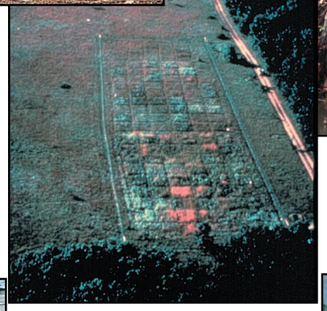
The LTER Network promotes comparative research on ecological processes

Pattern and control of organic matter accumulation in surface layers and sediments

Woody debris, which has a high carbon-to-nutrient ratio, has been found to delay recovery of the canopy trees. This photo was taken after Hurricane Hugo hit the Luquillo Experimental Forest, Puerto Rico, in 1989 (photo: Jean Lodge).

Patterns and frequency of disturbances

Prescribed fires in the Konza tallgrass prairie LTER site, a fire-derived and fire-maintained ecosystem (photo: Alan Knapp).



Pattern and control of primary production

Aerial view of a research plot at Cedar Creek Natural History Area LTER site, Minnesota, showing the effects of soil nutrient dynamics, herbivory and disturbance on composition and dynamics of grassland vegetation (photo: David Smith).

Spatial and temporal distribution of populations selected to represent trophic structure

The Palmer LTER site investigates the complexities of the Antarctic food web, which includes (clockwise from upper left) a bacterium, a diatom,a krill and an Adelie penguin.

Patterns and movements of inorganic inputs through soils, ground- and surface waters

An autosampler in the mangroves at Taylor River, where Florida Coastal Everglades LTER studies the flow of nutrients through the system.

Integrating social science research with ecological research recognizes the impact of human activities such as land-use change, introduction of exotic species, and over-exploitation of resources. Community gardens (left) are part of the Baltimore Ecosystem Study LTER site. Recreation and surrounding agricultural practices are part of the limnological studies of Lake Mendota, Madison, WI, part of the North Temperate Lakes LTER site (right).

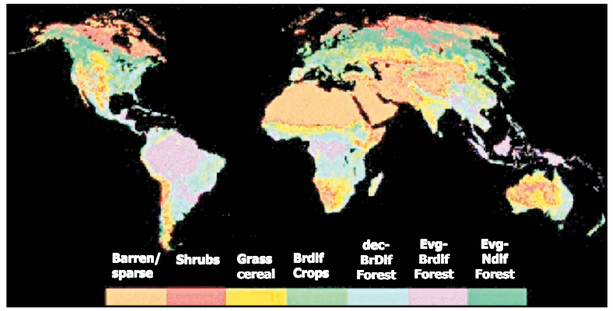
Cover photos (clockwise, from upper right):

- *The kelp forest is the focus of research of the **Santa Barbara Coastal LTER** (photo: Ron McPeak).*
- ***Plum Island Ecosystem LTER**—a study of the periodic removal of aboveground biomass, 'haying' has been practiced since colonial times (photo: Robert Buchsbaun)*
- *A boardwalk at the **Georgia Coastal Ecosystem LTER** site at Sapelo Island allows visitors and researchers access to the marshes (photo: Wade Sheldon)*
- *The prairie dog is a dominant species at the **Shortgrass Steppe LTER** site.*
- *LANDSAT 7 Enhanced Thematic Mapper image of the Virginia portion of the Delmarva Peninsula showing the barrier island/lagoon complex studied by the **Virginia Coast Reserve LTER** project (image: John Porter).*
- *Shrubs form islands of fertility in the Chihuahuan desert at the **Jornada Basin LTER** site (photo:Jerry Franklin).*
- ***Konza Prairie LTER** site studies native grazers as one of the influences on the structure and function of the tallgrass prairie (photo: A. Knapp).*

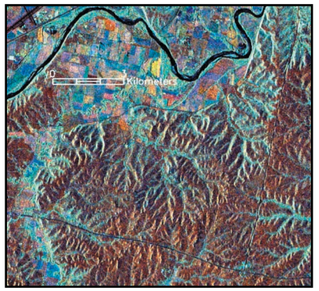
Research Technology

The rapid advancement of technology—from automated data collection in the field and incorporation of data from satellite observations to modeling complex ecological processes—is changing ecological science. Advances in research technology at LTER sites are facilitated through partnerships with organizations such as the San Diego Supercomputer Center, and National Aeronautics and Space Administration (NASA), to which LTER sites provide land reference data for calibrating satellite measurements.

An example of this work is the use of robotic instruments developed by NASA to mea ure changes in sunlight reaching the ground after passing through water vapor and particulate material suspended in Earth's atmosphere. Another example of the use of technology in ecological science is the use of carbon flux towers, which measure the effect of plants on atmospheric carbon dioxide. Scalable computer servers, state-of-the-art software and high bandwidth data links are used by the LTER Network Office to support this work, extending ecological observations from LTER sites to an evolving network of environmental observatories.



Global landcover image produced from NASA's Terra, the Earth Observing Satellite. While access to the technology and production of these data is invaluable for global-scale ecological research, international cooperation for field validation is vital.



Multi-date Synthetic Aperture Radar image of Konza Prairie from 1999, by Geoff Henebry (right). This type of imagery depicts changes in vegetation over time. Areas shown in green depict very little change, red areas show change from the average early in summer (May 22) and blue areas show change from the average late in the year (Aug 26).

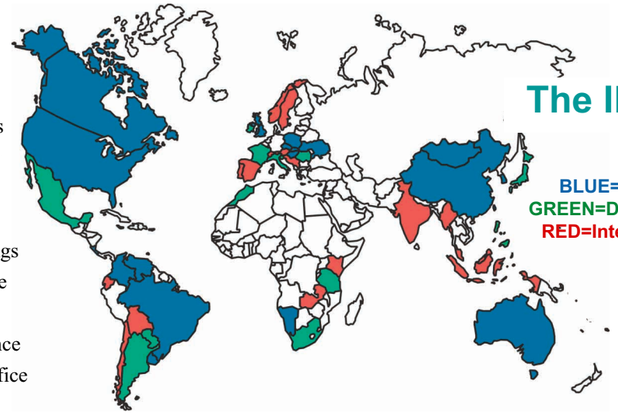
International LTER

The U.S. LTER Network has established linkages with existing and developing long-term research programs around the world. These linkages foster exchanges between individual scientists and research programs, participation in and organization of international meetings and training workshops, and global-scale research planning and collaboration.

With the support of the National Science Foundation, the U.S. LTER Network Office has become the central contact for development of the International LTER Network. Newly established liaison groups in regions such as Latin America, Central/ Eastern Europe, Southern Africa, and East Asia/Pacific are:

- Assisting in the establishment of long-term ecological research networks in countries around the globe;
- Catalyzing cooperative programs between U.S. LTER and long-term research sites and networks around the world;
- Developing and operating a communication and data sharing system between an international network of sites; and
- Facilitating the establishment of a global system of ecological research sites.

The Global Terrestrial Observing System (GTOS) and its Global Terrestrial Network (GT-Net) of sites share complementary objectives with ILTER. The central mission of GTOS is to provide data for detecting, quantifying, locating and providing early warning of changes in the capacity of terrestrial ecosystems to sustain development and improvements in human welfare. A goal is to link remote sensing systems with monitoring and research networks to integrate in situ observations. A website developed at the LTER Network Office disseminates data and policies for the collection of data.



http:www.ilternet.edu

*AND H. J. Andrews Experimental Forest

Location: Cascade Mountains, Oregon
Biome: Temperate coniferous forest
Research: Successional changes in ecosystems; forest-stream interactions; population dynamics of forest stands; patterns and rates of decomposition; disturbance regimes in forest landscapes.

ARC Arctic Tundra

Location: Toolik Lake, Alaska
Biome: Arctic tundra, lakes, streams
Research: Movement of nutrients from land to stream to lake; changes due to anthropogenic influences; controls of ecological processes by nutrients and by predation.

*BES Baltimore Ecosystem Study

Location: Baltimore, Maryland
Biome: The Gwynns Falls watershed
Research: Influence of land use and vegetation factors on soil microbial processes; ecosystem functions of cities, including surface/atmosphere energy exchange, hydrologic and nutrient flux, atmospheric deposition, the import/export of raw and processed materials and waste products, and fluxes of human populations and capital.

*BNZ Bonanza Creek Experimental Forest

Location: near Fairbanks, Alaska
Biome: Taiga
Research: Successional processes associated with wildfire and floodplains; facilitative and competitive interactions among plant species throughout succession; plant-mediated changes in resource and energy availability for decomposers; herbivorous control of plant species composition.

CAP Central Arizona - Phoenix

Location: Phoenix, Arizona
Biome: Sonoran Desert scrub and urban
Research: Interactions of ecological and urban socio-economic systems; influence of land-use change on ecological patterns and processes; movement of nutrients through urban flowpaths.

CDR Cedar Creek

Location: near Minneapolis, Minnesota
Biome: Eastern deciduous forest; tallgrass prairie; old fields; oak savannah and forest
Research: Successional dynamics; climatic variation and the wetland/upland boundary; plant-herbivore dynamics; fire.

CWT Coweeta Hydrologic Laboratory

Location: Southern Appalachian Mountains of North Carolina
Biome: Eastern deciduous forest
Research: Ecological consequences of regional land-use change; social sciences; ecosystem dynamics along both terrestrial and stream gradients; riparian zone regulation of terrestrial-aquatic linkages.

FCE Florida Coastal Everglades

Location: South Florida, Florida Bay
Biome: Freshwater marsh, estuarine mangrove, seagrass, estuary
Research: Effects of regional climate change and freshwater inflow on population and ecosystem level dynamics in wetland-dominated coastal landscapes. Research at this site emphasizes the oligohaline zone and takes advantage of the oligotrophic status of the Everglades.

GCE Georgia Coastal Ecosystem

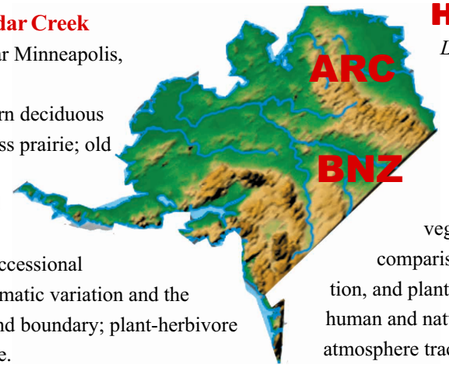
Location: Sapelo Island, Georgia
Biome: Salt marsh and estuary
Research: Surface and groundwater; salt-marshes, oyster reefs, tidal creeks, and the surficial aquifer; sediment/ground water nutrient dynamics; bacteria, fungi and invertebrate population dynamics.

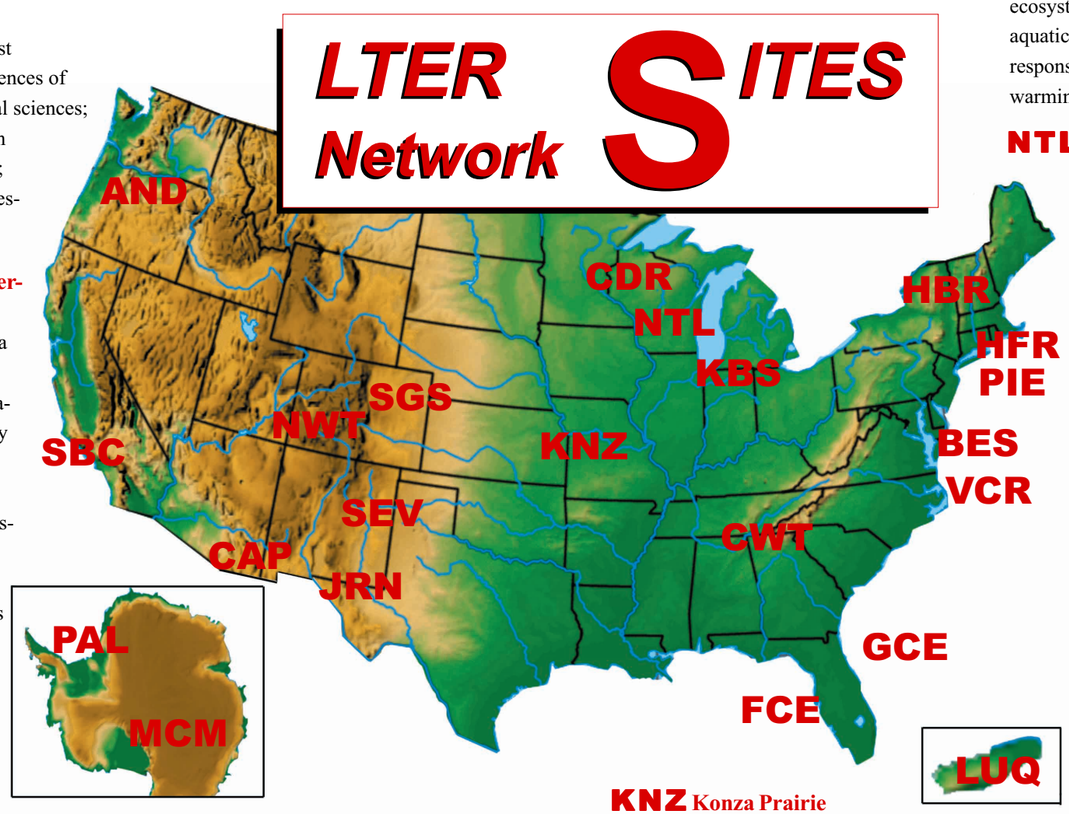
HFR Harvard Forest

Location: North-central Massachusetts *Biome:* Eastern deciduous forest
Research: Long-term climate change, disturbance history and vegetation dynamics; comparison of community, population, and plant architectural responses to human and natural disturbance; forest-atmosphere trace gas fluxes; organic matter accumulation, decomposition and mineralization; element cycling, fine root dynamics and forest microbiology.

*HBR Hubbard Brook

Location: White Mountains, New Hampshire
Biome: Eastern deciduous forest *Research:* Vegetation structure and production; dynamics of detritus in terrestrial and aquatic ecosystems; atmosphere-terrestrial-aquatic ecosystem linkages; heterotroph population dynamics; effects of human activities on ecosystems.





JRN Jornada Basin

Location: Southern New Mexico *Biome:* Hot desert *Research:* Desertification; primary production; nitrogen cycling; animal-induced soil disturbances; organic matter transport and processing; vertebrate and invertebrate population dynamics.

KBS Kellogg Biological Station

Location: Central Michigan *Biome:* Row-crop agriculture *Research:* Productivity and environmental impact of production-level cropping systems; patterns, causes, and consequences of microbial, plant, and insect diversity in agricultural landscapes, gene transfer, community dynamics, biogeochemical fluxes.

KNZ Konza Prairie

Location: Flint Hills, Kansas
Biome: Tallgrass prairie
Research: Effects of fire, grazing, and climatic variability on ecological patterns and processes in tallgrass prairie ecosystems; use of remotely sensed data and geographic information systems to evaluate grassland structure and dynamics.

*LUQ Luquillo Experimental Forest

Location: Luquillo Mountains, Puerto Rico
Biome: Tropical rainforest
Research: Ecosystem response to disturbance; land-stream interaction; trophic dynamics; detrital production and processing; management effects on ecosystem properties; integration of ecosystem models, and; geographical information systems research.

MCM McMurdo Dry Valleys

Location: Antarctica *Biome:* Polar desert oases *Research:* Microbial ecosystem dynamics in arid soils, ephemeral streams, and closed basin lakes; resource and environmental controls on terrestrial, stream and lake ecosystems; material transport between aquatic and terrestrial ecosystems; ecosystem response to greater hydrologic flux driven by warming climate.

NTL North Temperate Lakes

Location: Northern Wisconsin
Biome: Northern temperate lakes; eastern deciduous forest *Research:* Dynamics of lakes in a landscape and regional context; limnology, hydrology and geochemistry; producer and consumer ecology; ecology of invasions; ecosystem variability; climate forcing; social sciences.

NWT Niwot Ridge

Location: Rocky Mountains, Colorado
Biome: Alpine Tundra
Research: Causes and consequences of biotic diversity; nutrient cycling; trace gas dynamics, plant primary productivity and species composition; geomorphology, and paleoecology.

PAL Palmer Station

Location: Antarctic Peninsula
Biome: Pelagic Polar Marine
Research: Oceanic-ice circulation and modeling; sea-ice dynamics; biological/physical interactions; effect of sea-ice on primary production, consumer populations and apex predators; bio-optical models of primary production, spatial distribution and recruitment in consumer populations; seabird population dynamics.

PIE Plum Island Ecosystem

Location: Rowley Basin, Massachusetts
Biome: Coastal estuary
Research: Linkages between land and coastal waters involving organic carbon and organic nitrogen inputs to estuarine ecosystems from watersheds with various land covers and uses.

SBC Santa Barbara Coastal Ecosystem

Location: Santa Barbara, California
Biome: Semi-arid coastal zone/giant kelp forests *Research:* Processing and transport of land and ocean sources of nutrients, carbon, and sediments to kelp forest communities; reef food webs, effects of land-use on constituents of runoff.

SEV Sevilleta

Location: Central New Mexico
Biome: Intersection of subalpine mixed-conifer forest, riparian forest, grassland, cold desert, hot desert
Research: Landscape/organism population dynamics; watershed ecology; climate change; biospheric/atmospheric interactions; paleobotany/archaeology; microbial role in gas flux; landscape heterogeneity in ecotones; spatial/temporal variability.

SGS Shortgrass Steppe

Location: Northern Central plains of Colorado
Biome: Native grassland
Research: Soil water; above- and below-ground net primary production; plant population and community dynamics; effects of livestock grazing; soil organic matter accumulation and losses, soil nutrient dynamics; and ecosystem recovery from cultivation.

VCR Virginia Coast Reserve

Location: Near Oyster, Virginia
Biome: Coastal barrier islands
Research: Holocene barrier island geology; salt marsh ecology, geology and hydrology; ecology/evolution of insular vertebrates; primary/secondary succession; life-form modeling of succession.

*USDA Forest Service Site

Network-level Synthesis

The LTER program is characterized by long temporal and broad spatial scales of research, offering each scientist, student or educator a broader understanding of ecological phenomena. Cross-site comparisons fostered by the Network demonstrate the importance of comprehensive analyses of ecosystems and of distinguishing system features across multiple scales of time and space.

Examples of current synthesis efforts include:

- Climate variability and ecosystem response–Examining changes and effects of climatic phenomena over various temporal and spatial scales;
- Standardization of methods–Setting protocols for measuring soil properties for long-term ecological research;
- Global change–Leading a global effort to synthesize data on winter ice duration on lakes and rivers;
- Primary productivity–Comparing patterns of variation in primary productivity over a wide range of ecosystems;
- Organic matter processing–Conducting a long-term experiment on controls of decomposition over a wide range of ecosystem conditions (the LIDET experiment);
- Population studies–Studying the performance of plant species and communities on a circumpolar basis, known as the International Tundra Experiment (ITEX);
- Nutrient cycling–Comparing nitrogen cycling in streams, called the Lotic Intersite Nitrogen Experiment (LINX)

***Lotic Inter-site Nitrogen Experiment (LINX)**: $^{15}NH_4$ additions are made to streams to determine NH_4 uptake length and uptake rate, nitrogen turnover rates, and food web transfer of nitrogen. Pictured here are weirs on Mack Creek at the Andrews LTER site (left) and on Ball Creek at the Coweeta LTER site (below).*

***Long-term Intersite Decomposition Experiment Team (LIDET):** Researchers at 17 LTER sites and other researchers (28 total) are testing the degree to which substrate quality and macroclimate control the carbon and nitrogen dynamics of decomposing leaf, wood, and fine-root litter in a 10-year-long study. Litter bags at Sevilleta (right), Bonanza Creek (lower right), and Kellogg Biological Station (below), three of the participating LTER sites .*

Informatics

Increasing access to ecological information is an integral part of LTER science. Data collected at each site are accessible to other scientists and the general public. The LTER Network works with other research institutions to standardize information management practices to achieve network-wide and community-wide data integration, facilitating data exchange and advancing data analysis and synthesis. New and ongoing research programs in knowledge networking and informatics aimed at meeting the needs of ecological scientists worldwide will also help achieve this integration.

LTER information managers pioneered many aspects of modern site-based ecological data management. They actively share their experiences with the broader scientific community and collaborate on research and development of innovative information management technology. For more information, see the website: **www.ecoinformatics.org**, which includes references and complete publications useful to ecological scientists and information managers.

The Mission of the LTER Network

- **Understanding** *Gaining ecological understanding of a diverse array of ecosystems at multiple spatial and temporal scales*
- **Synthesis** *Using the network of sites to create general ecological knowledge through the synthesis of information gained from long-term research and development of theory*
- **Information Dissemination** *Creating well designed, well documented databases that are accessible to the broader scientific community*
- **Legacies** *Creating a legacy of well designed and well documented long-term observations, experiments, and archives of samples and specimens*
- **Training** *Developing a cadre of scientists who are equipped to conduct long-term, collaborative research to address complex ecological problems*
- **Outreach** *Providing knowledge to the broader ecological community, general public, resource managers, and policy makers to address complex environmental challenges*

Network Development and Management

The LTER Network was founded with the recognition that long-term and broad-scale research is necessary for understanding environmental phenomena. This understanding becomes increasingly important with increased human pressures on natural populations, communities, ecosystems, and the biosphere.

The LTER Network has developed over the past 20 years through periodic requests for proposals from the National Science Foundation. LTER sites were selected based on:

- Scientific merit;
- A broad spectrum of multidisciplinary scientists demonstrating an ability to work together toward common research goals;
- Existing long-term baseline data sets; and
- Strong institutional support and opportunities for leveraged funding.

In receiving funding from the National Science Foundation, the LTER site agrees to:

- Conduct research on comparable ecological processes;
- Make data accessible to the broader research community using common data management protocols;
- Participate in cross-site and cross-agency research; and
- Participate in Network-level and science synthesis activities.

The renewable six-year grants are independently peer-reviewed and renewed by the National Science Foundation (NSF) based on soundness of science and merit of Network participation. Each site and the Network Office undergo detailed reviews by NSF at the midpoint of each grant cycle. An advisory board composed of independent experts evaluates progress of the LTER Network and the Network Office every other year. NSF conducts comprehensive reviews of the entire LTER program every 10 years.

Network Funding and Support

Funding for the LTER Network is provided by:

The National Science Foundation

- Division of Environmental Biology
- Office of Polar Programs
- Directorate for Education and Human Resources
- Division of Ocean Sciences
- Division of Social, Behavioral, and Economic Research
- Division of International Programs
- Division of Biological Infrastructure

The USDA Forest Service financially supports six sites at which LTER projects are located (Andrews, Baltimore, Bonanza Creek, Coweeta, Hubbard Brook, Luquillo). At these sites, the USDA FS works jointly with LTER to measure and understand ecological and geophysical processes in order to improve management strategies.

The **National Aeronautics and Space Administration** has also provided assistance to the LTER Program through *Earth Science Enterprise*

***For more information contact*:**

The LTER Network Office
Department of Biology
University of New Mexico
Albuquerque NM 87131-1091
ph: 505/272-7278
fax: 505/272-7080
email:office@lternet.edu

Limnocorrals for examining responses of nutrient and fish manipulation in Toolik Lake, Arctic Tundra LTER site (photo: Jerry Franklin).

Early morning mist on Harvard Pond, Harvard Forest LTER site (photo: David Foster).

Research and Education Opportunities

The LTER Network invites the broader environmental research community, students and educators to utilize LTER sites for long- and short-term projects appropriate to individual sites, a group of sites or a region, or to the Network as a whole. Initial arrangements should be made through site personnel, and proposals for collaborative work should be submitted to the relevant disciplinary program of the National Science Foundation.

Contact NSF directly for information about short-term funding opportunities in a particular area of research.

http://www.nsf.gov

ABOVE: In the snowpack enhancement study at Niwot Ridge LTER site, the depth and duration of the snowpack is altered by the fence. This long-term project (International Tundra Experiment, or ITEX) is conducted at several sites across the LTER Network (photo: T. Seastedt).

LEFT: Researchers melt an icehole to gain access to a lake in Taylor Valley, Antarctica, at the McMurdo Dry Valleys LTER site (photo: R. Kine, NSF).

Experience for Graduate Students

The LTER Network has much to offer graduate students. Graduate students at all levels gain valuable experience collaborating with principal investigators, conducting network-wide intercomparison studies, employing new technologies and learning techniques for research at multiple temporal and spatial scales.

International cooperation between the U.S. LTER and the International LTER networks provides opportunities for extending research and collaborations beyond borders and beyond continents.

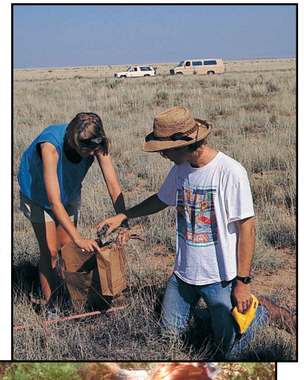
Network-level research opportunities offer students a sense of being part of something much larger than single-site research. The LTER Network offers a broad perspective about how research is conducted, and what motivates research at other institutions and in other parts of the world.

Undergraduate Education

The Long Term Ecological Research Network offers many excellent research and education opportunities for undergraduate students, primarily through the National Science Foundation's Research Experience for Undergraduates Program (REU) and the Undergraduate Mentorships in Environmental Biology (UMEB).

The crux of these programs is research. Each student collaborates directly with an LTER scientist and conducts a research project that relates to ongoing LTER projects.

The undergraduate programs expose highly qualified students to a broad range of scientific inquiry at LTER sites, and encourage significant peer-group interaction among the students. In some programs (which vary from site to site), students visit Washington D.C. to experience the environmental research policy-making process in addition to on-site research.



Students in the REU program assist in plant harvesting at the Sevilleta LTER site (photo: R. Parmenter).

K-12 education is built into the structure of the Central Arizona–Phoenix LTER. Here, elementary students examine an insect trap (photo: Brenda Shears).

Elementary and Secondary School Students and Teachers

With the support of the National Science Foundation, LTER is developing a model for experiential learning involving scientists, graduate students, teachers and other educators called Schoolyard LTER. This program exposes students to:

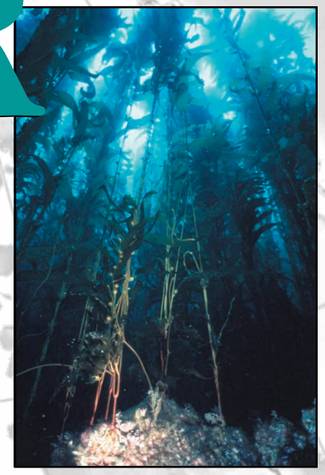
- Field research and LTER principles
- Field trips and classroom visits with ecological scientists
- Data collection and experimentation plots on or near school grounds

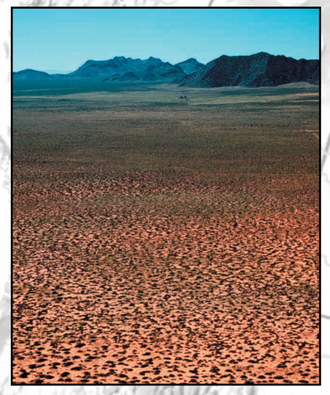
The program also offers K-12 teachers field research experiences, while working with scientists and educators to integrate their experiences into their classroom, upgrading Internet connectivity at schools, enhancing the ability of schools to utilize on-line data from the LTER sites, and eventually comparing data among Schoolyard LTER sites.

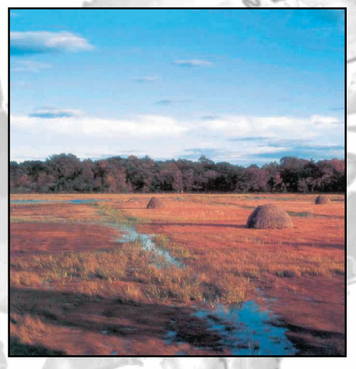
For more information about LTER K-12 education programs, please visit the website:
http://schoolyard.lternet.edu

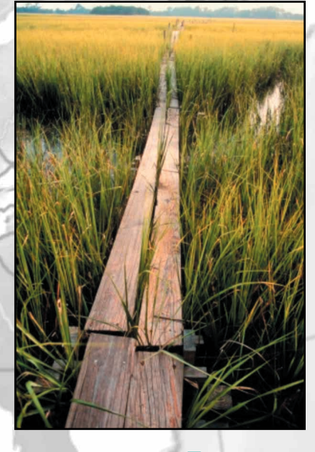
LTER

Long Term Ecological Research Network









With an initial six sites selected in 1980, the National Science Foundation established the Long Term Ecological Research Network to study broad spatial and temporal scale environmental phenomena. Currently, twenty-four sites represent the Network– a collaborative effort of more than 1,200 scientists, students, and educators, with opportunities for many more.

http://www.lternet.edu