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PROJECT DESCRIPTION

Background

This proposal responds to NSF solicitation 19-544 for a LTER National Coordination Office whose role is to "coordinate network level activities, including synthetic research, education, and outreach programs across the 28 LTER research sites, communicate these activities to diverse audiences, and provide centralized representation of the LTER network to the broad scientific community and the public." Since November 2015 we have played this role as the LTER National Communications Office (LNCO), operating out of the National Center for Ecological Analysis and Synthesis (NCEAS) at the University of CA Santa Barbara (UCSB) and working closely with the LTER Science Council, Executive Board, and chair to identify emerging scientific trends and challenges, opportunities for cross-site and cross-network collaboration, and respond to National Science Foundation (NSF) requests for information. We propose to assume the role of the national coordination office, which we recommend naming the "LTER Network Office" (LNO), with a program that will maintain and improve upon most of the activities of the current LNCO, but with some re-organization and reprioritization based on lessons learned during our first 3 years of operation. We propose the name change because we believe the simpler name succinctly captures the multiple, diverse network support activities of the office.

Results of Prior Support

Long Term Ecological Research (LTER) National Communications Office (LNCO),
DEB 1545288, 10/1/15-09/30/19

Since 2015 the LNCO has supported 6 productive synthesis working groups. In addition to transitioning from the network office in New Mexico, we modernized LTER communication and outreach with a new website, newsletter, science updates and an active social media presence. We also supported a wide range of network meetings including 3 Science Council (SC) meetings, an All Scientists Meeting (ASM), U.S. participation in the International LTER's first Open Science Meeting (OSM), 2 NSF symposia, and regular virtual meetings of the Executive Board and LTER standing committees.

Intellectual Merit

Working groups organized through the LNCO are developing new ecological theory in areas such as: scaling the biodiversity-productivity relationship; understanding the roles of metacommunities, spatial synchrony, and temporal synchrony in mediating response to disturbance; and integrating plant community responses from over 100 experiments that manipulate global change drivers. Working groups are constructing integrated data resources on soil organic matter and stream carbon and nitrogen relationships. Meetings such as annual SC meetings and triennial OSM and ASM have generated many ideas for future network initiatives, cross-site research and synthesis projects. The LNCO has assumed a lead role in translating these ideas into proposals for funding network science through NSF programs such as Research Coordination Networks and AccelNet.

Broader Impacts

As the public face of the U.S. LTER network, the LNCO makes LTER network science more accessible to students, educators, early career investigators, resource managers and others through the Network website, a monthly newsletter, social media outlets, a webinar series, and a children's book series. LNCO

personnel widely distribute LTER research, work, and collaboration opportunities. The 2018 LTER All Scientists' Meeting attracted 600 people, including 30 undergraduates and nearly 200 graduate students, as well as a number of agency scientists, for workshops on new science, techniques, and cross-network collaboration.

Publications

Full citations for LNCO synthesis products (Wilcox et al. 2017, Langley et al. 2018, Richter et al. 2018, Thompson et al. 2018, Isbell et al. 2018, Mori et al. 2018) are included in the references section. Nine additional publications, including a special issue of *Ecosphere*, as well as multiple datasets, are in review and in preparation.

Introduction

Intellectual Merit

Many ecological phenomena can only be understood through experimental and observational research spanning many decades, especially those phenomena that exhibit long term dynamics, are rare and episodic, and/or are not conducive to short term experiments (Risser 1991). As a result, rigorous long term ecological studies have had a disproportionate impact on the science of ecology (Hughes et al. 2017). Moreover, long term research has played an ever more important role in formulating environmental policy and management responses to critical environmental problems such as air and water pollution, invasive exotic species, and climate change (e.g., Groffman et al. 2012, Walsh et al. 2016, Driscoll et al. 2016). Since 1980, the Long Term Ecological Research (LTER) network has been the global "gold standard" for site-based, process-oriented, long term ecological research. Presently, 28 LTER sites encompass diverse ecosystems in the continental U.S., Alaska, Antarctica, and islands in the Caribbean and the Pacific, including deserts, estuaries, lakes, oceans, coral reefs, prairies, forests, alpine and Arctic tundra, urban areas, and production agriculture.

Background

The LTER Network Office (LNO) was established in 1983 to provide the LTER network with: computational, data management, and communication infrastructure for research and education; public outreach; network coordination among sites and with other scientific networks and organizations; administrative support; and creating an efficient and effective environment for synthetic research and education activities (Waide and Thomas 2013). In 2015, the LNO was reorganized as the LTER National Communications Office (LNCO) with the mandate to "foster and coordinate research, education, and outreach activities across the Network as well as facilitate Network governance" and to "promote the LTER program both nationally and internationally (NSF Program Solicitation 15-535)." At this time, the role of providing centralized data management was shifted to what would become the Environmental Data Initiative (EDI).

The functions of the LTER network office have evolved over time, but we interpret the current solicitation, which stipulates that the National Coordination Office will "coordinate network level activities, including synthetic research, education, and outreach programs across the 28 LTER research sites, communicate these activities to diverse audiences, and provide centralized representation of the LTER network to the broad scientific community and the public," as continuing the functions of the current LNCO but with relatively less emphasis on media relations and public outreach. The shift from a

grant to a Cooperative Agreement should allow the LTER national coordination office to work closely with NSF to see that the mission of the office is achieved.

Here we propose a program that will maintain and improve upon most of the activities of the current LNCO, but with some re-organization and reprioritization based on a reduced budget and lessons learned during our first 3+ years of operation. The program includes specific proposals for: community engagement, synthetic research, communication with diverse audiences, coordination of network education activities, and network office management.

LTER Community Engagement Plan

A backbone for collaboration

One important aspect of the LTER network's success is the long term relationships formed among colleagues who have worked together for decades. Knowledge exchange and ideas for cross-network collaboration and synthesis arise through site visits, All Scientists' Meetings, and informal gatherings at conferences — but the Network is large, dispersed, and its scientific scope is widening and evolving. The network is absorbing new LTER sites (e.g., additional high-latitude coastal and marine ecosystems), scientific approaches and perspectives (e.g., global and macrosystem perspectives), and rapidly developing fields of study (e.g., evolutionary ecology). Making the most of these opportunities requires even more effective networking capacity to connect a larger and more diverse community. Today's LTER network needs to be more accessible, inclusive, and responsive than ever.

The LTER network is comprised of many overlapping communities. Investigators form and re-form communities by ecosystem and research foci; support professionals coalesce around job function (information managers, education managers, program managers, outreach professionals); cross-cutting interest groups (such as science communication) or committees (such as diversity) include undergraduates, staff, and senior faculty. Any work group might involve individuals from inside and outside the network. To support such a dynamic enterprise, the network office must maintain consistent, accessible records and appropriate access to work-in-progress without incurring unsustainable overhead on the participants themselves.

Fortunately, the tools to manage such fluid and informal networks have been developing rapidly over the past few years. We propose to adopt a modern, cloud-based constituent relationship management (CRM) system with online community functionality to facilitate sharing of calendars, task lists, active documents, and discussion by committees and working groups in a way that offers easy and flexible access control (Nisar et al. 2019, Taraj et al 2016). The CRM will integrate with the current, recently redesigned network web site to display a current directory of site approved members. Maintaining currency of this system will require much less intervention by the LNO than required by current and previous approaches. Members will be able to login using a username and password of their choosing, update personal information, find and join groups with common interests, use shared workspaces, and update their own delivery preferences for all LTER content in one place.

This approach has many advantages in terms of efficiency alone, but we also expect that it will allow new members to more quickly integrate into the network, facilitate greater sharing of information and ideas, and encourage even greater initiative by lowering barriers to collaboration. LTER graduate students and new sites especially would benefit from quick integration into the network.

Additional details on plans for the CRM and online community can be found below in the *Management Plan* section.

Aligning practices across sites

The tremendous diversity of LTER sites — different ecosystems, different partners, different conceptual models — is a both a great asset and a great challenge. It presents opportunities to learn from a wide range of cross-site comparisons, but requires the program to find an appropriate balance between network level consistency and site autonomy.

Our approach for the past three years has been to work with LTER leaders to establish and implement consistent standards and practices where they are needed to maintain a well-functioning network with a consistent public face, while imposing the minimum requisite structure. We encourage alignment among sites by supporting and sharing community-driven best practices and recommending tools and training that will increase efficiency or improve connections across and beyond the network. We strive to support and encourage scientific, educational, and outreach initiatives arising from within the LTER community, prioritizing allocation of LNO resources to activities that would most benefit from the organizational capacity and focus of a network office.

The reduction in budget under the current solicitation requires even greater discipline and clarity about what functions the LNO can directly support. We envision activities falling into 3 categories as described in Figure 1.
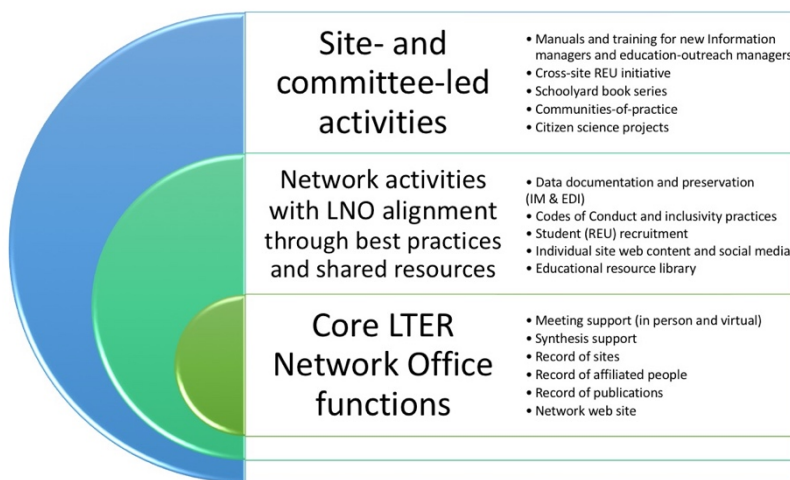

Figure 1. Tiered priorities for LNO activities.

- **Core functions** require the financial or informational resources of the network office.
- **Alignment activities** relate to primary site functions, but require information sharing via the network office.
- **Site- and committee-led activities** may depend on modest coordination by the network office but are driven by site and committee leadership and initiative.

We propose to scale back the network office involvement in committee-led activities, especially in the education arena. Specifically, we will no longer employ an Education Coordinator, although the LNO will continue to facilitate the work of the Education and Outreach committee by coordinating meetings, identifying and sharing new resources and funding opportunities, and providing tools for efficient collaboration. Please see the *Education* section for additional details.

Meetings

As virtual meeting technology has improved, the LTER network has moved toward holding more meetings via online video conferencing. The LNCO has supported online meetings via the Zoom meeting

platform, which is reliable, intuitive, free of charge at UCSB, and offers easy-to-use sharing and collaborative features. We currently support and attend monthly or quarterly videoconferences for seven internal committees as well as various working groups and synthesis activities. Between March 2018 and February 2019, the LNCO hosted over 150 separate online committee meetings involving over 2000 person-hours. The proposed LNO will increase the level of virtual meeting support by adding a few LTER-dedicated Zoom accounts, and defining a clearer protocol for requesting a meeting link. In addition, the LNO will produce and share best practice documents for online meeting facilitation, which can require a little extra attention to ensure that all communication styles are accommodated (Handke et al 2019, Hampton et al 2017).

Face-to-face meetings also play an important role in network coordination and synthesis efforts. Currently, the LNCO provides financial, logistical, and planning support for four in-person activities (beyond Synthesis working groups) each year. As the LNO we propose to continue supporting these activities, as summarized below. We also are prepared to organize the triennial All Scientists' Meeting (ASM), which is a major factor in LTER network cohesion, but funding for that activity will require a separate supplement to the LNO award.

1) Science Council Meeting. The location of this annual meeting rotates among LTER sites, offering the 60-70 participants their only consistent opportunity to experience and learn first-hand about one another's sites. Many multisite experiments and practices have been borne out of conversations at this three-day meeting. Participants include LTER site lead PIs, LNO staff, NSF program officers, and one additional investigator from each site (typically used to introduce emerging site leaders or bring key topical expertise). The LNO will partner with host-site leaders to plan meeting logistics and with the LTER Executive Board to plan meeting content.

2) NSF LTER Symposium. This annual half-day event is held at NSF Headquarters and organized jointly with the NSF Office of Public and Legislative Affairs. Five to six speakers are chosen to highlight recent scientific accomplishments and to maximize the opportunity to forge connections between the NSF LTER Program and other NSF offices as well as with federal agencies with science or science-based management agendas. Our proposed budget allocates funding for 6 speakers, which has worked well for the past two events.

3) Information Managers Annual Meeting. The LTER network's main products are scientific publications and the data behind them. Keeping that data findable, accessible, interoperable, and reusable (FAIR) is the purview of LTER site information managers and effective coordination and planning is essential. Site information managers meet annually — usually in conjunction with an Earth Science data related meeting such as the Earth Science Information Partners (ESIP). The LNO proposes to support about half of the total cost for one information manager from each site to attend an annual meeting. Additional costs may be covered by individual sites or the Environmental Data Initiative.

4) Scientific Meetings. Exhibit hall displays are an expensive and personnel-intensive way of promoting scientific programs. However, strategic participation at scientific meetings — through LTER branded workshops, symposia, talks, and mixers — provides a cost-effective means of staying abreast of network science and organizational concerns, while also presenting a point of contact for networks or individuals interested in connecting, collaborating, and partnering with the LTER network. LNO staff will attend one network-relevant scientific meeting each year and

will provide promotional materials and information for an NSF exhibit and press release in conjunction with other appropriate meetings such as Ecological Society of America (ESA), American Geophysical Union (AGU) and American Society of Limnology and Oceanography (ASLO).

Committee Support

In addition to the virtual and in-person meeting support described above, for the past two years, the LNCO has reserved small budgets for each of six major LTER network committees (Information Management, Educations and Outreach, Diversity, ILTER, Communication, Graduate Student). The budgets may be used for participant support expenditures in the service of seed initiatives and small planning meetings. In the past year, committee-directed expenditures have included funding for two teachers to participate in the LTER All Scientists' Meeting (Education and Outreach), a regional get-together for graduate students at Southwestern sites (Graduate Student), travel and subsistence funds for a project manager to offer on-site support for REU's at the All Scientists' Meeting (Diversity), and travel for one ILTER committee member to represent LTER at the International LTER Coordinating Committee Meeting (ILTER). Funds that are not spent by the committees within two years are returned to the primary LNCO budget.

This approach has proved to be effective — rewarding committee initiative and early agenda setting, while emphasizing the need to set and agree on priorities. We plan to continue the same approach as we move forward. Details on budget amounts and committee responsibilities are provided in the *Project Management* section below.

Web site

The newly redesigned LTER network web site (https://lternet.edu) was launched in January 2018, with frequent site and synthesis research updates, consistent site profiles and contact information, a network directory, calendar, committee descriptions, and social media feeds. It has served double duty as the public face of the LTER network and the network archive.

In our role as the Network *Communications* Office, we prioritized the public function of the web site, moving many of the internal coordination functions to less obvious locations. In keeping with the change in emphasis to a *Coordination* Office, we will consolidate and better integrate many of these internal functions into the cloud-based constituent relationship management (CRM) system while continuing to update and promote the public facing web site and newsletter (which are key elements of our plans for *LTER Community Engagement* and *Communicating with Diverse Audiences*).

Synthetic Research Plan

The LNCO invests considerable resources to support cross-site scientific synthesis that draws on LTER data and — together with data, research, and expertise from outside of the network — develops new theory, supports model development and testing, and poses fresh questions.

We propose to continue the basic framework of synthesis working groups, with small groups meeting 3-4 times over 1-2 years for 3-4 days at a time. We hope to slightly increase the number of groups by encouraging smaller groups (8-10 vs 12-16) where appropriate. Given their importance to group creativity and productivity, face-to-face meetings at NCEAS will continue to be a significant component of all working groups (Hampton and Parker 2011, National Research Council 2015, Baron et al. 2017). We will

also continue to support and promote increased use of virtual meetings to bring in peripheral working group members and to maintain momentum between in-person meetings.

Soliciting Synthesis Working Groups

The six LTER working groups selected in 2016 and 2017 (https://lternet.edu/current-working-groups/) responded to an open call for proposals, limited only by the requirement that they use LTER data from 2 or more sites. LTER's five core areas were suggested (but not required) for guidance regarding topics. In general, the LTER Science Council has affirmed their support for a competitive selection process with only broad guidance regarding topics. We support this approach because it generates a large pool of high quality proposals and allows the greatest latitude for creative and unanticipated ideas to emerge.

We propose to issue 2-3 calls for synthesis working group proposals over the 5-year funding cycle, timing them to capitalize on existing network activities such as annual Science Council meetings and the 2021 All Scientists Meeting. Clustering the working group awards in this way reduces administrative overhead associated with the selection process and creates opportunities for synergy among a cohort of working groups.

The LNO and the LTER Executive Board or a subcommittee will jointly develop requests for proposals that encourage researchers to:

1. self-organize around a mutually compelling set of ideas and questions;
2. bring together disparate data and information and restructure for new analyses or applications;
3. plan to commit adequate time for intense collaborative engagements;
4. reach beyond pre-existing groups of collaborators and tap new communities of researchers;
5. approach the problem with a specific, manageable work plan.

To encourage greater incorporation of coastal and marine ecosystems (which now make up nearly half of the LTER sites), we will also highlight the wealth of marine data resources and ensure that we distribute the RFP in marine, as well as terrestrial, ecology circles.

We will devote considerable effort to circulating the request for proposals because it raises broad awareness of LTER data resources — including datasets created by previous working groups — and encourages focused interaction between LTER sites and scientists and the broader ecological and environmental science community. Each new call for proposals will be advertised on listservs and newsletters of relevant scientific societies, partner organizations and programs, as well as through social media associated with the LNO and each of these organizations.

In addition to the request for proposals, we are developing introductory web pages that more fully describe the working group process and the factors that contribute to effective proposals, teams, and work plans. See for example, LNCO "Guidance for Working Group PIs" (https://lternet.edu/synthesis/guidance-working-group-pis/) and "Synthesis Resources" (https://lternet.edu/synthesis/synthesis-resources/). Resources from NCEAS' recently launched "learning hub" (https://www.nceas.ucsb.edu/learning-hub) will also be incorporated to better prepare investigators new to the synthesis process for developing successful (and ultimately productive) proposals. As we did for the 2016 and 2017 competitions, we will also host at least one widely advertised Q and A webinar to review the proposal process and to answer any questions or concerns.

Selection Process

As in previous calls, we will convene an *ad hoc* panel to review and rank proposals. The size of the panel will depend on the size of the proposal pool, but will, in any event, be no fewer than 6 individuals drawn in equal parts from current LTER community members and those without a current or recent association with an LTER site. In choosing panelists, we attend to several factors, including: research specialty, diversity of ecosystem experience, and incorporating diverse backgrounds. Panelists will be assigned proposals to review based on their areas of expertise, and each proposal will be read by at least 2 reviewers. The panel will meet virtually and participants will recuse themselves from discussion of proposals that present a conflict. We will send an unranked shortlist of highly scored proposals to the LTER Executive Board for discussion, with the final decision made jointly by the Chair of the LTER Science Council and the Director of the LNO. In choosing among equally competitive proposals, the Executive Board and LNO will aim for a portfolio of projects inclusive of terrestrial, coastal, and marine perspectives and representing a diverse set of participants.

LNO Support of Working Groups

Shortly after a synthesis award is made, LNO staff will reach out to begin conversations about needs for data, collaboration, and logistical support as well as timelines, allowable expenses, and reporting expectations. In their proposal, each working group will appoint a technical liaison; that individual will be offered supplemental training in open and reproducible science, if needed.

At the first working group meeting, all participants will join in two brief introductory discussions on the topics of:

1. Tools for collaborative and reproducible science; and

2. Advantages of diversity in collaborative groups and approaches for effective and inclusive facilitation in diverse groups.

The LNO scientific computing team will set up a suite of collaborative tools to support and foster collaboration among the working group participants, including unlimited data cloud storage, optional chat rooms for faster communication, and repository and version control systems for efficient and collaborative code development. Participants will also be given access and be trained to leverage NCEAS analytical servers to scale their analysis and models beyond personal computer capacities and centralize their data management.

We will continue to encourage and support best practices in the collaborative development of a fully scripted data processing and analysis workflow relying on free scripting languages (e.g. R, Python) to capture the scientific workflow. This approach — combined with the requirement to document, archive and share the synthesis outputs (scripts and data) — will advance reproducibility and reusability of the synthesis products. Data interns working with NCEAS scientific computing team will assist with data cleaning and harmonization tasks, as well as with archiving the resulting scripts. Through this internship program, the LNCO has trained 3 undergraduate and 6 graduate students in data science since 2015. We also collaborated with 2 NCEAS data science fellows from the Arctic Data Center program to develop a R package (https://nceas.github.io/metajam/) to ease the integration of metadata information into synthesis workflow.

Sharing Results

The NCO team will continue to collaborate closely with LTER information managers and the Environmental Data Initiative (EDI) to ensure that LTER data found and created during synthesis activities are properly preserved, documented, and shared. We will also collaborate with data repositories and DataONE on preserving the provenance of the original data and a record of the synthesis process. This will lead to a citable set of scripts and derived data products that will accompany submitted papers and enable others to reuse the synthesis products and workflows for future research. We will encourage open access publishing and have included a small budget to cover a portion of open access charges when other resources are not available.

In 2018, the LNCO hosted a series of webinars featuring the work of the LTER synthesis groups. It attracted 642 participants from 20 countries, as well as another 623 views of the archived recordings. The webinars generated relevant new ideas and connections for the synthesis working groups via a live question and answer session following each presentation. Presenter feedback also suggests that the webinars helped the groups consolidate their findings to-date, identify key knowledge gaps, and even helped to fill those gaps by connecting working groups with researchers who were not previously part of their networks.

We propose to continue synthesis webinars, and to incorporate them into a broader webinar series that will also feature talks and discussions with LTER leadership, related national and international researchers (including those from NEON, CZO, ILTER, and others), and data science organizations. We envision hosting two series of 3-4 seminars each, per year. The webinar series will be archived on YouTube and promoted on the web site, newsletter, and through the networks of other participating organizations.

Figure 2. Number of participants in LTER synthesis working groups across career stages by gender.

Figure 3. Number of responses in each category (great impact, moderate impact, slight impact, no impact, not applicable) to the question "To what degree have you experienced the following benefits through your participation in the working group?" Results are from 3 completed synthesis working groups.

Assessment and Feedback

We propose to continue monitoring and reporting basic metrics of participation, including the number, demographic distribution (example in Figure 2), and satisfaction of participants in working groups, gathered from a structured survey of working groups at four time points in their work. In addition, the survey asks a variety of questions to help us better understand and support synthesis activities (example in Figure 3), to study the role that various types of diversity play in experience and outcomes,
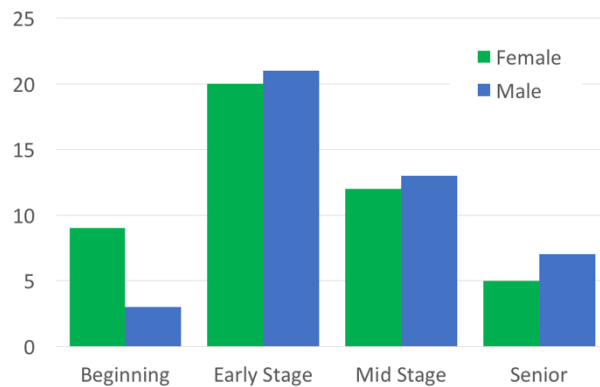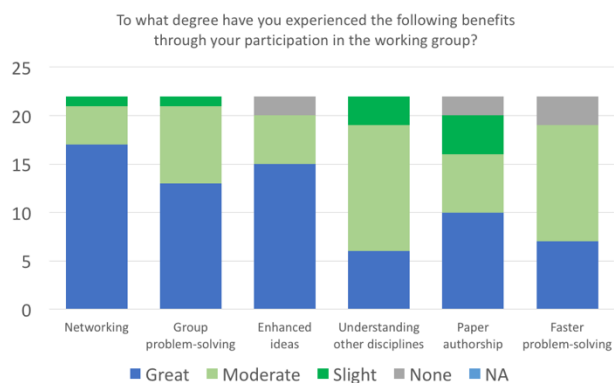
and to monitor evolution of new collaborations and research networks. As we launch new synthesis groups, we will adapt our existing survey and streamline its administration through Qualtrics.

The key products of a successful synthesis working group include scientific publications, new public data sets, new research initiatives and proposals for funding. We will remain in contact with working group leaders on a quarterly basis to track working group products for reporting and evaluation purposes. Follow up will continue for at least two years after the conclusion of in-person meetings to capture lagging outputs.

In addition to surveys, LNCO staff schedule "exit interviews" with working group leaders shortly after working group completion to gather more in-depth, qualitative reports on their experiences, outcomes, and any barriers or complications they noted in the process. We will learn from these results to constantly improve on the synthesis working group experience.

Broader Impacts

Communication with Diverse Audiences

Under the current NSF solicitation (19-544), the communication function, which was prominent in the previous solicitation (15-535), has been narrowed. Proposed LNO communications and outreach activities will focus on those that are necessary to sustain the LTER community and its activities, to connect with potential individual and organizational collaborators, to engage educators and students, and to reach resource managers who rely on LTER science to develop policy. The basic communications

Figure 4. Engaging underrepresented groups within key LNO audiences requires additional attention.

vehicles that were developed and expanded under the LNCO (web site, newsletter, social media) will continue to ground our strategy for communicating with these diverse audiences, but there will be a few changes in emphasis to better address cost-efficiency and inclusion. Strategies and assessment metrics for reaching key audiences are detailed in Table 1.

Moving forward, we will rely more heavily on webinars and scientific meetings, as the proposed audiences are more clearly defined and can be reached directly through the distribution lists of existing organizations. We will deliberately cultivate communications partners in related organizations to cross-post content and plan joint campaigns around the common interests of our members. Reaching underrepresented groups and individuals within each of these audiences (Figure 4) requires additional efforts described in more detail below.

To accommodate these additional targeted communications efforts, we will need to reduce training and professional development for communications and outreach managers at LTER sites. However, we will continue to assist the communications committee in forming and sustaining network-wide communities-of-practice (Tsai et al. 2010; Stevens et al. 2018) through the new online community as well as virtual panels, presentations, and watercoolers.

Table 1. Outreach strategy for four key LNO audiences.

Goals	Strategies	Assessment
AUDIENCE 1: LTER research scientists, staff, and students		
Strengthen a sense of LTER community identity and foster cooperation and collaboration	LTER web site (continuing); LTER Online Community (new); LTER Network News (continuing); Webinars (expanding); invite participation in social media campaigns (NEW?)	Web and intranet traffic; webinar attendance and satisfaction; social media followers and engagements
AUDIENCE 2: Partner organizations and potential collaborators		
Build and strengthen partnerships with other ecological networks, including CZO, NEON, and ILTER; Provide clear pathways for access to LTER sites, personnel, and data	Symposia, talks, and workshops at scientific conferences (expanding); joint webinar series (new); partner with communications and science staff in key networks to cross-post news and announcements (expanding); social media sharing of LTER content to partners and partner content to LTER communities (expanding)	Attendance and satisfaction at workshops, symposia, webinars; continued engagement resulting in new joint projects
AUDIENCE 3: Educators and their students		
Raise awareness of, and access to, LTER data and teaching resources	Maintain and promote "site education activities" website section (continuing); highlight existing science-art programs on website (new); continue and expand partnerships with STEM hubs such as Data Nuggets, SERC, and CLEANet (expanding); encourage social media sharing of LTER branded content with educators (expanding)	Web traffic, resource downloads; newsletter subscribers; increase in information inquiries; new engagements
AUDIENCE 4: Resource managers (public and private)		
Communicate LTER scientific discoveries and data resources, especially those with relevance to resource management.	Develop relationships with communications personnel at relevant agencies (expanding); Develop two-page briefs highlighting relevant findings, data sources and experts for each major agency (new); joint webinar series (new) and NSF LTER symposium (continuing)	Webinar and symposium participation and satisfaction; repeat requests for briefs; new engagements

Inclusionary Practices

After almost 40 years together, the LTER network has developed a strong sense of identity and community. Graduate and undergraduate students who attend network events often report feeling welcomed and supported. However, certain assumptions and shortcuts — common within close knit communities — can also unintentionally exclude new members, collaborators, and partners. This effect can be particularly insidious when those individuals are also underrepresented in the field.

To sustain its energy and relevance, the LTER network needs to preserve a strong sense of community while welcoming new talent, energy, and partnerships. The LNO commits to the following inclusionary practices in our own operations and communications and to fostering a 'climate of inclusion' throughout the network (Boekhorst 2014; Puritty et al. 2017).

1. Undefined acronyms and use of first names suggest that the reader or listener "should" already know the full context. Define all acronyms on first use and use first and last names in all printed and electronic materials.

2. Heavy use of email for information-sharing and collaboration makes it difficult for new group members to get oriented. The new online community will help maintain an accessible record of group activities and documents.

3. Not all differences are visible, but the consistent use of images without people of color or people with visible disabilities sends an exclusionary message. We will attend to this effect when choosing images for publication or social media.

4. Codes of Conduct clearly state the intention to be inclusive and provide encouragement for all members of a community to challenge inappropriate behavior. The code of conduct developed for the 2018 All Scientists' Meeting (https://lternet.edu/lter-meeting-code-of-conduct/) offers one example and specific sites — who often face more challenging reporting situations — are developing additional examples which the LNO will share.

5. Several NSF Inclusion Across the Nation of Communities of Learners (INCLUDES) projects are developing training and best practices for inclusion in the context of remote field sites. We will continue and expand partnerships with ADVANCEGeo, UFERN, and others to make these materials and trainings available to the LTER network.

Education

Education programs at LTER sites are vibrant enterprises, drawing on each site's place-based science to partner with local educators and citizen scientists. The education and outreach committee, composed of education and outreach managers from each site, is largely self-organizing and has been extraordinarily entrepreneurial in seeking funding from a variety of sources for programs that serve the larger network and community, such as the "Undergraduate-Field Experiences Research Network (U-FERN)", led by Kari O'Connell, previously the Education-Outreach Director for Andrews Forest LTER; "Science-Policy Exchange (SPX)", serving four Northeastern LTER sites; and "Embedding Public Engagement with Science at LTER Sites", led by Sarah Garlick of the Hubbard Brook Research Foundation.

As noted above, the LNO will no longer employ an Education Coordinator, but our existing personnel will continue to support LTER education efforts by hosting virtual committee meetings and providing a committee budget, which offers flexible seed funding to be spent at the committee's discretion for projects and meetings. We will maintain and expand the Education section of the network website and partner with STEM hubs to offer LTER branded content for national visibility.

One of the major losses for the LTER education community will be the support of a coordinator to assist with developing network-wide educational proposals. Several of these have emerged over the years, as noted above, but to be successful they require both a compelling vision and a champion. Most often, that level of leadership has come from a committed and experienced educator based at a site. Even without a

designated education coordinator, the LNO can continue to assist with virtual meetings, web site content development, and review of pre-submittal proposal drafts.

Project Management Plan

The LNO team will continue to maintain a weekly standing meeting schedule and shared google drives for quick access to project documents. At least one team member will attend LTER committee meetings and report back to the LNO project team.

Personnel Responsibilities

PI Frank Davis: overall project and budgetary oversight; high level oversight of the synthesis selection process; relationships with scientific partners and NSF.

Co-PI Martha Downs: day-to-day management of LNO; coordination and agenda setting for Science Council, Executive Board, and committees; relationships with scientific, educational, and communications partners; development and management of web site and online community; oversight of meeting logistics, including coordination with NCEAS administrative staff; outreach and communications oversight.

Co-PI Jennifer Caselle: synthesis selection process; coordination and evaluation of synthesis activities including oversight of working group progress and needs; coordination of webinar series.

Scientific Programmer Julien Brun: data science support for synthesis working groups; training and advice in data management, data analysis and scientific programming best practices; coordination with the EDI; recruitment, training, and supervision of data interns.

Outreach and Communications Officer Kristen Weiss: web site updates; newsletters; collateral materials; social media.

Existing NCEAS staff members (Gillquist, Piazza, Outin, Hetmank) will handle travel, logistics, and reimbursement, and technology support of LTER working groups as part of their general support of NCEAS working groups.
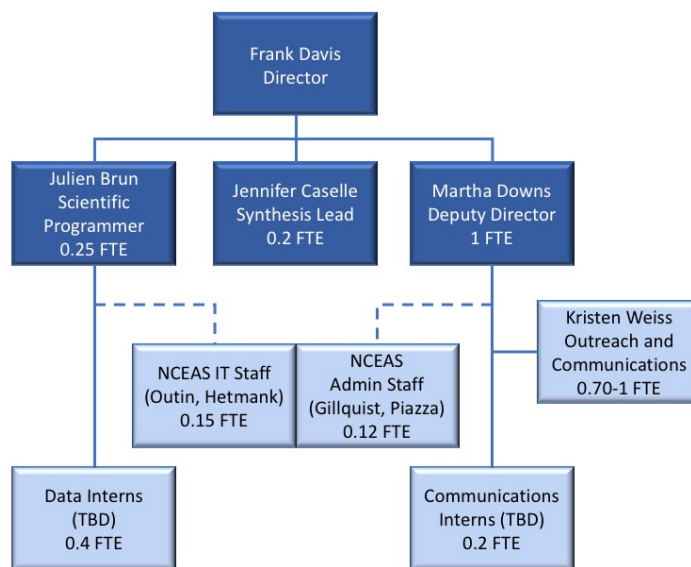

Figure 3. LNO organizational chart. Dark blue color indicates project leadership team. NCEAS staff are directly supervised by NCEAS Business Officer Julia Niessen. Niessen, along with Financial Analyst Ana Peters, provides financial and accounting support, but their salaries are fully covered under the NCEAS operating budget and thus they are not shown in the organizational chart.

Organizational Data

For the past three years, the LNCO has labored to migrate and maintain personnel records, shared document drives, and email lists by relying on free and custom-scripted solutions. We have concluded that the inefficiencies associated with this approach are more expensive than the cost of a modest annual

subscription for a cloud based system that is designed to support a distributed organization, that will be continually maintained and upgraded, and that has a large user base for mutual support.

We have investigated many systems, but have not yet completed a rigorous comparison of options and ease-of-use. Functionality that we deem essential includes: cloud-based, single sign-on (ideally with social sign-on option), self-service profile updates and password resets, public directories, committee workspaces and document sharing with flexible permissions, GDPR-compliant email automation, events management, API integration, and document repository. Leading candidates, given our budget constraints, include GoLightly (used by the Ecological Society of America), Salesforce Nonprofit Success Pack, and NEON CRM. We plan to complete the transition within the first two years of funding, after which we reduce the effort allocated to communications.

We are in the process of moving the LTER network bibliography to a shared group library in the Zotero application, which is designed as a reference manager, with tools to easily ingest new references from any web page. The LNCO is capitalizing on preparation for the decadal review to standardize publication reporting and attempting to align requirements with NSF-required publication reporting to reduce overhead for sites. The LTER network website will allow search and display of the Zotero library data via an application programming interface (API).

Network Coordination

Close contact with LTER network committees helps us to identify concerns and opportunities as they arise and allows us to facilitate the flow of information between committees. We have designated a specific LNO contact for each standing committee (Table 2), who attends the committee meetings and updates the rest of the LNO at our weekly project meetings.

Table 2. Committee responsibilities. Budget refers to in-person meeting costs (for meetings organized by the LNO) or participant support funds made available to each committee for committee-related travel and meetings.

Standing Committees	Meeting frequency	LNO staff contact	Budget
NSF LTER Working Group	Biweekly	Frank Davis	n/a
LTER Executive Board	Virtual meetings: monthly In-person meetings: annually	Frank Davis/Marty Downs	$80K
Information Management Executive Committee	Virtual meetings: monthly In-person meetings: annually	Marty Downs	$20K
Education/Outreach Committee	Virtual meetings: monthly	Marty Downs	$8K
US-ILTER Committee	Virtual meetings: monthly	Frank Davis	$3K
Graduate Student Committee	Virtual meetings: monthly	Kristen Weiss	$3K
Communications Committee	Virtual meetings: bimonthly	Kristen Weiss	$3K
Diversity Committee	Virtual Meetings: quarterly	Marty Downs/Jennifer Caselle	$3K
Synthesis Working Groups (4-6 simultaneous groups)	Virtual meetings: varies In person meetings: ~2 times per year	Jennifer Caselle/Julien Brun	varies

Assessment

Specific plans for assessing various aspects of the program are detailed in the descriptions above and summarized here. Our general approach to assessment relies on 4 kinds of data:

1. We believe that activities and services that the community finds useful will be used. We will track **participation** in virtual meeting services, webinars, web site, social media, email lists, and the online community.

2. We use **short, targeted surveys** to assess satisfaction and learning objectives with respect to a particular activity.

3. A **4-part longitudinal survey** of synthesis working groups entails some time for the LNO and the working groups, but we believe it provides valuable insight into the collaborative process.

4. Deliberate collection of **qualitative feedback**. We have established several triggers to deliberately seek feedback on the synthesis working group process and LNO coordination of the network. At the completion of each working group, we schedule exit interviews with working group leaders. Once a year, we set aside time to have a conversation with the LTER Executive Board. While we recognize that there are potential issues with this approach — including the very human propensity to avoid giving negative feedback (Rosen and Tesser 1970, Chalmers et al 2018) — we believe the efficiency of the process and the chance to ask clarifying questions outweigh that concern.

Qualifications of the PI, UCSB, and NCEAS

Davis served as founding NCEAS Deputy Director from 1995 to 1998, directed NCEAS from 2011-2017, and has directed the LTER Network Communications Office from 2016 to the present. He has extensive experience in long term field ecological research, synthesis research, and program leadership. He also participates in a wide range of professional activities that connect him to a broad scientific network as well as governmental and non-governmental organizations.

NCEAS offers an ideal location for the LTER Network Office. Nearing its twenty-fifth anniversary, the Center is fully funded through extramural contracts and grants, the State of California, and UCSB. The three pillars that support NCEAS renewed identity — scientific synthesis, data science, and training — are well aligned with the goals of the LTER Network Office. Because NCEAS support staff are engaged in similar activities across many extramural projects, NCEAS offers an efficiency of scale, allowing the LNO to budget fractions of individuals for synthesis support activities and to purchase seats in planned training activities rather than developing and funding them in whole.

In addition, LTER scientists have always played a large role at NCEAS as working group participants, sabbatical fellows, postdoctoral fellows, and members of the NCEAS Science Advisory Board. Operation of the LTER Network Office at NCEAS will continue that strong positive relationship.

Every year 500-1000 researchers visit NCEAS. One-third are international scientists and an increasingly large fraction is from public agencies, environmental NGOs and the private sector. By locating at NCEAS, the LNO will provide the LTER community with added exposure and opportunity to connect with a broadened base of collaborators and potential funding sources.

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FACILITIES EQUIPMENT AND OTHER RESOURCES

Computational resources and network

User friendly High Performance Computing (HPC) is available on a 48-node, 32-node, and several 16-node clusters, including large amount of RAM (up to 384GB for a specific node), for demanding modeling, statistical, visualization, and data management projects. Access to a 1024-node system on the UCSB campus is also available. Systems are all running 64-bit OSes loaded with state-of-the-art scientific software (e.g. RStudio server and JupyterHub), and access to storage arrays with aggregate holding capacity in the low hundreds of terabytes.

NCEAS has a number of desktop systems and laptops installed with custom scientific software and internet connectivity available for researchers to use during their visit. Meeting preparation and archival support are available through several web based collaboration solutions, including code versioning repositories (subversion; git), issue tracking software (redmine and bugzilla), Wikis (various), and content management systems (Plone, Drupal, WordPress).

Conferencing space and breakout offices

NCEAS houses a state-of-the-art scientific research and conferencing facility, that includes ample meeting space for two meetings of 25 persons and an array of collaboration devices, including large LED panels and microphone arrays to support remote meeting participation. Participants have access to advanced scientific programming expertise in the use of NCEAS' systems, as well as dedicated technical support personnel. NCEAS provides the facilities, equipment, and staff support to promote the analysis and synthesis of ecological and environmental information. NCEAS is located in the heart of downtown Santa Barbara, with a congenial climate year-round and highly convenient access to dining, lodging, and off hours outdoor recreation and cultural entertainment.

DATA MANAGEMENT PLAN

The LNO will fund little collection of new primary data. However, synthesis working groups will integrate existing data for cross-site analysis and synthesis and are likely to produce new derived databases which may include international collaborators. Such activities present special challenges, as the open data practices and sharing commitment will vary across scientific cultures. In addition, non-interoperable repositories and technological capacity may limit their ability to fully comply to LTER data policy.

Roles and Responsibilities

Primary responsibility for all data management decisions and priorities rests with PI Davis. NCEAS Scientific programmer Julien Brun and LNO Deputy Director Marty Downs have most frequent contact with working groups and will assist in communicating and applying data policies on a day-to-day basis.

Types of Data

This project is not intended to collect primary research data. Data could originate from 3 main sources:

1. data generated by modeling and analysis activities from synthesis working groups (derived products),

2. data generated through assessment and evaluation activities conducted to understand the effectiveness of the LNO activities (assessment data), and

3. data collected and maintained on behalf of the LTER network, such as bibliographic databases and participant databases (administrative data).

Working group and workshop participants will likely also create other products of the research lifecycle, including scientific software used in synthesis and analysis, visualization products, and manuscripts and articles arising from LTER research.

Policies for Access and Sharing and Appropriate Protection and Privacy

LNO data management will be consistent with current LTER (https://lternet.edu/policies/data-access) data management policies to the greatest extent possible. The primary goal for all policies is to make products of the LNO activities open and accessible for scientists to build upon. Synthesis group research products, including derived data, source code, documentation, and metadata will be available under an open license, in most cases immediately upon completion of the product, except in cases where this is restricted for legal (e.g., contractual restrictions) or ethical (e.g., human subjects data) reasons. Requests for legal or ethical restrictions on data sharing must be made in advance and in writing and are subject to the approval of PI Davis, who will ensure compliance with all federal, university, and Institutional Review Board policies on the use of restricted data.

The primary data on which synthesis group products are based may not always be subject to the same requirements, as it comes from diverse sources. Even in those cases where the primary data source is not required to be shared, we will work with synthesis group participants to achieve the greatest degree of data sharing possible and to exert a positive influence on data sharing policies.

For assessment and administrative data, the preference will be for release under a CC-0 license to clarify that data are not subject to copyright. For software, the preference will be for the Apache 2.0 license,

where possible, due to its permissive nature and its full grant of patent rights. Other open licenses will be allowed as well as appropriate, including CC-BY, MIT, BSD, CC-0, etc.

Data Storage, Preservation, and Discovery

All public data generated on the project will be fully documented and deposited in a registered research data repository and assigned a DOI, with the goal of providing for long term preservation, access, and citation. Target repositories will initially include the EDI Data repository and the KNB Data Repository, both of which are members of the DataONE federation. In some cases, international, ecosystem-specific repositories may be deemed more appropriate.

Source code, documentation, and other artifacts of the project will be managed on a day-to-day basis in a version control system operated by NCEAS at the University of California. The version control system provides open read access via HTTP and Git protocols, and has contingencies for disaster recovery including redundancy by real-time mirroring offsite and nightly backup. Copies of all open software repositories will be available through community endorsed repositories such as GitHub, although we acknowledge that these are likely to shift over time with technology changes. We will also encourage and support the deposition of full provenance information linking all components of synthesis activities, using standards such as the W3C PROV model.

Data, Metadata, and Software Standards

Archival products will follow best practices and standards from the community (http://www.dataone.org/best-practices), with a focus on open, nonproprietary formats. For data, we expect files to be archived in common Unicode text formats such as CSV files, or in open binary formats such as GeoTIFF, netCDF, and HDF5. Metadata will include a full description of data coverage (spatial, temporal, taxonomic), structure, contents, methodology, parameter names and units, and other information needed for proper interpretation. We will use the Ecological Metadata Language (EML) format for most datasets because it is commonly used in the EDI and the KNB Data Repositories, but we will also accept and utilize other common community standards as needed, including the FGDC Biological Data Profile and the ISO Geospatial metadata standards (e.g., ISO 19139). Data and metadata management will be supported through tools that directly integrate into scientists' daily workflow, including the ability to submit from the web, from analytical tools such as R and MATLAB, and Python.

LIST OF PROJECT PERSONNEL AND PARTNER ORGANIZATIONS

Named Personnel

1. Frank Davis, University of California-Santa Barbara, Lead-PI,
2. Martha Downs, University of California-Santa Barbara, co-PI
3. Jennifer Caselle, University of California-Santa Barbara, co-PI
4. Julien Brun, University of California-Santa Barbara, Other personnel
5. Kristen Weiss, University of California-Santa Barbara, Other personnel

Partner Organizations

6. LTER Science Council, unpaid collaborator
7. Environmental Data Initiative, unpaid collaborator
8. National Ecological Observatory Network, unpaid collaborator
9. Critical Zone Observatory Network, unpaid collaborator
10. ADVANCEGeo Partnership, unpaid collaborator