Midterm Review of the Long Term Ecological Research Network Office

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Review Committee: Randy Butler, Bob Groman, Nancy Huntly (Chair), Louise Mead, Jim Myers, Michael Piasecki, Brenda Shears

NSF Observers: Peter McCartney (Program Officer, DBI), Saran Twombly (Program Officer, DEB)

Executive Summary

The Midterm Review of the Long Term Ecological Research (LTER) Network Office (LNO) was held May 29-30, 2012, at the LNO in Albuquerque NM. The review team met with the LNO management team and several of the staff and had phone interviews with Principal Investigators and Information Managers from several of the LTER sites. There were clearly many areas where the LNO efforts were well acknowledged and appreciated and also areas where improvements should be made.

The committee commends the LNO on its accomplishments, particularly

- **Effective promotion of Network cohesion and science synthesis through logistical support for meetings.** LTER scientists and information managers viewed the LNO as essential to the ability of the LTER sites to function as a network. The ability of the LNO to promote synthesis through smooth organization and support of various meetings and working groups was particularly praised.

- **Moving forward with development of the NIS (Network Information System) including PASTA (Provenance Aware Synthesis Tracking Architecture).** Once on-line and fully populated, the NIS will facilitate discovery and access of both historical and current data across the LTER sites. It represents a significant advance over the current system and addresses criticisms about inaccessible data while also providing an LTER-wide data archive and a foundation for derived data products for science synthesis.

- **Development of strong collaborative relationships with the LTER information management (IM) community.** The level of engagement of information managers in LNO activities is impressive and a clear success for the LNO team. This engagement has two-way benefit in that it both assists the LNO in development of the NIS and also provides the LTER sites with cross-fertilization of expertise between sites and from the LNO.

- **Development of an improved web presence.** The new, soon-to-be-launched website, with its modern feel and audience-specific content, is a substantial advance.

The committee also identified some areas of concern. In these areas, the committee thinks that adaptation of current priorities and practices is needed to improve the likelihood of the project's success in meeting its goals. In particular, the committee suggests the following:

- **NIS/PASTA Deployment timeline.** The committee believes that the NIS has reached a stage where transitioning current capabilities into production and emphasizing data ingest and use within the new system will be more valuable than continuing to develop advanced functionality. The rationale is three-fold: The LTER science community is eager to begin using the NIS and delays would potentially blunt their enthusiasm; experience demonstrates that large-scale

software deployments benefit from an incremental deployment strategy and real-world feed-back from active users; current focus of the LNO on development of detailed capabilities of the NIS detracts from their ability to address other pressing needs. **The committee therefore recommends that the LNO develop a specific, and near-term, timeline for releasing a production version of the NIS and PASTA for use** – this would entail freezing functionality at a basic, reliable level, proceeding through beta testing, development of deployment and support plans, and deployment within a production environment. Releasing version 1 to the community for data population and beneficial use by early fall would provide the NIS developers and the LTER scientists with valuable early experience with the NIS and would inform the NIS developers on priorities for next steps.

- **Coordination of Synthesis with the NIS.** The committee noted general appreciation for the NIS by LTER researchers, but a relative lack of understanding of its potential capabilities. Further, the committee did not uncover any detailed plans among LTER researchers for the use of the NIS to advance their science or enable synthesis. **Recognizing the potential of the NIS as a mechanism to advance science synthesis, the committee recommends that LNO reprioritize its efforts to emphasize proactive engagement of LTER scientists in development and use of the NIS for synthesis.**

- **Broadening Communication.** While the LNO is providing significant value in coordinating LTER Network communications and developing a coherent Network message, the committee noted a relative lack of emphasis on communication with the ecological research and synthesis community beyond the LTER sites. Additionally, the committee noted an apparent strong emphasis on communication with site IMs and the LTER Executive Board, but much less attention to reaching LTER PIs and other site scientists. **The committee recommends that the LNO identify and implement a small and strategic set of activities to broaden the audiences it serves and to improve communications within the LTER community.** Better coordination of NIS and synthesis activities requires enhanced communication with researchers.

- **Basic Core IT Services.** The committee identified some unmet needs for basic cyberinfrastructure and IT support. Three areas require particular attention: Enabling better access of site personnel (e.g., via web services) to administrative data that the LNO has centralized, including site personnel data and bibliographic databases; providing sites with more expertise, practical training, and general support for the wide range of information management technologies in use, including those associated with the NIS; and supporting central maintenance and availability of site-developed tools and capabilities that might benefit a wider range of LTER sites. **The committee recommends that the LNO address these three areas of concern** as part of the effort to engage the LTER community in better using LNO capabilities and bringing the NIS into productive use.

- **Metrics for Assessment and Evaluation. The committee recommends that the LNO develop specific substantive goals and metrics with which to evaluate its progress and effectiveness.** These metrics will aid in more clearly articulating and communicating goals and timelines to help track progress and will assist in educating LNO stakeholders regarding the plans and timelines of complex activities, such as development and use of NIS services. The LNO assessment and evaluation must include a formal **risk assessment and risk mitigation plan for the NIS activities.**

- **Advisory input**. It appears that the LNO interacts relatively little with professionals outside of the LTER Network community and could benefit from a formal structure that brings outside opinion and expertise to the office. **The committee recommends that the LNO develop an external advisory structure** to strengthen their ability to learn about, incorporate, and interface with developing approaches, needs, and technologies.

Context for the Report

The Midterm Review of the Long Term Ecological Research (LTER) Network Office (LNO) was held May 29-30, 2012, at the LNO in Albuquerque NM. The review committee received materials describing goals and initial plans for the current LNO funded project (proposals DEB-0832652 and DEB-0936498 and associated Operations Plan) and other background documents that were provided by NSF or posted by the LNO on a website before the review. The LNO Executive Director, Dr. Robert Waide, other LNO leadership, LNO staff, and the current LTER Executive Board and Science Council Chair, Dr. Scott Collins, met with the review team to provide additional information on the progress and immediate plans of the LNO in each of its major areas of activity through a series of presentations, discussions, and question/answer sessions. The committee also spoke by phone with a number of LTER Principal Investigators (PIs) and information managers (IMs). This report summarizes the findings of the review team and their recommendations to NSF about progress of the LNO.

Organization, Management, and Institutional Support

The LTER Network Office (LNO) operates through Cooperative Agreements (CA) between the National Science Foundation and the University of New Mexico (UNM). The lead PI, Dr. Robert Waide, serves as Executive Director of the LNO and is the principal point of contact for UNM. Dr. Waide has a faculty appointment in the Department of Biology and also directs the Center for Research Excellence in Science and Technology (CREST) in the College of Arts and Sciences. He is responsible for the day-to-day operation of the LNO and implements programmatic recommendations of the LTER Executive Board, consistent with the CA with NSF. The general responsibilities of the Executive Director include cooperation with the Executive Board to set priorities for the LNO, development and the implementation of a strategic vision for the LNO, management and evaluation of staff, oversight of LNO efforts as outlined in the CA, and communication with the NSF, LTER, other agencies, and the general public.

As a result of his appointments, Dr. Waide reports to the NSF through an annual report of the LNO, and he is reviewed annually by the Executive Board of the LTER network of sites and by the Chair of the Biology Department. In addition, the Dean of Arts and Sciences at UNM reviews CREST. The Operational Plan serves as the measure against which the Executive Director is evaluated by the LTER Executive Board, but there does not seem to be a relationship between that review, the separate review of the Executive Director by UNM administration, and the review by NSF of the progress of the project the Executive Director administers. There do not appear to be significant problems arising from the independence of the reviews now, but there is potential for differences in goals among the different players to cause problems. The committee suggests that some coordination of the reviews of the Executive Director and LNO are desirable to assure that disparate criteria for evaluations do not compromise the responsibilities of the Executive Director to execute the terms of the CA.

The Executive Director supervises three senior staff members, the Director for Synthesis Support, the Chief Information Officer, and the Director of Core Services. The three senior staff

members and the Executive Director constitute the management team of the Network Office. The Network Information System (NIS) Developer may also participate in this management team. The senior staff members advise the Executive Director on matters pertaining to their areas of expertise and work with the Executive Director and other staff to further the goals of the LTER Network. They may assume the duties of the Executive Director in his absence. The Director for Synthesis Support and the Chief Information Officer are research faculty in the Department of Biology and are co-PIs on the current CA. The Director of Core Services is a UNM staff member. Under the overall supervision of the Executive Director, senior staff members have responsibility for three categories of activities (Synthesis Support, Core Services, and Information) and supervise the technical staff assigned to these activities. The Executive Director directly oversees External Relations and supervises the staff within that category. An Operational Plan derived from the Network Strategic Plan informs the Goals and Priorities of the LNO, and the Executive Director conducts annual performance reviews for members of the senior staff.

The review committee noted a relative lack of high-level formal duties for the position of Director of Synthesis Support, with the stated responsibilities primarily relating to management of LNO-supported meetings. In light of the recommendations elsewhere in this report to enhance support for synthesis activities and to integrate synthesis more effectively into development and operation of the NIS, the review committee suggests that LNO review and expand the responsibilities of the position of Director of Synthesis Support and assure that the responsibilities and the expertise of the Director and associated staff are aligned.

The LNO is housed at the University of New Mexico (UNM) main campus, within the CREST center and in the Center for Ecological Research, Informatics, and Art (CERIA) building, along with the Sevilleta LTER program and the Museum of Southwest Biology. This space is within a few minutes' walk of the administrative offices of the College of Arts and Sciences and Department of Biology. The Chair of the LTER Science Council and Executive Board, who is an LTER PI and serves as spokesperson for governing bodies of the LTER network of sites, is partially supported through the LNO budget and maintains a close working relationship with the Executive Director. The current Chair, Dr. Scott Collins, is co-located at UNM.

The LNO seems to be adequately (and enthusiastically) supported by the host University. The review committee met with President David Schmidly (who ended his tenure as President at the end of May); Vice President for Research Johannes Van Reenen; Mark Peceny, Dean of Arts and Sciences; and Richard Cripps, Chair of the Biology Department, all of whom voiced their support for the LNO and emphasized its value to UNM. They also indicated that UNM contributes some resources to the LNO, including the salary for the Executive Director via his appointment as tenured faculty, space for the LNO, and return of some indirect costs to CREST in support of LNO activities. Recently a digital repository, LoboVault, has been established and the review committee understands that this will be available for LTER data. Additionally, the University appears to have, and to be seeking additional, cyberinfrastructure awards for campus computing resources; we suggest LNO actively seek mutually beneficial relationships with these various cyberinfrastructure initiatives and the Office of the Vice President for Research in order to benefit as much as possible from the infusion of such resources at UNM.

It appeared to the review committee that the LNO is somewhat insular to the LTER community and University of New Mexico and would benefit from some external advisers or advisory body drawn from outside its current network of collaborations. Members of such a body could help increase awareness of the organization and services of other research hubs and could bring new ideas to the

attention of the LNO, as well as aid their efforts to interface with people and groups outside of the LTER network.

<div align="center">**Intellectual Merit**</div>

Administrative Core Services *(Basic Core IT Services are discussed below with cyberinfrastructure)*

Overall, the Core Services unit serves the LNO and the Network well. The Director of Core Services (DCS) is a certified research administrator and provides administrative support for the LNO staff and activities including working group support, travel, the triennial All Scientists Meetings, and all contracts, personnel, purchasing, and related tasks and services. The DCS is the liaison with the broader university policies and procedures and post-award compliance offices situated in the Comptroller's Office. The review committee's conversations with PIs and IM personnel indicated high regard for the work done by this unit in support of workshops and meetings. These conversations did reveal a few places where services could be made smoother or more effective: Some site personnel indicated a need for more proactive communication regarding the status of awards from the LNO that involve transfer of funds to another institution (e.g., what must be done to facilitate movement of funds from LNO to the other institution; what is the required or expected timeline). Additionally, as discussed in more detail in other sections of this report, the committee thinks that the LNO would benefit from more staff visits to LTER site locations.

Support for Research Synthesis

The LNO originated because of the perceived need for an entity that could improve the ability of the sites that comprise the LTER program, and the broader community, to collaborate to increase synthetic science using data from more than a single LTER site. Collaborative science and scientific synthesis are goals of the LTER network; they also are a major force that has promoted site cohesion and provided incentive for the LTER sites to function as a network. Accordingly, the LNO has emphasized meetings and planning that bring LTER personnel together, and LTER scientists recognize these activities as essential to their ability to do synthesis science and to their cohesion as a network. Further, development of the NIS was inspired in part by the need to better support synthesis science through the discovery and use of cross-site data.

During the review, the LNO identified their priorities for science synthesis support as: Planning (working groups engaged in strategic planning or development of Network research prospecti), projects (via seed funds for Working Groups and Post-doc Projects), and all-site LTER science meetings (the annual Science Council and triennial All Scientists Meetings). These activities of the LNO are among the most valued by the PIs and Information Managers with whom we spoke, all of whom indicated that the LNO provides excellent meeting organization and logistic services.

Although these services are clearly valuable, there appears to have been little adaptation or prioritization within this suite of activities. The LNO has recently provided more funds to support working groups and initiated a post-doctoral projects program, both of which seem well-chosen allocations of funds. However, as noted for other LNO activities, there does not appear to be a well-developed evaluation of this portfolio of activities. Formative evaluation that could help quantify impact of activities, identify changes in their effectiveness over time, and provide information on new strategies that might be more effective would be particularly helpful to the LNO in prioritizing their efforts and allocating funds.

There seems to have been little, if any, discussion of whether the current LNO activities are the most important services to enable the community research agenda and maximize the effectiveness of the Network. The committee recommends that the LNO be more active in discussion of a Network-level research agenda and that it reprioritize and coordinate its activities to best support LTER Network goals for synthesis science. Although the LNO's engagement of and collaboration with information managers is strong, that with PIs and site scientists appears weak and should be improved. The review committee anticipates that the NIS will be increasingly important as a mechanism to facilitate synthesis of cross-site data; engaging researchers early-and-often in aligning development and deployment of NIS capabilities will be critical in realizing its value to enable next-generation research.

The LNO stated that their goals for development of the NIS are to increase availability and quality of LTER data, increase timeliness and number of LTER derived data products, and increase knowledge generated from synthesis of LTER data. If this is to happen, the scientists who will define the leading science questions need to be familiar with the NIS and the developers of the NIS need to have informed input from the scientists who will use the data and data products. The review committee suggests that the Synthesis arm of the LNO actively seek better understanding of the needs of the LTER scientists and directly engage more LTER scientists with development of the NIS and its future functions. The LNO should be more aware of the ongoing activities, aspirations, and challenges of LTER scientists so that site scientists are engaged with and well-served by the LNO.

The LTER data and derived data products are also valuable to scientists from outside of the LTER network, but there appears to be no linkage of LNO efforts with this broader science community. The committee recommends that a representative group of external scientists be engaged to provide advice to the LNO. Engagement with scientists, from both within and outside of the LTER network, will greatly enhance the potential of the NIS to meet its goals of facilitating the next generation of synthesis science based on LTER data.

Development and Implementation of Cyberinfrastructure and Basic IT Services

Basic Core IT Services

The overall impression of the review committee was that the LNO handles basic core IT services quite well. This impression was supported by comments from site PIs and IMs, most of whom lauded the responsiveness of the LNO to questions about technical issues (especially via email directed to the NIS Developer and Lead Programmer). The interviewees almost verbatim repeated that overall "the LNO is doing a good job" and acknowledged that the LNO is instrumental to holding the Network together. The LNO is perceived to have a genuine desire to be helpful and supportive whenever there are technical issues with components of the LNO-developed IT at LTER sites (e.g., with EML, MetaCat, and I/O of files). Most site personnel with whom we spoke also recognized benefits to having an LNO that provides centralized services, such as the proposed backup for their data, and advantages to having a centralized IT system such as the NIS. They also praised the introduction of Tiger Teams to deal with specific technical issues; embedding the site IMs (for issues related to IT) and PIs (for issues related to science) was considered an excellent idea. The review committee commends the LNO for its success in coordinating with site IMs, especially given how difficult this has been for other large projects. Many of the site IMs and PIs also commented on the much improved web presence, something the committee also noticed.

Although both LTER personnel and the review committee recognize that the LNO has improved its Basic Core IT services and that these services are valued, several weaknesses remain. The review

committee distilled several items that reflect a somewhat broader issue of communication. Conversations with LTER site representatives clearly indicated insufficient communication of the LNO's goals, plans, and timelines. The committee found both insufficient communication from the LNO to sites about technical developments and insufficient solicitation of input from the sites to LNO activities; communication about scientific priorities appeared weaker than communication about technical issues. Communication seems to be a particularly critical issue for sites that lag behind in IT skill levels and are adversely affected by this lack in skill, especially with the increased need for expertise that comes as a result of the NIS development. Sites that are struggling to support basic IT knowledge levels need better support services. The committee also observed some frustration of site personnel with what appears to insufficient planning (or communication of plans) for integration of data into NIS and insufficient LNO support for this activity. The review committee recommends that the LNO pay closer attention to the process of integrating site data into the NIS; it is essential that they fully document the process, build and support generalized data integration tools that can aid the sites, and ensure that each site is prepared to integrate data with the NIS. Some sites need more training.

Additionally, personnel from two sites gave examples of site-developed tools that would be broadly useful to the LTER sites and indicated a need for the LNO to provide help in disseminating such tools to the broader LTER community. There is a need for a well-documented process to facilitate shared use of such IT tools; the LNO is best-situated to provide this service and to provide long-term stewardship of these tools.

The committee heard some concerns about the level of involvement of the sites' IMs in network activities, despite the recognized value to sites of allowing their IMs to engage in activities in support of LTER network goals. PIs and IMs expressed some concerns about balancing the responsibilities that are placed on some of the particularly skillful and experienced IMs. The time investments of these IMs in network activities may compete with time that is needed to meet responsibilities of their sites. NSF may want to consider this issue when it is addressing the broader LTER program; for instance, it may be necessary to supplement sites for compensation of IM time to build stronger network IM capacity.

The committee also found some perception among the site PIs and IMs that there are areas in which the LNO does not have sufficient expertise and so relies (sometimes heavily) on the expertise of site IMs instead of improving the capabilities of the LNO to provide technical guidance and leadership, whether through gaining additional knowledge or allocating additional staff. The LTER community appears to be evolving a culture of expecting technical guidance to be available from the LNO (which overall seems positive), and they need improved technical assistance from the LNO, including additional technical information, training, and support. A basic priority need is for more guidance on simple, practical methods for interacting with the NIS (e.g., improved expertise on EML). An improved and expanded 'technical hotline' function appears to be desired and needed by LTER site personnel. The review committee cautions that the current strong focus of the LNO on the NIS may be inhibiting their ability to address needs for basic technical support.

As indicated above, while the LNO is strong in its engagement with IMs and development of IT, far less attention seems to be given to engaging the LTER PIs and other scientists. Engagement of scientists is needed at many levels, but the committee notes the needs for scientists to be better engaged both in discussion, management, and curation of raw data and in development of science-driven priorities to guide the LNO's activities.

The following list summarizes the committee's observations of significant unmet need for expanded basic core IT services of the LNO:

- The LNO should attempt to satisfy more of the LTER sites' requests for help with programming and development. It may be necessary for the LNO to reprioritize staffing and roles to meet this critical need, as the NIS Developer and Lead Programmer cannot be expected to also be the primary purveyors of basic IT support.

- The LNO should address the need for web-service access to the personnel and bibliographic databases so that individual sites do not need to duplicate these databases locally.

- The LNO should increase visits to sites so that they can better serve their community by collaborating with site personnel in hands-on sessions to identify and solve problems, thus moving collaborative efforts forward at a site-specific level. A 'rover team' might be created for this purpose.

- The LNO should improve communication of IT plans, timeline, status, and associated expectations to the LTER community, especially to the scientists, so they are better prepared to gauge involvements and resource allocations. This would help to delineate better where the site IM activities end and where those of the LNO begin, and vice versa.

- The LNO must engage the site PIs much more aggressively in determining what the priority derived data products should be, as well as how to create them efficiently at the sites, such that they can be harvested, or, conversely, to prepare the base data so the LNO can develop them automatically.

- The LNO should better assess and communicate the needs for front end (e.g., EML loading) and back end (e.g., search, retrieval, analytical tools and workflows, publication, as exemplified by EcoTrends) applications of the NIS, and they should incorporate site-specific needs into the development of these applications.

- The LNO should develop lists of site needs for participation in the NIS and develop strategic priorities to provide training and assistance to support full and timely participation of sites in the NIS.

Network Information System

The Network Information System (NIS) is a collection of software services, most notable of which is Provenance Aware Synthesis Tracking Architecture or PASTA, that is designed and being implemented by the staff of the LNO to provide the LTER community with a comprehensive data management solution. NIS/PASTA provides a wide range of capabilities, but was designed primarily to provide replication of data collected by the LTER sites for preservation, search and discovery, access, and download of data from a centralized LNO location. The NIS is expected to provide the LTER research community with the ability to preserve its data in a highly accessible, well-documented state, complete with a set of accompanying services that are intended to advance internal and external use of the data, as well as enhance the ability to do synthesis science using cross-site data. The NIS program has been in development for the last two years and has recently achieved a major milestone by producing a beta version of the program, which has end-to-end functionality superior to the existing MetaCat system and is almost ready for testing outside of the development team.

The beta version of the NIS that was demonstrated at the mid-term review included quality checking of metadata, data quality checks, and the necessary web services to display and download both metadata and data. The NIS was designed to generate provenance metadata for any data that are modified within NIS/PASTA, including the origin of a derived product that is a result of combining data sets. The software also is able, through web services, to support external applications that can search and access datasets. NIS/PASTA additionally supports scientific workflows that may synthesize datasets into a new derived data product. The requirement that the NIS system make a copy of the data locally, co-resident with the metadata, ensures that the metadata and data are always available in the NIS. Because site-resident data files may be updated, corrected, or even inadvertently changed, it would be useful for the LNO to develop a process to ensure that the latest data are consistently enrolled in the NIS. For instance, the LNO might keep metadata (such as a hash) that would allow them to detect whether the local (LTER site) and central (LNO/NIS) copies were inconsistent.

The beta-release demonstration indicated that the NIS software was close to a usable state and the committee commends the LNO for this accomplishment. Phone interviews with PIs and IMs indicate that LTER sites are eager for the transition to the NIS to begin, and the review committee recommends that the LNO move quickly to take advantage of this enthusiasm and the accompanying opportunity to gain early operational and user experience with the NIS. Experience with other large software development suggests that incremental phased roll-out of capabilities that support the needs of specific science projects is far superior to an approach that delays production until after the entire suite of software functions has been completed. Phasing deployment provides early insight into how a system works, how users want to use it, what capabilities users need to succeed in their research, and how the system operates; these insights enable priorities for continuing phases of development and result in a running system that better addresses user needs. There also is a social impact of enrolling early users, as many software projects that deliver a technically capable system fail due to lack of understanding of the socialization of that new service to the users it is intended to serve.

The committee strongly recommends that the LNO begin planning to roll out an early version of the NIS by fall or winter of 2012. Waiting a year or more to roll out the first version of the NIS may very well miss the opportunity that is available now to engage scientists and information managers and gain their experiences and insights. Instead, we suggest that the LNO freeze the NIS development effort and focus on implementing the NIS on a suitable production platform. It is important to ensure that the NIS work correctly within its existing functionality, but delaying much longer would be a mistake.

The committee recommends that the LNO begin immediately to develop a phased deployment plan that includes testing, enrollment of early users who bring specific scientific goals, and creation of a production environment, support plan, and detailed data ingestion strategy. The data ingestion strategy should be developed in collaboration with site IMs and researchers and should be informed by science priorities. The LNO should take a lead in coordinating, prioritizing (based on user-specified science needs and questions), and providing expertise to assist sites in transitioning data into the NIS. Leadership from the LNO is needed to identify common practices and tools to assist sites in this effort.

To accomplish launching and use of the NIS, the LNO must plan for deployment and operational support of the NIS. It will be critical to plan how to efficiently roll out the service in a way that is efficient for sites, and does not cause them extra work. The LNO also must plan how to incrementally test and add new functionality and resolve bugs after the operational system is in place. These highlight the need to have a community bug-tracking system in place, as well as technical support personnel to help IMs and researchers that are trying to use the new system. A detailed operations plan is needed and must include backups, disaster recover, replication, and

scalability; the schedule for enrollment of data; the nature of the production facility; the expected network load; the security plan; the staffing plan; and authorization procedures.

As the above implies, we recommend that the LNO organize the overall data ingest effort as a Network activity rather than as a site-by-site effort. The LNO must work with those information managers who are ready to transition site data and metadata into the NIS to develop best practices and must assure that those best practices are conveyed to other sites. Information managers should be assured that they are using the production program (and thus won't have to reload data later) and they must understand the tools and processes that are available, how they should prioritize, and who at the LNO will provide what specific assistance. LNO staff must actively shift efforts in a dramatic way to accomplish these goals. History demonstrates that the best technical solutions do not automatically win; it is the technologies that are needed and supported and promoted the best that are adopted and succeed. In this spirit, the review committee acknowledges the significant technical success that NIS/PASTA already represents and recommends that the LNO begin to shift its support towards adoption of the NIS by the LTER community

<center>**Broader Impacts - Development, Outreach, and Training**</center>

The 2008 LTER LNO proposal identified four core components for development, outreach, and training: To enhance understanding of LTER; to promote LTER as a center of excellence offering a network of experts engaged in understanding long-term ecological research and processes; to facilitate and contribute to partnerships between LTER and other networks; to provide LTER scientists, IMs, and students with training in new technologies. The operational plan developed by the Executive Committee in response to this proposal specified four goals to help meet these broader aims: Create a Strategic Communication Plan; effectively communicate information about the LTER Network; build and maintain strategic partnerships; provide and coordinate training for LTER scientists and information specialists.

Strategic Communication Plan

An ad hoc communication committee created an extensive and ambitious Strategic Communication Plan to build the communication capacity of the LNO and LTER network. We commend the communication committee and LNO for this achievement and recognize that the Plan addresses concerns voiced by the LTER sites. The review committee recognizes that the LNO is working to accomplish smaller more manageable aspects of the Plan, but reiterates the caution that, as was stated in the Plan, additional funds would be necessary to fulfill much of the Plan.

Communication

The LNO has done much to improve communication of information about the LTER network, with the Public Information Officer (PIO) taking primary responsibility and phasing in changes and enhancements. Redesign of multimedia exhibits is well underway, a new website has been developed, national and regional press releases produced, and an electronic newsletter implemented. The new website is needed and can provide a relatively low-cost mechanism for improved communication. The review committee urges that addition of content to the new website be made a priority so that the website can be officially launched soon, perhaps at the annual Ecological Society of America meeting in August. Also, we urge the PIO to take advantage of opportunities to network with other NSF (and other)

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Center communications specialists and with the community of science writers and to investigate use of social media as efficient ways to enhance communication.

Following the site visit and discussions with LTER PIs and IMs, the review committee agreed that improving internal communication should be a priority over promotional communication. There is much need for, and much to be gained by, improved internal communication throughout the network, particularly across sites and between scientists at each site and the LNO. Such communication would likely advance synthesis by creating an atmosphere where science better informs the LNO actions and tool development.

The LNO is advised to seek cost-effective ways to facilitate communication, both across sites and to those outside of the Network. This could be made a core function of the new website. For example, graduate students at LTER sites could write blog entries about their research and the PIO could edit and post these on the new website. (This also would provide the graduate students some training in science communication, another potentially valuable service of the LNO.)

Partnerships

The Operational Plan outlined specific partnerships designed to benefit science, cyberinfrastructure development, and education within the LTER network. The LNO team has a number of partnerships with relevant projects and organizations with which it, and the LTER Network as a whole, have mutual interests. Many of these partnerships represent long-term interactions of staff with their colleagues and form a base for ongoing dialogs. Some of the partnerships appear to focus on sharing expertise, while a few focus on adding scope beyond the LNO strategic plan; some of the partnerships continue to have value, but others seem no longer to be useful. The review committee believes that the LNO could accelerate its development through more-strategic partnerships that directly address specific goals and have concrete joint tasks and deliverables. It appears that additional strategic partnerships could be valuable in development of social and environmental synthesis (with synthesis centers, DataNet projects targeting social data and synthesis, etc.), evaluation and analysis of the LTER citation network (with evaluation or network analysis research groups), improvement of consulting services (e.g., with other organizations that could provide EML expertise), analysis of risks (with similar efforts), and perhaps development of educational materials.

We suggest that the LNO review its plans and identify areas where partners could accelerate progress or help inform the design of internal efforts. Engaging partnerships to address LTER strategic goals and support active synthesis efforts, and clearly identifying the value to the Network of each engagement, will reduce the perception or reality of partnerships that distract the LNO team rather than contribute to progress in meeting their goals.

Training

The LNO provides various training opportunities for LTER scientists and information specialists. As an example, a workshop on Ecological Information Management was ongoing during our site visit. Although feedback from LTER sites indicates that workshops and working groups are valued, there appears to be considerable unmet need for training to improve the IT capabilities of information specialists. There may also be need for scientists to have increased skill in data management, data documentation, and data curation. While we acknowledge the challenges of bringing all LTER sites up to a high information management capability, there appears to be a need to reevaluate and rebalance the distribution of attention to training programs and staffing to provide training that better meets needs to build capabilities.

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Assessment and Evaluation

Many LNO activities appear to be progressing well and the services of the LNO overall are valued by LTER site personnel. However, the project generally lacks sufficient metrics to evaluate progress and effectiveness of the services being offered. This encumbers external analysis of progress and, more importantly, makes it difficult for the LNO team to self-assess and make decisions about how to allocate its limited resources. Further documenting such metrics also provides the service stakeholders better insight into plans and priorities.

The LNO proposal indicated that external evaluators would conduct formative and summative assessment of LNO programs at least annually by employing a mixture of qualitative and quantitative approaches with the specific aim of evaluating the following goals: Facilitate scientific synthesis; develop, implement, operate, and maintain cyberinfrastructure to support LTER activities; provide core services; enhance development and outreach. It is clear that the survey sent out to LTER site participants every other year attempts to evaluate some of these goals. However, the review committee found that the LNO needs more rigorous assessment and evaluation across all activities; additional investment of resources is warranted to obtain sharper and more useful assessment and evaluation.

The LNO proposal identified questions as evaluation measures, but these would be better cast as specific desired outcomes – what the LNO expects members of the LTER community to have done or gained as a result of LNO activities or interaction with the LNO – so that achievement of substantive goals can be more effectively assessed. Surveys can be tiresome to complete and it can be difficult to get adequate response rates. It may be helpful to use separate surveys for different topics or to use more integrative, higher-level metrics, so that participants are not asked to complete 50-question surveys about all topics all at once. The outside evaluator should also consider whether interviews would provide additional information.

We suggest additional metrics be used to evaluate the benefits of working groups and other network synthesis activities. Partnerships with Synthesis Centers (e.g., The National Evolutionary Synthesis Center, NESCent) could be helpful in improving evaluation metrics and approaches. For instance, NESCent has instruments for evaluating outcomes from synthesis activities that could serve as useful models.

Although the LNO has a timeline and milestones for the NIS/PASTA project and its development is on track, it is unclear that the existing tests and metrics are sufficiently well-defined to assess relative or overall values of the suite of cyberinfrastructure and IT services they provide and to be useful in balancing efforts to assure overall beneficial use. It would be helpful to the LNO staff to evaluate core services (e.g., video-conferencing and email solutions) based on real use numbers. They could then tell better if costs are justified by the level of use and the potential alternate solutions available. Dramatic shifts in usage numbers of a service also could be useful in monitoring if the service is functioning properly. The committee recommends that LNO find more effective ways to instrument and monitor the use of the NIS and other core services, and that they use that information to evaluate the costs/benefits of its services and adjust adaptively to deliver the most beneficial portfolio of services.

Risk Assessment

It was not clear that the LNO has given sufficient attention to risk assessment, as the risks that were presented during the site visit were only at the highest level and information about mitigation strategies and potential recovery options was informal. Clearly, evaluating risks and developing

strategies for their mitigation are essential to the reliability and health of any project, system, service, or activity. Several layers of risk should be documented and addressed by the LNO. While formalization of risk management takes effort and at some point has diminishing returns, LNO is at a point where more thorough assessment of risks will significantly improve the potential for successful project completion.

In a risk, threat, and vulnerability assessment, one of the essential early activities is to document assets that are of value to the organization or project. These assets may include things such as hardware, people, data, and reputation. For instance, one can articulate what data and functionality are critical and so what hardware and services are the key assets. One can then examine the risks, threats, and vulnerabilities to these assets and draw conclusions about their likelihood and severity, as well as the potential project-level impacts of their occurrence. Identifying mitigation and recovery strategies can then inform project plans and help assure delivery and beneficial use of a critical system or function. Simple strategies, such as replicating data, provisioning hardware as hot spares with all the required software loaded and ready to switch on, redundant networks, UPS systems, and more should be considered and included in the scope of development, deployment, and operations plans.

The development activities for NIS/PASTA are a central activity of the LNO, so are of particular concern. The LNO should review the design and implementation to clearly identify the risks, potentially leveraging expertise/experience on related projects, in order to protect the work that has already been put into that activity. This review should consider NIS/PASTA's dependencies, both internal and external. It is often helpful to consider risk in three categories, the risks associated with the design and development activity, those associated with transition to production, and the operational service risks. System-wide risks should be included (e.g., the risk that a science team will not enroll data because the tools are too difficult or that service will be unavailable due to extended network or power outages during critical times such as demonstrations and active data enrollment times).   A number of risk, threat, and vulnerability approaches are well-documented and could be adopted by the LNO. Mitigation strategies may include effective security monitoring, documented system and software patch processes, uninterrupted power supplies, redundant backups, and detailed documentation on any service that makes it easier for the non-expert employee to pick up the reins on a service. A list of prioritized risks, with strategies for their mitigation, would help the LNO to provide the highest level of reliable, trustworthy services. To be clear, we do not suggest an exhaustive multi-month process of assessment, but rather an approach that specifically identifies the highest-level risks to important activities and services and incorporates appropriate mitigation strategies into the scope of work.

Conclusions

The review committee commends the LNO team for the significant value it provides to the LTER Network. The recommendations in this report are viewed as adaptations that follow from the already strong core service and development efforts of the LNO and would help the LNO team fully achieve the goals of its current cooperative agreements. Moving NIS/PASTA into production and focusing on its immediate beneficial use, which is our strong recommendation, only makes sense because the core development efforts have succeeded in creating potentially valuable capabilities. Coordinating synthesis activities with NIS deployment also makes sense because LNO has helped the community coordinate around synthesis and has incorporated synthesis-enabling functionality into the NIS. Giving priority to broadening communication to include the broader set of site researchers and the larger ecological research community makes sense because communications with the Executive Board and information managers already are good.

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That said, the review committee believes that LNO is at a critical juncture where its success to date will not translate into long-term success in promoting synthesis science and efficient operations of the LTER Network without significant adjustments to how the LNO approaches the second half of the project period. The general themes that cross the committee's recommendations are that LNO should seek to strengthen the alignment of its activities with the science goals of its community and should adopt practices in communications, coordination, development, deployment, and evaluation that allow the LNO to identify community science goals, prioritize its activities to support them, and enter a loop where substantive evaluation can guide course corrections and optimization of efforts. The specific recommendations and guidance given herein map these themes to various LNO activities.

It is with admiration and anticipation that the committee submits this report. We look forward to seeing a talented team make important mid-course corrections and bring new capabilities to bear that will enable next-generation research by the LTER community.