Translating Science for Society

Broader Impacts of NSF's Long-Term Ecological Research Program

Researchers at three polar LTERs are detecting important responses to global climate change used for predictive modeling. Photo: NSF/ USAP photo by Josh Landis, RPSC.

The National Science Foundation's (NSF) Long-Term Ecological Research (LTER) Program supports fundamental research on ecological phenomena occurring over long time periods and across a wide range of geographical scales. The LTER Program's focus on integrated, multi-scientist investigations at every site leads to major syntheses and advances in the theoretical understanding of how ecosystems function. This brochure illustrates how, by applying this theoretical understanding to real-world issues, LTER science is increasingly being used to address pressing environmental problems, the management of ecosystems for the sustainable production of essential goods and services, and the education of future generations of scientists.

The LTER network comprises 26 field sites located primarily in the USA, with a geographic span from the poles to the tropics. The sites represent most of the Earth's major ecosystems and include deserts, grasslands, forests, tundra, urban areas, agricultural systems, freshwater lakes, coastal estuaries and salt marshes, coral reefs and coastal ocean zones. Sites share a common research agenda in five areas, which allows for comparisons to be made across the network and beyond. The five areas are (1) pattern and control of plant production, (2) spatial and temporal distributions of representative populations of plants, animals, and microbes, (3) distribution and dynamics of organic matter in surface soils, water, or sediments, (4) patterns of inputs and movements of inorganic nutrients and chemicals through the ecosystems, and (5) patterns, frequencies and effects of disturbances such as hurricanes, land-use changes or forest harvesting.

For more examples of LTER research applications visit the websites of individual LTER sites or read *20 Years of Research — LTER Vignettes* on the LTER website at ***http://www.lternet.edu***

Both the NSF and U.S. Department of Agriculture support the Hubbard Brook Forest LTER in New Hampshire. Helicopters are used to apply nutrients to forest experiments. Photo: Hubbard Brook Research Foundation.

Children learning ecological concepts at the Niwot Ridge LTER, Colorado. Photo: Casey A. Cass, University of Colorado.

Prescribed fire at the Sevilleta LTER, New Mexico. Photo: Douglas Moore, University of New Mexico.

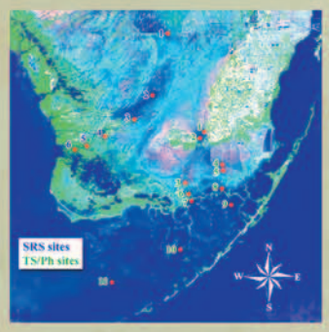
www.nsf.gov

www.lternet.edu

Applying Science to Megascale Water Management: Rejuvenating the Everglades

Florida Coastal Everglades LTER site, Florida
http://fcelter.fiu.edu/

The $8.3 billion Comprehensive Everglades Restoration Plan (CERP) depends upon credible scientific evidence to establish critical conservation criteria and goals for reversing a multitude of negative environmental trends in the greater Everglades ecosystem of southern Florida. For CERP to be successful scientists and managers must determine the basic water and nutrient requirements for a broad range of species and ecosystems, predict the effects of intentionally changing the water and nutrient conditions in the system, and then convert that knowledge into indicators useful for monitoring restoration progress. A management approach that is both adaptable and sensitive to the science is critical, and the Florida Coastal Everglades LTER site is proving to be a critical "hub" for bringing together a diversity of scientific and management "spokes." It includes nearly 50 Ph.D.-level scientists from academia and all major state and federal agencies involved in Everglades restoration, and provides a neutral scientific venue for interactions and collaborations. This ensures the incorporation of new scientific and technical information into ongoing restoration efforts while simultaneously helping to reduce future ecological and economic risks to the southern Florida region.



Study sites of the Florida Coastal Everglades LTER. Map: M. Rugge, Florida International University Landsat image: South Florida Water Management District.

A wetland ecologist samples a southern Everglades mangrove ecosystem. Photo: D. Childers, Florida International University.

A sampling site at the Florida Coastal Everglades LTER. Photo: Victor H. Rivera-Monroy and Robert R. Twilley, Louisiana State University.

Long-term experiments at the Andrews Forest LTER in Oregon yielded data affecting the future economic outlook for the Northwest's timber industry. Photo: H.J. Andrews Experimental Forest.

A graduate student coring an old-growth Douglas-fir at the Andrews LTER, Oregon. Photo: Jay Sexton.

Forest Carbon Research Unveils Potential Multi-Billion-Dollar Value for Non-Timber Use of Trees

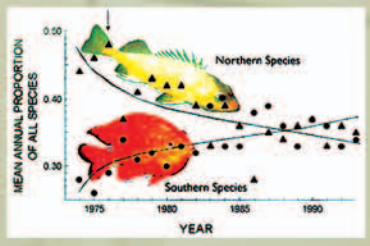
H.J. Andrews Experimental Forest LTER site, Oregon
http://www.fsl.orst.edu/lterhome.html/

Increasing concentrations of atmospheric greenhouse gases, including carbon dioxide, have been implicated as one of the causes of ongoing global climate change. The burning of fossil fuels releases carbon dioxide into the atmosphere, as do natural processes such as the decay of leaves, roots and wood. Forests remove carbon dioxide from the atmosphere by absorbing it during photosynthesis, leading to new growth of leaves, roots and wood. The balance between growth and decay determines whether a forest absorbs more atmospheric carbon dioxide than it releases. Investigators at the H.J. Andrews Forest LTER site found that Oregon's forests as a whole have been releasing more carbon than they have been absorbing over the past half-century, due in part to forest management practices that have tended to promote carbon dioxide release. However, the scientists also discovered that there is a considerable potential to reverse this trend by implementing alternative timber harvesting practices and by more rapidly replanting deforested areas. According to their models, new management approaches could lead to Oregon's forests doubling their carbon absorption capacity without reducing the total volume of harvested timber, the latter being critically important to the Northwest timber industry. These research findings may have tremendous economic consequences for international carbon credit trading, which involves assigning a monetary value to certain ecosystems depending on whether they release or absorb carbon. If a market for trading carbon credits develops, the enhanced carbon absorption capacity of Oregon's forests could translate into tradable carbon credits with values of up to $100 billion over the next 50 years.

Coastal Marine Reserves: Applying LTER Science to Conservation and Fisheries Planning

Santa Barbara Coastal LTER site, California
http://sbc.lternet.edu/

Marine protected areas are critical to both biodiversity conservation and fisheries management in coastal ocean waters. Their establishment and assessment require long-term data and sound scientific understanding. Recent changes in climate, physical and chemical conditions, and biological productivity of coastal oceans have affected recreational and commercial fisheries throughout southern California. Thirty years of data have enabled Santa Barbara Coastal LTER investigators and their collaborators to document a host of changes associated with long-term ocean warming. They found that many fish and invertebrate communities throughout the region have changed as a consequence of observed long-term phenomena, such as the proportion of southern species increasing relative to that of northern species (see graph), and that these trends coincide with substantial declines in total fish abundance and productivity. Their findings are consistent with an earlier prediction of a northward shift in species' ranges in response to ocean warming. This information provides the scientific basis for informed long-term planning and design of the Marine Reserve Program currently being implemented in California's coastal waters. This LTER site plays a vital role in developing and evaluating this multi-agency initiative to preserve coastal resources while sustaining near-shore marine fisheries to meet future demands.



30-year data on fish populations in southern California have enabled the Santa Barbara Coastal LTER scientists and collaborators to play key roles in implementing California's Marine Reserve Program. Image: University of California at Santa Barbara.

A marine biologist sampling kelp beds at the Santa Barbara Coastal LTER in California.

Managing Wildlife and Human Disease at the Urban-Rural Interface

Shortgrass Steppe LTER site, Colorado
http://sgs.cnr.colostate.edu/

The Shortgrass Steppe LTER site in north-central Colorado is ideally situated to conduct long-term monitoring of wildlife populations living in close proximity to humans. Researchers studying the dynamics of plague *(Yersinia pestis)* in black-tailed prairie dog *(Cynomys ludovicianus)* colonies are taking advantage of long-term climatic and plant productivity data to predict fluctuations in prairie dog populations and build risk models for plague, a potential disease threat to humans. Using over two decades worth of data, scientists have established a link between the local disappearance of prairie dog colonies caused by plague and climatic fluctuations associated with the periodic occurrence of El Niño/Southern Oscillation (ENSO) events. Although well-documented evidence of disease fluctuations in wildlife is rare, researchers at the Sevilleta LTER site in New Mexico have established a similar link between changes in deer mouse *(Peromyscus maniculatus)* populations that carry the Sin Nombre hantavirus, which can cause fatal disease in humans, and long-term climate fluctuations *(http://sev.lternet.edu/)*.

Long-term studies of prairie dog populations at the Shortgrass Steppe LTER, Colorado, revealed links between plague outbreaks in prairie dogs and recurring climate events. Photo: Tom and Pat Leeson.

Basic Science Guides Acid Mine Drainage Remediation

Niwot Ridge LTER site, Colorado
http://culter.colorado.edu:1030/

Acid mine drainage often leads to widespread environmental and human health problems and is especially problematic in the Rocky Mountains, a high-elevation region containing an estimated 100,000 acid mine drainage sites. At the Niwot Ridge alpine tundra LTER site in Colorado, research on surface-groundwater interactions led to the discovery of basic principles that are being used to guide the use of innovative procedures to efficiently eliminate or control acid mine drainage on a site-by-site basis. Challenges posed by the physical attributes of these sites are often confounded by cultural attitudes, as in the case of Leadville, CO where mining artifacts (such as tailings and shafts) that would normally have been removed or treated during remediation were instead declared historical landmarks and therefore rendered "untouchable". Faced with such complexities, Niwot Ridge LTER scientists developed new tools now being used to guide remediation at places like Leadville, which involves a multi-million dollar underground construction project that is paving the way for the decommissioning of an existing water treatment plant. The benefits to the town start with the elimination of the plant's $1-million-a-year operational costs, and will lead to a healthier environment for the community.

Maintaining Insect Biodiversity Aids Control of Agricultural Pests

Kellogg Biological Station LTER site, Michigan
http://lter.kbs.msu.edu/

First detected in 2000, the Asian soybean aphid *(Aphis glycines)* rapidly spread throughout the USA and Canada damaging crops, spreading plant viruses, and causing crop yield losses of up to 50 percent. Researchers at the Kellogg Biological Station LTER site in southwestern Michigan are using knowledge gained from 14 years of experimental chemical applications that span the breadth of possible agricultural management practices to formulate and test hypotheses about the impacts of predators and host plant quality on aphid populations. Results have revealed that predatory insects, such as lady beetles, are the dominant force controlling aphid populations and that agronomic practices can be tailored to encourage optimal communities of predators, which may be the most efficient way to manage aphid pests on farms. These long-term research results provide a firm basis for predicting how agricultural management options will affect aphid predator communities and, in turn, aid in achieving optimal aphid control.

Long-term experiments enabled the Kellogg Biological Station LTER, Michigan, to better understand crop pests and the predators that control them. Photo: Kellogg Biological Station.

Predation by adult lady beetles is a major factor in controlling soybean aphid populations. Photo: D.A. Landis, Michigan State University.

Community groups are a central focus in the extensive socioeconomic research conducted at the Baltimore Ecosystem Study, an urban LTER in Maryland. Photo: Jonathan M. Walsh.

Scientists sampling ground water wells below the Mary Murphy Mine in St. Elmo, Colorado. Photo: Larry Harwood, University of Colorado.

Sampling an urban stream at the Baltimore LTER, Maryland. Photo: Steward T.A. Pickett, Institute of Ecosystem Studies.

Using Science to Engage Urban Communities and Decision-Makers

Baltimore Ecosystem Study LTER site, Maryland
http://www.beslter.org/

Scientific research at the Baltimore Ecosystem LTER site has been a boon to the area's natural resource managers, planners and decision-makers — as well as to the local community. Scientists regularly share expertise and produce data sets, models and adaptive management tools to assist in the stewardship and protection of the area's natural resources. Research results have informed the development of policies and management strategies for issues such as forest buffers, stream contamination and restoration, "green technology" control of hurricane and stormwater runoff, urban tree mortality, and improvement of urban classification systems using remote imagery. The LTER research team regularly meets with urban designers and planners to ensure positive ecological and sociological outcomes during redevelopment at brownfield sites, where hazardous substances may pose problems, and at other urban revitalization projects in low-income neighborhoods. LTER scientists also actively engage Baltimore's citizens and decision-makers through annual open houses, regular science meetings and "synergy workshops", and are involved in a suite of targeted educational and outreach activities throughout the greater Baltimore area.

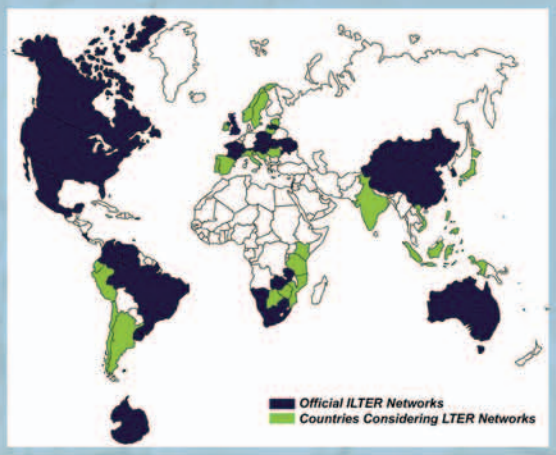
Human Dimensions of LTER

Two LTER sites are located in urban areas (Baltimore, MD and Phoenix, AZ) where social and ecological sciences tend to be the most closely coupled. Yet all LTER sites incorporate human dimensions to some degree into their overall research programs. The Coweeta (North Carolina) and the North Temperate Lakes (Wisconsin) LTER sites each have major components of research exploring the causes and consequences of land-use change and urbanization. Even the most remote sites examine the interplay between humans and the environment. For example, social scientists at the Bonanza Creek (Alaska) LTER site work with ecologists and Alaskan Native communities to study the boreal forest as a coupled social-ecological system that responds to changes in climatic, social and economic forces. Their work is advancing knowledge in areas such as the role of human activities in forest fire regimes and understanding resilience to rapid social and environmental changes in northern high-latitude countries — research with important policy and practical implications for issues such as global climate change and globalization.

For more information, view the LTER Social Science Committee reports at *http://lternet.edu/documents/committees/socialsciences.*

A tree frog "coquí" at the Luquillo Forest LTER, Puerto Rico. Luquillo is forging partnerships to address sustainable forestry in the Asian and American tropics. Photo: Aaron Shiels.

A university student explaining her research results at the Baltimore LTER to a local citizen at an outreach event. Photo: Jonathan M. Walsh.



Native Alaskan 10th graders taking ice cores at the Arctic LTER. Photo: Törsten Sachs, Alfred Wegener Institute for Polar and Marine Research, Germany

The Central Arizona-Phoenix and Baltimore urban LTERs took a major leap forward in long-term ecological research by focusing on humans as an essential component of ecosystems. Photo: Diane Hope.

International LTER Activities

Global scientific interest in developing long-term ecological research programs is expanding rapidly, reflecting an increasing appreciation of the importance of this type of approach in understanding and resolving complex environmental issues everywhere in the world. Formed in 1993, the International Long-Term Ecological Research (ILTER) Network currently has 30 member countries, with other nations actively establishing national programs as a prelude to ILTER membership. ILTER is a global federation of regional networks of sites where scientists collectively engage in multi- and interdisciplinary long-term and large spatial scale ecological observations and research emphasizing human-natural system interactions. US scientists and students regularly participate in international research, education and training activities as part of ILTER.

International research collaborations are critical for investigating and resolving global environmental problems, and ILTER is assuming an important role in this arena. In only one example of recent ILTER activities, the Luquillo LTER site in Puerto Rico has teamed with the Chinese Academy of Sciences to plan a workshop addressing the relationships between land-use changes and their consequences for sustainable forest management in the Asian and American tropics. For more information about ILTER, visit the web site *http://www.ilternet.edu/.*

A class taking field notes at the Niwot Ridge LTER, Colorado. Photo: Jane Larson.

3rd graders examining insect anatomy at the Jornada Basin LTER, New Mexico. Photo: Chihuahuan Desert Nature Park, Las Cruces, New Mexico.

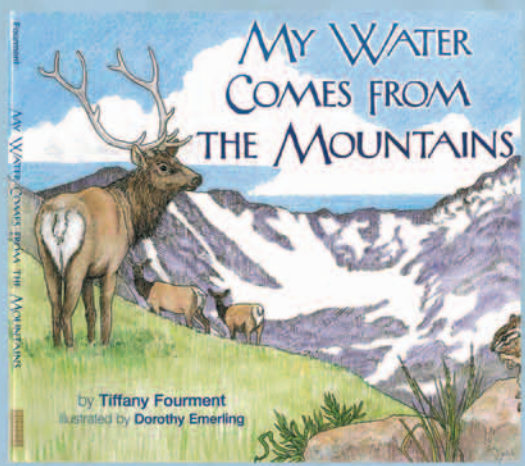
Middle school students collecting fish at the Coweeta Hydrologic Laboratory LTER, North Carolina. Photo: Susan Steiner, University of Georgia.

Participants at a teacher workshop at the Luquillo LTER, Puerto Rico. Photo: Luquillo Experimental Forest LTER.

Schoolyard LTER: Long-term K-12 Educational Programs

http://schoolyard.lternet.edu/

Education is an integral part of the LTER program and provides a forum where scientists and educators alike seek to share the significance of long-term research with, and improve the ecological literacy of, students at all levels as well as the general public. The non-traditional research approach of LTER is coupled with long-term educational initiatives to facilitate unique ways of training the ecologists of the 21st century and for teaching and learning ecological concepts. Every LTER site has a K-12 "Schoolyard" program that promotes the learning of ecological processes through a wide range of activities, such as development of instructional materials based on LTER research data, professional development of teachers, student and educator participation in LTER fieldwork, construction of web-based learning programs, and publication of children's books based on LTER science. Visit http://schoolyard.lternet.edu/ for examples of site-specific Schoolyard activities.



My Water Comes from the Mountains, based on the Niwot Ridge LTER in Colorado, enhances ecological literacy of local children. Book © 2004 by Roberts-Rinehart Publishers. Illustration © 2004 by Dorothy Emerling.

Two elementary students examine aquatic microorganisms as part of their science curriculum on ecosystems in suburban Maryland. Photo: Barry Myers.

7th graders collecting zooplankton through the ice at the North Temperate Lakes LTER, Wisconsin. Photo: Center for Limnology, University of Wisconsin-Madison.

Schoolyard LTER

http://schoolyard.lternet.edu/

6th graders at the Jornada Basin LTER, New Mexico, participating in long-term vegetation studies on plots adjacent to their school. Photo: Chihuahuan Desert Nature Park, Las Cruces, New Mexico.