THE LONG TERM ECOLOGICAL RESEARCH NETWORK

2013 ANNUAL REPORT

The LTER Network has a vision: a society in which exemplary science advances the health, productivity and welfare of the global environment, thereby advancing the health, prosperity, welfare and security of our nation.

To realize this vision, LTER strives to provide the scientific community, policy makers and society with the knowledge and predictive understanding necessary to conserve, protect and manage the nation's ecosystems, their biodiversity and the services they provide.

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On the cover: View from the Mohawk kelp forest (SBC); High temperatures and an abundance of asphalt create urban heat islands (CAP). Tiffany Fourment and students at Wild Bear Science and Nature Center, CO (NWT); Adelie penguins in Antarctica (PAL). **On this page:** Harvard Pond research site (HFR).

GUIDING PRINCIPLES

The LTER Network seeks to understand the long-term patterns and processes of ecological systems. To this end, Network scientists focus on six interrelated objectives:

1. **Understanding:** To understand a diverse array of ecosystems at multiple spatial and temporal scales.
2. **Synthesis:** To create general knowledge through long-term, interdisciplinary research, synthesis of information and development of theory.
3. **Information:** To inform the LTER and broader scientific community by creating well-designed and well-documented databases.
4. **Legacies:** To create a legacy of well-designed and documented long-term observations, experiments and archives of samples and specimens for future generations.
5. **Education:** To promote training, teaching and learning about long-term ecological research and the Earth's ecosystems, and to educate a new generation of scientists.
6. **Outreach:** To reach out to the broader scientific community, natural resource managers, policymakers and the general public by providing decision support, information, recommendations and the knowledge and capability to address complex environmental challenges.

LTER NETWORK RESEARCH

Individual scientists, students and educators at the 26 LTER sites contribute toward the LTER mission. Site-level work forms the foundation of knowledge, data, and observational and experimental legacies, while extensive field experience provides predictive information regarding responses to future ecological disturbances.

These efforts add to the basic body of scientific knowledge of long-term, large-scale ecological phenomena, while training programs increase the number of people with expertise in research and environmental problem solving. Ultimately, both site- and Network-level activities develop scientific capital – well-documented research, well-trained scientists and a well-informed citizenry.

The 26 LTER sites represent a wide variety of research emphases and approaches. Each site conducts a series of measurements and experiments directed towards the understanding of fundamental ecological principles, as well as studies addressing ecological issues specific to the site. The most common scientific approaches include observation, experimentation, comparative analysis, retrospective study and modeling.

MESSAGE FROM THE CHAIR

UNDERSTANDING EARTH'S ECOLOGY— TODAY AND IN THE FUTURE

The LTER Network is an innovative platform for training the next generation of natural scientists in collaborative, integrative long-term research. In 2013, LTER's eclectic network of researcher scientists continued to conduct cutting-edge science, addressing both ecological theory and environmental policy and practices. This annual report highlights a number of exciting findings, including the:

- Key role of coastal wetlands in storing terrestrial carbon
- Spatial distribution of urban heat island impacts
- Impacts of elevated atmospheric CO_2 levels on water use in forests at large spatial scales

In 2013 the U.S. LTER Network celebrated the 20th anniversary of the International LTER Network (**ilternet.edu**). Conceived at the 1993 All Scientists Meeting, ILTER now includes 37 active member networks. Last February's Mini-Symposium at the National Science Foundation (NSF) highlighted the global reach of long-term research through successful partnerships between U.S. and International LTER sites and scientists. The annual Science Council meeting at the Jornada LTER in Las Cruces, New Mexico revealed further international cooperation, as Prof. Manual Maass – head of the Mexico LTER Network and the ILTER Network's current chair – gave a fantastic keynote presentation.

One sobering challenge we faced in 2013 was October's two-week federal government shutdown. This event made it abundantly clear how much we depend on positive interactions with federal agencies and their scientists. Indeed, 10 LTER sites are located in areas either controlled by the U.S. government or on lands managed by federal agencies. All federal facilities at these sites were closed and most federal scientists were furloughed; in some cases, all scientists were barred from conducting research on federal property. Chillingly, the NSF was forced to consider cancelling the field season in Antarctica this year, though luckily that did not happen.

Throughout the year, the LTER Network Information System received data from LTER sites nationwide. LTER site data are now available through the Network Data Portal, which we continue to improve. LTER also makes data available through the DataONE website (**dataone.org**).

Finally, it is a pleasure to report on successful NSF evaluations of LTER programs. All NSF-sponsored site visits yielded positive reviews and useful suggestions for achieving the goals described in the sites' renewal proposals.

All in all, the LTER Network remains a vibrant community of researchers that continues to expand our knowledge of how earth's ecosystems respond to natural and anthropogenic forces. We are pleased to share our recent accomplishments in our 2013 Annual Report. We hope you find the stories of these accomplishments engaging and relevant.

Sincerely,

Scott Collins, Chair, LTER Science Council

LONG-TERM RESEARCH, LONG-TERM BENEFITS

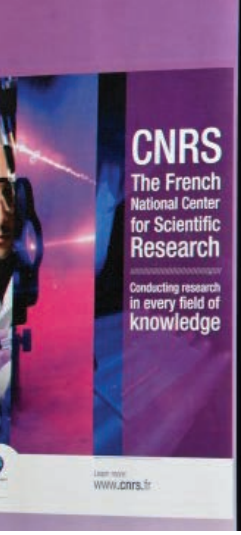
2013 was a year filled with accomplishments for the LTER Network. Here's a summary of the important developments, including cross-site and international collaborations, progress of the LTER Data Co-op, education initiatives, a unique workshop partnering scientists and journalists and reports on the 50th anniversary celebrations at two LTER sites.

LTER MEETS THE CHALLENGES OF 2013—AND BEYOND

Because the sites in our network focus on long-term ecological processes, the continuity of our efforts is critical to tracking and understanding environmental change. During 2013, disruptions in the federal government's support for research challenged our ability to maintain long-term experiments and observations. Working with the National Science Foundation (NSF), LTER sites successfully met this challenge and continued to produce important new insights into the way our nation's key ecosystems function.

The importance of long-term observations was apparent again this year as extreme events once again affected large parts of the country. For example, drought continued over large areas of the western U.S., leading to another very active fire season. LTER researchers in New Mexico have demonstrated links between dissolved oxygen sags and nutrient enrichment in streams and rivers after fires that impacted water quality as far as 50 kilometers downstream of the burn scars. Evaluating the importance of such extreme events to critical ecosystem services requires long records of baseline measurements and fundamental understanding of the way that ecosystems operate. The LTER Network's unique role in providing long-term records and in-depth understanding of key ecosystems makes it an important national asset.

LTER scientists continue to improve our knowledge of ecosystems and to synthesize this knowledge to facilitate the wise management of our nation's resources. In this annual report, we present examples of recent achievements and report progress toward the overall goals of the LTER Network.




Left: Scott Collins (Chair, LTER Science Council), with Zone Ateliers and French Embassy officials Xavier Morise, Françoise Gaill and Yvan Lagadeuc after signing the Memorandum of Understanding between the U.S. LTER Network and the Zone Ateliers Network of France. **Right:** Graduate student Roy Rich collects leaf samples to be analyzed for the TRY Initiative. This extensive plant trait databases contains more than 3 million records, covering 70,000 plant species and involving 180 partner institutions.

COLLABORATING ACROSS NATIONAL BOUNDARIES

2013 marked the 20th anniversary of the International Long Term Ecological Research Network (ILTER), an umbrella organization for 37 national networks conducting long-term studies. Founded at the 1993 U.S. LTER All Scientists Meeting to monitor global long-term ecological phenomena, the ILTER Network contributes to the understanding of international socio-ecological issues through site-based, long-term research projects and the comparison of data from a global network of sites. Membership in ILTER makes it possible for U.S. LTER scientists and graduate students to extend their research through collaborations at international sites, and long-term data collected at diverse ILTER sites helps investigators understand global questions. Examples of exciting international collaborations from 2013 include:

- The 11th International Congress for Ecology (INTECOL) in London, held in August, where LTER scientists gave presentations showcasing their ILTER connections
- The ILTER 20th Anniversary Symposium and Science Meeting in Seoul, held in October through generous support from the NSF
- Various partnerships with LTER Schoolyard programs outside the U.S., which enabled primary and secondary students to acquire valuable international connections

The annual LTER mini-symposium at NSF in February focused on research conducted with ILTER collaborators (see page 12). Today, LTER researchers engage in a broad range of international collaborations:

- Investigators at the Cedar Creek LTER site are working with researchers in 21 different countries. These include collaboration with the Max Planck Institute for Biogeochemistry (Jena, Germany) on dynamic global vegetation models and with the National Evolutionary Synthesis Center (NESCENT) Project on the evolutionary history of trait diversification, which examines macro-evolutionary changes in plant traits as influenced by environmental and evolutionary history.
- The Nutrient Network continues to expand and now has 75 sites across five continents. With eight participating LTER sites (AND, CDR, JRN, KBS, KNZ, NWT, SEV, SGS), the Nutrient Network is one of the largest cross-LTER studies using consistent methods.

- U.S. LTER and France's Zone Atelier (ZA-France) networks signed a Memorandum of Understanding (MoU) committing to share knowledge and skills through collaboration among sites and scientists. Scott Collins, Chair of the LTER Science Council, signed on behalf of LTER. In December, ZA-France invited Bob Waide, Executive Director of the LTER Network Office, to present the keynote address ("The Challenges and Rewards of Research Networks: Examples from the U.S. Long Term Ecological Research Program") at their annual meeting in Paris, France.
- Florida Coastal Everglades LTER published a special issue of *Marine and Freshwater Research*, highlighting results of international efforts to understand subtropical estuaries (funded through NSF ILTER Supplemental Funding).

LINKING RESEARCH AND POLICY

Six ecological research institutions, representing four LTER sites in the northeastern U.S., have joined forces to create the Science Policy Exchange (SPE). The SPE's aim is to increase the impact of long-term ecological research on policy and conservation in promoting environmental stewardship and human well-being. Already the exchange has launched a series of projects that confront challenges at the intersection of climate change, land use and pollution.

The SPE's founding institutions and affiliated LTER sites are the Cary Institute of Ecosystem Studies (through the Baltimore Ecosystem Study, BES), Harvard Forest (HFR), the Hubbard Brook Research Foundation (HBR), the Marine Biological Laboratory's Ecosystems Center (through the Plum Island Ecosystem, PIE), Syracuse University and the University of New Hampshire.

SCIENCE POLICY EXCHANGE

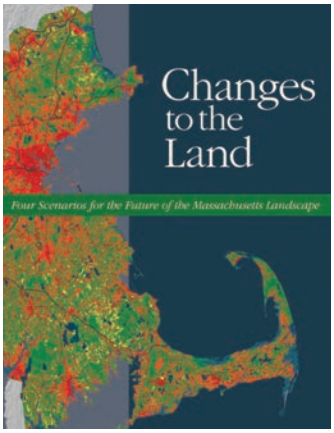
Funding for SPE is provided in part by the Grantham Foundation, Doris Duke Charitable Trust, Jessie B. Cox Charitable Trust, Kirby Foundation, the U.S. Forest Service's Northeastern States Research Cooperative and others.

LTERARTS' ECOLOGICAL REFLECTIONS HAS A RIPPLE EFFECT

In February 2013, in the midst of the LTER mini-symposium at the NSF in Virginia, visitors flocked to the opening of a unique exhibit, the result of collaborations between LTER scientists and local and regional artists. "Ecological Reflections: Sense of Place in Changing Places" showcased work by 39 artists and writers from 11 LTER sites across the continental U.S., Alaska and French Polynesia, revealing the cultural and ecological diversity of those sites. The exhibit included a wide variety of media, from fiber arts and paintings to short films, poetry and even an installation of live mangrove plants. Versions of the exhibit also appeared at the annual Ecological Society of America meeting in Minneapolis and the America's Grassland annual conference in Kansas.

Though the NSF exhibit ended in July, "Ecological Reflections" activities continued at the Virginia Coast Reserve LTER site with workshops for art teachers, and at the University of Virginia with the inauguration of an undergraduate nature-writing workshop. Following the success of these programs, we can look forward to further science-arts-humanities collaborations. Learn more about LTER Ecological Reflections efforts at **ecologicalreflections.com**.


"Uncultivated" by Lynn Cazabon



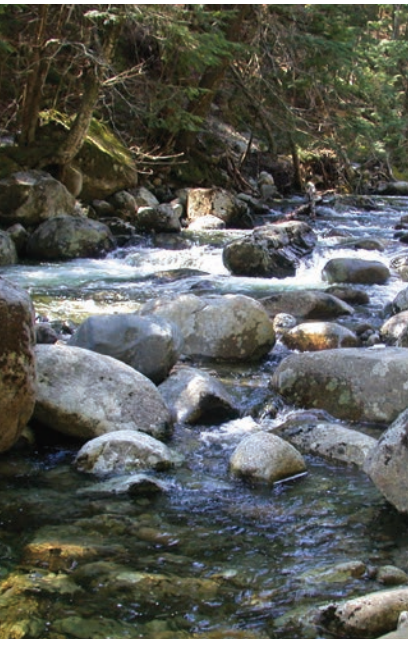

Journalists and scientists at KBS.

UNDERSTANDING FUTURE LANDSCAPE SCENARIOS

A groundbreaking study by the Harvard Forest LTER and the Smithsonian Institution reveals that recent development trends in Massachusetts threaten to undermine land-conservation gains, jeopardize water quality and limit the natural landscape's ability to protect against climate change. Fortunately, the research shows that alternatives exist for protecting vital forest benefits. The results of the two-year study are summarized in the new report, *Changes to the Land: Four Scenarios for the Future of the Massachusetts Landscape*.

COMMUNICATING WITH THE PUBLIC THROUGH THE PRESS

Aimed at fulfilling the LTER Network's outreach goal to "educate the broader ecological community, the general public, resource managers and policy makers," the Kellogg Biological Station (KBS) LTER led a climate-change communication workshop with the Society of Environmental Journalists, pairing up 11 LTER scientists with 11 reporters from across the country. The journalists came away impressed: "I already had a strong awareness of the LTER Network, but my appreciation of their value continues to grow with this experience," one participant noted. For their part, LTER scientists reported that they were more likely to contact their journalist partners because of the training. One scientist remarked, "I think both sides gained a better understanding of where the other side is coming from and what they are attempting to do."



HUBBARD BROOK ECOSYSTEM STUDY CELEBRATES 50 YEARS

July 2013 marked the 50th anniversary of one of the world's most respected and emulated long-term ecosystem studies. Nine distinguished speakers honored the Hubbard Brook Ecosystem Study (HBES) by delivering short "Herb Talks" in memory of co-founder F. Herbert Bormann. Bormann, along with Gene E. Likens, Robert S. Pierce and Noyce M. Johnson initiated HBES to investigate ecological, hydrological and biogeochemical interactions in watershed ecosystems. The Study's hallmark small watershed ecosystem approach has been replicated throughout the world. HBES is best known, however, for its discovery of acid rain in North America. Through HBES, hundreds of scientists have contributed to our knowledge of forests. Hubbard Brook scientists have produced thousands of scientific publications, and its alumni are leaders in academia and the conservation sphere. Today, 45 investigators conduct research at Hubbard Brook. The Study occurs at the Hubbard Brook Experimental Forest, in New Hampshire's White Mountain National Forest.

Graduate students and post-docs meeting in La Jolla, CA.

GRADUATE STUDENTS AND POST-DOCS TAKE THE LEAD

In March 2013, more than 30 graduate students and post-docs from the California Current Ecosystem (CCE), Moorea Coral Reef (MCR) and Santa Barbara Coastal (SBC) met at Scripps Institution of Oceanography (SIO)/University of California San Diego in La Jolla. This was the third biennial meeting of these three sites, in which participants presented their latest research on pelagic and benthic ecology, ocean acidification and physical oceanography. This year's symposium had a special focus on fostering cross-site interactions: combining outreach efforts, coordinating coastal field research and the sharing of data sets were among the ideas proposed. All sites also agreed to update their graduate student and post-doc research webpages in order to facilitate future collaborations.

MAKING DATA MORE ACCESSIBLE

In January 2013, almost a year and a half ahead of schedule, the LTER Network Office released key components of PASTA, the data repository for the LTER Network Information System (NIS) as a production-stable system. The early implementation of this phase of PASTA has ushered in a new era for LTER where the products of research at LTER sites can be published, protected and easily accessed by all. Through PASTA, researchers can now access over 19,000 data packages, nearly 4,000 of which were LTER-site contributions. In addition, PASTA houses more than 15,000 data packages from the EcoTrends Project (see page 10), along with 11 data packages from the decommissioned North Inlet LTER site. Access to the PASTA data package repository is available through the NIS Data Portal at **portal.lternet.edu**.

EDUCATION AT ALL LEVELS

LTER continued to inform and influence the development of national science standards. The 2012 National Research Council report, *A Framework for K-12 Science Education*, was based in part on LTER learning progressions research and formed the basis for the Next Generation Science Standards, released in 2013. Charles (Andy) Anderson, a KBS LTER researcher, reports, "Through the KBS LTER K-12 Partnership and the Network's cross-site Math-Science Partnership Program, LTER education research continues to influence science standards at the national level."

The LTER Network is widely recognized for its scientific contributions and educational products. The LTER Education Digital Library is a centrally coordinated collection of high quality, digital educational materials and science resources. The library is a trove of LTER educational materials for teachers, students and community leaders. As a Network-wide project, it enables outreach to a wide audience and also drives traffic to individual LTER sites. The digital library platform can be found at **educationlibrary.lternet.edu**. As the library continues to grow, we will establish review criteria to evaluate the wide range of resources the site will include – from animations and long-term data sets to citizen science protocols and curriculum modules.

To help citizen scientists monitor lake levels across Wisconsin, the North Temperate Lakes (NTL) LTER site has made its data viewable by the general public at the click of the mouse (see **lakechange.org** or **lter.limnology.wisc.edu/lakeinfo/lake-information-system**). The websites include graphs of long-term lake variables such as phosphorus, chlorophyll and water clarity for 11 study lakes; current lake-level conditions for lakes monitored by NTL and the U.S. Geological Survey; and a newly initiated volunteer monitoring program supported by NTL (see **lter.limnology.wisc.edu/lakeinfo/volunteer**). This new web feature will broaden the use of NTL data and engage more individuals in long-term monitoring.

Jornada LTER scientist Stephanie Bestelmeyer assists students with an inquiry-based science activity during a field trip in the Chihuahuan Desert Nature Park.

The video documentary *Water: A Zero Sum Game* was nominated by the Heartland Chapter of the National Academy of Television Arts and Sciences for an Emmy Award in the "Environment: Program/Feature" category. The video highlights research conducted by Mark Williams, Principal Investigator of the Niwot Ridge (NWT) LTER site and a fellow at the Institute of Arctic and Alpine Research. Williams, an expert in snow hydrology and mountain ecology, studies water from snowpack and its impact on the water supply to homes and municipalities.

TRACKING ECOLOGICAL TRENDS

Long-Term Trends in Ecological Systems: A Basis for Understanding Responses to Global Change is now available free to anyone interested in viewing trends in long-term ecological data from the LTER (**lternet.edu**) and Jornada LTER (**jornada.nmsu.edu**) websites. The writing style, background information and large number of color photos, maps and graphs allow users across a range of expertise to understand the information, and to use it for intra- and inter-site comparisons. The book is a product of the EcoTrends Project, a major collaborative effort involving scientists, students and staff from all LTER sites and the LTER Network Office, as well as U.S. Department of Agriculture (USDA) scientists. To obtain hard copies of this book, please contact Debra Peters at **debpeter@nmsu.edu**.

KBS CELEBRATES 50 YEARS OF AQUATIC RESEARCH

In October, more than 100 current and former faculty, students and staff met at Michigan State University's Kellogg Biological Station to celebrate 50 years of aquatic research and to honor Dr. George Lauff. Lauff served as KBS's director from 1964 to 1989 and helped make KBS an internationally recognized center for ecological research. At a symposium featuring former KBS scientists, retired MSU zoologist Don Hall recalled how Lauff's unique pitch helped convince a reluctant NSF to fund KBS's Experimental Pond Laboratory. "We asked for a set of giant, dirty test tubes," Hall said. "That's what convinced NSF to fund us." A dedicated supporter of education, Lauff donated his home to fund KBS student scholarships at Michigan State University. You can read more about the event at: **ns.msu.edu/index.php/2013/10/kbs-honors-former-director-marks-50-years-of-aquatic-ecology-research/**.

2013 RECOGNITION

Throughout the past year, several LTER scientists and students were recognized for their achievements with a variety of accolades and important scientific awards:

1 **JULIA JONES** (AND) was honored at Oregon State University as a 2013 recipient of the OSU Women's Center Woman of Achievement award, for women whose work has touched the lives of students and colleagues.

2 **MARK SCHULZE** (AND) the Director of the H. J. Andrews Experimental Forest, received a 2012 Outstanding Service award from the College of Forestry at Oregon State University for his exceptional work running the site.

3 **SARAH E. HOBBIE** (CDR) was elected to the National Academy of Sciences in April.

4 **ROBERT W. STERNER** (CDR), professor of Ecology, Evolution and Behavior at the University of Minnesota, became the new Principal Investigator for the CDR. Sterner also delivered a plenary lecture at the 2013 Symposium for European Freshwater Sciences in Münster, Germany.

5 **DAVE TILMAN** (CDR) was awarded the Alexander von Humboldt Medal from the International Association for Vegetation Science. Tilman was also awarded Honorary Membership to the British Ecological Society.

6 **AARON ELLISON** (HFR) and co-authors won a 2013 New England Society's Book Award for *Field Guide to the Ants of New England*.

7, 8 Research papers by **DAVID FOSTER** (HFR), "Land use history (1730-1990) and vegetation dynamics in central New England, USA," and **KATHERINE GROSS** (KBS), "Effect of seed size and growth form on seedling establishment of six monocarpic perennial plants," were recognized by the British Ecological Society as among the top 100 most influential papers ever published by the organization.

9 **TONY IVES** (NTL) was elected a member of the American Academy of Arts and Sciences. Ives also gave the MacArthur lecture at Ecological Society of America's 2013 meeting in Minneapolis.

10 **MARK WILLIAMS** (NWT), who is currently a Senior Fulbright Scholar in Nepal, was elected a Fellow of the American Geophysical Union. His Fulbright award is based on his research activities on snow hydrology and climate change at the NWT LTER program.

11 **ANNE E. GIBLIN** (PIE) was named a Fellow of the American Association for the Advancement of Science (AAAS).

12 **BRUCE PETERSON** (PIE) won the American Society of Limnology and Oceanography's A.C. Redfield Lifetime Achievement Award, "for innovative and transformative studies of carbon, nutrient and water cycles at process, ecosystem and global scales."

13, 14 **CARLA D'ANTONIO** (SBC) and **JOSHUA SCHIMEL** (SBC) were elected fellows of the Ecological Society of America.

15, 16 **DAN REED** (SBC) served as one of the guest editors for the special issue of *Oceanography* journal, which featured four contributions from SBC.

THE 2013 MINI-SYMPOSIUM On February 28, 2013, leaders from various LTER sites gathered in Arlington, Virginia to present their research findings and discuss their practical applications. Six presentations are summarized below, and you can learn more and view the videos at **http://bit.ly/1fd43yE**.

ILTER NETWORK: PAST, PRESENT, AND FUTURE

Kristin Vanderbilt
University of New Mexico
Sevilleta LTER

As the 20th anniversary of the International LTER (ILTER) Network (see page 6), 2013 was a year to assess the Network's steady growth and its future.

NSF and U.S. LTER contributed significantly to the development of ILTER. During its first decade, NSF supported many visits by U.S. LTER scientists and graduate students to ILTER sites, and vice versa. ILTER scientists studied the U.S. model of LTER research and information management, adapting and modifying it for their own networks. In 2006, ILTER became a legal entity. Today, the Network carries out a broad range of research, information management, fundraising and public policy activities.

NSF and LTER's substantial investment in ILTER has paid off. Collaboration between LTER and ILTER scientists extends the scale at which LTER science is done, as long-term datasets from a wide variety of ecosystems worldwide are synthesized to address global research questions.

INTERNATIONAL COORDINATION INCREASES EXPLANATORY POWER

Byron J. Adams, Brigham Young University
McMurdo Dry Valleys LTER

The extremely dry, windy, cold and saline environments at MCM are highly sensitive to natural and human drivers of ecological change. They are also very sensitive to research activities. More than a decade ago, scientists and program managers put a plan in place to protect the McMurdo Dry Valleys.

To ensure MCM's protection moving forward, and to improve predictive models of how Antarctica will respond to global changes, we are now developing a data monitoring and observation network (MCM TON). Our international team of scientists and program managers has developed standards to ensure that we collect the right data the right way in the right amounts, and make it available to those who need it; we have also developed standards for evaluating the effectiveness of current McMurdo Dry Valley ASMA environmental protection guidelines.

By coordinating measurements through the MCM TON, we have improved our ability to monitor environmental change in Dry Valley ecosystems and to assess the effectiveness of environmental management policies.

Art Schwarzschild (VCR) and Giorgio Matteuccii (Italy LTER) discuss opportunities for students at the annual ILTER conference this past October in Seoul, South Korea.

MCM LTER and New Zealand graduate students perform collaborative research on how stream and soil communities are responding to climate-driven environmental changes.

THE INTERNATIONAL MOUNTAIN LTER NETWORK

Mark W. Williams
University of Colorado-Boulder
Niwot Ridge LTER

Mountains are water towers, with snow and ice melt providing water security – and consequent food security – to downstream users. Nowhere in the world has climate change affected water security more than in the immense Hindu Kush-Himalaya mountain range, the source of water to more than 1.5 billion users. However, a complete understanding of the regional hydrology and glaciology of the region is lacking because of the logistical difficulties in collecting field data at elevations that exceed 8,000 meters.

To address this problem, Colorado's Niwot Ridge LTER program has partnered with Nepalese and Italian colleagues to begin a research program on climate change, retreating Himalayan glaciers and water security in Asia. The program builds on the success of previous partnerships, including a joint Nepali/Italian/NWT LTER expedition in the Everest region of Nepal in 2013. What our research at NWT LTER and many other sites has shown is that the sensitivity of mountain ecosystems to changes in climate begs most urgently for enhanced, worldwide protection.

MANY HANDS: FOSTERING ECOLOGICAL DATA SHARING

John H. Porter
University of Virginia
Virginia Coast Reserve LTER

The key goal of LTER information management is to make the data available to address long-term, regional, global and multidisciplinary questions. ILTER member sites can be an invaluable source of data for international comparative studies. However, for those data to be useful, there must be mechanisms for discovering and sharing data – and a willingness to do so.

Information managers from U.S. LTER sites have engaged in a wide variety of international collaborations over the last two decades. These interactions have included training workshops, extended personnel exchanges and science-synthesis workshops, in which researchers and information managers work together to better meet science data needs.

Information-management collaborations have generated numerous software products, as well as articles in journals like *Trends in Ecology and Evolution, Bioscience* and *Ecological Informatics*. The keys to the success of these collaborations have been finding the right partners, focusing on tangible products, providing multiple opportunities for interaction and holding periodic strategy meetings. Our experience has shown that many hands truly make light work!

High-elevation meteorological station at about 5,500 m, Kala Patar, Khumbu Region, Nepal. Everest (Chomolungma) in the middle background, Nuptse on the right.

Information managers Donald Henshaw and Chau-Chin Lin ponder a problem.

EXPANDING DIMENSIONS IN LANDSCAPE-AGROECOLOGICAL RESEARCH

J. Megan Woltz
Kellogg Biological Station LTER

Insects provide valuable ecosystem services that support human existence. In general, we find that landscapes with more non-crop habitat support a greater abundance and diversity of arthropod natural enemies, leading to greater biological control services for crop fields within those landscapes.

Researchers from LTER France have shown that the configuration of habitats within a landscape can also be important for natural enemy populations. Having adjacent crops with contrasting phenologies, for example, allows ground beetles to persist in an agricultural landscape by moving from one crop to another as conditions within a single crop become less favorable.

Would these benefits persist in larger field sizes? Methods from the original study were replicated in field crops in the North Central U.S., but with much larger field sizes, with similar results. Field data from both studies are being used to develop a landscape-modeling program to help researchers visualize the effect of various crop management regimes on natural enemy populations.

A FOCUS ON TROPICAL SYSTEMS

Tiffany Troxler
Florida Coastal Everglades LTER

The benefits of partnerships between U.S. LTER sites and international contacts and collaborators are manifold: a larger scale for investigations, more opportunities to exchange new ideas and advance ecological theory, and more ways to positively influence environmental policy.

In the past, researchers at the Florida Coastal Everglades (FCE) site pursued collaborative research to better understand how the ecology of FCE ecosystems compared with similar wetland ecosystems in the Caribbean, and how the perceived uniqueness of the Everglades compared to other wetland systems worldwide. These relationships have expanded into new initiatives, including global assessments of seagrass ecosystem carbon stocks and global patterns of dissolved organic and black carbon.

Another example of collaboration that broadens the impact of LTER science on a global scale includes the greenhouse gas (GHG) emission data synthesized by scientists working with the Intergovernmental Panel on Climate Change Task Force on National Greenhouse Gas Inventories. The data are used in national inventories of GHG, contributing to national mitigation and emission reduction plans.

Having adjacent crops with contrasting phenologies allows ground beetles to persist in an agricultural landscape by moving from one crop to another as conditions within one crop become less favorable.

Manuel Maass (ILTER chair and Mexico LTER), Fred Scatena (LUQ) and Cathy Pringle (GCE) meeting with reservoir engineers near Chamela, Mexico during the U.S.-Mexico Workshop: Catalyzing international collaborations to develop a platform for ecohydrological research.

LOOKING AHEAD TO NEW RESEARCH

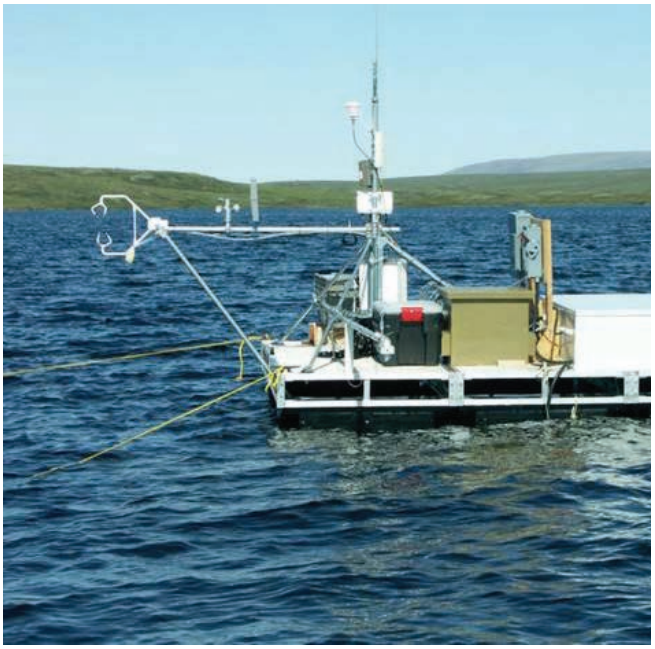
In this section, we highlight a number of LTER sites whose work was reviewed by NSF in 2013.

ARCTIC (ARC)

The Arctic has warmed significantly in recent decades, and arctic lands and freshwaters are changing in response. Since 1975, ARC investigators have studied these changes by monitoring tundra, streams and lakes; observing long-term, whole-ecosystem manipulations; and comparing sites in Alaska and throughout the Arctic.

ARC's long-term goal is to develop a predictive understanding of arctic landscape features and interactions. The current project (2010-2016) includes a particular emphasis on changing disturbance regimes (wildfire and thawing permafrost) and their interactions with climate.

ARC maintains a multifaceted education program, which includes a Schoolyard project in Barrow, courses in Arctic Ecology for journalists, and undergraduate and graduate research opportunities. ARC research provides a case study of a landscape where subsistence land use is still common and where the impact of climate change is observed directly.



To understand C cycling at the landscape level, ARC and collaborators maintain a total of nine eddy flux towers including this one on Toolik Lake.

Large, high-severity fires, such as the Willow Creek fire in 2010 shown above, are becoming more common throughout Alaska's boreal forest and are predicted to change successional pathways and permafrost stability.

BONANZA CREEK (BNZ)

The Alaska boreal forest has remained highly resilient to climate fluctuations for the past 6,000 years; however, climate-driven changes in disturbance regimes (fire, permafrost thaw and pest/pathogen outbreaks) over the past century are altering the interrelationships among biological, physical and social drivers to influence the regional system.

BNZ employs long-term monitoring, experiments, modeling and social-ecological studies across a regional network of sites to understand the interactive effects of changing climate and disturbance regimes on the Alaska boreal forest, the associated consequences for regional feedbacks to the climate system and the sustainability of Alaskan communities.

In addition to training undergraduate, graduate and post-doctoral students, BNZ is actively involved with K-12 students and educators throughout the state. BNZ also interacts with the visual, literary and performing arts community and collaborates with state and federal agencies and Native organizations.

CALIFORNIA CURRENT ECOSYSTEM (CCE)

CCE focuses on the mechanisms underlying changes in the coastal upwelling ecosystem of the southern California Current System. Initiated in 2004, CCE builds on the extraordinary CalCOFI ocean time series (now in its 7th decade), permitting scientists to resolve long-term natural and anthropogenic forcing.

CCE's at-sea experimental studies analyze key processes that lead to changes in the structure of ocean food webs, with particular emphasis on the planktonic organisms at the base. These experiments are integrated with innovative ocean observations using ocean gliders, autonomous moorings, shipboard measurements and satellite remote sensing. A suite of coupled physical-biological models integrates across time and space scales.

CCE includes active participation by numerous graduate students, post-docs and students in NSF's Research Experience for Undergraduates program. The site reaches out to the 'K-through-gray' community via programs in local schools, the nonprofit Ocean Institute and the Birch Aquarium at Scripps.

Students aboard the Ocean Institute's R/V *Sea Explorer*, heading out to sea to collect samples for a collaborative project between CCE and the Ocean Institute. This floating laboratory provides a unique opportunity for students by transforming scientific research into authentic learning experiences.

Residential landscapes are important features of the urban ecosystem in the Central Arizona-Phoenix LTER study area.

CENTRAL ARIZONA–PHOENIX (CAP)

Research in this arid, urban site addresses how the rapid urbanization of central Arizona changes ecological patterns and processes, ecosystem services and human outcomes. Researchers employ a variety of approaches in studying land-use and land-cover change; the complex interactions of climate, vegetation and people; water dynamics; movement and storage of chemical elements; and controls of species distributions and abundance.

Since its renewal in 2010, CAP scientists have made considerable progress in understanding the causes and impacts of the urban heat island effect and extreme heat on human health, as well as the role of vegetation in modulating climate.

CAP research is also evaluating the effectiveness of "green infrastructure" in providing services of storm-water modulation and water-quality improvement. Researchers also are quantifying the flows of materials – such as carbon, nitrogen, phosphorus and metals – within the urban ecosystem, and are seeking opportunities for better managing these resources.

HUBBARD BROOK (HBR)

Hubbard Brook (HBR) pioneered the small watershed mass-balance approach for studying complex interactions between organisms, soils and surface waters in forest ecosystems. In conjunction with experimental manipulations, HBR's 45-year record of hydrology, chemistry and biotic communities continues to provide insights and surprises.

In an ongoing large-scale experiment, researchers restored the amount of soil calcium that was lost as a consequence of acid deposition during the 20th century. This treatment reversed the decline of key forest species like sugar maple and red spruce, indicating conclusively that these declines were caused primarily by acid rain.

Research results from HBR are communicated to public audiences through the Science Links program. The program targets key policymakers to help inform their decisions on matters of regional, national and international importance such as acid deposition, nitrogen saturation, mercury pollution and forest carbon sequestration. In the works is a project on migratory songbirds and causes of their population fluctuations.

In 1999, peletized calcium (powdered wollastonite with a lignin sulfonate binder) was applied to watershed 1 of Hubbard Brook LTER using helicopters, in order to evaluate the role of calcium supply in regulating the structure and function of base-poor forest and aquatic ecosystems.

Aerial view of the KBS LTER main field site. Scientists at NSF's Kellogg Biological Station LTER are studying agricultural sustainability.

KELLOGG BIOLOGICAL STATION (KBS)

Research at the Kellogg Biological Station (KBS) LTER in southwest Michigan is focused on learning how agriculture can provide both high yields and environmental outcomes that benefit society.

By using a systems-level approach to measure, observe, compare and experimentally manipulate all major parts of agricultural landscapes, researchers contribute basic knowledge of environmental biology, geochemistry and social science. This knowledge informs relevant societal issues, such as sustainable biofuel production, climate change mitigation and the reduction of nitrogen pollution.

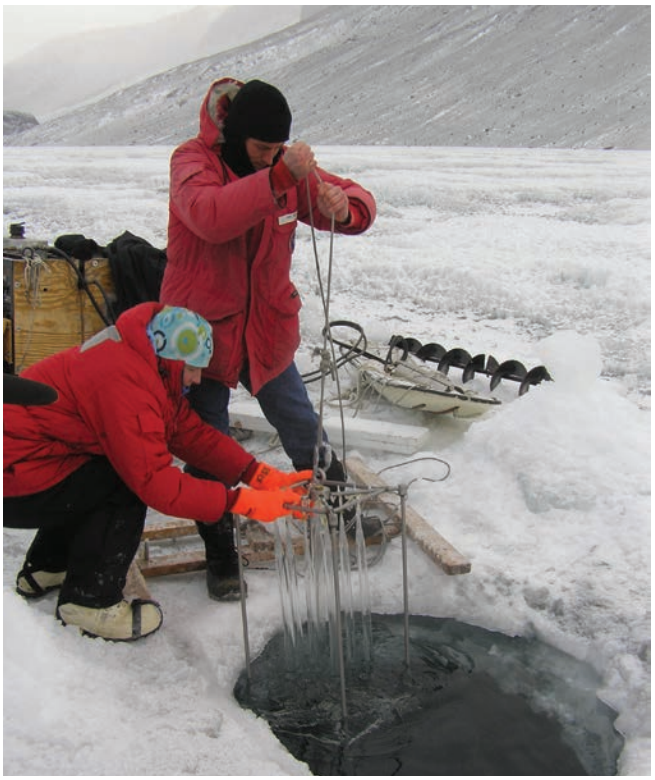
With almost half of contiguous U.S. land used for agriculture, an important goal of KBS outreach is to dialogue with stakeholders about the role agricultural ecology can play in farm management and policy. Professional development programs for K-12 teachers are grounded in research on how students understand scientific concepts such as carbon cycling, water and biodiversity.

MCMURDO DRY VALLEYS (MCM)

A mosaic of glaciers, ice-free patterned ground, glacial meltwater streams and perennially ice-covered lakes, the McMurdo Dry Valleys are the coldest and driest ecosystems in the LTER network. MCM research addresses how the response of Dry Valley ecosystems to climatic extremes is driven by enhanced landscape connectivity through the hydrologic and wind-borne transport of nutrients, sediments and organisms.

MCM has advanced its monitoring program, which began in 1992, by telemetering meteorological, lacustrine and stream flow data, and by expanding to two other valleys that serve as analogs for future conditions in Taylor Valley, the focus of current research efforts. MCM has recently initiated a long-term soil-wetting experiment to explore ecological responses to greater thawing of permafrost.

Through an ongoing outreach program, MCM scientists engage with urban U.S. schools, using activities associated with *The Lost Seal*, a book based on MCM research.



Dr. Elanor Bell and student Eric Bottos retrieve cultures of *C. raudensis* from Lake Bonney in the McMurdo Dry Valleys during early winter.

The Continental Divide as seen from Niwot Ridge. The equipment in the center of the photo is a warming experiment funded by DOE to UC-Merced.

NIWOT RIDGE (NWT)

NWT research addresses an essential ecosystem service – the naturally regulated flow of high-quality water from alpine sources. Since 1980, long-term ecosystem manipulations and monitoring at this site have provided key examples of global change and its effects on the timing and quality of snow melt that feeds downstream aquifers and ecosystems. Current studies assess a model of resource transport inspired by the extreme gradients in this landscape. Physical and ecological gradients can amplify biogeochemical processes, allowing earlier detection of change in mountain ecosystems. NWT researchers have also linked downstream aquatic pollution and forest fires to recent changes in nitrogen deposition and snow melt.

NWT serves students, educators, the media, policymakers and the public through web-based outreach tools and hands-on educational programs. The LTER Schoolyard Children's Book Series was initiated with NWT's *My Water Comes from the Mountains* books and kits, now reaching many underserved students in the Four Corners region of the U.S.

KEY FINDINGS

LTER research not only advances ecological science but also has a positive impact around the globe. Every year, LTER scientists report important discoveries that have practical applications for enhancing human society worldwide.

ANDREWS (AND)

CHALLENGING ASSUMPTIONS ABOUT OLD TREES Andrews Forest was part of a global analysis showing that (1) growth rate increased continuously with tree size, and (2) large, old trees fix larger amounts of carbon compared to smaller trees.

BALTIMORE ECOSYSTEM STUDY (BES)

MAPPING URBAN LANDS Traditional U.S. land classifications often emphasize the contrast between urban or built-up versus wild or managed, but these categories can be limiting to scientists and decision makers. BES researchers have developed a new system called HERCULES to better describe the relationships between social and ecological functions.

CEDAR CREEK (CDR)

TOO MUCH OF A GOOD THING An experiment in its third decade at Cedar Creek has shown that even low levels of nitrogen fertilization can reduce plant diversity. Cedar Creek is supporting the Nutrient Network in testing the generality of these results at 70 sites on five continents.

COWEETA (CWT)

CLEAN WATER AND LAND MARKETS Researchers at CWT have shown that many of the large effects of drought on trees occur on moist sites while competition for light has the strongest effects on moist sites in dry years. Combining such results with FIA data and projecting to the eastern U.S. suggests that trees are not migrating fast enough to track current rates of warming.

FLORIDA COASTAL EVERGLADES (FCE)

CARBON STOCK AT RISK FCE researchers have found that seagrass ecosystems remove large amounts of CO_2 from the atmosphere, storing it in underground soils. If we continue losing seagrass ecosystems to nutrient enrichment, coastline modifications and sea level rise, we may add large amounts of carbon to the atmosphere.

GEORGIA COASTAL ECOSYSTEMS (GCE)

NITROGEN TO THE COAST The export of excess nitrogen from rivers is one of the most significant problems facing coastal ecosystems, resulting in eutrophication, hypoxia and harmful algal blooms. However, GCE researchers studying major watersheds in the southeast found that increasing temperatures may reduce the amount of nitrogen that reaches estuaries.

HARVARD FOREST (HFR)

ENVISIONING THE FUTURE HFR researchers aim to understand the aggregate and interactive effects of climate and land-use change as they are superimposed onto naturally dynamic ecosystems.

JORNADA BASIN (JRN)

AN ABILITY TO RESTORE? Many attempts have been made to restore degraded soils to grasslands. Having identified key factors that limit restoration, JRN researchers are designing multi-scale experiments to promote grass recovery. Findings will prove important in an uncertain future, where temperature is expected to increase, but rainfall may increase or decrease.

KONZA PRAIRIE (KNZ)

A THREAT TO GRASSLANDS Woody vegetation has expanded in grasslands and savannas worldwide, with impacts on carbon cycling and regional biodiversity. KNZ's watersheds, with contrasting fire and grazing regimes, provide a laboratory for exploring the dynamics, causes and effects of woody plant encroachment.

LUQUILLO (LUQ)

TROPICAL CARBON CYCLING Tropical forests play a key role in the global carbon cycle by taking up more atmospheric CO_2 per year than any other biome. Long-term studies by LUQ scientists suggest that global warming will likely increase the amount of carbon lost from these forests, decreasing their ability to help slow climate change.

MOOREA CORAL REEF (MCR)

CORAL REEF OBSERVING NETWORK Coral reefs are highly valued ecosystems under increasing threat from natural and human-induced disturbances. Researchers and international partners formed the Coral Reef Environmental Observatory Network (CREON) to test and deploy automated sensors for recording data in coral reefs in Moorea, Australia, Taiwan and Thailand.

NORTH TEMPERATE LAKES (NTL)

FRESHWATER CARBON STORAGE To understand the role of aquatic environments beyond the ocean landscape in the global carbon cycle, NTL researchers are working to estimate both terrestrial and aquatic carbon storage and fluxes in Wisconsin's Northern Highland Lake District.

PALMER STATION ANTARCTICA (PAL)

BIOLOGICAL "HOT SPOTS" Long-term research at PAL has discovered a link between climate forcing at the hemisphere scale and local ocean circulation in underwater canyons, generating biological "hot spots" that govern the location of Adelie penguin colonies over time. Years with predominately cold, dry southerly winds result in higher krill numbers, leading to greater success in penguin breeding.

PLUM ISLAND ECOSYSTEMS (PIE)

SCALE MATTERS By conducting large-scale, long-term studies of entire river-estuary networks, PIE scientists revealed ways that human activities and natural processes interact to control the flow of water and nutrients from the land to the ocean. This science helps guide the reduction of harmful nitrogen pollution in coastal waters.

SANTA BARBARA COASTAL (SBC)

RECYCLING IN KELP FORESTS SBC is increasing our understanding of controls on giant kelp growth. Contrary to existing paradigms, SBC researchers have discovered how important recycled nitrogen is in sustaining the year-round growth of highly productive kelp forests.

SEVILLETA (SEV)

RAINFALL MANIPULATION A long-term experiment in the piñon-juniper woodlands at SEV has demonstrated plasticity and acclimation of leaf-level gas exchange in response to increased rainfall variability and extended droughts.

VIRGINIA COAST RESERVE (VCR)

HUMANS THREATEN WETLANDS Biophysical feedbacks observed at the Virginia Coastal Reserve and around the world indicate that marshes are naturally resistant to sea-level rise, but that humans disrupt the processes that maintain their stability by changing the climate, nutrient inputs, sediment delivery and subsidence rates.

KEY PUBLICATIONS

A short listing of important LTER papers published in major ecological journals in 2013.

1. Kirwan, M. L., & Megongial, J. P. (2013). Tidal wetland stability in the face of human impacts and sea-level rise. *Nature*, 504, 53-60.
2. Gelfand, I., Sahajpal, R., Zhang, X., Izaurralde, C. R., Gross, K. L., & Robertson, G. P. (2013). Sustainable bioenergy production from marginal lands in the US Midwest. *Nature*, 493, 514-517.
3. Robertson, B. A., Rehage, J. S. & Sih, A. (2013). Ecological novelty, and the emergence of evolutionary traps. *Trends in Ecology & Evolution*, 28 (9), 552-560.
4. Isbell, F., Reich, P. B., Tilman, D., Hobbie, S. E., Polasky, S., & Binder, S. (2013). Nutrient enrichment, biodiversity loss, and consequent declines in ecosystem productivity. *PNAS*, 110, 11911-11916.
5. Reich, P. B., & Hobbie, S. E. (2013). Decade-long soil nitrogen constraint on the CO_2 fertilization of plant biomass. *Nature Climate Change*, 3, 278-282.
6. Isbell, F., Tilman, D., Polasky, S., Binder, S., & Hawthorne, P. (2013). Low biodiversity state persists two decades after cessation of nutrient enrichment. *Ecology Letters*, 16, 454-460.
7. Frey, S. D., Lee, J., Melillo, J. M., & Six, J. (2013). The temperature response of soil microbial efficiency and its feedback to climate. *Nature Climate Change*, 3, 395-398.
8. Keenan, T. F., Hollinger, D. Y., Bohrer, G., Dragoni, D., Munger, J. W , Schmid, H. P., & Richardson, A. D. (2013). Increase in forest water-use efficiency as atmospheric carbon dioxide concentrations rise. *Nature*, 499, 324-327.
9. Barker-Plotkin, A. A., Foster, D. R., Carlson, J., & Magill, A. (2013). Survivors, not invaders, control forest development following simulated hurricane. *Ecology*, 94(2), 414-423.
10. Thompson, J. R., Carpenter, D. N., Cogbill, C. V., & Foster, D. R. (2013). Four centuries of change in northeastern United States forests. *PLoS ONE*, 8(9), e72540.
11. Williams, C. A., Vanderhoof, M. K., Khomik, M. & Ghimire, B. (2013). Post-clearcut dynamics of carbon, water and energy exchanges in a midlatitude temperate, deciduous broadleaf forest environment. *Global Change Biology*.
12. Wilson, H. F., Saiers, J. E., Raymond, P. A., & Sobczak, W. V. (2013). Hydrologic drivers and seasonality of dissolved organic carbon concentration, nitrogen content, bioavailability, and export in a forested New England stream. *Ecosystems*, 16(4), 604-616.
13. Giasson, M.-A., Ellison, A. M., Bowden, R. D., Crill, P. M., Davidson, E. A., Drake, J. E., Frey, S. D., Hadley, J. L., Lavine, M., Melillo, J. M., Munger, J. W., Nadelhoffer, K. J., Nicoll, L., Ollinger, S. V., Savage, K. E., Steudler, P. A., Tang, J., Varner, R. K., Wofsy, S. C., Foster, D. R., & Finzi, A. C. (2013). Soil respiration in a northeastern US temperate forest: a 22-year synthesis. *Ecosphere*, 4(11).
14. Orwig, D. A., Barker-Plotkin, A. A., Davidson, E. A., Lux. H., Savage, K. E., & Ellison, A. M. (2013). Foundation species loss affects vegetation structure more than ecosystem function in a northeastern USA forest. *PeerJ*, 1, e41.
15. Bauer, J. E., Cai, W., Raymond, P. A., Bianchi, T. S., Hopkinson, C. S., & Regnier, P. A. G. (2013). The changing carbon cycle of the coastal ocean. *Nature*, 504 (7478), 61.
16. Sistla, S. A., Moore, J. C., Simpson, R. T., Gough, L., Shaver, G. R., & Schimel, J. P. (2013). Long-term warming restructures Arctic tundra without changing net soil carbon storage. *Nature*, 497, 615-618.
17. Cory, R. M., Crump, B. C., Dobkowski, J. A., & Kling, G. W. (2013). Surface exposure to sunlight stimulates CO_2 from permafrost soil carbon in the Arctic. *PNAS*, 110, 3429-3434.
18. Hager, G. W., Belt, K. T., Stack, W., Burgess, K., Grove, J. M., Caplan, B., Hardcastle, M., Shelley, D., Pickett, S. T. A., & Groffman, P. M. (2013). Socioecological revitalization of an urban watershed. *Frontiers in Ecology and the Environment*, 11, 28-36.
19. Craine, J. M., Ocheltree, T. W., Nippert, J. B., Towne, E. G., Skibbe, A. M., Kembel, S. W., & Fargione, J. E. (2013). Global diversity of drought tolerance and grassland climate-change resilience. *Nature Climate Change*, 3, 63-67.

Thank you to the LTER Network sites for the use of photography in this publication. Credit is due to the site unless noted otherwise. **Cover:** Students by C. A. Cass (NWT); Penguins by Zena Cardman (PAL). **Page 2-3:** David Foster (HFR). **Page 5:** Insect sampling by Lina DiGregorio (AND). **Page 6:** MoU signing by Romain Parlier, Embassy of France; Pruning by Rebecca Montgomery (CDR). **Page 9:** La Jolla by CCE; Canopy Connections kids by Katie Nussbaum (AND). **Page 10:** Students by JRN; Dr. George Lauff by KBS/MSU. **Page 12:** ILTER meeting by John Porter. **Page 13:** NWT by Alana Wilson; VCR by John Porter. **Page 15:** BNZ by Roger W. Ruess. **Page 16:** CCE by The Ocean Institute. **Page 18:** MCM by Amy Chiuchiolo; NWT by Jeff Mitton. **Page 19:** FCE by Jim Fourqurean. **Page 20:** GCE by Joan Sheldon; JRN by John Kuehner; KNZ by Matt Whiles; MCR by Jessica Nielsen. **Page 21:** NTL by Dick Lathrop; PIE by Wilfred Wollheim; SBC by Ron H. McPeak/UC Regents; VCR by L. Cole.

CORE RESEARCH AREAS

Five research themes, known collectively as the Core Areas, are central to LTER Network science:

1. Pattern and control of primary production
2. Spatial and temporal distribution of populations, selected to represent trophic structure
3. Pattern and control of organic matter accumulation in surface layers and sediments
4. Patterns of inorganic inputs and movements of nutrients through soils, groundwater and surface waters
5. Patterns and frequency of site disturbances

These Core Areas require the involvement of many scientific disciplines, over long time horizons and broad geographical scales. Core Area data are collected at regular intervals, so information about an ecosystem's existing condition can be established prior to any experimental manipulation.

CROSS-SITE RESEARCH AND SYNTHESIS

The scientific infrastructure that the Network has built over the years – including the maintenance of databases and protocols in support of data discovery and acquisition – promotes and facilitates cross-site and regional analyses, leading to larger-scale synthesis and the development and testing of ecological theory.

The LTER Network offers the greater ecological research community, including students and foreign scientists, the opportunity for long- and short-term projects appropriate to individual sites, a group of sites or the Network as a whole.

INTERNATIONAL COLLABORATION

As a founding member of the ILTER Network, the U.S. LTER Network plays a central role in studying global ecological issues. Many LTER sites perform observations and conduct experiments with global partners. For example, LTER sites are working to study global comparisons of forest structure through the Center for Tropical Forest Science at the Smithsonian Tropical Research Institute. That program includes sites in 21 countries, encompassing 4.5 million individual trees from 8,500 species.

INFORMATION MANAGEMENT

When the LTER Network was first founded, scientists manually entered relatively small amounts of ecological data on an annual basis. Today, network sensors acquire much larger volumes of data each week. To address these changes, each research site has developed a system that supports its unique data life-cycle needs, from data acquisition through publication.

Successful communication and coordination between the LTER Network Office and site information managers supports the LTER Network's research agenda, and has helped produce these results:

- Common metadata standards
- Standard approaches to information management
- Centralized information architecture for strategic data integration
- Data stewardship
- Curated data storage that promotes Network synthesis
- Creation of data legacies

EDUCATION

LTER research provides a variety of unique educational opportunities to students at all academic levels – K-12, undergraduate, graduate and post-doc. The LTER science community includes academic and government scientists and educators, graduate and undergraduate students, and professional staff. As centers of excellence in ecological research, LTER sites hosted by universities, government agencies and non-profit research institutions also provide important training grounds for the next generation of scientists and leaders.

THE LTER NETWORK is recognized internationally as one of the longest-lived and most successful large groups conducting ecology research. For more than three decades, the Network has provided the scientific expertise, research platforms and long-term datasets necessary to document and analyze pressing environmental changes. With nearly 2,000 scientists, educators and students, the Network consists of 26 competitively chosen sites in the continental U.S., Alaska, Antarctica and islands in the Caribbean and Pacific. These sites span agricultural lands, alpine tundra, barrier islands, coastal lagoons, cold and hot deserts, coral reefs, estuaries, forests, freshwater wetlands, grasslands, kelp forests, lakes, open ocean, savannas, streams and urban landscapes.

SITE KEY

AND – Andrews Forest
ARC – Arctic
BES – Baltimore Ecosystem Study
BNZ – Bonanza Creek
CCE – California Current Ecosystem
CDR – Cedar Creek
CAP – Central Arizona - Phoenix
CWT – Coweeta
FCE – Florida Coastal Everglades
GCE – Georgia Coastal Ecosystems
HFR – Harvard Forest
HBR – Hubbard Brook
JRN – Jornada Basin
KBS – Kellogg Biological Station
KNZ – Konza Prairie
LUQ – Luquillo
MCM – McMurdo Dry Valleys
MCR – Moorea Coral Reef
NWT – Niwot Ridge
NTL – North Temperate Lakes
PAL – Palmer Antarctica
PIE – Plum Island Ecosystems
SBC – Santa Barbara Coastal
SEV – Sevilleta
SGS – Shortgrass Steppe
VCR – Virginia Coast Reserve

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