LTER

Long Term Ecological Research

The semi-annual newsletter of the Long Term Ecological Research Network

The Network News

Network Office Survives Transition

New Mexico Well Suited to New Office, New Ideas

Robert Waide, Executive Director, LTER Network Office

New Mexico, in addition to being the Land of Enchantment, is also a land of transition. Both of the New Mexican LTER sites focus on the transition between different types of ecosystems, and even within the confines of Greater Albuquerque the change from riverine through high desert to montane habitats provides an impressive amount of variability within only 30 minutes driving time. The Network Office fits right in with this pattern; practically everything, from the home page to the personnel, is in a state of transition. However, El Niño can't be blamed this time. We've brought these changes upon ourselves.

The move from Seattle to Albuquerque has presented a series of challenges for the personnel of NET. The first of these was, of course, finding the people to staff the new office. We have been very fortunate in two ways with regard to staffing. First, John Vande Castle decided to make the move with the Office, which provides us with invaluable institutional memory and experience. As important, we have been able to recruit an excellent group of people to take over the remaining positions, all of whom have been instrumental in maintaining the continuity of services that we offer to the LTER Network during the period of transition (please see pages 11-12). We look forward to completing the staff over the next few months.

NET's move to Albuquerque has afforded numerous opportunities for improving many of the office facilities. These improvements include new computer file servers and other equipment and the installation of updated software. Some of the acquisitions have resulted in temporary headaches, we look forward to having everything running smoothly in the near future.

A temporary hiatus in our capability to maintain and update network databases has been an unavoidable side effect of the move. We are addressing this problem as quickly as resources permit us. For example, we have initiated an effort through the Data Management Committee to make the LTER Personnel Database current. At the same time, we plan to add improvements to the management of the database to provide more flexibility in creating and using e-mail groups. We have begun a similar effort with the LTER website, only in this case we have mounted a major reconstruction effort. The new website, when complete, will both be more appealing and more functional. Many other similar projects are in queue.

We also inherited a legacy of ongoing projects that have kept us busy, especially in the International LTER arena. We are fortunate during this period to have our efforts bolstered by Chris French, who is on loan to the Network Office from International Programs at NSF. With Chris' advice and help, we have encouraged fledgling networks in Venezuela, Bolivia, Brazil, Uruguay, Mexico, Taiwan, China, Israel, and South Africa. Some of the developing international networks have reached the point where interactions with a group of LTER scientists would be both appropriate and rewarding. Brazil, Venezuela, China, Taiwan, Costa Rica, and the Czech Republic are all countries where direct scientist-to-scientist contact should be initiated in the near future. The Network Office stands ready to help any LTER scientist or group of scientists to develop proposals for visits to ILTER countries for the purpose of initiating research collaboration.

ILTER efforts have developed along regional lines. Affinity groups have sprung up among East Asian/Pacific and Latin American countries. A North American Regional LTER Network, comprised of the United States, Canada, and Mexico, is in the formative stage. When this regional network takes shape, it will provide enhanced opportunities for cross-site and regional experiments and syntheses.

One of the recommendations of the 10-year review of the LTER program was the creation of an international network of 100 sites, 50 in the United States and 50 in other countries. Of the 50 in the United States, it was proposed that half would be funded by NSF and half by other agencies. There now exist more than 50 LTER-like sites in the ILTER Network, and 21 in the national network. One of the tasks that I see for the Network Office is to foster interest in the LTER concept among federal agencies that fund ecological research. Recently, I attended a meeting in Bozeman of a group interested in developing an LTER-like program in Yellowstone National Park. There has also been interest in LTER expressed by scientists at several other national parks. With appropriate nurturing, these expressions of interest may develop into research programs that will complement the LTER effort.

In closing, I would like to thank all of you for being so patient during the transition of the Network Office. I believe that we have resolved the most important issues and that all that remains now is a lot of hard work. I would appreciate any suggestions or comments that you might have regarding how to improve our operation.

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LTER

The Network News

In this Issue

Network Office Survives Transition

Executive Director Bob Waide describes trials and tribulations of the move.....Page 1

Departments

Site X Site

News briefs from several sites; Cross-site research from Arctic and Niwot; Remote Sensing from Jornada; Palmer Sets Sail a New Research Vessel; Profiles of New Urban and Land Margin Sites; Introducing the New Network Office; more .....Pages 2—12

Net Working

Biodiversity Project; Information Management; New Education Committee Forms; Teachers get Hands-on Experience at McMurdo Dry Valleys LTER; LTER Teams up with the Santa Fe Institute; Asian Graduate Students visit HJ Andrews; more .....Pages 13—17

InterNational

An Update of ILTER Developments; Plans for collaborations between LTER and GTOS.....Pages 10—13

Miscellaneous

Publications and Calendar highlights.....Pages 23—24

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The University of New Mexico

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Sevilleta Acquires New GIS Data

Robert Parmenter, Sevilleta LTER

Early this year, the Sevilleta LTER participated in a NASA project that included the acquisition of one-meter resolution multispectral imagery covering the entire 100,000 ha Sevilleta National Wildlife Refuge. Funding for this project was provided by NASA's Stennis Space Center under the Mission to Planet Earth (MTPE) program. The grant was awarded to C. A. Benkelman of Positive Systems, Whitefish, MT.

Working with Sevilleta LTER GIS scientist Greg Shore, the Positive Systems team of researchers and aircraft pilots took images of the Sevilleta NWR on 28-29 January 1998, from a low-flying fixed-wing aircraft using the Positive Systems' ADAR System 5500 airborne sensor. Approximately 2,000 image frames of size 1500 x 1000 pixels (1500 m x 1000 m) each were acquired in four spectral bands, approximately matching the first four bands of the Landsat Thematic Mapper. Images were acquired with 30 percent overlap and sidelap, and will be mosaiced to form a composite Sevilleta NWR image of approximately six GB in size (that's right—GBs, not MBs!). The composite image is expected to be completed in early April 1998.

The acquisition of this high resolution, multispectral imagery will assist the Sevilleta LTER program in refining its vegetation map and process modelling studies. In addition, because the imagery will form an accurate GIS data layer, the imagery will be used to calibrate the extensive aerial photo holdings of the LTER for the Sevilleta field sites. These improvements in GIS coverage of the Sevilleta will be of considerable value to the entire research community studying the ecology, geology and anthropology of the central Rio Grande valley.

Please see the web site up for the ADAR project:
http://sevilleta.unm.edu/collaboration/nasa/adar/

Andrews Forest Celebrates 50 Years

Carol Wood, Oregon State University

The 50th anniversary of the H.J. Andrews Experimental Forest this year will be marked by a variety of activities. Established in 1948 as the Blue River Experimental Forest, the Forest was renamed in 1953 to honor H.J. Andrews, a Forest Service leader whose work in inventory of forest resources in the 1930s is still used today by scientists studying carbon sequestration in the region's forests.

The 50th anniversary will be celebrated at the Forest on 21 August 1998, featuring comments from research, management, and education leaders, as well as field discussions at various research-management venues. A new 5,000 square foot building with meeting facilities, teaching lab, and offices will be the centerpiece of a facilities open house.

Historian Max Geier is preparing a book on the history of the Andrews emphasizing the community of scientists and land managers who have worked at the Andrews to better understand forest and stream ecosystems, and the implications of that understanding for land management. The book is based in part on more than 40 interviews with people involved with the Andrews since its early days. This book will be published in an environmental history series of Oregon State University Press.

A second book by freelance writer Jon Louma will cover the workings of the forest ecosystem from tree tops to streams and soil. The processes and moments of discovery in decades of research will be central to this story to be published by Henry Holt.

Heavy Weather Pounds Coweeta

Brian Kloeppel, Coweeta LTER

January 1998 was an eventful weather month for the Coweeta LTER program. From 6 to 8 January, 19.13 cm of rain was measured at the base weather station causing extensive flooding in the region along with three small to moderate landslides that blocked two roads at Coweeta Hydrologic Laboratory (see photo below). The heavy rains were followed by heavy snows in the region on 27 January that accumulated to 75 cm in some parts of western North Carolina, closing interstate highways and requiring National Guard assistance in some areas. These two unusually severe weather events contributed to the total January 1998 monthly precipitation of 31.37 cm compared to the 64-year average (1934 to 1997) of 17.45 cm at the Coweeta Hydrologic Laboratory base weather station.

Above-average precipitation results in a landslide at Coweeta LTER. Photo courtesy Coweeta LTER

News from the Frozen Continent

The Palmer Station LTER Prepares for a Typical Annual Research Cruise; Christens a New Vessel

David M. Karl, University of Hawaii, Palmer Station LTER

The Palmer Station LTER (PAL) research program is the only marine site in the LTER network. The study area includes a range of habitats from shallow (< 5 m) coastal bays to the deep (> 3000 m) oceanic region that surrounds Antarctica. A grid of 100 stations contained in a 100 x 200 km rectangle aligned parallel to the North-Northeast axis of the Antarctic Peninsula defines the LTER study area (see illustration, opposite page).

An essential field component of the PAL research project is our annual month-long research cruise. During these expeditions, measurements are made of the distributions and abundances of microbial, plant and animal populations and on the physical and chemical conditions of their habitats. These comprehensive, trans-disciplinary at-sea measurements are the heart and soul of the PAL program.

Expedition planning typically begins in April, less than one month after returning from Antarctica at the conclusion of the previous field season. Personnel lists are prepared well in advance of deployment to Antarctica because of the medical and dental exams that are required to ensure our team's ability to withstand the rigors of high latitude field work. Detailed lists of supplies and chemicals needed to conduct our field programs must also be prepared, reviewed and ordered. There are no hardware stores or chemical supply houses on the frozen continent. In June, the PAL principal investigators meet to plan the detailed sampling and shipboard experimental protocols and to make a final decision on selection of the expedition Chief Scientist. Throughout the summer, plans are finalized. By fall, all participating scientists are physically qualified and we begin to make our final travel plans, including important issues such as the arrangement of dog-sitters, bill-payers and the other essentials of life that simply must continue in our absence. Some of the PAL scientists deploy for Antarctica as early as October to begin field work at land-based Palmer Station ahead of the annual cruise. These scientists typically remain in the field for nearly six months at which time they are ready to return home to prepare for the next field season and to get reaquainted with friends and family members. Such is the life of a dedicated PAL scientist.

Our annual LTER research cruise usually departs on or about the first of January from Punta Arenas, Chile, on the Straits of Magellan. Scientists begin to arrive in "PA" a few days before departure to locate and unpack their gear and to set up the shipboard laboratories. Punta Arenas is a small, friendly town literally at the end of the road in the Patagonian region of South America. Before the Panama Canal was constructed, Punta Arenas was a major port and center of commerce for all ships rounding Cape Horn. Today the port continues to support an active fishery and, more recently, an emergent ecotourism industry that includes Antarctic vacation cruises.

One final bit of important business in Punta Arenas is receipt of the Antarctic clothing issue. The Antarctic Support Associates, the civilian contractor for NSF, maintains a warehouse at the port, which facilitates cruise staging. At their polar department store each participant receives a full wardrobe of functional, warm clothing from polypropylene undergarments to a polar hat—all neatly packed into a personal duffel bag. This is a godsend for those of us who live in warm climates (like myself—in Hawaii) and do not normally wear long pants, much less a parka. Now, after nine months of planning and preparation the research vessel that will be our home for the next several weeks is ready to weigh anchor and head south to the Antarctic Peninsula.

Maiden Voyage

The Antarctic Research and Supply Vessel *Laurence M. Gould* was christened by the ship's sponsor Mrs. Ruth Siple on 9 October 1997 at the North American Shipbuilders facility in La Rose, Louisiana. The dedication ceremony was attended by NSF and PAL representatives. This newly constructed vessel is named in honor of Laurence McKinley Gould, a world-renowned geologist and educator. Gould was the second-in-command of Richard Byrd's first Antarctic expedition in 1929 and later served as President of Carleton College. He died in 1996, at the age of 99. The *Laurence M. Gould* replaces the Norwegian-flagged vessel *Polar Duke*, which served the U.S. Antarctic research community for the past 13 years.

The new vessel departed from Port Fourchon, Louisiana, on Christmas Day and arrived in Punta Arenas in mid-January to begin her five-year charter service for support of research programs in the region of the Antarctic Peninsula, including the PAL-LTER research activities. Her maiden voyage, the 1998 PAL-LTER annual cruise, was just successfully completed. All those aboard agree that the "Larry" *Gould* meets or exceeds all expectations.

First Winter Cruise Planned

If that is not enough activity to fill an entire year, 1998 will be remembered by the PAL scientists because of our plans to conduct a second cruise—this one in the dead of austral winter. Planning for this May-June "ice cruise" is already in the advanced stages. Only a few winter cruises have ever been attempted in this portion of Antarctica and our team considers this to be an excellent opportunity to study the secrets of winter survival in the polar darkness. We also thought that this might be a good way to test the full capabilities of our new vessel, under some of most extreme environmental conditions imaginable. Stay tuned for news of the outcome.

Please visit the Palmer Station LTER Web site:
http://www.icess.ucsb.edu/lter/lter.html

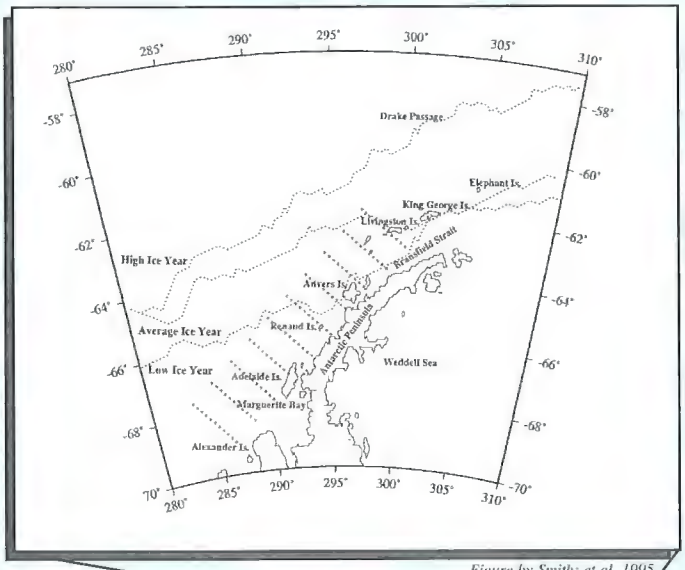
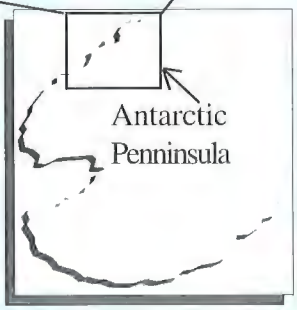


Figure by Smith; et al. 1995

The Palmer LTER Large-scale Grid



Because of the relatively large geographical area and the high degree of spatial and temporal variability that is known to exist in Southern Ocean ecosystems, the Palmer LTER research team relies on data that are collected using a variety of direct and indirect measurement techniques. These range from incubation experiments conducted in one-liter bottles at the shore-based research labs at Palmer Station to synoptic satellite-based images of the entire Southern Ocean.

Photos by Dave Karl

Christening the Laurence M. Gould *at the North American Shipbuilders facility in La Rose, Louisiana.*

Palmer Station, Antarctica.

Sampling for krill with a plankton net on the research vessel Laurence M. Gould.

Nesting Adelie penguins.

Viewing the Desert from a Distance

Advancing Remote Sensing Technology at the Jornada LTER

Laura F. Huenneke, New Mexico State University,Department of Biology and Kris Havstad, USDA-Agricultural Research Service, Jornada LTER

Arid and semiarid lands cover nearly one third of the earth's land mass and are of considerable importance from both human and ecological perspectives. Unfortunately, drylands are notoriously difficult to sample and monitor, given their vast extent, harsh environmental conditions, and sparse biota that varies tremendously over space and time. The development of efficient methods for monitoring aridlands and for extrapolating from small plot or process studies to useful spatial scales has become an important objective for remote sensing researchers.

The Jornada Basin LTER site has become an important laboratory for the development and testing of remote sensing technologies in arid landscapes. For more than a decade, researchers in Geography from New Mexico State University and from San Diego State University have worked to apply satellite sensing technology to the Jornada's landscapes and to correlate these data with handheld reflectrometry. In recent years the pace, breadth, and intensity of work has picked up considerably. Here we describe several of the most recent efforts to advance remote sensing research at the Jornada.

The JORNEX project is funded by the USDA Agricultural Research Service (ARS) global change research program, and includes researchers from five ARS research units (including Al Rango and several others from the Hydrology Laboratory in Beltsville) and from the Staring Centre in Wageningen, The Netherlands. The goal is to quantify land surface hydrology and energy balance in the heterogeneous landscapes of the Jornada basin. The 1995-96 field campaigns integrated airborne remote sensing and ground measurements with the ongoing productivity measurements of the LTER program and satellite data from Landsat TM (thematic mapper), NOAA-AVHRR (Advanced Very High Resolution Radiometry), and GOES-VISSR. Fixed-wing aircraft provided several types of data (multispectral video imagery, laser altimetry, thermal infrared radiometer, 4-band visible and near-infrared radiometer) from several altitudes; while on-the-ground measurements were made of spectral reflectance, LAI (Leaf Area Index), surface energy flux (from Bowen ratio and eddy correlation measurements), and vegetative composition and structure. In 1997-98, the project was expanded to include cross-site work with the Sevilleta and Shortgrass Steppe LTER sites. Barbara Nolen, the GIS specialist for the Jornada LTER and the Jornada Experimental Range, provided extensive leadership and coordination of the multiple agency interaction. Her organizational efforts included acquiring approvals for flights over White Sands Missile Range and the Mexican border—a tremendous logistical challenge!

In 1997, an intensive data collection effort was conducted collaboratively among 20 agencies including Jornada LTER, Sevilleta LTER, USDA-ARS, MODIS, MISR, and ASTER personnel. AVIRIS and Landsat TM data were acquired at both the Sevilleta and Jornada in May and TIMS was acquired at both sites in June. The Jornada LTER's **Barabara Nolen** assembled this image from thumbnails of NASA flightlines, and was key to providing assistance toimagery access, GIS support, and global positioning data. In appreciation of this support, Barbara received the 1997 Collaborator of the Year Award from the USDA's Natural Resources Institute in Beltsville, MD.

A project led by Jornada / New Mexico State University investigator Vince Gutschick, funded by the U.S. Department of Energy's National Institute for Global Environmental Change (NIGEC), focuses on regularities in plant control of evapotranspiration and carbon gain across sites. The project is an effort to move from measurements of water and carbon flux at the leaf and plant (physiological) scales to the regional (km) scale, testing the representativeness of data from flux-tower sites. Remote sensing methodology is primarily low-level aerial photography analyzed by image processing, giving LAI and vegetative composition and structure over intermediate scales. Investigators are now using Landsat TM imagery to estimate evapotranspiration using the energy residual method. The project ties together six sites nationally (five that have long-term flux monitoring).

Sandra Turner and Alan Johnson (NMSU Geography), and Walt Whitford (U.S. Environmental Protection Agency), are building on a previously published classification of the Jornada basin and surrounding regions, to assess the accuracy of the classification based on NDVI's obtained from NOAA/AVHRR imagery. Extensive ground truthing was used to assess the relative effectiveness of using a single season's data versus a composite image produced over several years, incorporating phenological differences and differences in response to interannual climatic variability. The composite approach was better than a classification based on any single year, but error analysis suggested that healthy scepticism is justified in any attempts to base management decisions on such a classification.

In May 1997, researchers from 10 agencies and institutions converged on the Jornada desert grassland for the Prototype Validation Exercise. The collaboration was planned to validate both instrumentation and sampling strategies for several of the new sensors that will be part of NASA's Earth Orbiting System (EOS). After a successful campaign, it now looks as if Jornada will be a validation site for MODIS (a program within EOS), in great part due to the technical assistance the site can provide. The excellent support on the site, combined with the growing archive of both ground-based and remotely sensed data, has reinforced the Jornada Basin's position as one of the world's premier arid ecosystem "laboratories."

NSF Funds First Long-term Studies of Urban Ecology

LTER Gains Two New Urban Sites

The National Science Foundation (NSF) has awarded grants for two long-term studies of urban ecology, representing the first attempts ever made to study the long-term ecology of urban environments.

The awards will involve research on urban environments in the cities of Phoenix, Arizona, and Baltimore, Maryland. Phoenix and Baltimore will soon become the most thoroughly and scientifically studied urban environments in the world, according to Scott Collins, director of NSF's LTER program.

"Factors that control urban ecosystems are not only environmental, but also social and economic. These factors and their interactions need to be considered to understand urban ecosystems over long time frames and broad spatial scales," Collins says.

The new NSF grants have been made to Arizona State University, for the Central Arizona-Phoenix urban LTER site, and to the Institute of Ecosystem Studies in Millbrook, New York, for the Baltimore Ecosystem Study urban LTER site. Scientists at several other institutions also share in these awards.

Phoenix and Baltimore were chosen in part because, according to Collins, they represent two ends of the spectrum, in terms of their histories. "Phoenix is changing very quickly, with desert turning into farmland, industrial and residential sites almost weekly. In Phoenix, 'before' and 'after' experiments are possible. Baltimore, on the other hand, has a history that extends back to the 1700s. This long history will allow ecologists to look at human settlements as ecosystems, across three centuries" Collins says. "The results should give us a good idea of how humans and the lands they inhabit are interacting."

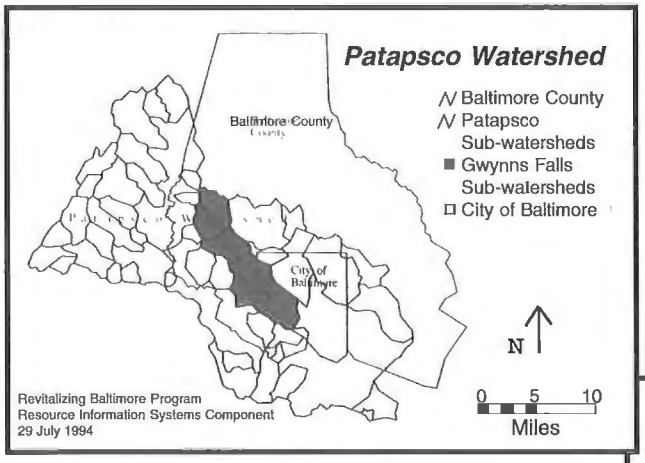
Baltimore Ecosystem Study

How urban and suburban areas function as ecological systems is poorly known. This lack of ecological knowledge is especially problematical because urbanization, including the urban sprawl in suburban areas, is one of the major changes people are causing at the global scale.

Two research approaches are needed to increase the ecological knowledge of urban ecosystems. First, social, cultural, and economic processes must be linked with ecological processes in order to understand urban areas as integrated systems. Second, because the specific features of this integrated ecological-social system change over time, a long-term perspective reaching back into the past and projecting into the future is needed. The socio-economic and ecological changes resulting from urbanization are of long duration in many metropolitan areas, and have cumulative effects, as well as indirect effects, feedbacks, and time lags. A long-term, integrative approach will allow documentation of the outcome of bold social/ecological experiments. To complement these research approaches, public education and the application of ecological knowledge can play an integral role in linking scientific understanding with management, environmental quality and social justice issues in urban America.

The first major question to be addressed is, "What are the fluxes of energy and matter in urban ecosystems, and how do they change over the long term?" The second major question about urban ecosystems is, "How does the spatial structure of ecological, physical, and socio-economic factors in the metropolis affect ecosystem function?" The third major question concerns the linkages between basic research about the urban ecosystem and the general public: "How can urban residents develop and use an understanding of the metropolis as an ecological system to improve the quality of their environment and their daily lives?"

There can and should be a dynamic interplay between the intellectual pursuit of ecological understanding and the development of ecological literacy and ecologically sound practices in the metropolitan area. The general public, students and teachers, and various policy-makers and environmental managers all have a stake in the outcome of such an endeavor. While all ecology educators would assert that understanding the environment has utility, we now have the opportunity to test this relationship in a bold and long-term fashion.



The Baltimore Ecosystem Study

http://baltimore.umbc.edu/lter/

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The Baltimore Ecosystem Study will examine the effects of humans on their environment–and vice versa–focusing on the 17,150 ha Gwynn Falls watershed, which begins in a mixed forested/agricultural area near Reistertown, MD and runs through the city of Baltimore.

Right, a former automobile road in Leakin Park, Baltimore.

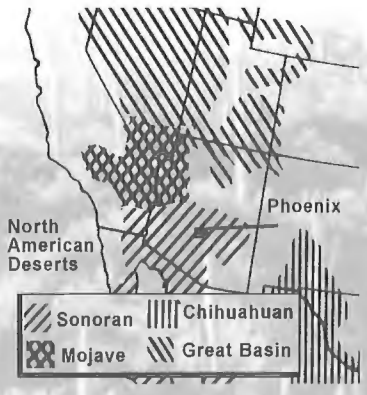
Introducing New Urban LTER Sites;

Central Arizona - Phoenix LTER

Urbanization of the arid regions of the western and southwestern U.S. is a comparatively recent phenomenon with meteoric expansion largely coming after World War II. Arizona has been identified as the second fastest growing state in the nation for the past six years, with Phoenix its capital and the largest city in the Southwest. The Phoenix metropolitan area's spectacular growth in population—doubling twice in the past 35 years—and its rapid and continuing expansion into former agricultural and pristine settings provides a unique opportunity to monitor human-induced ecological transformations, resulting from rapid land-use transformations.

Arizona is a state of diverse local climates and closely juxtaposed life zones, with at least five major vegetation communities existing within the CAP boundaries. Moreover, central Arizona stands astride major geographic and climatic transition zones between the Sonoran and Chihuahuan Deserts, the Sierra and Rocky Mountain ranges, and weather patterns dominated by the Pacific Ocean as well as the Gulf of Mexico. With less than seven inches of annual rainfall, Phoenix is situated in a truly arid landscape with concomitant reliance on surface or groundwater, a high moisture evaporation rate, and continual threat of desertification. That these same issues are faced by those living on a one-third of the world's land surface makes the relationships examined in this LTER relevant to people around the globe.

Historic patterns of growth in the central Arizona-Phoenix region will be reconstructed by using maps, planning documents, aerial photographs, and satellite imagery to generate a record of urban change. Computer modeling will be centered on a hierarchical, spatially explicit, patch dynamic approach. Land-use patches include parks, open space, native vegetation, and residential, commercial, and industrial categories. At intermediate scales, landscape models will be developed to determine the effects of multiple patches. A regional simulation model of the entire area will be developed to predict and test the ecological consequences of alternative patterns of future development.



Patch-specific ecological characteristics will be monitored in five core categories: primary production, natural population and community characteristics, storage and dynamics of organic matter, movement of materials (including water) and patterns of disturbance that occur through redevelopment, fire, or flood. Furthermore, patch types will be compared from city center toward the outer fringe, permitting data collection and analysis intended for land-use planning.

The CAP LTER will have a unique opportunity to investigate the relationship between land-use decisions and ecological consequences in an urban environment.

Finally, the CAP LTER has an explicit commitment to engage the broader Phoenix community, both in K-12 education and the general public's understanding of science. Students will participate in data collection both directly and remotely. Teachers will be provided with curriculum tools and activities to increase opportunities for the entire classroom to engage in an active scientific experiment. Partnerships with Phoenix community groups will allow informal science education to occur regardless of the age of the resident.

The key objectives for the CAP LTER are to generate and test ecological theory in an urban environment; enhance the understanding of the ecology of cities; identify the interrelationships between ecological and socioeconomic factors; collect and make available a tremendous corpus of reliable scientific information for use by scholars, policymakers, and the greater public; and engage the general public, especially K-12 students, in the process of scientific discovery.

The CAP LTER will involve dozens of scientists from six colleges at ASU Main, as well as ASU West and Maricopa Community College District. The Project Directors of the CAP LTER are Charles Redman, Director of the Center for Environmental Studies and Nancy Grimm, Associate Professor, Department of Biology. Strategic partnerships with more than 20 community organizations, agencies, and municipalities will provide opportunities for the entire region to contribute to and benefit from the long-term research associated with this exciting program.

The Central Arizona — Phoenix LTER

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CAP LTER graduate student Jennifer Edmonds collects water samples from the Salt River. *Photo by Diane Hope*

Plum Island Sound LTER

LMER Site Joins LTER Network

Human activities in rivers and watersheds have altered enormously the timing, magnitude and nature of inputs of materials such as water, sediments, nutrients and organic matter to estuaries (Hopkinson and Vallino 1995). One of the dominant themes of estuarine research in recent decades has been the effects of inorganic nutrients on eutrophication of coastal waters. Studies have detailed how inorganic nutrient inputs from land influence primary productivity, the depletion of oxygen, habitats, and trophic relationships in coastal waters. However, another important but neglected linkage between land and coastal waters is the input of dissolved and particulate organic carbon and organic nitrogen.

Organic nitrogen inputs are frequently greater than inorganic nitrogen inputs and in many cases the input of organic carbon from land is greater than the *in situ* production of organic carbon. Despite the quantitative importance of organic matter inputs from land, there are few data on its actual use in coastal waters and even fewer on effects of organic matter loading on coastal ecosystem trophic structure and trophic productivity.

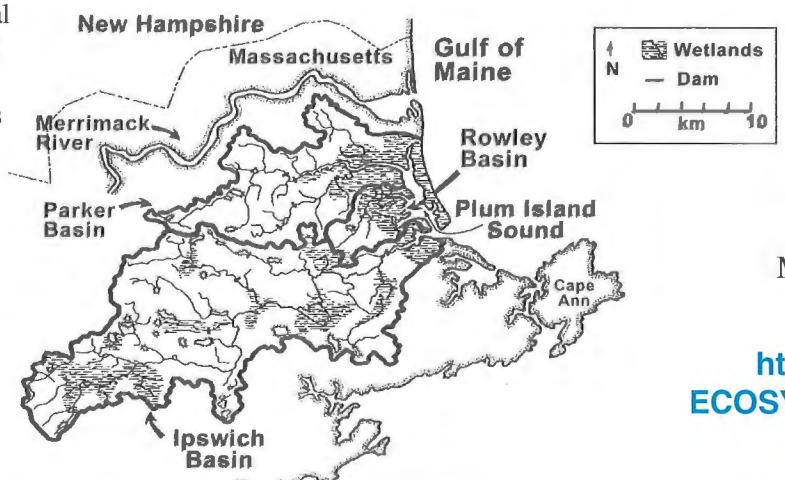
Yet, in other ecosystems such as rivers, lakes, and the deep-sea, effects of allochthonous organic matter inputs on trophic structure and ecosystem metabolism have been well documented.

Climate variability and long-term patterns of climate change also can have immense effects on the timing, magnitude and nature of material inputs. Infrequent storms can accomplish in days what normally occurs over decades. For instance, heavy rainfall associated with tropical storm Agnes increased Susquehanna River flow to record levels, which resulted in 30 years of "normal" sediment discharge occurring in one week (Hirshberg and Schubel 1979).

Variations and long-term increases in sea level affect estuaries from their seaward end. Tides and sea level have significant effects on water and marsh sediment salinity, plant community composition (Olff et al. 1988), primary production (Morris and Haskin 1990, Morris 1995), access to marsh surface habitats by nekton (Rozas 1995) and sediment accretion (Callaway et al. 1996).

The interaction of organic matter and nutrient inputs from land and variations in the external forcings (climate, land use, river discharge, sea level) regulating estuarine mixing and residence time will dictate the extent of nutrient and organic matter processing during estuarine transport and will determine the spatial patterns of productivity and trophic structure.

The study will be conducted in three land-margin ecosystems. Primary focus is the Plum Island Sound Ecosystem where research will be conducted in watersheds and estuaries. Comparative research will be conducted in two other estuaries enabling us to test responses within and across biogeographic provinces and climatic regions. Wells Estuary in Maine, and North Inlet estuary in South Carolina are part of the NOAA National Estuarine Research Reserve network. While all three systems have extensive bordering inter-tidal marshes and approximately equivalent ratios of marsh to water, the freshwater runoff ranges from being almost insignificant in North Inlet, to moderate in Plum Island and large in Wells.



Plum Island Sound

Charles Hopkinson, Jr.
Principal Investigator
The Ecosystems Center
Marine Biological Laboratory
Woods Hole, MA 02543.

http://www.mbl.edu/html/ECOSYSTEMS/lmer/plumisla/plumisla.html

Introducing
The **New LTER Network Office**
Profiles of the People who Put it All Together

Louise Williams
Administrative Assistant

Louise was born and raised in Milwaukee and attended the University of Wisconsin-Milwaukee. She married and raised three children. After her husband passed away, she attended Spencerian College and studied court reporting. She then combined family life with that of a free-lance court reporter, working out of her home until her youngest child was in high school.

The family moved from Milwaukee to Albuquerque in 1974, where Louise continued free-lance court reporting, eventually forming her own court-reporting firm.

Louise left court reporting and began working at the University of New Mexico in 1991 in the School of Medicine. She was Administrative Assistant to the Chairman of the Department of Surgery before transferring to the Biology Department in the spring of 1997 to work at the LTER Network Office. Louise thinks scientists are really cool and are so much easier to get along with than lawyers and doctors. She enjoys learning new things and is fascinated by the work that is being done at the LTER sites.

Patricia Sprott
Publications and Information Specialist

A native of the San Francisco Bay Area, Patty studied English at the University of Florida. After several years as a magazine writer and editor, she returned to school to study environmental science at Florida International University in Miami. There she discovered that she loved field work but feared alligators and oversized flying insects.

High and dry in Albuquerque, she did free-lance writing and edited journals in the English Department at the University of New Mexico before the Network Office came to town. "In this position I can combine my love for communication with my interest in environmental research. In a word — it's a dream." Talk to Patty about your ideas for electronic and print publishing, as well as skiing, mountain biking, rock climbing and backpacking.

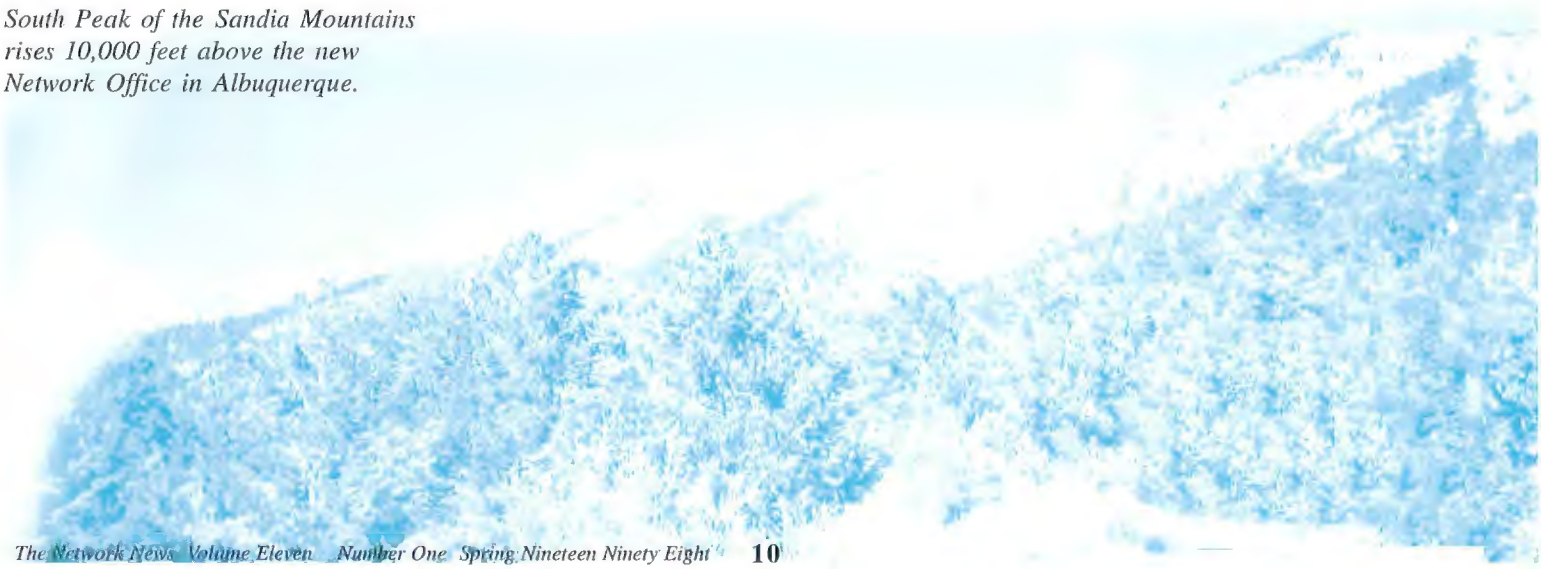
James W. Brunt
Associate Director for Information Management

After a brief stint in the private sector, James rejoined the Network to coordinate the development of the Network Information System, thus continuing a long history with LTER. Beginning as a student technician at the Jornada LTER at NMSU in 1984, he completed a B.S. in Botany and Chemistry there in 1986 and went on to complete a Masters degree in Ecology and Experimental Statistics in 1988. James got his first exposure to data management there while a GRA on the Science Workbench project. In 1989 he went to work for the Sevilleta LTER project as their data manager where he stayed until 1996. While at Sevilleta he was very active in the LTER data management group and international data management efforts–developing training courses and symposia. He has published a number of articles and co-edited a book on data management and ecological informatics and is working on another collaborative book project on ecological data. He has served as a reviewer and panel member for the National Science Foundation, USDA Forest Service, and DOE.

A native of New Mexico, James lives in Albuquerque with his wife, Mariel, and their new son, Will.

John Vande Castle
Associate Director for Technology

South Peak of the Sandia Mountains rises 10,000 feet above the new Network Office in Albuquerque.



John moved from the LTER Network Office in Seattle to his new position as research associate professor in the Biology Department at the University of New Mexico. His research interests focus on spatial and temporal ecosystem dynamics. With a background in terrestrial and aquatic biology as well as computer science and remote sensing, John's main focus in the LTER program is coordinating technology development. This includes integrating new methods and techniques into ecological research, such as new instrumentation, computer applications, information resources and remote sensing techniques.

Christine French

International Programs

Chris says she is an easterner by circumstance, but a westerner by preference. After growing up in Wilmington, Delaware, she worked her way westward as a student at the University of Toronto and the University of Arizona, where she received a B.S. in zoology in 1970. During her graduate studies in aquatic ecology at the University of California at Santa Barbara, a short break after her MA to work in the Environmental Sciences Program Office at the Smithsonian Institution in Washington, DC, turned into a career and a twenty five year stay in Washington. During that time, she has been active in the local chapters of the ESA, as Secretary-Treasurer, and the Association of Women in Science as Chapter membership chair.

Since 1975, Chris has been a program manager in the Division of International Programs (INT) at the National Science Foundation, working first with the Latin American regional portfolio and later with Western European programs. She was sent by INT to the International LTER workshop that was held in association with the All-Scientists Meeting in 1993, which planted the seed of the idea that she some day might find a way to work with the LTER Network. It took three years, but she finally was able to arrange an "outbound IPA" assignment from NSF to work on a variety of international initiatives with the Network Office.

Whether she is at the Network Office in Albuquerque, at NSF in Virginia, or anywhere else in the world for that matter, Chris hopes you will contact her if you have any questions or ideas for international research or education.

Robert Waide

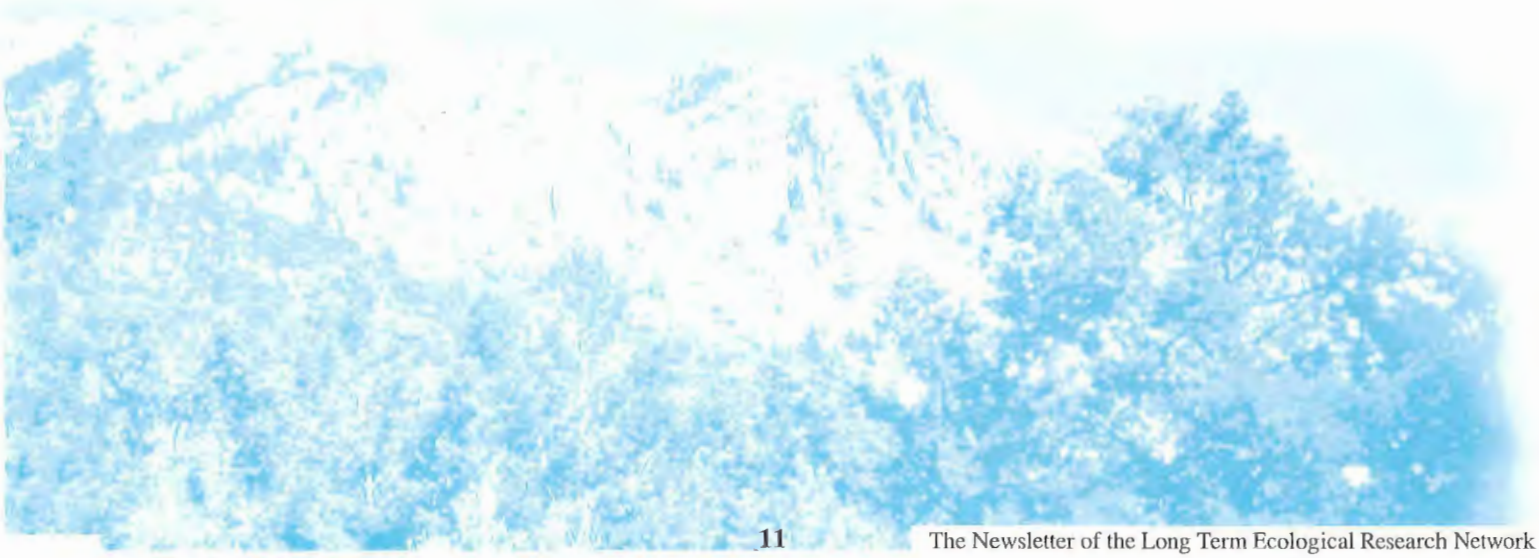
Executive Director

A native of Chicago, Bob received an undergraduate degree in Biology from the University of Illinois and advanced degrees in Zoology from the University of Wisconsin-Madison. His Master's thesis dealt with the ecology of bird communities in rain forest and human-altered habitats in Colombia. He then initiated a doctoral study of the ecological relationships among tropical resident and north temperate migrant birds in the state of Campeche, Mexico.

During a post-doctoral appointment in the Section of Birds at the Carnegie Museum of Natural History, Pittsburgh, he conducted a study of the foraging and breeding ecology of Myiarchus flycatchers on Cozumel Island.

In 1980, he joined the Terrestrial Ecology Division of the Center for Energy and Environment Research in San Juan, Puerto Rico. He served as Director of the Division (subsequently renamed the Institute for Tropical Ecosystem Studies) from 1982-1997, and attained the rank of tenured Professor in the School of Natural Sciences of the University of Puerto Rico. He was Principal Investigator of the Luquillo Long Term Ecological Research (LTER) project from 1988 through 1997. He also served as Director of the Puerto Rico Center for Research Excellence in Science and Technology (CREST) from 1995 to 1997.

Bob has served as a reviewer and panel member for the National Science Foundation and as a member of the Advisory Committee for the La Selva Biological Station of the Organization for Tropical Studies. In addition, he has been a peer reviewer for *Ecology*, *The Auk*, *The Condor*, *Wilson Bulletin*, and the National Geographic Society. His research interests include the structure and dynamics of trophic webs, maintenance of biodiversity, long-term population dynamics of birds, and the influence of natural and anthropogenic disturbance on tropical forest ecosystems. He is author of more than 40 scientific publications and a book. He and his wife, Valli, have two children, Valiangelic and Dayanara.



Snowpack Enhancement Study

Niwot Ridge takes its Snowfence to Artic Tundra for a Cross-site Comparison

Tim Seastedt, Niwot Rdge LTER

In high-elevation or high-altitude environments, enhanced snowpack is commonly predicted as a consequence of global change. Studies have demonstrated that enhanced snowpack can greatly alter decomposition and trace-gas dynamics, provided this snowpack modifies the subnivean thermal regime by extending the time interval that H_2O remains in liquid form (e.g. Brooks et al. *Biogeochemistry* 32:93-113). Three different projects funded by LTER and NSF-DPP are being used to measure the relative importance of enhanced snowpack in different plant community types found in alpine and arctic tundra.

A 60-meter long by 2.8 meter high snowfence was installed at Niwot Ridge in summer of 1993 as part of a long-term experiment to study effects of enhanced snow deposition on species and ecosystem processes of moist and dry communities in alpine tundra. In 1994, two similar fences were constructed on moist and dry tundra sites at Toolik Lake, Alaska (Arctic LTER).

All sites have been instrumented with temperature and moisture monitoring equipment. Vegetation plots along the snow enhancement gradient created by these fences were established within the drift zones and were paired with control plots outside the snow manipulation area. Measurements were taken of community composition, microclimate, permafrost and snow temperature, decomposition, soil characteristics, plant phenology, growth and reproduction. These sites are being used as experimental sites by REU students and graduate students, as well as being monitored for long-term changes.

In the Colorado alpine, the enhanced snowpack reduces growing season length by almost 50 percent in the deepest part of the drift, and the snow can raise the average soil surface temperature of a previously wind-blown dry alpine area by about 12° C. These changes have substantially altered the vegetation and dramatically increased surface litter decomposition rates. The arctic results suggest more modest changes in both growing season and soil temperature changes, and preliminary results suggest that surface litter decomposition is at most weakly influenced, if at all, by these differences.

Enhanced snowpack tends to stress the dominant species of the dry sites. As species replacements are very slow (and perhaps slower in the alpine than in the arctic due to extreme thermal stresses during the short growing season), this stress translates to a period where plant productivity is diminished while decomposition is enhanced. This response, similar in many respects to that observed in a clearcut, produces a pulse of mineralized nutrients that do not appear to be retained by the system. We will continue to study these sites to see if, as in the forest response, an accretion phase of nutrients is associated with recovery.

The two ecosystem types as well as the two different communities being studied within these ecosystem types exhibit unique responses that are related to the way that enhanced snowpack expresses itself in terms of specific microclimatic modifications. These changes then produce a transitional period where the biotic responses, including both a functional response of organisms present at the time of disturbance as well as the successional effects induced by species replacements, further alter the microclimate regime of the snowfence areas.

In addition to enhanced snowpack, these sites have also been used in warming experiments. Small greenhouse plots have been placed within and adjacent to snowfence areas to observe the concurrent effects of warming on plant response. This latter experiment is part of the International Tundra Experiment (ITEX), which is replicated in over 20 circumpolar countries.

Investigators on these projects include Skip and Marilyn Walker, Ingrid Hanne, Buck Sanford and Tim Seastedt at the University of Colorado, and Jeff Welker, Jace Fannestock and Mike Jones at the University of Wyoming. Skip Walker and Jeff Welker are funded by NSF-NPP for much of the Toolik Lake work, and Marilyn Walker is supported by NSP-NPP to the ITEX program for the greenhouse studies.

Building on Biodiversity

Cross-Site Study Illuminates Strengths, Shortcomings in LTER Data

Robert B. Waide, Executive Director - NET

Although biodiversity is not officially recognized as one of the LTER core research areas, it is widely seen as an important focus of investigation throughout the Network. Studies of biodiversity are fundamental in understanding the ecological processes embodied by the five core areas. For this reason, site-level studies and experiments on the importance of biodiversity have always been common within the LTER Network. Recently the LTER Network has focused on developing a broader-scale understanding of the processes that lead to and maintain biodiversity and the influence that these processes have on ecosystem structure and function.

The VCR Coordinating Committee (CC) meeting in May 1995 provided a springboard for a discussion of the breadth of studies of biodiversity at LTER sites and the potential role that LTER could play in the field of biodiversity. Two activities were initiated at VCR, a survey of biodiversity research being conducted at LTER sites and planning for a workshop on biodiversity, which was held at the October 1995 CC meeting at the Cedar Creek LTER site. Here, representatives of each site presented results from the survey, which have been collected into an electronic document (with the help of John Porter of VCR). *(Please see http://atlantic.evsc. virginia.edu/LTER_biod/)*

A large number of potential studies were proposed at that meeting, but the issue that attracted the most interest was an examination of the relationship between productivity and species richness. There was general agreement that data available from LTER sites would be useful in examining this relationship. Mike Willig (LUQ) and I agreed to follow up this discussion with a proposal to the National Center for Ecological Analysis and Synthesis. This proposal, titled "An Analysis of the Relationship between Productivity and Diversity using Experimental Results from the LTER Network", led to a 10-day meeting at NCEAS in September, 1996. *Please see http://www. nceas. ucsb.edu/fmt/doc?/nceas-web/projects/95WAIDE1 for the full proposal.*

Representatives from 15 LTER sites and four other scientists gathered for that working group, to address these questions:

1. What is the shape of the relationship between productivity and diversity?
2. Is this relationship consistent among systems? Among trophic levels?
3. Do different mechanisms control biodiversity at different points along the productivity gradient?
4. What is the spatial scale of diversity in different systems?
5. Do these spatial patterns shift from low to high productivity?
6. How does diversity respond to manipulated shifts in productivity?
7. What kind of experiment would we design to reveal the mechanisms underlying the relationship between biodiversity and productivity?

Each participant was asked to provide three kinds of data: 1) data from individual LTER sites that described the relationship between diversity and productivity over the available range of spatial scales and productivities; 2) data from the literature that described the relationship between diversity and productivity over the full ranges of diversity and productivity that exist for each LTER biome worldwide; and 3) data on experimental manipulations of productivity at each LTER site and their subsequent effect on diversity.

We immediately encountered problems in comparison of data taken at different scales, which required us to develop new analytical approaches to address the core questions. After 10 days we were tantalizingly close to uncovering what we believed to be scale-dependent patterns in the relationship between productivity and species richness. Two subsequent meetings (April and October 1997) by a subset of the working group were required to refine the analysis and complete manuscripts.

Seven manuscripts resulting from the workshop have been submitted to *Ecology* as a Special Feature, and workshop participants are preparing a manuscript to be submitted to *Annual Review of Ecology and Systematics* (thanks to encouragement from Judy Meyer). This latter manuscript will expand on the literature search compiled for the workshop and incorporate studies that focus on diversity as a driver of productivity.

The remaining challenge is to build on the results of the workshop to develop future cross-site studies or experiments that will shed further light on the relationship between productivity and diversity. I encourage those of you who may be interested in this topic to contact me so that we can begin a threaded discussion group.

Participants of the NCEAS Working Group, Santa Barbara, September, 1996

- **Laura Gough** *Arctic LTER*
- **Glenn Patrick Juday** *Bonanza Creek LTER*
- **Clarence Lehman** *Cedar Creek LTER*
- **John C. Moore** *Short Grass Steppe LTER*
- **Bruce J. Wallace** *Coweeta LTER*
- **Glenn Motzkin** *Harvard Forest LTER*
- **Jeff Herrick** *Jornada LTER*
- **Katherine L. Gross** *Kellogg LTER*
- **Gary Mittelbach** *Kellogg LTER*
- **Scott L. Collins** *Konza Prairie LTER*
- **Robert B. Waide** *Luquillo LTER*
- **Michael R. Willig** *Luquillo LTER*
- **Stephen B. Cox***Luquillo LTER*
- **Lee Turner** *Niwot Ridge LTER*
- **Stanley I. Dodson** *North Temperate Lakes LTER*
- **Maria Vernet** *Palmer LTER*
- **Robert R. Parmenter** *Sevilleta LTER*
- **Linda K. Blum** *Virginia Coast Reserve LTER*
- **Mike Kaspari** *University of Oklahoma*
- **Samuel S. Scheiner** *Arizona State University West*
- **Craig W. Osenberg** *University of Florida*
- **Michael L. Rosenzweig** *University of Arizona*

ILTER Graduate Students Visit HJ Andrews Experimental Forest

First Stage in an International Student Exchange Program

Kristin Vanderbilt, Graduate Student, HJ Andrews Experimental Forest LTER

Twelve Asian ILTER guests visited the Andrews LTER Site August 15 through 19, 1997 with great success. The nine Taiwanese and three Japanese students (plus one professor from Taiwan) arrived on a Friday and spent Saturday and Sunday at the HJ Andrews Field Station and LTER site.

Over the weekend the group was joined by many of the graduate students who are conducting research there, each of whom gave a short presentation on their work. Topics included decomposition, soils, fluvial geomorphology, hydrology, coarse woody debris movement in streams, amphibians, fire ecology, gap dynamics, and biogeochemistry. The group asked many questions and showed great interest.

The group from Taiwan and Japan, and their American host, Kristin Vanderbilt (top row, third from right). *Photo courtesy Kristin Vanderbilt*

"I think the research here is much more applied and management oriented than what most of them are doing at their own LTER sites" says Kristin Vanderbilt, who organized many of the weekend activities and guest lectures. "Our guests showcased their own research projects for us on Sunday evening, each student giving a 10-minute slide show. They had obviously spent a lot of time preparing, and the presentations were well done. We certainly appreciated the effort they made to share their work and pictures of their countries with us."

The group traveled to Corvallis on Monday morning, where the ILTER students toured GIS and remote-sensing labs at the Forest Science Laboratory. Kristin had arranged for the President of OSU, Paul Risser, to greet them, and he shared his perspective on the LTER program. Other local leaders also were on hand to greet the students. The group had lunch in the sunny FSL courtyard, and were joined by several of the primary investigators on the LTER grant, and also many of the students who had given talks at the HJA. Following lunch, Fred Swanson and Mark Harmon spoke on the meaning of LTER.

The group traveled to the Wind River Forest Site in Washington on Monday afternoon and stayed at a rustic inn. At 6:30 the next morning, they were at the canopy crane site, ready for the first lift.

By 8 a.m., the entire group had enjoyed a ride and the Taiwanese students departed for the Portland airport. The Japanese students, who had a later flight time, stayed and hiked around the Wind River site for a few hours.

"It was a very busy few days, but it was quite enjoyable," Kristin says. "I think everyone involved benefited from this experience. We learned about the science and research communities in each other's countries, and about what motivates choices of research topics.

"This was a broadening experience, and I think we all came away with a different perspective on what LTER and ILTER has to offer. I think we all got a sense of being part of something much greater than the single site where we do our studies, and the possibility of conducting collaboratory research between U.S. sites and sites in Japan, Taiwan, or other countries seems far less remote."

Mark Meleason discusses his research–modeling the reansport of coarse woody debris in streams–to the group of visiting Asian LTER graduate students on the bank of Lookout Creek, H.J. Andrews Experimental Forest in Oregon, August 1997. *Photo by Kristin Vanderbilt*

LTER Forms New Education Committee

With great interest from a wide spectrum of individuals and institutions, LTER has formed a new Education Committee to lead K-12 educational involvement in LTER. The Committee's efforts are well supported by both the Division of Environmental Biology and Education and Human Resources at NSF, and the committee's membership reflects this interdisciplinary approach.

The Education Committee will have its first meeting in Fort Collins, concomitant with the spring Coordinating Committee meeting, where planning will take place for a larger meeting and, eventually, a national seminar to get the effort fully underway. Preliminary goals include:

- Developing a program(s) for K-12 teacher enhancement that involves a research experience component at LTER or similar sites (e.g., Biological Field Stations).
- Facilitating development of School LTER programs that can serve as satellite sites for standardized measurements and experiments as well as collaboration with the LTER Network.
- Facilitating the development of scientific tools and techniques for use by K-12 School LTER sites.
- Facilitating the use of internet and web sites to share School LTER data.
- Developing funding efforts for K-12 teacher programs and school participation.
- Developing publication materials (electronic and printed) on these LTER K-12 activities for outreach and promotion.
- Developing a minority-outreach effort.

Chairing the new committee is Diane Ebert-May, who is currently the director of the Science and Mathematics Learning Center at Northern Arizona University and faculty member in the Biology Department. Diane has a long history with LTER and has conducted her alpine plant ecology research at Niwot Ridge. She became deeply involved in science education upon accepting the position at NAU and is the chair-elect of the Education Section of ESA. Diane's recent biology education research appears in *Bioscience* (October 1997).

McMurdo Dry Valleys LTER Provides Hands-on Experience for Science Teachers

"Teachers need first hand experience in order to know what field research is about and understand how research questions are formed," says Barb Schulz, biology teacher at Lakeside High school in Washington.

Barb knows, now, after two weeks in the field at McMurdo Dry Valleys LTER site. "Reading papers, watching videos, or surfing the web will never substitute for hands-on collaboration as part of the research team in the field."

While most science teachers do their best to provide collaborative inquiry experiences for their students, many teachers have no mentored research experience of their own. Field science experience is usually not offered to undergraduate students, and many teachers begin their careers directly after student teaching.

"You have a large number of science teachers being asked to teach inquiry science with no valid knowledge of the practice in research fields," Schulz says.

The LTER field research experience provided an opportunity for Barb to go into the field and work at the LTER site in the dry valleys of the Antarctic mountains. "You can't even begin to imagine how much my students valued the fact that I was interested enough in science and research to actually go to the Antarctic to do research," Schulz says.

"They were impressed that I was selected as part of the research team, and it seemed as though they tried harder to impress me with their efforts and good quality work. And the fact that they had e-mail access to me and my research made the experience even more valid for them."

Barb made daily journal entries via electronic mail, and collaborated with her students during the semester before the trip. "They helped design the experimental parameters with which I worked as I investigated the feeding rates of rotifers living on the microbial mats along the perimeter of Lake Hoare."

Students in classrooms across the country also had access to Barb's journal notes on the web and could send e-mail to her with suggestions and participate in the actual research through the web site (http://www.tea.rice.edu).

"I received many questions and suggestions for things to try during my research while on the ice from students across the country. The really nice thing about my research project is that rotifers can be found almost anywhere around the world. Students can then collect some and try their own experiments."

Barb believes that LTER sites are of real interest to biology teachers for several reasons. "They represent sites where students can read about research being conducted in real time," she says. "Many of us have environmental research going on in our local communities. Watershed studies are really popular at this time." Barb says it is helpful to have data and research questions from all LTER sites readily available to students and would like to see more. "We have used info from several sites with both regular biology and advanced biology classes."

Please visit the website for more information about Teachers Experiencing Antarctica (http://tea.rice.edu/).

Barb Shulz prepares to take samples from Lake Hoare

The Santa Fe Institute's Complex Systems Summer School

Ned Gardiner, Coweeta LTER GIS Coordinator
University of Georgia

During the month of June 1997, the Santa Fe Institute (SFI) hosted 84 students, researchers, and professionals from around the world for the Tenth Annual Complex Systems Summer School. The SFI pursues interdisciplinary research leading to syntheses in science through on-site research, off-site support of established scholars, and undergraduate, graduate, and post-doctoral programs. Many of its past successes have been in computer science and simulation modeling. The summer program was designed to introduce students from diverse fields to the theories and applications of "complex systems", with specific examples drawn from mathematical, physical, and biological sciences. "Complex systems" loosely describes the set of real and simulated phenomena whose nonlinear, emergent properties are not predictable from the individual behaviors of constituent elements.

SFI invited two graduate students from the LTER network to attend the school in 1997: Heidi Dierssen of McMurdo Dry Valleys, Antarctica, and Ned Gardiner of Coweeta, North Carolina. Their participation represented a small aspect of the SFI's ecology program; it also provided LTER with increased access to the SFI. Experienced modelers, simulation novices, and pure empiricists will each find value in the summer program at SFI. Here's why.

The informal educational experience of the SFI Summer School is perhaps its greatest asset. Participants can interact with individuals from many disciplines, including physics, medicine, operations research, computer science, neurobiology, ecology, logic, philosophy, meteorology, and more. The socio-cultural diversity also makes for interesting interactions outside the classroom.

The curriculum includes: (1) eight week-long lecture series by visiting researchers; and (2) shorter series or one-time sessions by resident and visiting scholars. The week-long lectures included such diverse topics as geology and geomorphology, the human brain, a crash course in mathematics and statistics, complexity and evolution, genetic algorithms in computer science, and mathematical representations of two-dimensional forms. Brief discussions included spin glasses, computation theory and the evolution of language, demonstrations of nonlinearity from physics, modeling mass extinctions, and biogeography.

Lecturers shared hard-won insights into modeling real systems. The central problem of how and why to create a model presents the individual with immediate practical and epistemological hurdles. One must first determine the purpose of the simulation. For example, is the purpose (1) application or validation of established theory (First Principles), (2) developing general concepts from observed patterns (Synthesis), (3) or description (Hierarchy and Realism). Below are examples which demonstrate the interdependence of those goals and some procedural issues to address when formulating simulations.

First Principles

My first example demonstrates a rationale, based on established theory, to increase the number of parameters in a previously-accepted model in order to obtain accurate descriptions of observed behaviors. Geologist Susan Kieffer has explored, tested, and applied well-established physical theories and principals from fluid mechanics in her study of supercritical flow in constricted rivers, geysers, volcanoes, and eruptions on other planets. Her research has required her to revisit the basic assumptions made by hydraulicists and aerodynamicists when representing their systems mathematically. In hydraulics, it is common to ignore the effects of the compressibility of water. In aeronautics, one ignores the effects of gravity. These simplifications are quantitatively justified in light of the reasonable approximations they have yielded in natural, experimental, and applied settings (Kieffer 1989). Mach and Froude numbers describe the ratio of gases and fluids, respectively, to their critical velocities. If a medium exceeds its own critical velocity, then supercritical flow may arise, characterized by

... a complicated flow field consisting of oblique and normal shocks and mixed regions of subsonic and supersonic flow... within the jet. Because the decelerating waves are nonlinear, the jet 'overshoots' ambient conditions, and multiple shock and rarefaction waves are required to achieve the pressure balance. (Kieffer 1989)

In her model of standing waves in the Colorado River, Kieffer showed that one must consider both gravity and compressibility in applications involving super-critical flow. Kieffer further argued that eruptions of Old Faithful geyser and the Mt. St. Helens blast were both super-critical and that models of their behavior must consider compressibility and gravity. More generally, Kieffer demonstrated that unpredictable behaviors emerge when otherwise well-understood general theories are

SFI Summer Research Undergraduates (REUs) in the SFI courtyard against a slate wall. For more information on the REU program, please see http://www.santafe.edu/sfi/education/REU.html

Photo by Laurie Smith

applied to real phenomena.

Synthesis

The second example treats modeling as a tool for synthesis and theory building. Borrowing from electrical engineering, Frank Hoppensteadt has developed an operationally simple, but realistic, representation of the behaviors of interacting neurons, namely the Voltage-Controlled Oscillating Network (VCON) model (Hoppensteadt 1997). Hoppensteadt was a strong advocate of mathematically representing ordinary language models; such "canonical models" (his definition) characteristically describe components throughout a complex system which share a similar function or definition. In this sense, he argued, mathematical representations are meant to facilitate a scientist's intuition regarding system behavior. Concurring with Hoppensteadt's approach, Shepherd suggested that modeling focus on realistic, observable suppositions.

In practice this means the relevance of a model for a real biological system depends on the extent to which its subcomponents are not arbitrary, but represent properties that can be tested in the biological system (Shepherd 1990). Shepherd discussed behavior within the nervous system as the expression of emergent properties by "functional units", or hierarchical levels of biological organization (Shepherd et al. 1990; Shepherd 1990). Hierarchy theory, familiar to ecologists, is a convenient simplification and abstraction to the scientist. Neurobiologists have described the nervous system in reasonable detail at many of these abstracted levels. At the cellular and subcellular levels, for example, we now understand firing patterns, ionization-deionization, inhibition, and excitatory feedbacks in neuronal systems. Many have studied brain function at broader physiological hierarchies which may span laterally-connected component systems. At that hierarchical level, one infers the functional roles of distinct areas of the brain. Syntheses in neuroscience have been born from merging reductionist and hierarchical approaches to modeling. The former has provided a mechanistic description of processes; the latter allowed researchers to focus on particular behaviors or properties which emerge out of the complex interactions among entire networks of cells, regions of the brain, and interactions with other organ systems.

Hierarchy and Realism

The third example treats the case many ecologists face: observed behavior at a given hierarchical level may not be supportable by understanding each of the components contributing to the observed behavior. In this case, geomorphologist Brad Werner argued for descriptive accuracy at one hierarchical level over realism at a lower one. For example, it is nonsensical to model the angular momentum of individual grains of sand when studying dune formation over ranges spanning several kilometers. Because realistic modeling of natural systems exceeds computational limitations, one must be comfortable at some point abstracting and describing emergent behavior *per se*, without complete understanding of the physical properties underlying the behavior. Werner presented several geomorphological models for rivers, hillslopes, periglacial, and aeolian landforms. Primarily, he reasoned, the researcher should observe the system of interest in close detail. Because geomorphological systems are driven by processes operating across many scales of time and space, he suggested that one formulate *a priori* the functional relationship between dominant variables and the pattern of interest. To do so, one must determine the appropriate spatial and temporal hierarchy of concern. Next, construct a simple mathematical model to explore whether or not the chosen approach would yield realistic results. By this method, modeling and field observations go hand in hand as hypotheses are developed and refined.

Whether your research is purely theoretical or entirely empirical, modeling can be used (1) to synthesize knowledge and (2) to compare expectations, simulation results, and observable phenomena. The necessary investment of effort by ecologists is simple to justify: simulation offers insights into patterns and behavior which would be experimentally elusive, at the very least. Further, modeling is the principal avenue by which ecologists may draw from parallel research in complex systems by physicists, economists, and computer scientists. If describing complex systems is your goal, I recommend the Santa Fe Institute as host to a rich treasure of modeling examples and tools.

The Santa Fe Institute is a private, non-profit, multidisciplinary research and education center, founded in 1984. SFI catalyzes new collaborative, multidisciplinary projects that break down the barriers between the traditional disciplines, spreading ideas and methodologies among diverse individuals and encouraging the practical applications of these results.

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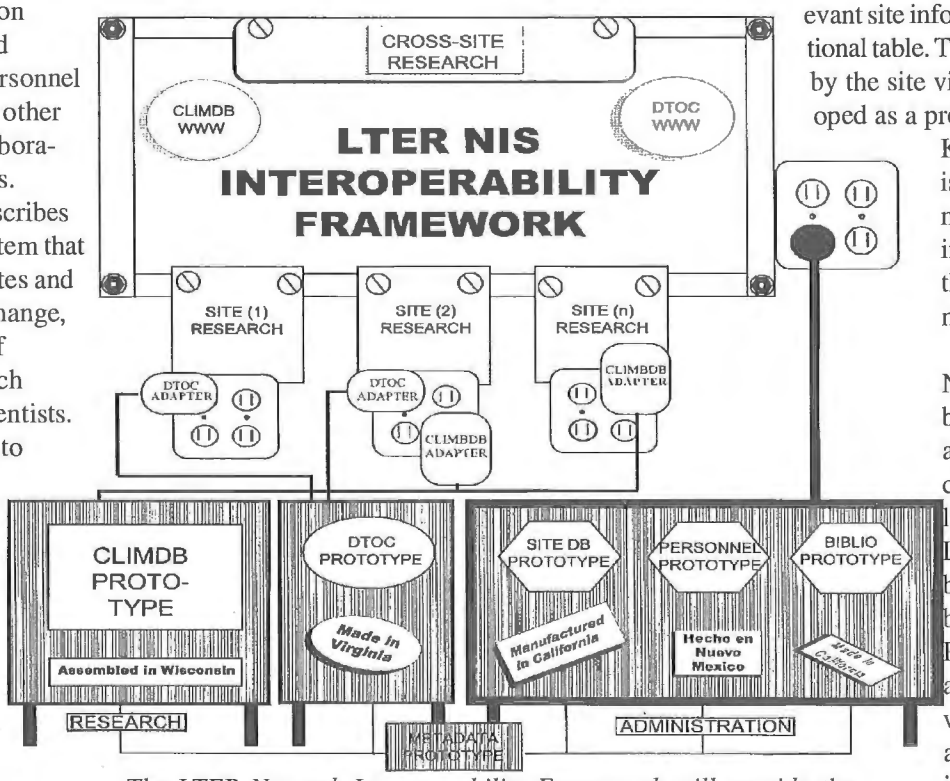
INFORMATION MANAGEMENT

Using the World Wide Web to Advance Data Management in LTER

James Brunt—Associate Director for Information Management

The latest developments in information management in LTER take advantage of advances in web-based database interfaces to provide access to network-wide data sets via a single point of entry. Following the LTER network information system (NIS) plan (LTER *Network Newsletter*, Spring/Summer 1996), a number of prototypes were developed addressing different data types found in the network. These include the climate databases (project name: CLIMDB), the site description information (SITEDB), a basic data catalog (DTOC), and the personnel database (PERSDB). In addition to these developments, LTER Network information managers (IMs) and Network Office personnel continue to pursue other activities and collaborations in informatics.

The NIS plan describes an information system that seamlessly facilitates and integrates data exchange, with the mission of meeting the research needs of LTER scientists. The strategy being to design and develop a distributed, LTER-wide information system using a modular approach while maintaining and building on present functionality. An NIS working group is in the process of evaluating the prototype modules (described in detail below). These prototypes each use a different database/web technology and are being developed and tested at LTER sites prior to being installed at the Network Office. This work will lead to the development of the LTER NIS interoperability framework–a set of specifications that describe the interactions of discrete units of the system, into which additional, future modules can be added.



The LTER Network Interoperability Framework will provide the specifications for connecting LTER site information modules with the LTER Network Information System. As envisioned, the system is completely modular allowing for databases and sites, to be plugged-in at any time.

CLIMDB: The climate database prototype is an interactive, web-based, interface to standardized LTER Network climate data. To develop CLIMDB, LTER IMs (Don Henshaw (AND), Robin Stubbs and Barbara Benson (NTL), Karen Baker (PAL), Darrell Blodgett (BNZ), and John Porter (VCR)) worked with LTER climate researchers to apply current database technology to the climate data standards. Plans are now in progress to migrate CLIMDB, which is currently in an ORACLE database being supported by NTL, to MS SQL at the Network Office.

DTOC: The Data Table of Contents is an automated, web-based data catalog for LTER site data sets. It contains a streamlined, standardized metadata set related to each research data set. This information is "harvested" from the site information systems, using similar conceptual methods to CLIMDB and provides the groundwork for the implementation of a cross-site, standardized metadata model that would be the backbone of the NIS interoperability framework. LTER IMs John Porter, Mike Hartman (NWT), and Chris Wasser (SGS) developed DTOC which is being moved from the VCR site information system to the Network Office.

SITEDB: The site description database project adds another level of metadata compliance to the NIS. This work, prompted both from a scientific and an administrative need for detailed, descriptive information about each LTER site, presents standardized web page views for each site in addition to having all the relevant site information available in a single relational table. This information can be maintained by the site via a web-based interface. Developed as a prototype by Darrell Blodgett, and Karen Baker, the implementation is in miniSQL at BNZ. Development and potential for integration into the NIS will be considered at the next annual data manager's meeting in Baltimore.

PERSDB: The LTER Network personnel database has been migrated to MS SQL from an old ingres database to more closely control entries and mail lists, and for integration with the LTER NIS. This database can now be updated by the sites via web-based interface implemented in PERL. Darrell Blodgett (BNZ) and Peter McCartney (CAP) are working with James Brunt (NET) and the Network office staff to improve the capabilities.

Other Information Management Activities: LTER IMs are actively cooperating with several national agency/interagency efforts to facilitate interoperability between the LTER Network and the greater scientific community. An important effort this year was the U.S. National Committee for CODATA. Susan Stafford (AND) and John Porter participated in the 1997 CODATA meeting which focused on managing and integrating scientific data across diverse systems. Stafford gave an invited paper on "Long-Term Ecological Research – The Challenge of Keeping and Remembering".

LTER IMs participated in the ESA Long-Term Studies Section/Organization of Biological Field Stations (OBFS) workshop on Information Management prior to the 1997 ESA meeting. Those presenting were John Porter, Susan Stafford, Karen Baker, John

Briggs (KNZ), Barbara Benson, Doug Moore (SEV), Rudolf Nottrott (NCEAS) and Don Henshaw. The workshop was organized by long-time colleague William K. Michener (Joseph W. Jones Ecological Research Center), James Gosz (SEV), Art Mckee (AND/OBFS), and John Porter, and will result in a timely and informative publication.

The LTER Data Management steering committee (Datatask) held a planning meeting with the LTER NIS working group and computer scientists from NACSE (Northwest Alliance for Computer Science and Engineering) at Oregon State University in February. NACSE scientists are interested in furthering collaboration on the LTER NIS "centributed" database concepts. The groups have agreed to collaborate on interfaces to LTER data. Work in progress will apply a NACSE software tool, "hyperSQL", to CLIMDB giving it recursive query capabilities. LTER IM participants included Darrell Blodgett, Karen Baker, James Brunt (NET), Mike Hartman, Don Henshaw, John Porter, Susan Stafford, Robin Stubbs (NTL), and Chris Wasser.

LTER IMs Don Henshaw and John Porter participated in the XROOTS workshop in March, along with a larger group of root scientists. The workshop focused on testing and using innovative software tools and database structures to integrate different data sources relevant to the study of roots. Caroline Bledsoe led the workshop, with technical wizardry provided by Jordan Hastings, former IM at the MCM. The software facilitated two-way exchanges between spreadsheets (a favored analytical tool in the root community) and an underlying database. Additional information is available at http://www.xroots.org

LTER Network Office personnel and Network IMs are planning a Latin American Information Management Meeting in Venezuela as part of the regional ILTER meeting to be held there in June. This meeting will bring together data managers from LTER sites all over Latin America and will lay the groundwork for developing international standards for data exchange and interoperability and will provide exchange of information that will be valuable to the developing ILTER networks. This workshop is the culmination of the ILTER meeting in Brazil last year and a planning meeting that was held at Sevilleta in December hosted by James Brunt, Eda Melendez (LUQ), and Gregg Mackeigan (SEV).

Please see http://www.lternet.edu/ilter/latin_america/im

All these advances were made possible both through financial support of the Network Office for work of the LTER Data Management and Climate Committees and by direct participation of NET and site personnel. The NIS prototypes can be reached via http://www.lternet.edu/nis.

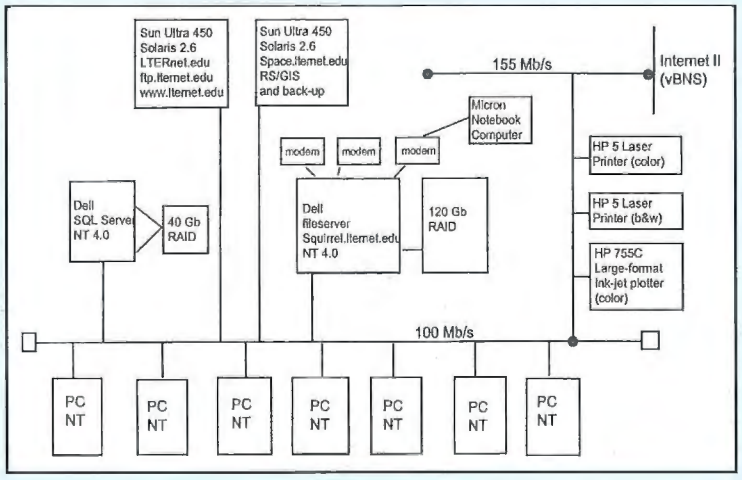
EQUIPMENT CHECK
A Tour of the Network Office Hardware

John Vande Castle—Associate Director for Technology

The backbone of the NIS is the Network Office Data Center. Recently installed scalable servers and increased network bandwidth will better serve the LTER Network and ecological community. Two Sun 450 Enterprise servers and two Dell Poweredge servers are the primary computers serving LTERNET. The combination of Sun Solaris operating system on the UltraSparc platform and the Windows NT operating system on the Intel platform allows for maximum flexibility in incorporating new developments and technology, each with strengths that compliment the other.

Unix Servers The first is a Sun Ultra-Enterprise 450 server with 4-300mhz UltraSPARC cpu's, 1gb memory, 20gb local disk, tape backup including DDS3-12/24 gb, redundant power and uninterruptable power supply (UPS). A second, identical machine is used as a development/processing/GIS and backup server.

Windows NT Servers/Workstations A Dell Poweredge 4200 server running NT 4.0 Server and MS-SQL server supports NET database maintainence and is the "domain controller" for LTER. This includes LTER Email forwarding/group database lists used by "lternet". The system has 2-300mhz Pentium II, 256mb memory, DDS3 tape backup, a 40gb RAID5 disk (six 9-gb disks), redundant power supplies and UPS. A second Dell Poweredge 2200 server, configured similarly, provides backup domain/sql services, NET remote dial-up access (RAS) using 3-USR "v.everything" modems, and is also the primary LTER file server. It uses a 120gb RAID5 disk array (16 9-gb disks in a single enclosure), shared to the Unix workstations using INTEGRAPH's "NFS Diskshare". Office workstations (Dell and Micron notebooks) are 200-300mhz Pentium II systems running NT 4.0 Workstation, and dedicated 100 BT connection to the UNM Internet backbone (and eventually to the vBNS).



Computer Peripherals HP Deskjets (870cxi) are used in most offices with an HP 5(b/w), HP Color Laserjet 5, and HP 755CM wide-format printer/plotter all shared via HP "Jetdirect" cards. Publication work is also supported by an HP flatbed scanner, Polaroid 7000 slide/film recorder and Polaroid Sprintscan 35 slide scanner. A 4X CD writer is used for data backup and distribution. A Kodak DC50 digital still, JVC-DV1 digital video and Pentax 35mm cameras are used for photography. An Epson 5000 video projector is used for computer display.

Software Solaris 2.6 is running as an operating system on the Sun Unix platforms, with MS NT 4 Server/Workstation on the PC's. The complete MS Office suite (and Backoffice) is used for general work, including Outlook for Calendar/Email. Pagemaker and Photoshop are used for publications. Unix and NT 4.0 versions of Erdas/Imagine and Arc/Info is used for GIS support. MS SQL server is used for databases, with plans to implement Unix Oracle.

Most of the funding for the LTER Network Office (NET) hardware is provided by a grant from the National Science Foundation, Division of Environmental Biology, as well as other divisions of NSF, and cooperative agreement with the University of New Mexico Department of Biology. Shared costs with UNM, including the Sevilleta LTER program have resulted in substantial savings. Educational programs of the various vendors have also resulted in substantial savings. Product mentions are not endorsments, but the result of extensive research, and based on budget, past experience and future plans.

International Networks Gaining Momentum

Christine French—International Programs

This has been an exciting year for international expansion of the LTER network model, bringing with it increased opportunities for US LTER scientists and students to engage in rewarding international collaborations. Korea joined the Asian networks, and Poland has been approved for an LTER Network. The Australian LTER effort is back on line, and five national networks in Latin America have appeared and are moving on a fast track toward a regional network. U.S. Network Office staff have begun or continued interactions to assist parties interested in national network development in Portugal, Morocco, South Africa, and the Ukraine, as well as Latin America. The European Science Foundation (ESF) is exploring the possible interest of European research groups in forming a regional network in Western Europe.

One or more of the Network Office staff as well as representatives of several sites participated in workshops and meetings all over the world to discuss and encourage LTER developments. These included regional meetings in Brazil, and Japan, and national meetings in Canada, Chile, Mexico, Poland, Bolivia, South Africa, and Venezuela. James Brunt and others organized a planning workshop of Latin American data managers held at the Sevilleta field station in December 1997. The U.S. LTER Network was also represented at a number of international meetings held by GCTE and GTOS. Jim Gosz made an invited presentation on LTER at the February 1998 meeting of the Life and Environmental Science Committee of the ESF.

In November 1996, ILTER held a multi-site meeting hosted by both the Smithsonian Tropical Research Institute in Panama and by the Organization for Tropical Studies at its La Selva field station in Costa Rica. The momentum from that meeting carried forward to various national and regional developments within Latin America.

The Taiwanese LTER Network hosted the annual ILTER Network meeting in November 1997. Participants from 18 countries accepted the proposal by Jim Gosz, ILTER Network chair, that the ILTER Network participate in GTOS (see article, facing page). Nancy Grimm, lead PI of the new Central Arizona – Phoenix LTER site made a presentation on urban LTER to the ILTER audience, at the request of some of the Asian representatives from heavily urban regions.

Considering the explosive growth of national and regional ILTER networks since the inaugural discussions at the 1993 All Scientists meeting, ILTER members agreed to produce a new book describing the status of the ILTER community.

Developments in Latin America are particularly noteworthy. In the past year, formal national networks have been designed and established by scientists in Brazil, Costa Rica, Uruguay and Venezuela, with the encouragement and funding of national sponsors. Mexican scientists have held planning meetings and nationwide consultations to develop a network structure and process that suits their national interests. Preliminary discussions at the 1996 ILTER meeting in Panama led to a regional meeting in Brazil in 1997 attended by scientists from six countries who produced a number of recommendations for the formation of a Latin American network. Plans and needs for this regional network will be discussed further at the next Latin American meeting, to be hosted by Venezuela in June 1998. A major theme of the meeting will be information management capabilities, infrastructure and standards for the Latin American region, based on planning documents prepared at a working group meeting hosted by the U.S. Network Office and attended by Eda Melendez of the Luquillo LTER site. Several data managers from the U.S. LTER network will participate in the meeting in Venezuela.

A promising new ILTER activity involving students began in 1997 (see article page 18). With encouragement and funding from NSF's International Programs Division, the Network Office arranged visits to several U.S. LTER sites by a group of Asian graduate students and young researchers. A reciprocal visit by U.S. students to Asian sites has been organized for June 1998. It is hoped that graduate student visits can be arranged to other parts of the world to introduce U.S. students to more sites, people and opportunities for future international research collaborations.

U.S. LTER involvement in most of the above activities was greatly facilitated by NSF's generosity in both funding the associated costs, and augmenting the staff of the Network Office for this purpose. NSF has assigned Christine French to work at the Network Office specifically to develop and implement a variety of international activities (cfrench@lternet.edu).

A highlight of the coming year is the 1998 ILTER meeting to be held in conjunction with INTECOL, for which the U.S. LTER Network has organized a day and a half symposium (see http://www.lternet.edu/ilter/)

The establishment of LTER networks in so many countries expands opportunities for cross-site studies and other cooperativer ecological research, enhancing the outlook for valuable scientific contributions that long term research can make.

Above: Foz de Iguaçu, Brazil, site of the Latin American Regional ILTER meeting, June 1997. Left: Participants line up for a group shot. Photos by Christine French

Gaining a Global Perspective

Linking GTOS and the LTER Network

James Gosz—Chair, LTER Network Coordinating Committee

An exciting new opportunity for interactivity and development of long-term research on a global scale has become available through the Global Terrestrial Observation System (GTOS) and the Global Terrestrial Network (GT-Net). The objectives of GT-Net and ILTER are complementary and an interaction would be beneficial to both.

Of prime interest to all countries is the participation in the GT-Net demonstration project involving the MODIS satellite imagery that will produce estimates of net primary production and net ecosystem production. Several LTER sites have been involved with this effort.

The MODIS demonstration project would provide site-specific data on; 1) vegetation cover, 2) Leaf Area Index, 3) soils, 4) climate, and measurements of actual net primary production and flux measurements to validate the imagery estimates of these factors. It is recognized that not all international sites may be able to supply all of these data sets, especially in the developing regions.

The LTER Coordinating Committee recommended that the Network Office develop an outline for scientific and technological support to the GTOS Secretariat for work on terrestrial measurements and informatics, to be funded by the GTOS Secretariat.

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.

The Global Terrestrial Observing System (GTOS) was established in January 1996 by five co-sponsoring organizations:

- United Nations Environment Program (UNEP)
- Food and Agriculture Organization of the United Nations (FAO)
- United Nations Educational, Scientific and Cultural Organization (UNESCO)
- World Meteorological Organization (WMO)
- International Council of Scientific Unions (ICSU)

Together with similar global observing systems for climate (GCOS) and the oceans (GOOS), GTOS has been created in response to international calls for a deeper understanding of global change in the Earth System.

To meet its objectives, GTOS will foster an integrated, equitable partnership of a wide variety of data providers and users that meets both the short-term development needs of national governments and the longer-term needs of the global change research community. High priority will be given to the needs of developing countries, which will be among GTOS' most important data users.

GTOS is envisaged as a "partnership of partnerships", formed largely by linking existing monitoring sites and networks and present and planned satellite remote sensing systems. GTOS will provide the framework from which data from earth-observing satellites and environmental databases can be integrated with *in situ* observations.

More information about GTOS can be found at the website:
http://www.fao.org/GTOS

TERMS OF REFERENCE

Under the general direction of James Gosz, Chair of the GTOS Steering Committee, the U.S. Long Term Ecological Research (LTER) Network Office (NET) will provide work toward the development and implementation of a global network of terrestrial monitoring sites (GT-Net). The components described below will be integrated into ongoing International LTER (ILTER) research support activities at NET.

1. Develop a web site for GT-Net at the ILTER Network Office in Albuquerque, New Mexico, in cooperation with the Secretariat in Rome. This web site will store and disseminate policies on data management, as well as dissemination and documentation of methods from among the members of GT-Net.

2. Develop a GTOS metadata policy for the release and exchange of data related to terrestrial measurements in consultation with network and site participants

3. Develop, implement, and maintain a global database of metadata about the networks and sites participating in GT-Net, based on the TEMS database, and make the database available on the GT-Net web site described above. Updates and new entries would also be done via a web-interface.

4.Provide computer support for the assembly and exchange of data to facilitate the work of the GT-Net, as agreed on by a case by case basis. NET Office computer servers and analytical software will be made available as needed to support these efforts. The collaboration that the NET Office has with the San Diego SuperComputer Center would facilitate the assembly, storage and exchange of data.

5. Develop a personnel database and e-mail list for GT-Net that can be maintained, and searched via a web-based interface.

6. Support the implementation of demonstration projects and other GT-Net activities. The MODIS demonstration project is the first activity and NET will be responsible for reviewing existing data, collecting data from sites and providing software, imagery and help to sites that participate. This work will be based on work already completed for climate-related terrestrial measurements (TOPC).

7. Develop a mechanism for documenting the various methods used for measuring or calculating terrestrial variables. Make the mechanism available for use by the members of GT-Net as well as other terrestrial monitoring networks and sites. Develop and maintain a library of methods that are used by sites and networks and provide a reference list of these methods on the web; For key variables undertake efforts to harmonize measurement methodologies or other wise assure compatibility of data.

Development and implementation will be done with existing LTER Network staff under the direction of the Associate Director for Information Management, James W. Brunt, and the Associate Director for Technological Advancement, John Vande Castle.These components will be integrated along with GT-NET and ILTER activities, and will be supported on Network Office computer equipment. The web site and database will be produced in standard format that can be easily transferred to other computer equipment in other GT-Net locations.

Publications

Recent Publications from LTER Resesarchers

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Calendar *Coming Events of Interest to the LTER Community*

Please Refer to the LTER Website for More Information: http://www.lternet.edu

April 22-23
Coordinating Committee Meeting
SGS LTER Ft Collins, CO
Check the LTER Website for complete details

May 31 - June 3
Latin American Regional LTER meeting, with special theme of information management
Puerto Ordaz, Venezuela

June 6-26
U.S. LTER Graduate Students visit to LTER sites in Taiwan and Peoples Republic of China

June 7-12
ASLO/ESA Conference "The Land-Water Interface: Science for a Sustainable Biosphere" St Louis, MO

July 1
Publication of the New ILTER Network Book, describing status of LTER networks across the globe

***July** 19-25*
INTECOL Congress
Florence, Italy

July 21-22
ILTER Symposium
Florence, Italy

July 26
(tentative) ILTER annual business meeting
Florence, Italy

July 31-August 1
Information Managers Meeting
Balitmore, MD

August 2
LTER Special Session
"Long Term Ecological Research: The New Urban Focus" jointly sponsored with the Ecological Society of America
Baltimore, MD

August 2-6
Annual ESA Meeting—held jointly with American Institute of Biological Sciences
Baltimore, MD

August 31-September 4
Scientific Conference on Antarctic Research (SCAR)
Christchurch, New Zealand (Long Term Ecological Research Session)

September 7-11
International Association of Landscape Ecology.
Long Term Studies Session.
Prague, Czech Republic

September 8-10
International Symposium on Applications of LTER, sponsored by the Chinese LTER Network.
Beijing, China

October 15-18
Coordinating Committee Meeting
"The interaction of natural and socialeconomic processess in controling long term human interactions with the landscape"
NTL LTER Madison, WI
Check the LTER Website for complete details

November 1-6
North American Symposium; "Toward a unified framework for inventorying and monitoring forest ecosystem resources"
Guadalajara, Jalisco, Mexico.

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