REPORT: Summary and analysis of changes in LTER RFPs, 1980-2016

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TO: Peter Groffman, LTER EB Chair
FR: Julia Jones, Michael Paul Nelson, Andrews Forest LTER
RE: Summary of changes in LTER rfps 1980-2016.

Initiated in 1980, the National Science Foundation-funded Long-term Ecological Research (LTER) program has grown to be the major global network for long-term ecological research. Requests for proposals (rfps) and renewal instructions issued by the National Science Foundation define NSF's perceptions of the essential attributes of LTER and determine the outcomes of new and renewal proposals. However, the wording of the solicitation has changed over time, and so have the rates at which LTER sites have been placed on probation or been terminated.

In the spirit of LTER, we undertook an analysis of long-term data: the NSF LTER rfps from 1980, 1981, LTER renewal instructions from 2002, 2006, 2008, and 2011, and rfps for 2012, 2014, and 2016. We identified a set of key topics/terms in the rfps, tracked their appearance over time, and documented changes in associated wording. The topics/terms analyzed were:

- overall goals
- conceptual framework
- modeling
- theory
- predict
- social science
- long-term data and research
- intersite analyses and synthesis
- information management, data availability
- site management, leadership

The analysis reveals key changes in the definition and criteria for LTER (Figure 1, Appendix A, Tables 1, 2):

1. The original rfps (1980, 1981) established the main goals and essential features of LTER (core areas, long-term questions, intersite analysis, information management/data availability, and continuity of leadership)
2. By 2002, PIs were asked to discuss "conceptual framework" and "modeling".
3. In 2012 the rfp became much longer. It introduced a number of unprecedented criteria involving conceptual frameworks, modeling, social science, theory, and prediction. The 2012 rfp also added new stipulations regarding intersite analysis, information management, and site management.
4. From 2012 to 2016 there were a number of important changes in the wording of these new criteria.

The changes in the rfps coincide with an increase in the rate at which sites have been placed on probation or been terminated (Figure 2).

Because of the many changes in the rfps, it is not surprising that panels, program officers, and PIs have been confused about expectations for and evaluation of LTER proposals.

These findings may suggest themes for discussion with NSF program officers about the definition of LTER, the review criteria, and the long-term success of the LTER program. This analysis is a contribution to a discussion about the larger issue of administration of LTER sites and the LTER network at this juncture in the latter half of the program's fourth decade. The importance of good administration by NSF (in co-dependence with site leaders) goes well beyond the immediately-affected community of the US LTER sites, given the standing that LTER has achieved in the global system of more than 40 countries with research/observatory networks modeled on the US LTER system.

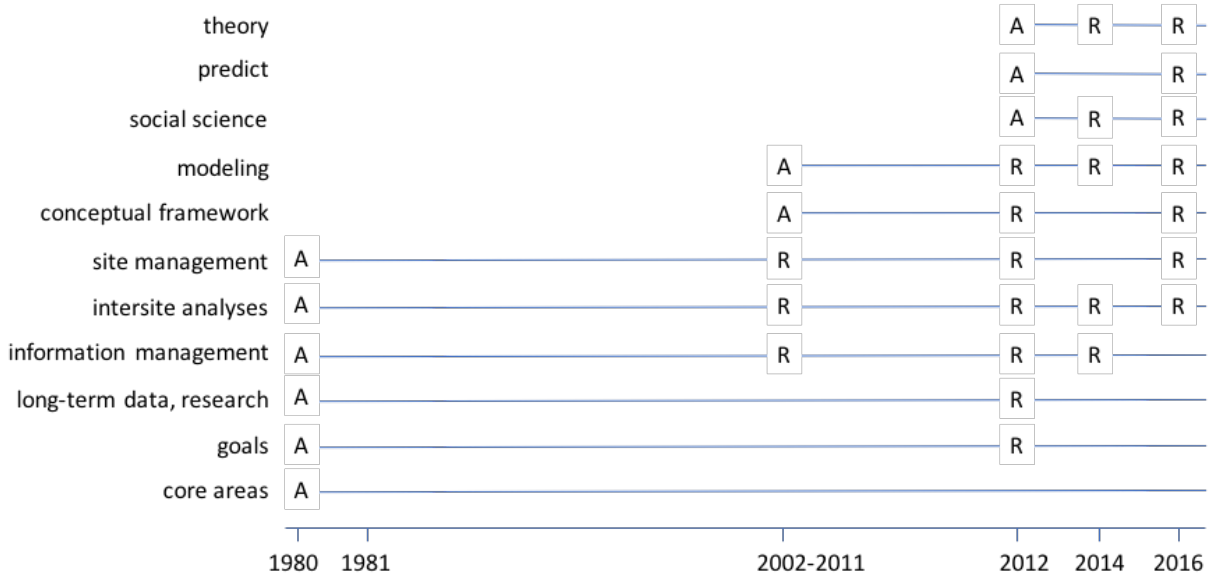

Figure 1. First appearance (A) and subsequent revisions (R) of key terms and concepts in NSF LTER solicitations from 1980, 1981, 2002, 2006, 2008, 2011, 2012, 2014, and 2016.

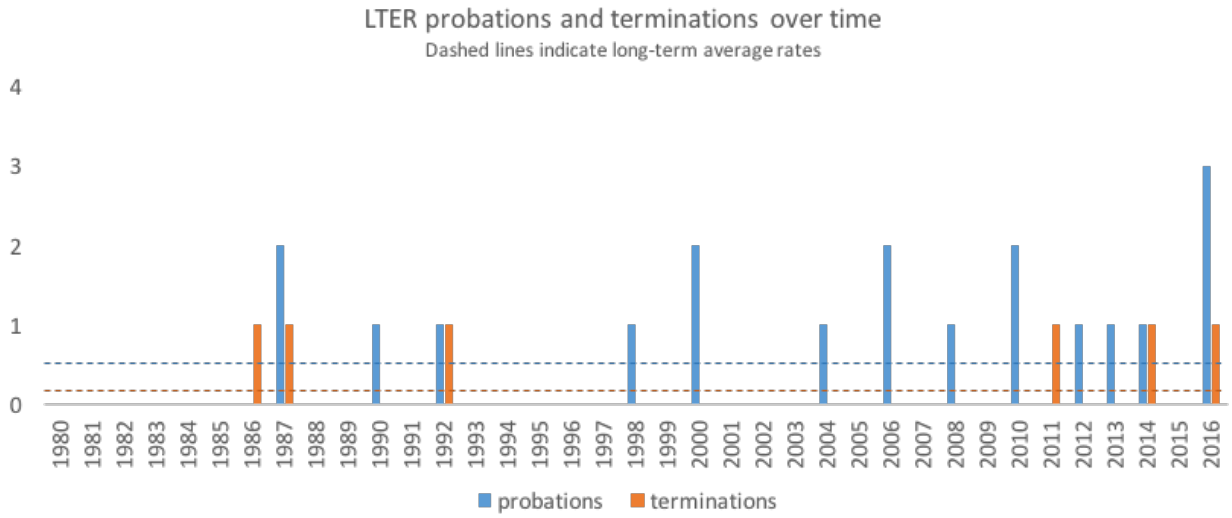

Figure 2. Numbers of LTER sites placed on probation or terminated by year. Sources: Tables 3 and 4.

Appendix A. Key changes in wording of LTER solicitations relative to the key topics are shown as a list (below) and in table form in Tables 1 and 2. The changes include the addition of a number of concepts and criteria starting in 2012, and continual revision and redefinition of the associated criteria from 2012 to 2016.

List form (topics of analysis shown in bold font):

1. Overall objectives, conceptual framework, modeling, theory, social science:
    a. Overall goals
        i. In 1980 the goals of LTER were defined as: "(1) initiate the collection of comparative data at a network of sites representing major biotic regions of North America and (2) evaluate the scientific, technical, and managerial problems associated with such long-term comparative research"
        ii. In 2012 wording was added: "research should address the LTER Program's goals of 1) **achieving a mechanistic understanding** of ecological responses to past and present environmental change at multiple scales; 2) using this understanding to **predict**

ecological, evolutionary, and social responses to future environmental change; and, when appropriate 3) **informing social strategies to adapt** to this change."

iii. In 2014 wording was changed to "and - if appropriate - social responses to future environmental change.

b. Conceptual framework
   i. 1980, 1981 this was not mentioned.
   ii. By 2002, wording had been added: "Develop and explain the conceptual framework that provides the unifying ecological theme for your site."
   iii. In 2016, the following wording was added/changed: ""[Research] questions must be based on a conceptual framework **that examines and predicts how the components of natural ecosystems, including populations and communities, interact to produce a comprehensive understanding of ecosystem structure and function**. … proposed research will be evaluated based on the following principles: 1. formulation of a conceptual framework that **integrates across populations, communities, and ecosystems** … 2. use of this framework **to develop predictions** that link processes and observations across levels of organization or across temporal or spatial scales."

c. Modeling
   i. In 2002, wording was added: "Clearly, modeling efforts are important, and they should be discussed in detail as appropriate."
   ii. In 2012, wording was added: "proposed research will be evaluated based on … use of existing, or development of new, **conceptual, analytical and numerical models** to guide the research"
   iii. In 2014 the following wording was changed: "proposed research will be evaluated based on … **refinement of models to incorporate sources of uncertainty and model-data assimilation"**
   iv. In 2016 the following wording was changed/added: "proposed research will be evaluated based on … 4. development, refinement, and testing of **predictive models** that include sources of uncertainty.

d. Theory
   i. 1980-2011 this was not mentioned.
   ii. In 2012 new criteria were added: "Successful renewal proposals must **test major ecological or ecosystem theories"**
   iii. In 2014 the following wording was changed: "Successful renewal proposals must test major **ecological theories or concepts**."

e. Predict/prediction
   i. 1980-2011 this was not mentioned.
   ii. In 2012, wording was added: "research should address the LTER Program's goals of 1) … and 2) using this understanding to **predict** ecological, evolutionary, and social responses
   iii. In 2016, wording had been added: "[Research] questions must be based on a conceptual framework that examines and **predicts** how the components of natural ecosystems … … the proposed research will be evaluated based on …: 2. use of this framework to develop **predictions** that link processes and observations … … 4. development, refinement, and testing of **predictive models** that include sources of uncertainty.

f. Social Science
   i. 1980 to 2011 this term was not mentioned
   ii. In 2012, wording was added: "if social science is proposed, the extent to which the research **draws from and contributes to social science theory and understanding**."
   iii. In 2014, wording was changed to: "NSF recognizes that human decisions, behavior, and actions may contribute to LTER research. LTER renewal projects may elect to include social science research **if it helps to advance or to understand key, conceptually motivated ecological questions**."

2. Long-term data and research
   a. in 1980 this was not addressed

b. in 1981 this wording was added: “Projects should ... elaborat[e] long-term questions and hypotheses that rely upon the core data.”
c. As of 2002 (but note the dataset lacks examples from 1982 through 2001) the following wording had been added: “describe in some detail the long-term experiments, sampling protocols and monitoring that you are doing, and explain how these relate to your conceptual framework ... conceptually integrate [short-term] efforts to your long-term studies.”
d. In 2012 this wording was changed to: “sites and the network must … define **questions that uniquely demand study on decadal time scales**. These questions should be ones that cannot be addressed through other, more standard funding programs at NSF ... The research must be innovative, conceptually motivated, and **thoroughly justify the need for long-term support** to understand ecological systems and processes.”
e. In 2014 wording was added: “New research questions should arise from analyses of long-term data.”

3. Intersite analyses and synthesis
    a. In 1980 the rfp stated “Investigators must … coordinate their studies across sites”
    b. In 1981 wording was added: “research groups will be expected to coordinate their studies with those **at other LTER sites**.”
    c. By 2002 wording had been added/changed to: “Outline any regionalization, cross-site, or other collaborative efforts involving the LTER network that are planned ... **Close ... with a synthesis** that shows how your major activities will be integrated.”
    d. In 2008 wording was added/changed: “Close ... with a synthesis that shows how your major activities **will lead to a deeper understanding of the ecosystem and its relationship to other biomes represented within the LTER network**.”
    e. In 2012 wording was added/changed to: “**Sites are encouraged** to develop network-level interactions … Renewal proposals **are encouraged** to broaden the spatial scale of long-term analyses through comparative research with other LTER sites or studies outside of the LTER network … Proposals will be evaluated based on ... advancement of fundamental understanding of long-term ecological dynamics through cross-site collaborations or collaborations outside of the LTER network.
    f. In 2014 wording was added: “These broader scale activities should extend the conceptual framework proposed for innovative site-based research.”
    g. In 2016, wording was changed to: “Where appropriate, **projects among sites or with collaborators outside of the LTER network <u>may be included</u>**. ... If cross-site or other collaborative efforts are proposed, they should fit intellectually within the overarching research plan …”
4. Information management, data availability
    a. In 1980, the rfp stated: “attention must be given to ... data storage and retrieval.”
    b. By 2002, wording had been changed/added: “Describe your data and information management system. How is the data manager involved in the design of research projects? What mechanisms do you employ to get researchers to contribute their data to the LTER database? How quickly are data sets made available to other researchers? What criteria are used to limit or provide access of LTER data sets to other researchers? How often are data sets updated on the WWW?”
    c. In 2012, wording was changed to: “proposals also must articulate milestones and deliverables for data management that, at the very least, include timelines for data release, publication of discovery-level metadata, and online access for all core data collected at a site. ... Proposals should include ... Information Management and Technology, including milestones and deliverable products from data management thatcontribute to compliance with LTER Network goals of full data accessibility ... As a Supplementary Document, include a table that lists all data sets from the site that are available electronically and provide documentation of the use of these data by investigators and others not associated with your LTER site”
    d. In 2014, the following wording was dropped: “provide documentation of the use of these data by investigators and others not associated with your LTER site”
5. Site management, leadership
    a. In 1980, the rfp stated that the proposal must “ensure continuity of leadership.”
    b. By 2002, the following wording had been added/changed: “Describe how you manage your site. How are funding and research decisions made and actions implemented? What efforts are made to

encourage non-LTER scientists from your institution or other institutions to use your site as a research platform? How are you involving a diversity of scientists at the site? Include any plans for enhancing diversity of scientists at your site."

c. In 2012, the wording was changed to: "Proposals should include ...Site Management, including personnel, fiscal, administrative, institutional, and logistical issues. … [and] Plans for involving new researchers in site activities … Supplementary Documents must include a Site Management Plan … Describe how site-level research, which involves a number of individuals and diverse projects, will be managed. This must include a cohesive management plan that is adequate for a project of the size and complexity proposed. The plan should describe how funding and research decisions will be made and implemented, along with efforts to integrate non-LTER scientists into research activities. Describe efforts to increase diversity among site participants … address continuity of leadership, succession planning, and the recruitment of new scientists."
d. In 2016, wording was changed/added: "Involvement of new or early-career researchers in project activities is encouraged. If the Lead PI for the renewal changes, this change should be explained."

The relevant quotations from the rfps and renewal instructions are shown in the Tables 1 and 2.

Table 1. Change over time in wording of key topics in LTER, including goals of LTER, conceptual framework, modeling, theory, prediction, and social science. Red font indicates the first appearance of this wording relative to the previous solicitations; key topics/terms are highlighted.

Topic	1980/81	2002 to 2011	2012	2014	2016
Overall goals	The goals of LTER are to augment the progress of ecosystem science through (1) collection of comparative data at a network of sites representing major biotic regions of the U.S. and (2) cooperative evaluation of the scientific, technical, and managerial problems associated with long-term comparative research.	--	research should address the LTER Program's goals of 1) achieving a mechanistic understanding of ecological responses to past and present environmental change at multiple scales; 2) using this understanding to predict ecological, evolutionary, and social responses to future environmental change; and, when appropriate 3) informing social strategies to adapt to this change	[research] should have the goals of achieving a mechanistic understanding of biological responses to past and present environmental change at multiple scales and of using this understanding to predict ecological, evolutionary, and - if appropriate - social responses to future environmental change.	research should have the goals of achieving a mechanistic understanding of biological responses to past and present environmental change at multiple scales and of using this understanding to predict ecological, evolutionary, and - if appropriate - social responses to future environmental change.
Conceptual framework	--	Develop and explain the conceptual framework that provides the unifying ecological theme for your site.	…the proposed research will be evaluated based on …2. encouragement of or demand for new conceptual frameworks or theory that will significantly advance understanding of site-specific dynamics and relate site-specific results to other ecosystems at different spatial scales … Essential to this section is a clear articulation of the conceptual framework and individual questions that motivate an integrated research plan	the proposed research will be evaluated based on …2. encouragement of or demand for new conceptual frameworks or theory that will significantly advance understanding of site-specific dynamics and relate site-specific results to other ecosystems at different spatial scales … Essential to this section is a clear articulation of the conceptual framework and individual questions that constitute an integrated research plan.	[Research] questions must be based on a conceptual framework that examines and predicts how the components of natural ecosystems, including populations and communities, interact to produce a comprehensive understanding of ecosystem structure and function. … the proposed research will be evaluated based on …: 1. formulation of a conceptual framework that integrates across populations, communities, and ecosystems. 2. use of this framework to develop predictions that link processes and observations across levels of organization or across temporal or spatial scales.

Modeling	--	… modeling efforts are important, and they should be discussed in detail as appropriate.	... the proposed research will be evaluated based on …3. use of existing, or development of new, conceptual, analytical and numerical models to guide the research ... Describe proposed models or model development in sufficient detail to allow evaluation, and explain how these support the conceptual framework	... the proposed research will be evaluated based on … 3. refinement of models to incorporate sources of uncertainty and model-data assimilation … proposed models or model development must be presented in sufficient detail to allow evaluation, including the model structure and how the models account for different sources of uncertainty	... the proposed research will be evaluated based on … 4. development, refinement, and testing of predictive models that include sources of uncertainty.
Theory	--	--	Successful renewal proposals must test major ecological or ecosystem theories. These theories must motivate a suite of cohesive and well integrated questions that organize the proposed research … the proposed research will be evaluated based on …: 1. focus on important and general ecological questions that a) derive from key theories	Successful renewal proposals must test major ecological theories or concepts. … Analyses of [core] data provide the foundation for testing major theories, ... the proposed research will be evaluated based on: 1. focus on important and general ecological questions that a) derive from key theories, … 2. encouragement of or demand for new conceptual frameworks or theory	... the proposed research will be evaluated based on: 1. focus on important and general ecological questions that a) derive from theory
Predict	--	--	research should address the LTER Program's goals of … 2) using this understanding to predict ecological, evolutionary, and social responses to future environmental change	research should address the LTER Program's goals of … 2) using this understanding to predict ecological, evolutionary, and - if appropriate - social response	research should have the goals of … using this understanding to predict ecological, evolutionary, and - if appropriate - social responses … [Research] questions must be based on a conceptual framework that examines and predicts how the components of natural ecosystems … … the proposed research will be evaluated based on …: 2. use of this framework to develop

					predictions that link processes and observations … … 4. development, refinement, and testing of predictive models that include sources of uncertainty.
Social science	--	--	… the proposed research will be evaluated based on … …5. if social science is proposed, the extent to which the research draws from and contributes to social science theory and understanding.	LTER renewal projects may elect to include social science research if it helps to advance or to understand key, conceptually motivated ecological questions.	… the proposed research will be evaluated based on … 5. for the two urban sites, the likelihood that proposed activities will contribute to an integrated understanding of social, economic, and ecological interactions in urban environments. LTER renewal projects may elect to include social science research if it helps to advance or to understand key, conceptually motivated ecological questions.

Table 2. Text of LTER rfp topics/terms over time. Phrases in the table are quotations from the RFPs. Text in red is new for that year (has not appeared in any prior year). Red font indicates the first appearance of this wording relative to the previous solicitations.

Year/title	Topic				
	Overall objectives, conceptual framework, modeling, theory, social science	long-term data and research	intersite analyses and synthesis	information management, data availability	Site management, Leadership
1980	The goals of LTER are to (1) initiate the collection of comparative data at a network of sites representing major biotic regions of North America		Attention must be given to the tasks of assuring information comparability and inter-project coordination. … Investigators must …	attention must be given to ... data storage and retrieval	must ensure continuity of leadership

	and (2) evaluate the scientific, technical, and managerial problems associated with such long-term comparative research. … Investigators must focus on a series of core research topics…		coordinate their studies across sites		
1981	The goals of LTER are to augment the progress of ecosystem science through (1) collection of comparative data at a network of sites representing major biotic regions of the U.S. and (2) cooperative evaluation of the scientific, technical, and managerial problems associated with long-term comparative research.	Projects should ... elaborat[e] long-term questions and hypotheses that rely upon the core data	research groups will be expected to coordinate their studies with those at other LTER sites		should give assurances related to ... continuity of site leadership
2002 renewal	Develop and explain the conceptual framework that provides the unifying ecological theme for your site. ... Clearly, modeling efforts are important, and they should be discussed in detail as appropriate.	describe in some detail the long-term experiments, sampling protocols and monitoring that you are doing, and explain how these relate to your conceptual framework ... conceptually integrate [short-term] efforts to your long-term studies	Outline any regionalization, cross-site, or other collaborative efforts involving the LTER network that are planned ... close ... with a synthesis that shows how your major activities will be integrated	Describe your data and information management system. How is the data manager involved in the design of research projects? What mechanisms do you employ to get researchers to contribute their data to the LTER database? How quickly are data sets made available to other researchers? What criteria are used to limit or provide access of LTER data sets to other researchers? How often are data sets updated on the WWW?	Describe how you manage your site. How are funding and research decisions made and actions implemented? What efforts are made to encourage non-LTER scientists from your institution or other institutions to use your site as a research platform? How are you involving a diversity of scientists at the site? Include any plans for enhancing diversity of scientists at your site.
2006	Develop and explain the	describe in some detail the	Outline any	Describe your data and	Describe how you

renewal	conceptual framework that provides the unifying ecological theme for your site. ... Clearly, modeling efforts are important, and they should be discussed in detail as appropriate.	long-term experiments, sampling protocols and monitoring that you are doing, and explain how these relate to your conceptual framework ... explain how ... short-term studies relate to your conceptual framework	regionalization, cross-site, or other collaborative efforts involving the LTER network that are planned ... close ... with a synthesis that shows how your major activities will be integrated.	information management system. How is the data manager involved in the design of research projects? What mechanisms do you employ to get researchers to contribute their data to the LTER database? How quickly are data sets made available to other researchers? What criteria are used to limit or provide access of LTER data sets to other researchers? How often are data sets updated on the WWW?	manage your site. How are funding and research decisions made and actions implemented? What efforts are made to encourage non-LTER scientists from your institution or other institutions to use your site as a research platform? How are you involving a diversity of scientists at the site? Include any plans for enhancing diversity of scientists at your site. Discuss relevant institutional relations issues.
2008 renewal	Develop and explain the conceptual framework that provides the unifying ecological theme for your site. ... Clearly, modeling efforts are important and should be discussed in detail as appropriate.	describe in some detail the long-term experiments, sampling protocols and monitoring that you are doing or propose to do, and explain how these relate to your conceptual framework ... Conceptually integrate [short-term] efforts with your long-term studies	Outline any regionalization, cross-site, or other collaborative efforts involving the LTER network that are planned ... close ... with a synthesis that shows how your major activities will lead to a deeper understanding of the ecosystem and its relationship to other biomes represented within the LTER network	Describe your data and information management system. How is the data manager involved in the design of research projects? What mechanisms do you employ to get researchers to contribute their data to the LTER database? How quickly are data sets made available to other researchers? What criteria are used to limit or provide access of LTER data sets to other researchers? How often are data sets updated on the WWW?	Describe how you manage your site. How are funding and research decisions made and actions implemented? What efforts are made to encourage non-LTER scientists from your institution or other institutions to use your site as a research platform? How are you involving a diversity of scientists at the site? Include any plans for enhancing diversity of scientists at your site. Discuss relevant institutional relations issues.
2011	Develop and explain the	describe in some detail the	Outline any	Describe your data and	Describe

renewal	conceptual framework that provides the unifying ecological theme for your site. ... Modeling efforts are important and should be discussed in detail as appropriate.	long-term experiments, sampling protocols and monitoring that you are doing or propose to do, and explain how these relate to your conceptual framework ... explain how ... short-term studies relate to your conceptual framework	regionalization, cross-site, or other collaborative efforts involving the LTER network that are planned. ... close ... with a synthesis that shows how your major activities will lead to a deeper understanding of the ecosystem and its relationship to other biomes represented within the LTER network.	information management system. How is the data manager involved in the design of research projects? What mechanisms do you employ to get researchers to contribute their data to the LTER database? How quickly are data sets made available to other researchers? What criteria are used to limit or provide access of LTER data sets to other researchers? How often are data sets updated on the WWW? *Please refer to and utilize the associated attachments to this message.*	how you manage your site. How are funding and research decisions made and actions implemented? What efforts are made to encourage non-LTER scientists from your institution or other institutions to use your site as a research platform? How are you involving a diversity of scientists at the site? Include any plans for enhancing diversity of scientists at your site. Discuss relevant institutional relations issues.
2012 renewal	successful renewal proposals must test major ecological or ecosystem theories. These theories must motivate a suite of cohesive and well integrated questions that organize the proposed research, and this research should address the LTER Program's goals of 1) achieving a mechanistic understanding of ecological responses to past and present environmental change at multiple scales; 2) using this understanding to predict ecological, evolutionary, and social	To succeed in an increasingly complex universe of environmental science, sites and the network must clearly define questions that uniquely demand study on decadal time scales. These questions should be ones that cannot be addressed through other, more standard funding programs at NSF ... The research must be innovative, conceptually motivated, and thoroughly justify the need for long-term support to understand ecological systems and processes.	Sites are encouraged to develop network-level interactions in order to integrate data necessary to tackle complex questions at diverse spatial scales, and to develop active collaborations with emerging programs that consider long time and broad spatial scales. ... Renewal proposals are encouraged to broaden the spatial scale of long-term analyses through comparative research with other LTER sites or studies outside of the LTER network. These cross-site	Renewal proposals also must articulate milestones and deliverables for data management that, at the very least, include timelines for data release, publication of discovery-level metadata, and online access for all core data collected at a site. ... Proposals should include ... Information Management and Technology, including milestones and deliverable products from data management that contribute to compliance with LTER Network goals of full data accessibility ...	Proposals should include ...Site Management, including personnel, fiscal, administrative, institutional, and logistical issues. Plans for involving new researchers in site activities Supplementary Documents must include Site Management Plan … Describe how site-level research, which involves a number of individuals and diverse projects, will be managed. This must include a cohesive management plan that is

	responses to future environmental change; and, when appropriate 3) informing social strategies to adapt to this change ... Proposals should include ... Scientific goals, including both 1) site-specific research and 2) cross-site, non-LTER, international research, or involvement with other network-like activities. These must be placed within a cohesive, integrative, and synthetic research plan ... The scientific goals of the proposed research will be evaluated based on the following principles: 1. focus on important and general ecological questions that a) derive from key theories, b) are motivated by long-term data in hand and c) require additional, long-term data collection to be answered 2. encouragement of or demand for new conceptual frameworks or theory that will significantly advance understanding of site-specific dynamics and relate site-specific results	... Describe in appropriate detail the long-term experiments and observations that will be carried out, and explain how they fit into the proposed conceptual framework	or cross-study activities should respond directly to the motivating conceptual framework proposed for innovative site-based research. They also should contribute to a broader understanding of the mechanisms underlying ecological responses to climate change, nutrient loading, loss of biodiversity, or changes in trophic structure, for example. Proposals will be evaluated based on ... advancement of fundamental understanding of long-term ecological dynamics through cross-site collaborations or collaborations outside of the LTER network ... Integrate cross-site or other collaborative efforts into the overall research plan, and describe how these will advance understanding of site-specific dynamics or relate site-specific results to other ecosystems at different spatial scales. Close this section with a synthesis that ties together the proposed research activities, and shows how	As a Supplementary Document, include a table that lists all data sets from the site that are available electronically and provide documentation of the use of these data by investigators and others not associated with your LTER site ... Supplementary Documents must include Data Management Plan A table listing all site databases that are electronically accessible, as described above	adequate for a project of the size and complexity proposed. The plan should describe how funding and research decisions will be made and implemented, along with efforts to integrate non-LTER scientists into research activities. Describe efforts to increase diversity among site participants. … address continuity of leadership, succession planning, and the recruitment of new scientists…

	to other ecosystems at different spatial scales 3. use of existing, or development of new, conceptual, analytical and numerical models to guide the research ... 5) if social science is proposed, the extent to which the research draws from and contributes to social science theory and understanding. ... Essential to this section is a clear articulation of the conceptual framework and individual questions that motivate an integrated research plan ... Describe proposed models or model development in sufficient detail to allow evaluation, and explain how these support the conceptual framework		they will significantly advance understanding of ecological or ecosystem dynamics at different spatial and temporal scales.		
2014 rfp	Successful renewal proposals must test major ecological theories or concepts. ... The scientific goals of the proposed research will be evaluated based on the following principles: 1. focus on important and general ecological	Proposed research should be organized around a suite of integrated questions that arise from the analysis of long-term data. It should have the goals of achieving a mechanistic understanding of biological responses to past and present environmental change at multiple scales	LTER investigators are encouraged to broaden the spatial scales of their long-term analyses through comparative research with other LTER or non-LTER projects. These broader scale activities should extend the conceptual framework proposed for innovative site-based	Renewal proposals also must articulate milestones and deliverables for data management that, at the very least, include timelines for data release, publication of discovery-level metadata, and online access for all core data through the LTER Network Information System.	Proposals should include ... Project Management, including personnel, fiscal, administrative, institutional, and logistical issues. Plans for involving new researchers in site activities Supplementary

	questions that a) derive from key theories, b) are motivated by the analysis of long-term data, and c) require additional, long-term data collection to be answered 2. encouragement of or demand for new conceptual frameworks or theory that will significantly advance understanding of site-specific dynamics and relate site-specific results to other ecosystems at different spatial scales 3. refinement of models to incorporate sources of uncertainty and model-data assimilation ... Essential to this section is a clear articulation of the conceptual framework and individual questions that constitute an integrated research plan. proposed models or model development must be presented in sufficient detail to allow evaluation, including the model structure and how the models account for different sources of uncertainty	and of using this understanding to predict ecological, evolutionary, and - if appropriate - social responses to future environmental change. Renewal projects must clearly define questions that demand study on decadal time scales. New research questions should arise from analyses of long-term data New activities should be conceptually integrated with ongoing, longer-term studies.	research. They also should contribute to a broader understanding of the mechanisms underlying ecological responses to climate change, nutrient loading, loss of biodiversity, or changes in trophic structure, for example. ... ... the proposed research will be evaluated based on ... 4. collaborations with other LTER or non-LTER researchers to understand ecosystem dynamics across broad spatial and temporal scales	... Proposals should include ... Information Management and Technology, including milestones and deliverable products from data management that result in availability of all data via the LTER Network Information System Supplementary Documents must include A table that lists all data sets from the site currently deposited into the LTER Network Information System. 2. Data Management Plan	Documents must include Project Management Plan … Describe how the proposed research, which could involve a number of individuals and diverse projects, will be managed. This must include a cohesive management plan that is adequate for a project of the size and complexity proposed. The plan should describe how funding and research decisions will be made and implemented, and efforts to integrate non-LTER scientists into research activities. Describe efforts to increase diversity among site participants. … address continuity of leadership, succession planning, and the recruitment of new scientists…

	NSF recognizes that human decisions, behavior, and actions may contribute to LTER research. LTER renewal projects may elect to include social science research if it helps to advance or to understand key, conceptually motivated ecological questions.				
2016 rfp	[Research] questions must be based on a conceptual framework that examines and predicts how the components of natural ecosystems, including populations and communities, interact to produce a comprehensive understanding of ecosystem structure and function. The scientific goals of the proposed research will be evaluated based on the following principles: 1. formulation of a conceptual framework that integrates across populations, communities, and ecosystems. 2. use of this framework to develop predictions that link processes and observations across levels of organization or across	The proposed research should be organized around a suite of integrated questions that arise from the analysis of long-term data. The research should have the goals of achieving a mechanistic understanding of biological responses to past and present environmental change at multiple scales and of using this understanding to predict ecological, evolutionary, and - if appropriate - social responses to future environmental change. Renewal projects must clearly define questions that demand study on decadal time scales. ... New research questions should arise from analyses of long-term data. ...	Where appropriate, projects among sites or with collaborators outside of the LTER network may be included. ... If cross-site or other collaborative efforts are proposed, they should fit intellectually within the overarching research plan, and authors should describe how these will advance understanding of site-specific dynamics or relate site-specific results to communities or ecosystems at different spatial scales. This section of the proposal should conclude with a synthesis that ties together the proposed research activities and shows how they will significantly advance understanding of	Renewal proposals also must articulate milestones and deliverables for data management that include timelines for data release, publication of discovery-level metadata, and online access for all core data through the LTER Network Information System. Supplementary Documents must include A table that lists all data sets from the site currently deposited into the LTER Network Information System. 2. Data Management Plan	Proposals should include ... Project Management, including personnel, fiscal, administrative, institutional, and logistical issues. Involvement of new or early-career researchers in project activities in encouraged. If the Lead PI for the renewal changes, this change should be explained. Supplementary Documents must include Project Management Plan … Describe how the proposed research, which could involve a number of individuals and diverse projects, will be managed. This must include a cohesive management plan that is adequate for a project of the size and

	temporal or spatial scales. 3. identification of important, general ecological questions that a) derive from theory, b) are motivated by the analysis of longterm data, and c) require additional, long-term data collection to be answered. 4. development, refinement, and testing of predictive models that include sources of uncertainty. 5. for the two urban sites, the likelihood that proposed activities will contribute to an integrated understanding of social, economic, and ecological interactions in urban environments. ... NSF recognizes that human decisions, behavior, and actions may contribute to LTER research. LTER renewal projects may elect to include social science research if it helps to advance or to understand key, conceptually motivated ecological questions. ... Essential to this section is a clear articulation of the	New activities should be conceptually integrated with ongoing, longer-term studies.	ecological dynamics at different spatial and temporal scales		complexity proposed. The plan should describe how funding and research decisions will be made and implemented, and efforts to integrate non-LTER scientists into research activities. Describe efforts to increase diversity among site participants. … address continuity of leadership, succession planning, and the recruitment of new scientists…

	conceptual framework and individual questions that constitute an integrated research plan. ... proposed models or model development must be presented in sufficient detail to allow evaluation, including the model structure, and should explain how the models account for different sources of uncertainty				

Table 3. LTER cohorts (date of initial funding) and life spans as of 2016.

1980

Andrews Forest – to present
Coweeta – to 2016 (wind down to 2019)
North Temperate Lakes – to present
Niwot Ridge – to present
Konza Prairie – to present
North Inlet – to 1990 (wind down or end date 1993)

1982

Shortgrass Steppe (originally Central Plains Experimental Range) – to 2011 (wind down to 2014)
Okefenokee – to 1987 (wind down to 1989)
Illinois/Large Rivers – to 1987 (wind down to 1989)
Cedar Creek - to present
Jornada Basin – to present

1987

Arctic Tundra at Toolik Lake – to present
Bonanza Creek – to present
Hubbard Brook – to present
Kellogg Biological Station – to present
Virginia Coastal Reserve – to present

1988

Luquillo – to present
Sevilleta – to 2014 (wind down to 2017)
Harvard Forest – to present

1991

Palmer Station – to present

1992

McMurdo Dry Valleys – to present

1997

Central Arizona Phoenix – to present
Baltimore Urban – to present

1998

Plum Island – to present

2000

Georgia Coastal – to present
Florida Coastal – to present
Santa Barbara Coastal – to present

2004

California Current – to present
Moorea Coral Reef – to present

2017

3 new sites will come into existence

Table 4. History of LTER site leadership and probations. Source: **All LTER Principal Investigator History as of March 14 2011.** This list of the lead principal investigators at each LTER site provides a historical perspective on the development of the LTER program. * - Probation; ** - Terminated. Source: http://intranet2.lternet.edu/node/3280/ Red font indicates additions from Julia Jones based on LTER life span dataset and current site profiles, https://lternet.edu/lter-sites. NOTE: some site profiles on the LNCO site are not current.

Andrews Experimental Forest (AND)
1980 - 1985 R. H. Waring (LPI), J. F. Franklin, K. Cummins
1986 - 1990 J. F. Franklin (LPI), S.V. Gregory, F. Swanson
1991 - 1996 F. J. Swanson (LPI), S.V. Gregory, M. Harmon, J. D. Lattin, D. Perry, P. Sollins, S. Stafford
1996 - 2002 F. J. Swanson (LPI), S. V. Gregory, M. E. Harmon (LPI mid-grant)
2002 - 2008 M. E. Harmon (LPI), B. J. Bond (LPI mid-grant), S. L. Johnson, J. A. Jones, F. J. Swanson
2008 - 2014 B. J. Bond (LPI), M. P. Nelson (LPI mid-grant), M.E. Harmon, S. L. Johnson, J. A. Jones, T. A. Spies
2014 – 2020 M. P. Nelson (LPI), M. Betts, H. Gosnell, S. L. Johnson, J. A. Jones

Arctic (ARC)
1987 - 1992 J. Hobbie (LPI), J. O'Brien, B. Peterson, G. Shaver
1992 - 1998 J. Hobbie (LPI), J. O'Brien, B. Peterson, G. Shaver
1998 - 2004 J. Hobbie (LPI), G. Kling, J. O'Brien, B. Peterson, G. Shaver
2005 - 2010 J. Hobbie (LPI), G. Kling, J. O'Brien, B. Peterson, G. Shaver
2010 - 2016 G. R. Shaver (LPI), W. B. Bowden, A. E. Giblin, G. W. Kling, C. Luecke
2016 – 2022 G.R. Shaver

Baltimore Ecosystem Study (BES)
1998 - 2004 S. T. Picket (LPI)
2004 - 2010 S. T. Picket (LPI)
2010 - 2016 S. T. Picket (LPI)
2016 – 2018* Emma Rosi-Marshall (LPI)

Bonanza Creek Experimental Forest (BNZ)
1987 - 1992 Van Cleve (LPI), T. Chapin, L. Viereck (COI in 1990)
1992 - 1995 Van Cleve (LPI), L. Viereck
1996 - 1997 T. Chapin (LPI), R. W. Ruess, J. Yarie, L. Viereck, T. L. Wurtz
1998 - 2000* T. Chapin (LPI)
2000 - 2004 T. Chapin (LPI), A. D. McGuire, R. W. Ruess, D. A Walker
2004 - 2006* T. Chapin (LPI), T. Hanley, A. Lloyd, A. D. McGuire, R. W. Ruess
2006 - 2010 T. Chapin (LPI), T. Hanley, A. Lloyd, A. D. McGuire, R. W. Ruess
2010 - 2016 R. W. Ruess (LPI), T. Hanley, J. B. Jones, M. Mack, A. D. McGuire
2016 – 2022 R.W. Ruess

California Current Ecosystem (CCE)
2004 - 2010 M. D. Ohman (LPI), K. Barbeau, R. Goericke, M. R. Landry, A. J. Miller
2010 - 2016 M. D. Ohman (LPI), K. Barbeau, R. Goericke, M. R. Landry, A. J. Miller
2016 – 2022 M.D. Ohman

Cedar Creek Natural History Area (CDR)
1982 - 1987 D. Tilman (LPI), J. R. Tester
1987 - 1989* D. Tilman (LPI) J. R. Tester
1989 - 1994 D. Tilman (LPI), E. Gorham, D. Grigal
1994 - 2001 D. Tilman (LPI), P. Reich, D. Grigal
2001 - 2006 D. Tilman (LPI), P. Reich, S. Hobbie
2006 - 2012 D. Tilman (LPI), P. Reich, S. Hobbie, S. Polasky
2012 – 2018 E. Seabloom (LPI)

Central Arizona—Phoenix (CAP)
1997 - 2004 N. B. Grimm, C. L. Redman, S. Fisher, J. Wu, A. de los Santos, Jr.
2004 - 2006 N. B. Grimm, C. L. Redman, D. Hope, P. McCartney, M. Elser, J. Briggs, C. Gries
2007 - 2008 N. B. Grimm, C. L. Redman, M. Elser, J. Briggs, C. Gries
2009 - 2010 N. B. Grimm, C. L. Redman, M. Elser
2010 - 2016 D. Childers (LPI), C. L. Redman, B. L. Turner, C. Boone, S. Harlan
2016 - 2018* N.B. Grimm (LPI)

Coweeta Hydrological Laboratory (CWT)
1980 - 1985 D. Crossley (LPI), E.P. Odum
1985 - 1990 D. Crossley (LPI)
1990 - 1996 J. Meyer (LPI), W. Swank
1996 - 2002 D. Coleman (LPI), J. Vose
2002 - 2010 T. L. Gragson (LPI), J. Vose, B. Kloeppel
2008 - 2014 T. L. Gragson (LPI)
2014 – 2016* R Jackson (LPI),
2016 – 2018** R Jackson (LPI)

Florida Coastal Everglades (FCE)
2000 - 2003 D. Childers (LPI), J. Boyer, J. Fourqurean, R. Jaffe, R. Jones, J. Trexler
2003 - 2006 D. Childers (LPI), J. Boyer, J. Fourqurean, R. Jaffe, J. Trexler
2006 - 2007 D. Childers (LPI), E. Gaiser, M. Heithaus, R. Jaffe, R. Price
2007 - 2012 E. Gaiser (LPI), R. Jaffe, M. Heithaus, R. Price, L. Ogden (COI 2008)
2012 – 2018 E. Gaiser (LPI)

Georgia Coastal Ecosytems (GCE)
2000 - 2006 J. T. Hollibaugh (LPI), S. Pennings
2006 - 2012 M. Alber (LPI), S. Pennings
2012 – 2018 M. Alber (LPI)

Harvard Forest (HFR)
1988 - 1994 J. G. Torrey (LPI), J. Aber, F. Bazzaz, D. R. Foster, J. Melillo, S. Wofsy
1994 - 2000 D. R. Foster (LPI), J. Aber. F. Bazzaz, E. Boose, J. Melillo, S. Wofsy
2000 - 2006 D. R. Foster (LPI), J. Aber, F. Bazzaz. E. Boose, J. Melillo, S. Wofsy
2006 - 2012 D. R. Foster (LPI), E. Boose, A. Ellison, S. Frey, J. Melillo, S. Ollinger, S. Wofsy, W. Munger
2012 – 2018 D. Foster (LPI)

Hubbard Brook Experimental Forest (HBR)
1988 - 1992 T. J. Fahey, C. T. Driscoll
1992 - 1998 T. J. Fahey, C. T. Driscoll
1998 - 2004 T. J. Fahey, C. T. Driscoll
2004 - 2010 T. J. Fahey, C. T. Driscoll
2010 - 2016 T. J. Fahey, C. T. Driscoll
2016 – 2022 C.T. Driscoll (LPI)

Illinois and Mississippi Rivers (ILL)
1980 - 1985 R. Sparks (LPI)
1986 - 1988** R. Sparks (LPI)

Jornada Basin (JRN)
1982 - 1987 W. G. Whitford (LPI), G. L. Cunningham, P. Wierenga, J. Ludwig, W. Conley, M. Hussain
1987 - 1988* W. G. Whitford (LPI)
1989 - 1991 W. G. Whitford (LPI), G. L. Cunningham, L. F. Huenneke, T.J. Ward
1991 - 1994 W. H. Schlesinger (LPI)
1994 - 2000 W. H. Schlesinger (LPI), J. Reynolds
2000 - 2003 L. F. Huenneke (LPI), D. P. Peters, K. M. Havstad, H. C. Monger

2003 - 2006 D. P. Peters (LPI), K. M. Havstad, H. C. Monger
2006 - 2013 D. P. Peters (LPI), B. Bestelmeyer, K. M. Havstad, H. C. Monger
2012 – 2018 D.P. Peters (LPI)

Kellogg Biological Station (KBS)
1988 - 1992 G. P. Robertson (LPI), E. A. Paul, M. J. Klug
1992 - 1998 G. P. Robertson (LPI), E. A. Paul, K. L. Gross, S. H. Gage, R. R. Harwood
1998 - 2004 G. P. Robertson (LPI), K. L. Gross, S. H. Gage, S. K. Hamilton, R. R. Harwood, C. K. Vanderpool
2004 - 2010 G. P. Robertson (LPI), K. L. Gross, S. K. Hamilton, D. A. Landis, T. M. Schmidt, S. M. Swinton
2010 - 2015 G. P. Robertson (LPI), K. L. Gross, S. K. Hamilton, D. A. Landis, T. M. Schmidt, S. S. Snapp, S. M. Swinton
2016 – 2018* S.K. Hamilton (LPI)

Konza Prairie (KNZ)
1980 - 1985 G. R. Marzolf (LPI), J. L. Zimmerman, D. W. Kaufman
1986 - 1988 D. W. Kaufman (LPI)
1988 - 1990 T. R. Seastedt (LPI)
1991 - 1996 A. K. Knapp (LPI), J. M. Briggs, D. C. Hartnett, D. W. Kaufman, C. M. Tate
1997 - 1999 A. K. Knapp (LPI), J. M. Briggs, D. C. Hartnett, D. W. Kaufman, W. K. Dodds
1999 - 2002 J. M. Blair (LPI), J. M. Briggs, D. C. Hartnett, D. W. Kaufman, W. K. Dodds
2002 - 2008 J. M. Blair (LPI), J. M. Briggs, D. C. Hartnett, L. C. Johnson, A. K. Knapp
2008 - 2014 J. M. Blair (LPI), W. K. Dodds, D. C. Hartnett, A. Joern, J. B. Nippert
2014 – 2020 J. M. Blair (LPI)

Luquillo Experimental Forest (LUQ)
1988 - 1994 R. B. Waide (LPI), A. Lugo
1994 - 2000 R. B. Waide (LPI), A. Lugo, F. Scatena, J. Zimmerman
2000 - 2002* J. Zimmerman (LPI), A. Lugo, D. J. Lodge
2002 - 2006 N. Brokaw (LPI), A. Lugo, D. J. Lodge
2006 - 2013* N. Brokaw (LPI), A. Lugo
2012 - 2018*?? J. Zimmerman (LPI)

McMurdo Dry Valleys (MCM)
1993 - 1997 R. Wharton (LPI), B. Lyons, A. Fountain, D. Wall, J. Priscu, D. Moorhead, R. Virginia, D. McKnight, C. Tate
1997 - 1999 B. Lyons (LPI), A. Fountain, D. Wall, J. Priscu, D. Moorhead, R. Virginia, D. McKnight, C. Tate
1999 - 2005 B. Lyons (LPI), A. Fountain, D. Wall, J. Priscu, D. Moorhead, P. Doran, R. Virginia, D. McKnight
2005 - 2008 B. Lyons (LPI), A. Fountain, D. Wall, J. Priscu, W. Hunt, P. Doran, R. Virginia, D. McKnight
2008 - 2010 A. Fountain (LPI), B. Lyons D. Wall, J. Priscu, W. Hunt, P. Doran, R. Virginia, D. McKnight
2010 - 2011 D. McKnight (LPI), B. Lyons D. Wall, J. Priscu, M. Gooseff, P. Doran, R. Virginia
2011 - 2017 D. McKnight (LPI), A. Fountain, M. Gooseff, J. Priscu, C. Takacs-Vesbach

Moorea Coral Reef (MCR)
2004 - 2009 R. J. Schmitt (LPI), S. J. Holbrook, R. C. Carpenter, P. J. Edmunds
2010 - 2012* R. J. Schmitt (LPI), S. J. Holbrook, R. C. Carpenter, P. J. Edmunds
2011 - 2014 R. J. Schmitt (LPI), S. J. Holbrook, R. C. Carpenter, P. J. Edmunds
2014-2020 R.J. Schmitt

Niwot Ridge (NWT)
1980 - 1985 P. J. Webber (LPI)
1985 - 1990 P. J. Webber, N. French (LPI-1997), N Caine (LPI 1988)
1990 - 1992* N. Caine (LPI)
1992 - 1998 T. R. Seastedt (LPI), M. Williams, N. Caine, W. Bowman, C. Wessman
1998 - 2004 T. R. Seastedt (LPI), M. Williams, W. Bowman, A. Townsend, D. McKnight
2004 - 2010 M. Williams (LPI), T. Seastedt, A. Townsend, D. McKnight, W. Bowman
2010 - 2016 M. Williams (LPI), T. Seastedt, A. Townsend, D. McKnight, W. Bowman

2016 – 2022 K. Suding

North Inlet (NIN)
1980 - 1985 F. J. Vernberg
1986 - 1991 F. J. Vernberg
1992 - 1993** F. J. Vernberg

North Temperate Lakes (NTL)
1980 - 1986 J. Magnuson (LPI), M. Anderson, D. Armstrong, C. Bowser, T. Brock, R. Ragotzkie, (COI 1980: M. Adams, T. Frost)
1986 - 1991 J. Magnuson (LPI)
1995 - 1996 J. Magnuson (LPI), T. Allen, D. Armstrong, T. Lillesand (Site Augmentation)
1996 - 2002 J. Magnuson (LPI), S. Carpenter, T. Kratz, T. Frost, M. Turner
2002 - 2008 S. Carpenter (LPI), M. Turner, W. Provencher, T. Lillesand, T. Kratz
2008 - 2009 S. Carpenter (LPI), T. Kratz, W. Provencher, E. Stanley, M. Turner
2009 - 2014 E. Stanley (LPI), S. Carpenter, T. Kratz, W. Provencher, M. Turner
2014 – 2020 E. Stanley

Okefenokee National Wildlife Refuge (OKE)
1980 - 1985 B. C. Patten
1986 - 1987** B. C. Patten

Palmer Station (PAL)
1990 - 1996 R. Ross (LPI), R. Smith, L. Quetin, B. Prezelin
1996 - 2002 R. Smith (LPI), R. Ross, L. Quetin
2002 - 2008 H. Ducklow (LPI)
2008 - 2014 H. Ducklow (LPI)

Plum Island Ecosystem (PIE)
1998 - 2004 C. Hopkinson (LPI), L. Deegan, A. Giblin, J. Hobbie, B. Peterson, J. Vallino
2004 - 2010 C. Hopkinson (LPI), L. Deegan, J. Vallino, J. Morris, C. Vorosmarty
2010 - 2012* A. Giblin (LPI), C. Hopkinson, J. Vallino, W. Wollheim
2012 – 2018 A. Giblin

Santa Barbara Coastal (SBC)
2000 - 2006 D. Reed (LPI), S. Cooper, S. Gaines, S. Holbrook, J. Melack
2006 - 2012 D. Reed (LPI), S. Gaines, S. Holbrook, J. Melack, D. Siegal

Sevilleta (SEV)
1988 - 1994 J. Gosz, J. Brown, B. Milne, M. Molles
1994 - 2000 B. Milne, J. Brown, C. Dahm, A. Evans, T. Yates
2000 - 2002* J. Gosz, B. Parmenter, T. Lowery, W. Pockman, J. Brunt
2002 - 2002* J. Gosz, B. Parmenter, W. Pockman, B. Wolf, T. Yates
2003 - 2006 C. Dahm (interim LPI) S. Collins (LPI)
2006 - 2013* S. Collins (LPI), C. Dahm, W. Pockman, M. Litvak, K. Vanderbilt
201? – 2017** W. Pockman

Shortgrass Steppe (SGS)
1982-1986 W. Lauenroth (LPI), R. Woodmansee
1987-1990 W. Lauenroth (LPI)
1990-1006 W. Lauenroth (LPI), I. Burke, D.V. Schilfgaarde, J. Forwood
1996-2000 I. Burke (LPI), W. Lauenroth, E. Kelly
2000-2002 E. Kelly (LPI), I. Burke, W. Lauenroth
2002-2008 E. Kelly (LPI), I. Burke, M. Antolin, I. Burke, J. Morgan, J. Moore
2008-2010* M. Antolin (LPI), I, Burke, E. Kelly, W. Lauenroth, J. Moore, J. Morgan
2010-2012* J. Moore (LPI), M. Antolin, J. Derner, N. Kaplan, E. Kelly

201?-201?**

Virginia Coast Reserve (VCR)
1986 - 1992 R. Dueser (LPI), W. Odum, H. Shugart, L. Blum
1992 - 1994* H. Shugart (LPI), L. Blum, B. Hayden
1994 - 2000 B. Hayden (LPI), H. Shugart, J. Porter, D. Smith
2000 - 2006 B. Hayden (LPI), K. McGlathery, J. Porter
2006 - 2012 K. McGlathery (LPI), P. Wiberg, J. Porter

LTER Network Office (LNO)
1981 - 1984 R. Marzolf (LPI)
1984 - 1990 J. Franklin (LPI)
1991 - 1993 J. Franklin (LPI), J. Vande Castle
1993 - 1995 J. Franklin (LPI), J. Vande Castle
1995 - 1998 J. Vande Castle
1997 - 2003 J. Gosz (LPI), J. Vande Castle, J. Brunt (R. Waide LPI 8/97)
2003 - 2009 R. Waide (LPI), J. Vande Castle, J. Brunt, W. Michener
2009 - 2015 R. Waide (LPI), J. Vande Castle, J. Brunt
2015 – 20?? F.W. Davis