, identify and document key existing and desired services and develop a priority list for these services (Executive Director)
- Establish process for prioritization of LNO activities in support of LTER sites, the LTER Network, NSF, and other clients (Executive Director)
- Work with the Network Information System Advisory Committee to develop IT plans that meet Network needs and address federal and international requirements (AD for Information Management)
- Document current organizational relationships and reporting structures (AD for Project Development)

- Review and implement a new organizational model within UNM (e.g. independent center) in light of objectives, including the need for a Program Manager position for day-to-day oversight of this new center (Executive Director)
- Clarify relationship of LNO senior staff to UNM by developing, testing, revising, and implementing an evaluation process for research faculty (Executive Director)

New actions will be added to the Strategic Plan based on the annual review LNO by the Network Office and the outcome of the network planning process.

Response to Executive Committee Recommendations

The EC identifies and targets the following items for attention by the LNO during 2005:

1. Procedures for document archiving, searching, and retrieval need to be improved.

Response – The LNO focused effort on revising and updating the LTER document archive with the goal of providing simple and easy search and retrieval capabilities. The document archive contains links to a series of key historical documents and should function as the primary source for LTER and non-LTER personnel seeking LTER records. Four steps were completed in 2005 in order to make the archive more accessible. A reorganization of the web page provides a more intuitive search image. A more powerful search engine improves the capability of finding specific documents, and links to new and popular additions to the archive. A new document classification was developed and implemented that better matches the more common searches. Finally, document names were standardized. See:

http://intranet.lternet.edu/modules.php?op=modload&name=UpDownload&file=index

2. LNO assistance to sites, upon request, with website development should be encouraged.

Response – The LNO has always attempted to assist sites with website development consistent with the resources available. At present, the LNO has 1.5 FTE assigned to website development and technical implementation. The primary responsibility of the these two staff members is the LTER Network and intranet web sites, and maintenance of these sites occupies most of their time. Additional sites that have been developed, implemented, or consulted on this year include the All Scientists Meeting site, the TRENDS volume site, and the site supporting the Briggs/Knapp shrub dynamics group, which group provided the focus for the science theme at the VCR CC meeting and the upcoming mini-symposium. LNO staff provided assistance to four sites (HBR, SEV, LUQ, and BES) with website development in 2005-2006, as well as assistance to numerous sites with technical questions about website implementation. All requests for assistance from sites were honored, although final resolution of some may still be pending. In addition, we provided web-based collaboration tools to the LTER Graduate Students, the LTER Planning Grant Working Groups, and LTER Information managers, created site maps for Schoolyard and ILTER web sites, and redesigned site pages for all

sites in LTER network (see http://www.lternet.edu/sites/). In addition, LNO staff played a key role in developing web site design and content recommendations for the Network.

3. LNO should continue to assist sites with EML implementation, to the degree possible given budget constraints.

Response – LNO staff have addressed EML implementation in two important ways, by providing direct assistance to sites to facilitate the implementation of EML and by providing software tools that use EML to achieve network-level data management objectives. LNO obtained funds from the National Biological Information Infrastructure program of USGS to recruit an informatics specialist, Inigo San Gil, who focuses on EML implementation. During 2005-2006, Dr. San Gil provided direct on-site and remote assistance to individual LTER sites to transform the site's metadata to the network standard, the EML. This greatly increased the level of metadata standardization in the network as well as making available a more robust search capability after the documents are harvested. Inigo worked with 23 sites on a variety of issues including Controlled Vocabulary, the LTER Metadata Catalog, LTER metadata standardization, the LTER Custom Unit Registry, and the EML 2 BDP Crosswalk. In addition, Duane Costa and Mark Servilla built on the EML standard to create the new Metacat Search Interface (see http://metacat.lternet.edu) and make improvements to the Metacat Harvester, which automatically harvests EML documents from 20 LTER Network sites and has resulted in the registration of over 3,500 metadata documents in the LTER Network Metadata Catalog. With the continuation of our NBII metadata initiative we will continue this work in 2006 focusing on including currently non-participating sites in the Metadata Catalog and increasing the richness of EML along the tiered-trajectory for each site now participating.

4. As the role of LNO continues to evolve (e.g. during the planning process), LNO should routinely clarify the roles, responsibilities, and expectations of both staff and senior management.

Response – LNO staff have been closely involved in Planning Grant activities pertinent to this recommendation. Bob Waide and John Magnuson are involved in the Governance Working Group, which is charged with evaluating the existing relationship among elements of the LTER network and recommending improvements in the governance structure. Acceptance of these recommendations by the Coordinating Committee will help refine the responsibilities of LNO staff. An explicit re-evaluation of the LNO Strategic Plan will be undertaken once the final recommendations of the Planning Grant are determined. In the meantime, the efforts of LNO staff are being re-targeted as needs arise during the planning process. For example, John Vande Castle and James Brunt have redirected effort to the Cyberinfrastructure planning element of the Planning Grant. A review of roles and responsibilities in light of Planning Grant recommendations takes place during the annual review of each staff member.

5. LNO should continue to be creative and flexible with the kinds of synthesis activities that can be funded through LNO (e.g. cross-site working group activities).

Response – The LNO determines the use of funding for cross-site working group activities on an annual basis with the LTER Executive Committee. During 2005-2006, we projected support for new working groups to total around $55,000. One of these working groups was aimed at developing the Science Theme for the VCR Coordinating Committee meeting, which subsequently formed the basis for the NSF mini-symposium in March 2006. We will re-evaluate the kinds of activities to be supported in 2006-2007 at the upcoming Executive Committee meeting.

6. The LNO Director should investigate alternative funding mechanisms for support of the 2006 All Scientists Meeting, in the event that NSF supplemental support is inadequate.

Response – The LNO developed an alternative funding plan for the 2006 ASM that was based on new funding from NSF and redirection of $75K from scheduled meetings and other LNO budget categories. This plan was presented at the VCR CC meeting. Fortunately, DEB and other NSF directorates have now agreed to supply sufficient funding to conduct the Estes Park meeting. Therefore, the alternative funding plan will not be necessary, and these funds can be used for pre- or post-ASM working groups.

Major Findings

Executive Summary

The scope and priority of activities conducted by the LTER Network Office (LNO) are closely linked to the overall objectives of the LTER Network and the tasks defined through the Cooperative Agreement between NSF and the University of New Mexico. The Scope of Work described in the Cooperative Agreement comprises ten core task areas. During the last year, the LNO has realized 20 major accomplishments related to our core task areas, as well as many achievements in response to specific tasks.

- LNO Senior Staff participated in the development of a $300,000 supplement proposal to the LTER planning grant to develop a strategic plan for Cyberinfrastructure to complement the Network Strategic Plan. This proposal was funded in June 2005, and James Brunt and John Vande Castle are among the four individuals leading this project. As part of this project, Vande Castle conducted an inventory of cyberinfrastructure capabilities at sites. LNO staff members are facilitating the organization and logistics of focus group meetings in association with this supplement as well as for the overall planning activity.

- LNO staff greatly increased the level of metadata standardization in the network by providing direct on-site and remote assistance to individual LTER sites to transform the site's metadata to the network standard EML. This effort was greatly facilitated by the ongoing NBII/LTER metadata initiative.

- LNO staff continued to make improvements and increased the participation in the LTER Network Metadata Catalog. This work has resulted in the registration of over 3,500 metadata documents from the LTER Network. The Metacat Harvester automatically harvests EML documents from 20 LTER Network sites.

- LNO staff developed an Advanced Query Interface to the metadata catalog that provides researchers the ability to formulate complex query strings when searching the LTER Metacat database to quickly narrow search results. This includes a graphical spatial search capability.

- LNO continued a major partnership with the National Biological Information Infrastructure (NBII) to develop an LTER/NBII metadata initiative and fund a new position in ecological informatics. This position, funded by NBII and occupied by Inigo San Gil, is now in its second year and expands the relationship between LTER and NBII informatics programs while providing technical support to LTER sites and information managers.

- William Michener, Associate Director for Development for LNO, served as co-director of the National Ecological Observatory Network (NEON) Project Office. This Office plays a key role in managing the NEON Design Consortium, under which NEON will be fully planned, designed and budgeted. Michener's contributions to this project were supported through a Cooperative Agreement between the National Science Foundation and the American Institute of Biological Sciences.

- LNO staff completed a Network Information System Strategic Plan working with the Network Information System Advisory Committee (NISAC). James Brunt edited and was lead author on the NIS Strategic Plan, a vision document that provides guidance for the development of the NIS, which was approved by the LTER Coordinating Committee (CC) in May 2005.

- LNO staff completed a major revision to the LTER Network Data Policies. James Brunt led an evaluation of existing site data access requirements and was the lead author on a revision of the LTER data access policies that was approved by the CC in September 2005.

- LNO staff completed a successful NIS pilot study using grid technologies. Mark Servilla led a six-month pilot project demonstrating the combined capabilities of LTER and the National Center for Supercomputing Applications (NCSA) in grid technologies. This pilot project was demonstrated successfully at the Fall Coordinating Committee meeting, and the effort is being continued as a full proposal to utilize grid technologies in the development of the Network Information System. Development of the NIS is being carried out by LNO staff in coordination with NISAC and advances in the SEEK project.

- The LNO formed and facilitated the activities of the 2006 All Scientists Meeting Program Committee. Bob Waide, Bill Michener, and John Vande Castle all serve on this committee. LNO staff prepared a supplement proposal to obtain $175,000 in funds for this meeting from NSF, managed contracts with the meeting venue, and facilitated the activities of the Program Committee through the development of web pages, the creation of an e-mail alias, and the support for conference calls.

- John Vande Castle continued to manage the acquisition of Very High Resolution Reconnaissance Imagery, MODIS time series subsets, International Space Station photography, and the deployment of Aerosol Robotic Network (AERONET) sun photometers at LTER sites. Vande Castle was the point of contact with relevant agencies for the acquisition of these data for all sites in the LTER Network.

- LNO staff completed major revisions of the LTER Network brochure, the LTER document archive, the LTER web page, the electronic version of the Network News, and the LTER display. In addition, McOwiti Thomas collaborated with NSF staff on a new brochure highlighting applications of LTER research. He also developed a new format for the print version of the Network News.

- The LNO staff continued to develop and troubleshoot the new Ecoinformatics Training and Usability Testing Lab. Despite serious problems with purchased equipment and delays in completing installations on the part of UNM, the laboratory was made operational in time to complete several informatics training sessions. LNO staff negotiated replacement of defective Dell machines to a newer and more reliable model and reconfigured the Training Laboratory with these new machines.

- LNO staff produced a new administrative interface to the bibliography database that allows sites to upload or harvest their bibliographies to the all-site bibliography. LNO staff assisted sites in repopulating this database to make it current. At this time there is 80% participation in this database.

- LNO staff improved the search interface for the bibliography to include the ability to export EML for citations or groups of citations. The interface has been made publicly available through the LNO source code server for sites to use. This interface is also in use for the Standard Methods and OBFS databases.

- LNO staff led the development of an EML Custom-unit Registry database. This network resource for metadata standardization contains both standard and custom scientific units defined in the Scientific, Technical, and Medical Markup Language (STMML) syntax and as required by the Ecological Metadata Language standard. The database was demonstrated at the LTER Information Manager's Meeting in Montreal Canada during August 2005.

- LNO staff developed a new LTER Network News Portal that is a major revision of the online Network Newsletter from a static electronic version to dynamic

news portal with frequent updates between paper publications. This new format allows for more user participation and creates more outlets for network news (RSS feeds, etc.)

- Inigo San Gil produced an EML/NBII Metadata Crosswalk that greatly improves the existing metadata crosswalk between the EML and the government standard, the Biological Data Profile (BDP). He also developed an internet application to make the crosswalk application public.

- The LNO managed the transition to an interim Chair of the Coordinating Committee upon the retirement of Jim Gosz. LNO worked with the Executive Committee to identify candidates for the election of a new Chair in 2006.

- The LNO underwent a successful mid-term review of operations by NSF.

More detailed descriptions of accomplishments are given in the following sections organized according to Service to LTER sites, Service to the LTER Network, Service to NSF, and Service to the Broader Community.

Service to LTER sites

Service to LTER sites takes a variety of forms including support for travel, meeting coordination, technical advice, support of communications and database systems, and response to requests from individual investigators. LNO staff members prioritize their time among site and network support activities according to criteria developed as part of the LNO Strategic Plan. Many activities benefit both sites and the network. The following represents a sampling of activities conducted that primarily benefited sites.

- As part of our annual review process, the LNO prepares and administers a survey to sites in collaboration with the LTER Executive Committee. Sites were surveyed in January 2005 to identify needs for additional support. Results of these surveys were transmitted to the Executive Committee for use in the annual review of the LNO.

- Greg Shore, Systems Administrator, managed LNO infrastructure to provide 24/7 access to key services by sites. Greg responded to requests for assistance from at least 16 LTER sites. Some of the issues addressed included troubleshooting an FTP file transfer problem, assisting with video teleconference testing, providing recommendations and specifications for new PC systems, setting up a remote VNC connection for troubleshooting a Kepler software problem, providing information for detection and recovery an from Apache web server Gallery PHP cross-site scripting security exploit, troubleshooting approaches to remedy a network connectivity outage related to security measures, troubleshooting ERDAS Imagine image rectification software problems, providing training in satellite image rectification techniques and strategies, assisting sites to complete Domain Name Service (DNS) zone file changes for pointing to new web server

and a new data catalog server, supplying wireless access for the September, 2005, CC meeting in Virginia, and supplying wireless access and Polycom video teleconference system for April, 2005, CC meeting in Key Largo, FL.

- Inigo San Gil provided direct on-site and remote assistance to individual LTER sites to transform the site's metadata to the network standard, the EML. This greatly increased the level of metadata standardization in the network as well as making available a more robust search capability after the documents are harvested. Inigo worked with 23 sites on a variety of issues including Controlled Vocabulary, the LTER Metadata Catalog, LTER metadata standardization, the LTER Custom Unit Registry, and the EML 2 BDP Crosswalk.

- Marshall White continued to provide web hosting and web support to the HBR LTER, consulted with the SEV LTER to further develop their website and intranet, consulted with BES LTER on web based application development, began working with LUQ LTER in redesign of their website, and provided input to the LTER Information Management web development working group.

- Bob Waide visited three LTER sites (Palmer, Niwot, Florida Coastal Everglades) to assess needs of sites and scientists and provide information on LNO activities.

- Waide continued his collaboration in a NASA-funded project to conduct LIDAR overflights of selected LTER and non-LTER sites. The goal of this project is to develop techniques for surveying biodiversity using forest structure measures derived from radar data. At present, five LTER sites (HBR, HFR, CWT, SEV and AND) are involved in the project.

- Senior LNO staff coordinated cross-site research activities involving LTER and non-LTER investigators by serving as intermediaries between sites and investigators and by providing letters of support for proposals for work at LTER sites.

- Deana Pennington led a Science Environment for Ecological Knowledge/Biodiversity and Ecological Analysis and Modeling (SEEK/BEAM) activity collaborating with LTER scientists and Information Managers from nine sites to design and develop needed integration and analysis cyberinfrastructure. Pennington organized and led two working group meetings.

- John Vande Castle continued to work with USGS/Reston contacts for the operational acquisition of high resolution reconnaissance data for LTER sites. This work included providing information for special acquisition of coastal LTER sites to collect additional information during the 2004 hurricane season. Very high spatial resolution data is now required on an on-going basis for all LTER sites. These data are now being operationally archived through the USGS and can be accessed by LTER researchers with proper security clearance. It is presumed that all these data will be available on a declassified basis in the near future, or within

20 years according to current US regulations. A dedicated LTER web page exists to describe these data and provide information on how the data can be accessed.

- As Chair of the LTER Technology Committee, Vande Castle continued to provide support for development of technology within the LTER Program. Vande Castle wrote and maintained web pages on LTER Technology (http://lternet.edu/technology/). Vande Castle worked with the Technology Committee in the development of the 2006 Cyberinfrastructure assessment of LTER sites and the LTER Network Office. Feedback and input from the LTER Technology Committee was used to design a survey used as a basis for this assessment.

Service to the LTER Network

The LNO facilitates supports, and implements decisions and policies of the LTER Chair, Executive Committee and Coordinating Committee. As the entity charged with providing resources to support the LTER mission and goals, most of the LNO's efforts address network-level priorities. These priorities are established by LTER governing bodies and are embodied in the LTER bylaws, planning documents, and committee recommendations. Many routine activities in support of LTER priorities are carried out in the background, with schedules set internally by LNO management. However, tasks that occupy large amounts of LNO resources are submitted to appropriate LTER governance bodies for approval, as described in the LNO Strategic Plan. The following describes LNO activities that support the LTER network.

One of the most important activities of LNO is the dissemination of results obtained by LTER scientists. Scientific publications based on LTER research inform the ecological community of our accomplishments. The Network Strategic Plan establishes the goal of expanding the use of LTER knowledge in education, policy-making, management and public understanding of scientific issues. LNO contributes to fulfilling this goal through an outreach program that utilizes print and electronic media, personal presentations, video, the World Wide Web, workshops, symposia, and other means of disseminating information. Specifically, in the past year:

- We added material to the existing intranet and LTERnet pages as necessary to support the NSF Mini-symposiums, two Coordinating Committee meetings, the 2006 All Scientists Meeting, the LNO Mid Term Review, the LTER Opportunities Database, the meeting of the LTER National Advisory Board, various Committee pages, and the Schoolyard LTER program, among others.

- LNO staff collected images for the new LTER display and offered input into its design. We also created style sheets and "branding" materials for the new LTER web site template, and helped to publicize the Ecoinformatics Training and Usability Testing Lab The revision of the hard-copy Network News and the Network News Portal on the web page received positive feedback from users including NSF.

- McOwiti Thomas worked with the Executive Director to continue the development of internal strategies and methods for disseminating LTER information. The communication plan envisages a more proactive strategy for disseminating LTER research results and other information to a wider public. Thomas submitted the first draft to the Executive Director for comments and suggestions, which have been incorporated into the second draft of the communication plan.

- McOwiti Thomas and Patricia Bonito updated LTER/LNO publications and developed new public information materials and tools. Among the materials updated were the Network web page, which got a fresh look, new format, and new content, several site brochures, and the LTER traveling display (for which a mini-update was done for ESA/INTECOL 2005). New materials include new site brochures, network poster, targeted one-page information sheets and flyers describing aspects of LTER work (e.g., Graduate and Undergraduate Education one-pagers, a Schoolyard LTER one-pager, and flyers for the Feng Shui Synergies Foundation). The Network newsletter was redesigned to give it a new look and to make it more reader-friendly. The newsletter's online version also got a new format that allows for faster updates, corrections, and posting of fresh stories. LNO Public Information and Outreach also assisted (by providing text material, photos, editorial services and suggestions) in the development of the NSF's Broader Impacts brochure.

- LNO staff developed content for the LTER network web sites and databases. This task included a redesign of the LTER Network News website, and assistance to sites (e.g. SEV) and affiliated organizations (e.g., NEON) by Marshall White and Jeanine McGann in developing and maintaining their websites. Under the guidance of the Executive Director, the LTER databases/archives were overhauled and redesigned to improve access and the search capabilities.

- We increased the LTER presence and awareness of LTER activities to the scientific community and the public by displaying the LTER exhibit at meetings such as the Ecological Society of America's Annual Meeting (Montreal, Canada in 2005), the SACNAS (Society for Advancement of Chicanos and Native Americans in Science) National Conference (Denver, CO, 2005); and a presence at the NSF Mini-symposium and the AAAS Annual Meeting (Washington, D.C., 2005).

- A design team consisting of McOwiti Thomas, Jeanine McGann, Marshall White, and Laura Downey developed a new corporate image for LTER. Under the guidance of the Public Information Officer (Thomas), the design team is currently developing new guidelines for use of LTER photos and logos; a new color scheme and guidelines for usage of graphic elements such as fonts in LTER publications; and is considering a redesign of the LTER logo.

- LNO produced articles for and edited two LTER Network Newsletters, working closely with writers from other LTER sites to assure broad, balanced coverage of research, outreach, publishing and other site activities. McOwiti Thomas worked with the printer to manage production and distribution, and reformatted both issues for presentation and distribution on the Web.

The LNO has widespread responsibilities in the governance structure of the LTER Network.

- The Executive Director participated in the activities of the Executive Committee, the Coordinating Committee, and the Science Task Force for the Planning Grant.

- The Executive and Associate Directors participated in the activities of the NIS Advisory Committee, the Information Management Committee, the Information Management Executive Committee, the International Committee, and the Technology Committee.

- The Executive and Associate Directors served on the governance and cyberinfrastructure working groups for the LTER planning project.

The LNO maintains communication and computational infrastructure and manages Network databases.

- LNO staff continued to improve the use, access and update capabilities of the personnel database. New interfaces enhance the discovery of personnel data and improve accessibility to users encouraging users to participate in the management of their own personnel data.

- LNO staff developed a new document archive that creates a more transparent structure to allow for easier document searches and additions. The backend database was moved from access to MySQL and the interface is done through a web-based content management system. LNO staff reclassified and transferred all existing documents to the new system cleaning up broken links and standardizing titles.

- LNO staff developed a new LTER Network News Portal that is a major revision of the online Network Newsletter from a static electronic version to dynamic news portal with frequent updates between paper publications. This new format allows for more user participation and creates more outlets for network news (RSS feeds, etc.)

- LNO staff continued to integrate LTER Network databases to increase the ease of updates and create the capability for sites to automate update via web services interface. The next phase will expose the database as an EML data source with a consistent Application Programming Interface.

- The LTER Network Personnel database now contains over 2000 Scientists, an increase of just under 200 from last year. There have been no major pushes for getting information updated in the last year so we attribute this to increases in site activity.

- The All-Site Bibliography is now being exposed through a server that is compliant with the international Z39.50 standard used by libraries and bibliographies around the world, and can be browsed by all Z39.50 clients including EndNote.

- We have been collaborating with the Canopy Database Project to develop a cross-site study database framework. We have supported several site IMs on this development, and results have been very useful. This provides groundwork for standardized approaches to grassland ANPP.

- The LTER Metadata Catalog is online and searchable at metacat.lternet.edu with an LNO developed advanced search interface. This new catalog is based on EML harvested from sites and represents the richest search capabilities available for LTER data. This catalog replaces the LTER Data Table of Contents (DTOC).

- Historic LTER data were maintained in the remote sensing archive, and new data acquired as part of the Spatial Data Workbench were added to the archive.

- Backups of databases were performed on a regular schedule, and shadow databases have been successfully restored from backups on a routine basis.

- LNO prepared or edited reports and minutes from Coordinating Committee, Executive Committee, Information Management (IM) Committee, and IM Executive Committee/Network Information System Advisory Committee meetings, teleconferences, and video conferences and posted these reports on the appropriate LTER web page.

- LNO staff continued construction of the Ecoinformatics Training and Usability Testing Lab including structural and electrical modifications, installation of furniture, and installation/testing of integrated Audio/Visual system.

- LNO staff provided setup and technical support of Training Lab for five LTER/SEEK/OBFS training activities during the year.

- Marshall White has provided web based collaboration tools to various groups within LTER including the LTER Graduate Students, the LTER Planning Grant Working Groups, and LTER Information managers.

A key responsibility of the LNO is to help increase the pace of scientific synthesis in the LTER Network. This task is accomplished through direct and indirect support of site- and network-based research syntheses.

- A call for proposals for research working groups resulted in 10 requests for support, of which six were funded. LNO staff organized the call for proposals, distributed the proposals to the Executive Committee, and coordinated the review of the proposals. Working groups from these proposals have been supported by funds from the LNO.

- The LNO facilitated the fifth annual LTER mini-symposium at NSF. The theme of the mini-symposium was "Long-Term Marine Research and the Grand Challenges in Ecology"

- LNO supported the annual science theme meeting, whose topic was "Ecosystems in Transition". The organizers were John Briggs (CAP) and Alan Knapp, (SGS, KNZ). The science theme meeting was conducted as part of the Fall Coordinating Committee meeting at VCR.

- LNO staff facilitated planning for the 2006 All Scientists Meeting by identifying and reserving the venue, obtaining funds, organizing the Program Committee, developing a web page for the dissemination of information and program development, and providing institutional memory about past meetings.

- Through collaboration with the TRENDS working group and the National Center for Ecological Analysis and Synthesis, LNO staff initiated the development of a new data module for the LTER Network Information System. This data module will consist of dynamic data sets representing information that will be contained in the TRENDS book, part of the LTER-Oxford book series. These data sets will be registered and available through the LTER Metacat.

- Bob Waide served on the editorial committee for the TRENDS book in the Oxford series and the LNO provided support for the first meeting of this committee.

- The LNO obtained funds for and implemented a Polycom Bridge unit to expand capabilities for videoconferencing within the LTER network. This unit will allow multiple, simultaneous videoconferences using high-speed internet connections. LTER use will include increased interactions among members of research working groups as well as administrative and governance meetings. Other groups, including the Organization for Biological Field Stations, the Design Consortium for NEON, and the LTER Planning Grant Working Groups, will have access to these capabilities.

The LNO is responsible for facilitating communication among sites and individuals regarding LTER and LNO activities.

- We prepared a survey to sites to determine needs and satisfaction with LNO services. This survey was administered and evaluated by the LTER Executive Committee.

- LNO staff prepared several documents describing the structure and function of the LNO. These documents were disseminated in hard copy during visits to sites, sent to the LTER community through e-mail messages, and posted on the web site.

- LNO staff wrote articles for the Network News describing LNO activities and solicited articles from site describing their accomplishments. We created the Network News Portal for more rapid dissemination of information using RSS feeds.

- James Brunt provided quarterly reports to information managers and monthly reports to IMEXEC on the status of network office activities.

- James Brunt developed a regular column for the Network News entitled, "Informatics Highlights in the LTER Network".

- James Brunt developed a white paper on "Collaborate Conferencing Options Available to LTER Network Scientists."

- James Brunt attended the IM committee meeting in Montreal where he discussed LNO staffing and responsibilities.

The LNO serves as a point of contact between the LTER Network and other entities and agencies.

- We continued to coordinate interactions between the LTER Network and NSF, the U.S. State Department, the National Biological Information Infrastructure (NBII), other agencies, and other national and international networks. Specific activities included the organization of NSF participation in LTER meetings, conference calls, and videoconferences.

- We responded to multiple requests for information from individuals and organizations about the LTER Network.

The LNO has responsibility for the development of proposals to support network-level activities and the administration of funds from these proposals. In addition, we are responsible for reporting the activity of the LNO to NSF, the LTER Coordinating Committee, and the University of New Mexico.

- We prepared a supplemental proposal to NSF for funds for the 2006 All Scientists Meeting. LNO staff played a central role in developing a supplement proposal for the Cyberinfrastructure working group for the LTER planning grant.

- We administered funds from the NSF under our Cooperative Agreement as well as funds contributed by the University of New Mexico as cost-sharing for the Cooperative Agreement. Marjorie McConnell, our Senior Program Manager, instituted mechanisms to track expenditures for multiple accounts in real time. She supervised Doug Swearingen and Andrea Briscoe, who tracked and assigned expenditures and prepared reports for the Senior Staff.

- Marjorie McConnell tracked reporting requirements and assured that all reports were submitted to agencies in a timely manner.

- During the present year, the following separate grant accounts were managed: 1) a workshop on Environmental Cyber-infrastructure needs for distributed sensor networks (NSF), 2) OBFS administrative database (Mellon Foundation), 3) the Spatial Data Workbench (NPACI), 4) the Resource Discovery Initiative for Field Stations (NSF), 5) the Science Environment for Ecological Knowledge (NSF), 6) National Biological Information Infrastructure (USGS), 7) Predictive Modeling Visualization (DARPA), 8) the NEON Design Consortium (AIBS/NSF), and 9) LTER Network Strategic Planning Activity.

- We created and reconciled sub-accounts for 16 LTER cross-site working groups.

- We produced separate annual reports to the LTER Coordinating Committee, and the University of New Mexico.

- We prepared for and were exposed to reviews from the LTER Executive Committee, the University of New Mexico, and the National Science Foundation.

- Pamela Madrid, our Office Manager, George Garcia, Caleb Hickman, and LNO staff organized, coordinated logistics, managed finances, and helped prepare reports for the following meetings: Coordinating Committee (2), Cross Site Workshops (9), Information Manager's Meeting (1), IM Executive Committee (1), Mini-Symposium (1), National Advisory Board (1), Mid-Term Site Review (1), SEEK (2; 1 in January 2006), SEEK All Hands Meeting (1), SEEK Working Committee (4; 1 in January 2006), Cyber-Infrastructure Meeting (1), OBFS Workshop (1), GIS Workshop (1), LTER Planning Grant Conference Committee (2; 1 in February 2006), LTER Planning Grant Subcommittees (6), LTER Planning Grant All Hands Meeting (1), LTER Planning Grant STF (2). A total of 570 participants attended these meetings.

- We organized meetings and maintained communications for three significant grants addressing global IT infrastructure (SEEK, RCN, and NPACI).

The LNO facilitates efforts to improve cyberinfrastructure in the LTER Network and takes the lead in informatics tasks as determined by the LTER Coordinating and Network Information System Advisory Committees.

- John Vande Castle and James Brunt worked with members of the LTER Planning Grant to write a successful supplement grant focused on Cyberinfrastructure (CI) needs for future LTER Network research that might be proposed from the planning grant. John Vande Castle provided most of the logistical support for meetings within this effort. This included interactions with leaders of CI efforts from Observatory and other research groups such as NEON, CUAHSI, CENS, and NCEAS. The meetings to assess the CI needs for future LTER research provided a significant link to experts as well as to the planning efforts of these groups. A section of the LTER Planning Grant Wiki was developed to support and document results of the CI efforts, and is available at: http://intranet.lternet.edu/planning/index.php/Cyberinfrastructure

- As part of the CI Efforts, Vande Castle and Brunt contributed to and edited white papers resulting from Focus Group meetings of CI needs for LTER Network cross-site experiments, data integration and CI infrastructure.

- As part of the CI planning effort, John Vande Castle performed an assessment of the current CI infrastructure of all the LTER sites. Starting with a template from the first CI Team meeting of the planning effort, with input from members of the LTER Technology and Information Management Committees, a survey was developed for this assessment. John worked with the Information Management Committee members and site principal investigators to make sure every site in the LTER program was included in the assessment. This survey was an important part of all the LTER CI meetings related to CI infrastructure. The site survey, as well as a separate survey of the LTER Network Office current CI infrastructure is available at http://lternet.edu/techology.

- John Vande Castle worked with NASA contacts at the Johnson Space Flight Center (JSFC) to accurately locate and register LTER site locations for acquisition of photographic images on board the International Space Station (ISS). A science plan was written for the ISS 11 and future missions to acquire imagery of LTER sites on an operational basis. A large number of images have now been acquired. A program including a survey of LTER researchers is now being devised to obtain feedback from researchers on the usefulness and potential changes that could be made for future acquisitions. In addition to the new photography, there exist a large number of images, as many as 400 to 1000 images of sites from past ISS and space shuttle images. A dedicated LTER web page was written to document this effort and provide access to the search functions maintained at JSFC for these data.

- A similar effort was made with IT contacts at the Oak Ridge National Laboratory, NASA Distributed Active Archive Center (DAAC). We located and registered LTER research sites for generation of subset time series data from the MODIS sensor aboard the NASA Terra and Aqua satellite systems. These time series datasets provide data on 7x7 km scenes for parameters such as normalized and

enhanced vegetation indices, leaf area index data, surface albedo, temperature and land cover. A dedicated LTER web page was written to document this effort and provide access to the search functions maintained at the DAAC for these data. An evaluation program for these data will also be included to obtain feedback from LTER scientists pertaining to the usefulness of the data for their research and potential improvements of site locations and other details.

- John Vande Castle attended the IM Committee meeting in Portland where he discussed aspects of the updated remote sensing archive and the LTER Cyberinfrastructure assessment efforts.

- John Vande Castle attended meetings with members of Internet2 to plan potential collaborations with federated applications of common wireless technologies for field research. This work resulted in a proposal by Internet2 to NSF for support of a 2006 workshop on wireless technologies for NSF research groups, observatories and other agencies.

- Mark Servilla and LNO staff have continued the development and deployment of the LTER Metacat database, the Metacat Harvester, the Metacat Advanced Query Interface, and site support tools for creation of Ecological Metadata Language (EML) documents, and documenting and harvesting the LTER Network Office Remote Sensing archive as EML. Deployment and operation of the Metadata Catalog has resulted in the registration of over 5,000 metadata documents; over 3,500 of which are from the LTER Network. The development of the Advanced Query Interface provides researchers the ability to formulate complex query strings when searching the LTER Metacat database to quickly narrow search results. The Metacat Harvester automatically harvests EML documents from 20 LTER Network sites. The LTER Network Office Remote Sensing archive, found as EML within the LTER Metacat database, serves LTER researchers by providing key information regarding the disposition of available digital raster imagery of LTER sites.

- Mark Servilla led the LTER Grid Pilot Study that investigated the efficacy of grid middleware in overcoming interoperability issues between heterogeneous computing systems used by different LTER sites. This included grid middleware components for use in system authentication (X.509 Certificates coupled with MyProxy), reliable transport (GridFTP), audit logging (Syslog-NG), and data analysis using high performance computers (Matlab running on a parallel processor computer). The use of such components allowed a user to log into the system one-time, while accessing numerous distributed services. All transactions were logged into a single database for use in analyzing data access and data provenance. The pilot study was demonstrated to the LTER Coordinating Committee in September 2005.

- Mark Servilla lead the development of the LTER EML Custom Unit Registry – The registry contains both standard and custom scientific units defined in the

Scientific, Technical, and Medical Markup Language (STMML) syntax and is required by the Ecological Metadata Language standard. The completed registry system was demonstrated to the LTER Information Manager's in Montreal Canada during August 2005.   The registry is currently accessible only through a web browser interface. Although this interface is beneficial, to extend this interface by using a web service will allow automatic integration of such content into other EML documents.

- Servilla, Brunt and Costa are participating in an investigation to develop an LTER Controlled Vocabulary through the discovery of keywords and terms used in the LTER community through an analysis of LTER EML metadata and other LTER document sources. Further analysis of these terms will be used to develop tools to enrich metadata documents with additional keywords, tools to enrich metadata searches by interacting with on-line thesauri, and a hierarchy of terms for browsing and searching metadata more efficiently.

- Inigo San Gil provided direct on-site and remote assistance to individual LTER sites to transform the site's metadata to the network standard, the EML. This greatly increased the level of metadata standardization in the network as well as making available a more robust search capability after the documents are harvested.

- Inigo San Gil produced an EML/NBII Metadata Crosswalk that greatly improves the existing metadata crosswalk between the EML and the government standard, the Biological data profile (BDP). He also developed an internet application to make the crosswalk application public.

- Inigo San Gil exposed LTER metadata to the NBII metadata clearinghouse by developing an automated procedure to create harvest list to place all standardized LTER metadata in the NBII clearinghouse. This makes the updating of the LTER metadata records in the NBII clearing houses automatic.

- James Brunt coordinated meetings for IMEXEC, IM, EML Implementation Standards, and Canopy Database Project, including conference calls and televideo conferences.

- James Brunt developed a vision document on metadata management for the Network entitled "Tacit Knowledge Acquisition."

- James Brunt also contributed as Co-PI to a BDI proposal entitled "Network Information Systems for Ecological Synthesis: An Open Framework for Query, Harvest and Validation of Distributed Datasets."

- James Brunt contributed to a successful memorandum of understanding and developed the subsequent proposal to NBII for funding of a metadata standards initiative that will create a technical support position at LNO.

- James Brunt was lead author of the Network Data Policy Revision as tasked by NISAC which was approved by the CC at the Fall 2005 meeting.

- James Brunt developed all-site bibliography interfaces and revisions and led the effort for repopulation of this database.

- James Brunt was lead author of the Network Information System Strategic Plan which was approved by the CC at the Spring 2005 meeting.

- Duane Costa developed and deployed the Metacat Advanced Search Interface, maintained the Metacat Harvester software and user documentation, and assisted with revision of Metacat documentation.

- Jeanine McGann created site maps for www.lternet.edu, intranet.lternet.edu, schoolyard.lternet.edu, and www.ilternet.edu and redesigned site pages for all sites in LTER network http://www.lternet.edu/sites/ and she created the editable project forum for those working on LTER Education Handbook. McGann created new php-based job posting pages for use on intranet savanna.lternet.edu/jobs. She created a design document for the proposed IM mentoring web page and created the new committee page for US ILTER Committee http://committees.lternet.edu/. She helped create web based interfaces for new sitedb pages, and she created layout and formatted workshop reports for ASM. McGann designed the "Grand Challenges" web site http://www.lternet.edu/grandchallenges/ and she worked with LTER grad students to design a new website for the Graduate Student Committee.

- Jeanine McGann proofread the Spring and Fall newsletters, posted the spring newsletter online and assisted with the layout. McGann formatted and posted the NAB page with bios and member information on LTER intranet pages, and posted new Databits sections for Spring and Fall.

- Greg Shore performed a variety of system administration tasks in support of the Computational and Communication Infrastructure maintained by the LNO. He maintained 24x7 access to email, web, and ftp servers, and provided for backup and restoration of file systems. He enforced LAN, WAN, computer security. He was responsible for installation and maintenance of server operating systems and application software. He installed and maintained desktop operating systems and application software, and provided user support to network office staff as well as ad-hoc technical assistance to sites. He installed and maintained computer and network hardware and tested and selected new software. He worked with a student assistant and other LNO staff to complete the Ecoinformatics Training and Usability Testing Lab.

Service to NSF

The Cooperative Agreement between the National Science Foundation and the University of New Mexico details tasks that are to be carried out by the LNO. A limited number of these tasks represent service to the NSF. In addition, NSF occasionally requests the participation of LNO staff in meetings and other activities as representatives of the LTER Network. The following describes some of the services the LNO has provided to the NSF.

- LNO staff facilitated planning for a mini-symposium held at NSF in March 2006. The topic of the meeting was "Building on the legacy of LTER Research: Ecology for the Future". LTER scientists made six presentations to an audience comprising NSF program officers, and representatives of other agencies.

- LNO staff members frequently responded to requests for information from NSF, including advance notice of significant publications and media releases describing results from LTER research.

- McOwiti Thomas worked with his counterpart at NSF to develop a brochure on the broader impacts of LTER research.

- At the request of NSF, Michener and Waide prepared a work packet for the GEOSS planning effort that discussed mechanisms for saving and preserving long-term datasets.

- Patricia Bonito prepared a brochure on the International LTER Network. Printing of this brochure is awaiting the resolution of wording of the ILTER Mission Statement.

- LNO staff hosted separate visits by Drs. Henry Gholz and Penelope Firth of DEB. In addition, LNO staff participated in NSF Day at the University of New Mexico by providing support for the meeting and the LTER Network display.

- LNO staff identified and provided visual images to NSF for use in presentation by the Director and other NSF employees.

- We assisted NSF in getting permission to reprint images in their "Broader Implications" brochure.

- The LNO facilitated communication between NSF and LTER sites for a variety of purposes.

- Deana Pennington participated in the CI-Team and BDI panel reviews.

- James Brunt participated on the NSF BDI panel and provided 3 ad-hoc reviews to other NSF programs.

- We prepared annual reports to NSF.

Service to the broader scientific community

The LTER Network has a responsibility to share publicly-funded information and discoveries with the broader scientific community, policy makers, and the public. Information sharing often takes place through scientific publications, but the LNO facilitates the communication of results in many other forms. The following examples illustrate some of the activities of the LNO in this arena.

- Bill Michener continued extensive interactions with network partners and building community outreach activities. In particular, he organized and participated in workshops and working group meetings with: SEEK (the Science Environment for Ecological Knowledge), PBI (Partnership for Biodiversity Informatics, which includes the National Center for Ecological Analysis and Synthesis, the University of Kansas, University of California-San Diego, and the LTER Network), NBII (the National Biological Information Infrastructure, an affiliate of the US Geological Survey), RCN (a Research Coordination Network comprised of multiple LTER and non-LTER universities that are committed to enhancing the discovery of information resources at field stations and marine laboratories), NEON (the proposed National Ecological Observatory Network and related planning activities supported by the American Institute of Biological Sciences), the Center for Microbial Ecology, and multiple NSF-sponsored workshops on building cyberinfrastructure for the environmental sciences.

- Michener co-organized a special session at the ESA annual meeting in Montreal, presenting an overview of the planning process and an update of the NEON project execution plan now in development.

- Michener co-organized two SEEK All Hand's Meetings.

- Michener and Deana Pennington collaborated with the ecological niche modeling community to design and develop needed integration and analysis cyberinfrastructure.

- Bob Waide served on the Organization Committee for the Collaborative Large-Scale Engineering Analysis Network for Environmental Research (CLEANER) Program.

- John Vande Castle provided ancillary support for the ILTER Network as the group continues its transition from LNO support. LTER Databases and email groups were updated to make them more easily transportable to outside systems. Minor updates to the ILTER web pages were made, as well as a permanent

backup made of the entire ILTER website, which was provided to the ILTER Network Committee Chair.

- Bob Waide represented LTER on the AIBS Public Policy Committee.

- The LNO raised funds from sites to pay for a membership in AIBS for the LTER Network.

- Deana Pennington conducted research with eleven national and international biodiversity scientists regarding scientific knowledge acquisition for formal representation in advanced technologies.

- Deana Pennington organized a workshop in ecologic knowledge representation.

- Laura Downey conducted user profiling, user testing, and structured feedback activities in two training workshops.

- Laura Downey served as associate editor in a new online usability peer-reviewed journal.

- Laura Downey served as a program committee member for the 2006 conference of the Usability Professionals' Association.

- Bill Michener, Deana Pennington, and Samantha Romanello organized a series of activities for the community that communicated results of the SEEK project. These included:
    - Two week-long training workshops on ecoinformatics and GIS that were held at the University of New Mexico for the Organization of Biological Field Stations.
    - One week-long introduction to ecoinformatics training workshop for early career faculty and postdoctoral associates.

- Deana Pennington and Samantha Romanello organized an evening session on "Empowering ecologists with informatics education and training" at the annual ESA meeting in Montreal.

- Deana Pennington was an invited instructor for the National Institute for Technology & Liberal Arts Education GIS in Landscape Ecology Workshop

- Patty Bonito worked with NSF, the ILTER Committee and LNO staff Bob Waide and John Vande Castle to finalize the current version of the ILTER brochure and made it available to the ILTER Network Committee in digital form.

- Jianting Zhang collaborated with computer scientists from GEON and SEEK to develop automated geospatial processing techniques that are a necessary generic cyberinfrastructure across disciplines

- Jianting Zhang collaborated with the SEEK project to develop robust, distributed ecological models for the ecological niche modeling community

- Waide served as secretary of the Long Term Studies Section of ESA.

- Michener and Brunt organized and participated in a workshop on data registries that lead the ESA toward implementation of a data registry system for its journals.

- James Brunt initiated work to provide redundancy and fail-over for the ESA registry LDAP, Metacat, and DNS components working with Matt Jones at NCEAS.

- James Brunt served on the National Advisory Board for the Natureserver Internet Data Delivery project.

- James Brunt migrated the Ecological Standard Methods database to a more robust platform and made it available via lternet.edu and obfs.org.

- James Brunt migrated the OBFS bibliography and courses database to a more open, robust platform and made the interfaces available.

- Bob Waide organized a symposium with Hague Vaughan and Manuel Maass at the joint ESA-Mexican Ecological Society meeting in Merida, Yucatan. The symposium focused on improving methods for delivering scientific information to decision makers, and was a joint effort among U.S., Mexican and Canadian LTER Networks.

- Marshall White developed and implemented a content management system for OBFS web site and made several revisions to the backend database supporting this system.

- Bob Waide and Jim Reichman of NCEAS organized a working group to identify appropriate metrics to demonstrate the broader effects that organizations like LTER and NCEAS have on the scientific establishment.

- Bob Waide and Jim Gosz co-organized a paper session at the 2005 INTECOL meeting titled "Multiple Time Scales of Ecological Processes: Results from the LTER Network".

Contributions

Development of your own discipline

By coordinating cross-site activities of the LTER Network, the Network Office contributes directly to development of partnerships and collaboratories in ecological

science. We provide leadership in the field of ecology, especially in critical areas involving the development of knowledge networks. Moreover, we provide expertise and leadership in the development of new kinds of networks (e.g., NEON, CLEANER) and new initiatives for existing networks. By emphasizing interdisciplinary and cross-site research activities, we advance our understanding of complex systems, including human-driven systems. Specifically, we are working with the LTER Science Task Force to plan a new approach for LTER Network science that incorporates new sites, networks, and disciplines to address grand challenges in ecology. The partnerships we have formed with SDSC, NCEAS, NCSA, and the University of Kansas directly promote the integration of the fields of informatics and ecology. The LNO has played a key role in defining the importance of informatics in ecology and in disseminating knowledge about ecoinformatics throughout the ecological community. We have provided leadership in the important areas of data sharing, connectivity, and the acquisition and implementation of new technologies.

Many of the achievements of the LNO contribute to the development of the disciplines of ecology and ecoinformatics. For example:

- The LNO has been strongly involved in the planning for the emerging NEON and CLEANER networks. These new networks will provide significant new opportunities to advance ecological science and represent one of the most important innovations in our field in decades.
- The LTER Strategic Planning process has the potential to increase significantly the pace of synthesis within the discipline of ecology. The LNO has played a key role in facilitating the development of this new initiative.
- The Custom Unit Registry provides researchers in the ecological community an Internet-based relational database for searching and storing scientific units as defined by the Scientific, Technical, and Medical Markup Language (STMML) and used as the unit definition standard in the Ecological Metadata Language. The Custom Unit Registry provides both a web browser (http://fire.lternet.edu/customUnit) and a web-service interface to access and update the database. The benefit of the Custom Unit Registry is that researchers can now reference the registry when creating new EML documents in a manual and automated fashion.
- The Metadata Catalog provides researchers an Internet-based interface for storing, retrieving, and searching EML metadata documents. The entire Metadata Catalog product suite includes an automated harvesting application (Metacat Harvester) that seamlessly pulls EML documents from individual LTER sites and inserts them into the Metacat database, the Metacat Advanced Query Interface for developing complex metadata queries, and numerous site specific tools for converting legacy metadata into the EML metadata standard.
- The LTER Metadata Standardization project provides a consensus network standard to share metadata and optimize cross-site synthesis. Custom tools to standardize the metadata were deployed in many LTER sites. These tools are the genesis for long term-standard metadata management applicable to both LTER and non-LTER sites.

- The Metadata Crosswalk bridges the two major metadata standards for the geospatial, biological and ecological disciplines. The improvements introduced by metadata crosswalks facilitate metadata entry by widening the array of tools available to the users. The crosswalk enhances the exposure of the research conducted at LTER sites to the broad public community by making the metadata format compatible with the format used by related federal institutions such as USGS, ORNL and NBII.
- About 3,000 LTER records are now publicly available through the NBII clearinghouse. This continuous automated process ensures that the public has the most up-to-date LTER metadata records.
- The Personnel Database Update offers users a simple, effective means to keep track of their own information as well as a portal for access by the broader ecological community to this kind of information.
- The revision of the LTER Document Archive responded to user requests to improve ease of discovery by users and updating by data managers. The improved archive provides easier access to LTER documents to both LTER and non-LTER scientists.
- The Network News Portal redesign made network news a dynamic feature of the LTER web site, thereby increasing the flow of information to the broader scientific community.

Development of other disciplines of science and engineering

Our participation in the KDI and SEEK projects jointly with SDSC and NCEAS contributes to the fields of cyberinfrastructure, computer science, and informatics. Network development, research in computer science, ecological research concerning biocomplexity, and educational activities are purposefully linked in these proposals. Both of these projects provide test beds for integrating multidisciplinary, multi-scale data for addressing critical environmental questions. The efficient discovery of new ecological insights from these systems will provide validation of the informatics approaches being tested. Similarly, advances in computer science research involving probabilistic testing of hypotheses will guide ecological research and accelerate progress in understanding complex phenomena in general. The governance and information management models developed under the LTER program have relevance for networks in other disciplines (e.g., CLEANER).

Specific results from LNO activities that enhance the development of other disciplines include:

- The Grid Pilot Study resulted in the "Biophony Grid Portal" – a web-portal application that allows a researcher to search for and analyze acoustic data that is collected from a distributed array of acoustic sensors associated with the work of Dr. Stuart Gage. The success of the Grid Pilot Study, exemplified by the Biophony Grid Portal application, fully demonstrated the efficacy of grid middleware in supporting LTER science, and identified middleware components that could meet the requirements of a production version of an LTER Grid. Such

insight would have been difficult to grasp without a hands-on evaluation of the technology.

- The Custom Unit Registry includes advances that are relevant to the disciplines of computer science, information science, biology, and ecology.
- The Metadata Catalog incorporates new approaches in computer science and information science.

Education and development of human resources

The LTER educational activities facilitated by the Network Office include development of web-based information on ecology for use by K-12 students, support of Schoolyard LTER sites at secondary schools, assistance to undergraduates and graduate students in identifying educational and research opportunities, organization of international student exchanges, facilitation of the activities of the LTER Graduate Student Committee, and the development of proposals aimed at the integration of education at all levels into LTER research programs. In the long-term, the LNO is working with the LTER Executive and Education Committees to define a strategic plan for integrating education and research seamlessly across all educational levels. In addition, the LNO, in collaboration with SEEK and the Resource Development Initiative for Field Stations, has created a state of the art facility at the University of New Mexico for training in ecoinformatics. This facility is dedicated to ecoinformatics training and has already hosted several courses for new faculty, post-docs, and graduate students. The long-term potential of this facility is significant.

Physical, institutional, and information resources for science and technology

The technical and information resources developed and maintained by the LNO are available for use by the 2000+ scientists of the LTER Network as well as the ecological community in general. The Long-Term Ecological Research Network Office occupies a 2,700 square-foot suite comprising seven offices, an 8 person technical workspace, and two 40-person conference rooms in the CERIA building on the main campus of University of New Mexico. This space is ideally positioned to support the activities and research proposed. One of the conference rooms is equipped with a Polycom VU FX – 4-port IP video conferencing hub. This equipment is portable and can be easily relocated in any of the working group conference facilities described above. In addition, we have a Polycom single port VU video conferencing unit that can be easily moved or shipped around as necessary to support this activity.

We are completing a dedicated computer training facility of our own design that will complement the above facilities and will be under complete control of the program – this is unheard of in most institutions where computer classrooms are always shared and usually under control of a centralized scheduling system. Computers, AV equipment, and furniture have been installed, and the facility is now operational. The equipment for the facility was purchased by the SEEK ITR grant and University of New Mexico Cost-Share.

In addition, we are planning for a Polycom bridge system to be completed sometime in 2006. This system will provide on demand videoconferencing for up to 48 users at a time, and will be available to the broader ecological community.

Sevilleta Research Station and Conference Facility

The UNM Department of Biology maintains a unique facility to support research and conferences 55 miles south of the UNM campus in a scenic section of the 200,000 hectare Sevilleta National Wildlife Refuge near the Rio Grande River. This facility can house 48 people and has full conference facilities including two large conference rooms with multi-media projection systems, a library, computer center, computer teaching lab, institutional kitchen, office space, and additionally includes quiet work-enhancing isolation complete with resident wildlife. The station is fully interconnected via fiber optics and has wired and wireless Ethernet in all facilities including bedrooms. The station is connected to the Internet via a point-to-point T-1 that connects directly to the Internet II router and the UNM gigabit backbone. This creates an environment conducive to productivity via the combined effects of solitude and connectivity. Participants can take a hike with their wireless enabled laptop or seek any number of secluded refugia around the compound. This facility is available for scheduling of proposed workgroup activities and is very supportive of this type of research effort.

Computing Facilities to Support Training

The LNO and SEEK projects support a 20 seat Ecoinformatics Training and Usability Testing Lab where training and development workshops can be held for all aspects of the network information system development effort as well as research and synthesis workshops. This one-of-a-kind facility is equipped with modern computing, communication and audio-visual equipment to provide maximum contact between trainer and trainees. The LNO is currently developing an operation plan for this facility to ensure it's continued efficient operation.

Computing Facilities to Support Research

The LNO supports computing facilities to support the LNO operations, and faculty and staff computing. In addition, the LNO houses computer infrastructure and data center for support of the LTER Network Information System. The climate controlled data center has scalable servers and enhanced network bandwidth to better serve the LTER Network and its partners in the ecological community. Four Dell Poweredge 2650 Dual Multiprocessor servers (2-2.4Ghz Pentium IV, 4Gb memory, LTO tape backup, a 1 Tb RAID5 disk array, redundant power supplies and UPS), and two Sun E-450 Enterprise servers (4-300mhz UltraSPARC CPUs, 1gb memory, 20gb local disk, tape backup including Benchmark DLT7 tape robot and DDS3- 12/24 gb, redundant power supplies and uninterruptible power) serve the LTERnet.edu domain. The combination of the Sun Solaris operating system on the UltraSparc platform and the Linux and Windows operating systems on the Intel platform allows for maximum flexibility in incorporating new developments and technology. MS SQL server, Mysql, and Postgres are used for

databases. In addition, the office has a number of large format color output devices and a variety of formats of scanning data input devices.

The UNM campus is wired with Gigabit redundant fiber backbone that connects all the zones in which the LNO will operate. Our facilities have both fiber and copper gigabit ethernet connections. Research activities at UNM enjoy a fractional OC-3 fiber connection to the Internet II via Denver that is connected directly to the gigabit backbone infrastructure. In addition, the University of New Mexico has just become a full member of the National LambdaRail consortium. National LambdaRail (NLR) is a major initiative of U.S. research universities and private sector technology companies to provide a national scale infrastructure for research and experimentation in networking technologies and applications.

Public welfare beyond science and engineering

Three of the objectives of the LTER Network directly address public welfare beyond science and engineering:
- To create a legacy of well-designed and documented long-term observations, experiments, and archives of samples and specimens for future generations.
- To promote training, teaching, and learning about long-term ecological research and the earth's ecosystems, and to educate a new generation of scientists.
- To reach out to the broader scientific community, natural resource managers, policymakers, and the general public by providing decision support, information, recommendations and the knowledge and capability to address complex environmental challenges.

In an effort to go beyond these objectives, members of the LNO staff have participated in the planning for the proposed National Ecological Observatory Network (NEON). NEON will be the first national ecological measurement and observation system designed both to answer regional- to continental-scale scientific questions and to have the interdisciplinary participation necessary to achieve credible ecological forecasting and prediction. As such, NEON will transform the way we perform science by enabling the integration of research and education from natural to human systems, and from genomes to the biosphere. Social scientists and educators will join ecologists and physical scientists in NEON planning and design and participate as observatory users, recognizing that we live on landscapes that are, to varying degrees, human-dominated ecosystems.

Immediate broader impacts to be realized are associated with the diversity that is built into the leadership of the NEON Design Consortium (i.e., inclusion of multiple disciplines, traditionally underrepresented groups and broad geographic representation). We believe that by providing for diversity "at the top," we will help insure appropriate diversity in populating the workforce (committees) that will be critical to the success of the NEON Design Consortium. Furthermore, in designing NEON, we will tap the intellectual capital across the full range of four-year institutions. We will also include the

insight of post-doctoral associates—NEON's next generation of leaders—in our design efforts.

The broader impact of our work in designing NEON will also be fundamentally enhanced by a focus on questions recognized by the National Research Council as being fundamentally important to the nation—climate change, invasive species, ecology of infectious diseases, biodiversity, nutrient cycling, and land use change—plus hydroecology and "emerging issues."

Appendix 1. Priority activities for the LTER Network Office

Service to LTER Sites

- Coordinate governance and scientific meetings
- Design, develop content, and supervise maintenance of LTER network web sites.
- Participate in and organize scientific activities as part of the All Scientists Meetings in 2003, 2006, and 2009, including planning and follow-up working groups.
- Identify and support 6-8 small research working groups a year, and seek other funds to increase that number to 20-25 following an All Scientists Meeting.
- Provide technical assistance to LTER sites.
- Facilitate the production of site volumes for the Oxford Synthesis series by providing editing and other technical assistance to sites, so that a complete set of volumes synthesizing research at all sites is available by the end of the decade.
- Provide limited support to LTER Network scientists in producing quality publications that describe the importance of LTER research aimed at general scientific audiences.
- In off years (2004, 2005, 2007, 2008), facilitate the organization of joint symposia at annual meetings of associated disciplines and support participation of LTER scientists in these symposia.
- Communicate knowledge about technical advances and computational and communication infrastructure to LTER sites.
- Prepare and print site brochures
- Prepare, edit, print, and distribute two Network Newsletters each year.
- Maintain 24x7 access to email, web, ftp servers.
- Report and communicate to LTER sites and the network
- Assure database integrity through daily backup and verification routines.
- Provide for backup and restoration of LNO computer file systems.
- Monitor and maintain remote sensing archive.
- Promote data standardization across sites
- Revise and print the LTER Personnel Directory every third year.

Service to the LTER Network

- Provide a point of contact between the LTER Network and external entities including NSF and other agencies and research centers
- Develop linkages between the LTER Network and other networks and research centers to facilitate improvements in LTER science
- Promote and support synthetic research collaborations designed to achieve the objectives of the LTER Decade of Synthesis.
- Work with the Network Information System Advisory Committee and the Information Management Committee to establish the Network Information System
- Provide support to and facilitate the activities of LTER standing committees

- Participate in and support the planning activities being conducted by the LTER Network
- Plan for future activities in coordination with the EC and CC.
- In coordination with the CC, identify and support at least one major synthesis effort each year
- Lead in developing one value-added database per year in association with the science theme meeting.
- Administer funds for LTER activities
- Prepare proposals for network-level activities
- Promote metadata standards within the LTER Network
- Curate, maintain, and expand LTER Network Databases
- Revise and print the LTER Network brochure every third year.
- Review and upgrade the LTER traveling exhibit every third year.
- Prepare materials for All Scientists Meetings every third year.
- Research and synthesize widely scattered historical documents associated with the development and scientific significance of the LTER program.
- Prepare and disseminate short descriptions of LTER research results on a regular basis and make these available to funding agencies, policy makers and the general public.
- Review and evaluate LNO staff
- Monitor and maintain the LNO Local Area Network.
- Enforce LAN, WAN, and computer security models at LNO.
- Upgrade and maintain LNO server operating systems and application software.
- Upgrade and maintain LNO desktop operating systems and application software.
- Provide user support to LNO Staff.
- Plan for and procure LNO hardware, software, and supplies.
- Upgrade and maintain LNO computer and network hardware

Service to NSF

- Develop a strategic plan focusing on LNO's mission, its role in relation to other organizations, and the most effective structure for managing LNO and its relations with external entities.
- Respond to requests for information about the accomplishments of the LTER Network for NSF presentations and publications
- Serve as a conduit for information requests from NSF to LTER sites and the Network
- Promote community collaboration and standardization efforts in IM
- Maintain the ILTER website

Service to the broader scientific community

- Develop linkages between the LTER Network and other networks and research centers to disseminate the benefits of LTER science
- Encourage the development of scientific enterprises that address national needs

- Train scientists in IM/IT tools developed
- Foster collaborations with organizations such as the Ecological Society of America to produce scientific fact sheets and other material that conveys scientific information to an audience that includes the general public, educators, managers, and policy-makers.
- Perform community service (proposal review, panel participation, etc.)
- Disseminate information to organizations involved in encouraging the participation of underrepresented minorities in science to increase the diversity of LTER scientists.