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Long Term Ecological Research Network

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## Status of the U.S. Long-Term Ecological Research Network

Robert B. Waide  
Executive Director  
LTER Network Office

### Introduction

The network of sites dedicated to long-term ecological research in the United States has grown steadily since it was formed in 1980. In addition to adding individual sites, the focus of the network has shifted from a concentration on individual site research to a broader synthetic viewpoint. As funding for the program has increased, expectations of results have shifted to include not only individual researcher, single site products but also cross-site, network-wide, and international collaborative studies. The goal of these latter studies is to search out general ecological principles that apply to many ecosystems at many different scales. Comparative and synthetic approaches have become the norm in the U.S. LTER Network.

At the same time that the Network was expanding its scope, the National Science Foundation initiated efforts to broaden participation in LTER research. The purpose of these efforts included a desire to involve additional investigators at satellite research sites, an interest in attracting scientists working at landscape and regional scales, and a need to apply results from LTER research to the solution of societal problems. Trail efforts to expand the studies conducted at individual sites were implemented at the Coweeta and North Temperate Lake sites by inviting the participation of social scientists and by expanding the geographical scale of the research. More recently, this trend has been carried further by the inclusion of two new urban sites in the LTER Network.

The mission of the LTER Network as it is now understood is to conduct and nurture ecological research by:

- Understanding general ecological phenomena which occur over longer temporal and spatial scales;
- Creating a legacy of well-designed and documented long-term experiments and observations for the use of future generations;
- Conducting major synthetic and theoretical efforts; and
- Providing information for the identification and solution of societal problems.

### History of the Network

The concept of long-term ecological research sites dedicated to collaborative research was developed during a series of three workshops sponsored by the National Science Foundation (NSF) from 1977-1979. At these workshops the philosophy of collaborative research was developed and a centralized working hypothesis approach to collaboration proposed. Five core areas of research were defined to orient long-term ecological research projects toward question/hypothesis formulation and resolution. The five core research areas common to all LTER sites are:

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

In 1979, NSF announced a call for proposals for pilot projects in long-term ecological research with goals of 1) initiating the collection of comparative data at a network of sites representing major biotic regions of North America, and 2) evaluating the scientific, technical and managerial problems associated with such long-term comparative research. The first request for LTER proposals resulted in the selection and funding of an initial set of six sites:

H.J. Andrews Experimental Forest, Oregon  
 Coweeta Hydrologic Laboratory, North Carolina  
 Konza Prairie Research Natural Area, Kansas  
 Niwot Ridge/Green Lakes Valley, Colorado  
 North Inlet Marsh, South Carolina  
 North Temperate Lakes, Wisconsin

Competitions in 1980 and 1987 added 10 additional sites:

Arctic Tundra, northern slope of Alaska  
 Bonanza Creek Experimental Forest, Alaska  
 Cedar Creek Natural History Area, Michigan  
 Central Plains Experimental Range, Colorado  
 (now called Shortgrass Steppe)  
 Hubbard Brook Experimental Forest, New Hampshire  
 Illinois Rivers, Illinois  
 Jornada Basin, New Mexico  
 W.K. Kellogg Biological Station, Michigan  
 Okefenokee, Georgia  
 Virginia Coast Reserve, Virginia

In 1988, two sites withdrew (Illinois Rivers and Okefenokee) and three new sites were added:

Harvard Forest, Massachusetts  
 Luquillo Experimental Forest, Puerto Rico  
 Sevilleta National Wildlife Refuge, New Mexico

Competitions in 1990 and 1992 through the divisions of Polar Programs and Environmental Biology for sites in Antarctica resulted in the addition of two more sites by 1993:

Palmer Station, Antarctica  
 McMurdo Dry Valleys, Antarctica

The withdrawal of one site in 1993 (North Inlet) and the addition of the two new urban sites in 1997 (Baltimore and Central Arizona-Phoenix) leaves a current total of 20 sites (Figure 1).

Figure 1



## The Network Office

In 1983, NSF established the LTER Network Office at Oregon State University under the direction of the LTER Coordinating Committee chair and the LTER Coordinating and Executive committees. The goals of the Network Office are:

- to facilitate communication among the LTER sites and between the LTER Program and other scientific communities
- to support the planning and conduct of collaborative research efforts, including provision of some technical support services
- to facilitate intersite scientific activities
- to provide a focal point and collective representation of the LTER Network in its external relationships
- to develop linkages with other relevant long-term research programs, site networks, and science and technology centers.

In 1989, the coordination grant was moved to the University of Washington, in the College of Forest Resources. A Network Data Manager was hired and a Network-wide electronic mail forwarding system was developed. The Network Office hired a Network Manager and acquisition of satellite imagery and aerial photography for all sites began. Over the following years, the Network Office developed data bases on LTER personnel, core data sets, and publications. A World Wide Web site for the LTER Network was established at Network Office. Three All-Scientists meetings were coordinated from the Network Office Staff. In 1996, NSF announced an open competition for the LTER Network Office cooperative agreement. The University of New Mexico was awarded the cooperative agreement, and the Network Office moved there in 1997. An Executive Director was recruited to head the office.

## Cross-site initiatives

In 1994, NSF announced a special competition for cross-site comparisons and synthesis at LTER and non-LTER sites in response to the 10-year review of the LTER Program. Nine awards ranging from \$109,353 to \$200,000 were given to LTER and non-LTER U.S. sites, and sites in Ireland, Scotland, Costa Rica, Argentina and Russia. In 1995, a second special competition for cross-site comparisons and synthesis was conducted, with thirteen awards ranging from \$150,000 to \$200,000 given. These competitions have stimulated cross-site interactions both within the LTER Network and between the Network and other sites. At present, eleven different cross-site studies, ranging from a study of the relationship between net primary productivity and biodiversity to the development of standard soil methodologies for use at LTER sites, have involved the majority of sites in the Network. In addition, each individual site has developed its own collaborative studies with other research programs within and outside of the LTER Network.

## Education

A primary goal of the LTER Network is to provide a wide-range of educational opportunities for students at participating institutions. Both undergraduate and graduate students are both direct and indirect beneficiaries of LTER awards. The number of students who benefit from LTER awards each year includes those who receive stipends from the awards and those who use the field station and equipment in support of their undergraduate and graduate research programs. In addition, the LTER Network, through its association with other networks worldwide, provides opportunities for the international interchange of students and faculty. A prime of example of this kind of opportunity is the interchange of Asian and U.S. students presently being organized.

## Composition of the Network

Among the primary strengths of the U.S. LTER Network are the quality and diversity of the research done at its individual sites. The 20 sites that make up the Network represent an enormous range of biological diversity and institutional affiliations. A brief description of each site is appended below.

H.J. Andrews Experimental Forest, Oregon

Institutional affiliations: Oregon State University; USDA Forest Service, Pacific Northwest Research Station.

Principal biome/main communities: Temperate coniferous forest. Douglas-fir/western hemlock/western red cedar; true fir and mountain hemlock; streams.

Research topics: Successional changes in ecosystems; forest-stream interactions; population dynamics of forest stands; patterns and rates of decomposition; disturbance regimes in forest landscapes.

Arctic Tundra, Alaska

Institutional affiliations: The Ecosystem Center, Marine Biological Laboratory; Universities of Alaska, Massachusetts, Minnesota, Cincinnati, and Kansas; Clarkson University.

Principal biome/main communities: Arctic tundra, lakes, streams. Tussock tundra; heath tundra; riverine willows; oligotrophic lakes; headwater streams.

Research topics: Movement of nutrients from land to stream to lake; changes due to anthropogenic influences; controls of ecological processes by nutrients and by predation.

Bonanza Creek Experimental Forest, Fairbanks, Alaska

Institutional affiliations: University of Alaska; Institute of Northern Forestry, USDA Forest Service, Pacific Northwest Research Station.

Principal biome/main communities: Taiga. Areas of boreal forest including permafrost-free uplands and permafrost-dominated north slopes and lowlands; floodplain seres.

Research topics: 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; hydrologic regime and stream ecology.

Cedar Creek Natural History Area, Minnesota

Institutional affiliations: University of Minnesota.

Principal biome/main communities: Eastern deciduous forest and tallgrass prairie. Old fields; oak savanna and forest, conifer bog; lakes; pine forest; wetland marsh and carr.

Research topics: Successional dynamics; primary productivity and disturbance patterns; nutrient budgets and cycles; climatic variation and the wetland/upland boundary; plant-herbivore dynamics.

Central Arizona-Phoenix, Arizona

Institutional affiliations: Arizona State University; Maricopa Community Colleges.

Principal biome/main communities: Sonoran Desertscrub. Urban parks, residential, interior remnant desert patches, urban fringe, regulated river and floodplain (dry), effluent-dominated river...

Research topics: Interactions of ecological and socioeconomic systems in an urban environment; influence of pattern of development (land use change) on ecological pattern and process; movement of nutrients through highly manipulated, urban flowpaths; interactions of introduced and native species in urban environment; millenium- and century-scale geomorphic change in landforms and interaction with engineering works.

Coweeta Hydrologic Laboratory, Otto, North Carolina

Institutional affiliations: University of Georgia; USDA Forest Service, Southeastern Forest Experiment Station.

Principal biome/main communities: Eastern deciduous forest. Hardwood forests and white pine plantations.

Research topics: Long-term dynamics of forest ecosystems including forest disturbance and stress along an environmental gradient; stream ecosystems along an environmental gradient; and the riparian zone as a regulator of terrestrial-aquatic linkages.

#### Harvard Forest, Massachusetts

Institutional affiliations: Harvard University; Universities of New Hampshire and Massachusetts; The Ecosystem Center, Marine Biological Laboratory.

Principal biome/main communities: Eastern deciduous forest. Hardwood-white-pine-hemlock forest; spruce swamp forest; conifer plantations.

Research topics: 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.

#### Hubbard Brook Experimental Forest, New Hampshire

Institutional affiliations: Yale, Cornell, and Syracuse Universities; Institute of Ecosystem Studies; USDA Forest Service, Northeastern Forest Experiment Station.

Principal biome/main communities: Eastern deciduous forest. Northern hardwood forests in various developmental stages, spruce-fir forests; streams and lakes.

Research topics: 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.

#### Jornada Experimental Range, New Mexico

Institutional affiliations: New Mexico State University; USDA ARS Jornada Experimental Range; Duke University, NC; NOAA, Research Triangle Park, NC; University of New Mexico; Dartmouth College, NH; Oregon Graduate Center; Texas Technological University; SUNY Buffalo, NY; University of Leicester, UK; Kings College, London, UK; EPA-EMAP, Las Vegas, NV

Principal biome/main communities: Hot desert. Playa, piedmont, and swale; bajada, basin, mountain and swale shrubland; mesquite dunes

Research topics: Desertification; factors affecting primary production; animal-induced soil disturbances; direct and indirect consumer effects; vertebrate and invertebrate population dynamics; grazing effects on ecosystem structure and function; biodiversity and ecosystem function; small mammal effects on soil and vegetation heterogeneity; soil microbial processes; surface hydrology; trace gas emissions from soils; eolian processes

#### W.K. Kellogg Biological Station, Hickory Corners, Michigan

Institutional affiliations: Michigan State University, Michigan Agricultural Experiment Station

Principal biome/main communities: Row-crop agriculture. Conventional and organic-based corn-soybean-wheat cultivation; perennial biomass cultivation; native successional communities.

Research topics: Ecological interactions underlying the 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.

#### Konza Prairie Research Natural Area, Manhattan, Kansas

Institutional affiliations: Kansas State University.

Principal biome/main communities: Tallgrass prairie. Tallgrass prairie; gallery forest; prairie stream.

Research topics: 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.

#### Luquillo Experimental Forest, Puerto Rico

Institutional affiliations: Center for Energy and Environment Research, University of Puerto Rico; Institute of Tropical Forestry, USDA Forest Service, Southern Experiment Station.

Principal biome/main communities: Tropical rainforest. Tabonuco forest; palo Colorado forest; palm brake; dwarf forest and montane streams.

Research topics: Patterns of and ecosystem response to different patterns of disturbance; land-stream interactions; effect of management on ecosystem properties; integration of ecosystem models and geographic information systems

#### McMurdo Dry Valleys, Antarctica

Institutional affiliations: Desert Research Institute, Reno, Nevada; U.S. Geological Survey, Boulder, Colorado.

Principal biome/main communities: Polar desert oases.

Research topics: 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.

#### Niwot Ridge-Green Lakes Valley, Colorado

Institutional affiliations: Institute of Arctic and Alpine Research, University of Colorado.

Principal biome/main communities: Alpine tundra. Fellfield; meadow; herbaceous and shrub tundras; cliffs and talus; glacial lakes; streams and wetlands.

Research topics: Patterns and controls of nutrient cycling; trace gas dynamics, plant primary productivity and species composition; geomorphology, and paleoecology.

#### North Temperate Lakes, Wisconsin

Institutional affiliations: Center for Limnology, University of Wisconsin-Madison, Wisconsin.

Principal biome/main communities: Northern temperate lakes in glacial landscapes in urban, agricultural and forested watersheds. Oligotrophic, dystrophic and eutrophic lakes; temporary forest ponds; warm and cold streams; sphagnum-leatherleaf bog; conifer swamp; mixed deciduous and coniferous forests.

Research topics: Physical, chemical and biological limnology; hydrology and geochemistry; climate forcing; producer and consumer ecology; ecology of invasions; ecosystem variability; lakescape and landscape ecology.

#### Palmer Station, Antarctica

Institutional affiliations: University of California at Santa Barbara; University of California at San Diego; University of Hawaii; Montana State University; Old Dominion University

Principal biome/main communities: Polar marine. Coastal and open ocean pelagic communities; seabird nesting areas.

Research topics: Marine ecology of the Southern Ocean focused within the Western Antarctic Peninsula area, including: physical forcing (atmospheric, oceanic and sea ice) of the ecosystem with emphasis on the ecological consequences of sea-ice variability; biological processes with emphasis on microbial, primary production and the life-history parameters of secondary producers (krill) and apex predators (penguins); physical/optical/chemical/biological modeling that links ecosystem processes to environmental variables.

#### Sevilleta National Wildlife Refuge, New Mexico

Institutional affiliations: University of New Mexico; U.S. Fish and Wildlife Service.

Principal biome/main communities: Multiple--intersection of subalpine mixed-conifer forest/meadow, riparian cottonwood forest, dry mountainland, grassland, cold desert, hot desert. Conifer savanna; creosote

bush; desert grassland; mesquite and sand dunes; Great Basin shrub and shortgrass steppes; tallgrass swales; riparian communities.

Research topics: Landscape and organism population dynamics in a biome tension zone; semiarid watershed ecology; climate change; biospheric/atmospheric interactions; paleobotany/archaeology; microbial role in gas flux; and control of landscape heterogeneity; scale effects on spatial and temporal variability.

#### Short-grass Steppe, Colorado

Institutional affiliations: Colorado State University; USDA Forest Service; USDA Agricultural Research Service.

Principal biome/main communities: Shortgrass steppe. Floodplain; shrubland; saltmeadow.

Research topics: Soil water; above- and belowground 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.

#### Virginia Coast Reserve, Virginia

Institutional affiliations: University of Virginia.

Principal biome/main communities: Coastal barrier islands. Sandy intertidal; open beach; shrubthicket; mature pine forest; salt marsh; estuary.

Research topics: Holocene barrier island geology; salt marsh ecology, geology, and hydrology; ecology/evolution of insular vertebrates; primary/secondary succession; life-form modeling of succession.