Year 1 Progress Report

Central Arizona-Phoenix LTER (# DEB-9714833)
Land-use change and ecological processes in an urban ecosystem of the Sonoran Desert

I. General Information

The CAP LTER is a multifaceted project aimed at answering the general question, "How does the pattern of development of the city alter ecological conditions of the city and its surrounding environment, and vice versa?" Central to answering this question is understanding how land use change is driven by societal decisions, how this alters ecological pattern and process, and how changes in ecological conditions further influence human decision making. The overall approach will incorporate a hierarchical, patch dynamics model for the metropolis as an ecosystem, but studies and models at smaller spatial scales and lower levels of organization are integral to this work.

The project began in November 1997. During the first 9 months of its existence, we took multiple tacks to initiating long term studies. Several initial projects were selected and started in early spring 1999, falling under the general categories of: 1) data synthesis (amassing, checking, formatting, and using existing data from municipalities, agencies, and governmental and non-governmental organizations); 2) pilot projects for long term monitoring (working out the details of methods, site selection, statistical characteristics of data sets, etc. for designing efficient and appropriate long term monitoring projects); 3) experiments (both unique opportunities for one-time experiments and repeat surveys or experiments to compare with studies done 10 or 20 years ago); 4) developing frameworks for modeling structure and patch topology.

Considerable effort went into ensuring open lines of communication and achieving maximal input from the large number of participating core scientists (>50). We accomplished this by establishing an All Scientists Committee, which meets monthly in a forum focusing on the science (open to any interested parties), a Management Leadership Council (consisting of leaders of the 11 core-area teams: Database, Modeling, Land Use Change, Human-Environment Feedbacks, Primary Production, Populations, Organic Matter, Material Transport & Transformation, Disturbance, Geosciences & Engineering, and K-12/Informal Science Education), which met approximately monthly during the first 6 months, and an Executive Committee, which met weekly through the establishment of the initial projects. At this writing, 43 faculty, 6 outside scientists (e.g., from USGS), 4 post-doctoral scholars, 32 graduate students, and 10 undergraduates (including REU students) have been or currently are actively involved in 26 CAP LTER initial projects. Project descriptions can be viewed on the CAP LTER web site (http://caplter.asu.edu/).

II. Highlights of Research Accomplishments and Plans for Year 2

Our activities in the first 9 months have centered on acquiring requisite information for setting up a rational, spatially based monitoring program. We have acquired existing data to get a sense of the overall structure of the CAP study area, including historic spatial patterns, in order to define patch topology and long term monitoring schemes, and to construct initial materials budgets for the whole system. Several projects are intended to work out the details and methods to be used in future monitoring projects (urban water chemistry, primary production, organic matter storage and soil respiration, arthropod sampling). Some initial projects are intended to investigate

underlying dynamics that are likely to be key drivers of ecosystem processes and human-ecosystem interaction (e.g., describing urban growth patterns, uncovering the relationships between land cover and land use, defining the economic value of open space). Modeling activities (regimes of channel change over the past 100 years, materials mass balance, hierarchical patch dynamics model, and a statistical analysis of sampling strategies required to capture spatial patterns) have begun in concert with data synthesis and new data acquisition activities. Finally, we have capitalized on several unique opportunities to revisit studies done decades ago, or to take advantage of dramatic changes in land use (new housing developments, establishment of a "Town Lake" in the now-dry Salt River bed). The following narrative is not intended to summarize all of the projects initiated during 1998, but to highlight some key areas and outline plans for year 2.

Remote sensing and patch topology: The definition of patch types and their distribution in the CAP-LTER area is highly variable depending on individual project goals. Further, "patches" in a remote sensing context are limited to the resolution of the dataset being studied (in this case, 30 meters for Landsat TM) and may change with time. Therefore, this project involves completion of a land cover map, derived from remotely sensed data, for the region. Classified land cover information forms the baseline dataset for ecological, geological, and geographic models of spatial and temporal change used to investigate the urban environment.

Geosciences and Engineering: Three main projects in the Geosciences and Engineering area (supported by the Geosciences and Engineering Supplement) are studies of quaternary geomorphology of the Phoenix basin, century-scale channel change in the Salt River, and a pilot project on the Tempe Town Lake/Rio Salado. In the quaternary geomorphology project, landscape development in the CAP LTER region is studied by compiling existing information and by applying traditional and new geological mapping techniques (for example, cosmogenic dating is used to establish numerical ages for incision and aggradation events). Landscape development over the last million years has determined the distribution of materials at the surface and in the shallow subsurface and has controlled the topographic form of the region. These effects define the spatial and temporal context for the ecological relationships that we study. The recent geologic history of the CAP LTER region has been dominated by the activity of the rivers that flow through it. The Gila River and its important tributaries -- the Salt, Hassayampa, and Agua Fria Rivers -- has existed as a major tributary of the Colorado River for the past 8-9 million years. Alluvial deposits filled the Basin floor for much of the early and middle Pleistocene. This was followed in the late Pleistocene and early Holocene by a period of downcutting during which the drainages removed some earlier alluvial material and formed a series of inset terraces. This alternation of aggradation and entrenchment was apparently driven by climatically correlated changes in surface transport rates and sediment supply.

Century-scale channel change project: The main research questions addressed in this investigation of the Salt and Gila Rivers in Maricopa County, Arizona, are what are the spatial and temporal characteristics of physical change in the channels of the rivers, and what explains these changes? The basic approach of the research is to use maps as well as historical aerial and ground photography to build a record of changes in channel form and location over the past century and a half, and then to use GIS techniques to analyze the spatial characteristics of the changes. Causal mechanisms will be linked to the observed changes by correlating the history of potential causes such as dam closure, land use changes, engineering structures, and hydroclimatic changes with resulting channel adjustments such as changes in size, location, pattern, sediment characteristics, and cross-sectional shape. Major findings to date are as follows: 1) Large scale changes in channel location and configuration are the result of episodic floods in the system. Large scale change is event driven, the product of these events that occur on average only once every five or ten years.

Little change occurs as a result of fluvial processes between floods. 2) Local scale changes in channel location and configuration are the result of direct human activities, especially sand and gravel and mining. Some reaches of the river have most of their geomorphology determined by mining related processes. 3) Timing of changes from mining for any particular reach of the river is related to the position of the reach with respect to the urban fringe. Because mining is most intense near the fringe in order to supply building materials as close to the point of consumption as possible, mining activity is most intense in those reaches at the fringe. During the fall 1997-summer 1998 period, GIS investigation based on maps and aerial photography was the primary focus, and this effort is now nearing completion. During the fall 1998-summer 1999 period, relocation of historical ground photographic sites, repeat photography, and hydraulic analysis will be the focus.

Rio Salado/Tempe Town Lake Project: This will be a focus of research (and attempts to secure additional funding) during Year 2. The city of Tempe is constructing a large lake by installing collapsible dams in a 3-km stretch of the Salt River bed. Filling is scheduled for spring 1999. We view this project as an excellent microcosm of the entire CAP LTER, since the "urban experiment" represented by the establishment of this ecosystem will involve all of the components envisioned in our conceptual scheme of urban ecosystems: land use change, change in ecological conditions, human feedbacks, and geophysical and societal constraints and drivers.

Land-use change: One initial project of the land-use change team focuses on the morphology of the urban fringe. In addition, this team is involved in development of the CAP LTER GIS database through their collaboration with the Maricopa Association of Governments.

The urban fringe project tracks the spatial distribution of the expanding urban fringe between 1990 and 1997. A clear interpretation of data analyzed thus far is that every location is changing in metropolitan Phoenix. A donut spatial structure results. While housing loss occurs in central locations, net residential densities increase at the urban fringe. Also under development is a study of urban fringe morphology using sequential maps of housing completions between 1990 and 1997. An index of the location of the urban fringe is being developed; with it, studies tracking the change in urban fringe location over time can be linked to studies of ecological pattern and process in newly established housing developments.

Primary production and organic matter: We initiated pilot projects in spring 1998 on both primary production and organic matter (soil respiration) that utilized the same design and the same sites. The design consists of 6 treatments with 3 replicates each for a total of 18 field sites. The treatments are (1) undisurbed Sonoran desert, (2) agricultural field (alfalfa), (3) xeriscape residential yard developed from desert, (4) xeriscape residential yard developed from agricultural field, (5) mesiscape residential yard developed from desert, (6) mesiscape residential yard developed from agricultural field. Air temperatures are expected to be lower in a turf (mesiscape) than in the crushed granite (xeriscape), and lower above concrete than above asphalt pavement. Greater plant growth and productivity are expected in the cooler cover types, and should be correlated with lower air temperatures. Finally, soil respiration is measured monthly at each site. When 6-10 months of data are in hand for this project, we will use the results to design long-term monitoring studies of primary production and soil respiration.

Populations: Our monitoring of populations will focus on 3 groups: vascular plants, arthropods, and birds. Thus, we have initiated pilot studies of these groups, taking advantage of existing datasets as well as the data-gathering potential of K-12 classes and the public.

Work on vascular plants includes development of a Phoenix flora data base (to be available

on the web this fall), and a re-survey of plant communities in desert remnant patches that were described 20 y ago. In addition, a graduate student project comparing vertebrate communities in the "urban islands" of desert remnant buttes with buttes outside the metropolitan boundary has been supported by the CAP LTER. Four plant community surveys have been completed. Continuing efforts have two goals: (1) creation of a preliminary classification of desert plant communities, and (2) correlate this classification with remote sensing information, and (3) coordinate this project with the education project so as to enlist schools in extending sampling efforts.

The primary goal of the arthropod project is to establish long-term monitoring of populations and communities of arthropods (insects and arachnids), within the context of the patch mosaic model. Arthropods are logical choices for monitoring because 1) they are diverse and thus provide a fairly quick picture of biological diversity 2) they respond quickly habitat/disturbance/soil/vegetation changes and hence fit well with monitoring by other groups 3) they are fairly easy to collect 4) they represent a spectrum of feeding (trophic) levels, including decomposers, herbivores, predators, and parasites and 5) they are important sociological, agronomical, economical and agricultural components of human altered habitats. Although several sampling methods will eventually be used to collect arthropods, we settled on pitfall traps for ground/litter insects since they are relatively low tech and easy to use. We have selected four representative habitat patch types for preliminary sampling consisting of desert remnants, suburban xeriscapes, agricultural, and industrial/commercial. We have selected 4 of each these patch types located in northeast, south central, north central and northwest quadrants of the Phoenix urban areas. Permissions have been obtained after some delay (sites are on private property, each with different owners) and currently all 16 sites have been sampled at least once (21 pitfall traps per site), and we will continue collections at each site every month until December. This project has generated a large number of samples (336 sample jars per month), each with an enormous diversity and abundances of arthropods (often > 1000 individuals of > 20 species in *each* sample pitfall trap). The information from this pilot study will be used to select representative populations on which to focus, and to refine the spatial and temporal sampling regime.

The goals of the bird project are (1) to document the changes in avian richness and abundance over time and space, and (2) to determine the biotic/abiotic and socio-economic/political factors that cause these changes to occur. To accomplish these goals, we are conducting bird censuses in four key habitats in the CAP LTER study area. These habitats include older residential neighborhoods (8 sites), younger residential neighborhoods (8 sites), remnant desert areas (6 sites), and golf courses (8 sites). Each site contains a 1 km transect (divided into ten 100 m segments) that is sampled 3 times per month. Hired birders count birds within 20 m and 40 m of each side of a transect within a 30 minute time period. In addition, using the same methodology, volunteers (60 people to date) are censusing birds in their respective neighborhoods across the study area. Birds have been censused since May 1. Data analyses will explore whether different avian species occur in each of the four key habitats in the CAP LTER study area. Satellite images, high aerial photography, and vegetative ground surveys will then be used to study the effects of landscape structure on avian populations. In addition, research will be coordinated with that of the land use change team to analyze how zoning ordinances and city regulations in and around the transect areas influence bird abundance and richness.

Transport and retention of materials: Two large projects have been initiated in this area. The first is a compilation and synthesis of existing data that is intended to give us a preliminary mass balance for nutrients and salts (mass balance project). The second project involves long-term monitoring of surface water inputs and outputs. In addition to these main projects, we also have initiated studies of material transport from urban surfaces during storms and we plan a synoptic

sampling of canals.

The goal of the mass balance project is to develop preliminary mass balances for nitrogen and salts in the Phoenix LTER watershed. Among the key questions are: (1) What is the net retention of salts and nitrogen in the Phoenix ecosystem? (2) How have changes in population and land use (e.g., a shift from agricultural production to urban development) affected accumulation rates of these materials? The mass balances include external inputs (surface water, groundwater, atmospheric deposition, fertilizer, food, etc.), internal production (e.g., dairy waste, municipal wastewater), outputs (surface and groundwater; human exports, etc.), and accumulation (landfills, surficial soils, vadose zone, groundwater). Preliminary findings are: 1) major N imports include fertilizer and food (animal and human); 2) internal production of animal wastes (from > 100,000 dairy cows) and municipal sewage (from 2 million people) are large budget terms; 3) much of the wastewater N is either lost by denitrification or accumulated (through recharge); 4) surface and groundwater inputs are small by comparison, and 5) nitrogen retention is apparently very high. We hypothesize that accumulation in groundwater and the vadose zone is very large in relation to inputs. Because the accuracy of determining accumulation "by difference" will be low, we are also trying to determine groundwater and vadose zone accumulation rates directly. Year 2 will be spent refining these estimates, continuing acquisition and analysis of data, and publication of a paper describing N mass balance.

In the monitoring project we are asking what are the fluxes of key nutrients, salts and trace metals imported to and exported from the CAP LTER urban areas in surface waters (rivers and canals) and what contribution do they make to the whole system mass balance? In addition, what are the spatial patterns of nutrient, salt and metal transport within the urban ecosystem and how do these fluxes change over time in response to increasing urbanization and variations in climate? To quantify and monitor the annual surface water inputs and exports for the whole CAP LTER study area, a regular water sampling program has been established at 7 key sites, to supplement and continue the database assembled by the USGS (NAWQA program).

Analysis of available USGS data shows that the annual loads of most constituents (expressed on a per unit area basis) are invariably larger for the basins draining the urban center than those upstream of and on the fringe of the urban area. Annual exports of N and P increase by a factor of 3 from the fringes to the urban centers and drainage basins on the downstream side of the metropolis, while for trace metals such as Pb there is an 8-fold increase. Preliminary LTER samples have shown that concentrations of nitrate-N, ammonium-N and phosphate in surface waters increase by an order of magnitude on passage through the metropolis and surrounding agricultural areas. High concentrations of dissolved organic carbon have been observed in samples of urban storm runoff. Wide variations in major ion concentrations, pH and conductivity between study sites appear to be largely related to differences in the bedrock geology of the drainage basins. Studies directed towards a process-based understanding of nutrient and materials transport and storage within specific urban patch types will be developed in the coming year. Work initiated by the USGS on a series of urban sub-basins will be continued by LTER. We intend to combine patch-specific studies of nutrient dynamics with data on transport in urban runoff, as a means of linking the 'patch-based' and 'whole system mass balance' approaches.

Disturbance: A reconnaissance of the fire services of the greater metropolitan area was conducted as a pilot project to a more complete study of urban fire ecology. This is a truly new area of disturbance ecology; it is unlikely that a model of urban fire ecology exists. Phoenix has no history of major wildfire, but is built and maintained on the industrial fire (internal combustion). This project is in the data acquisition stage but has great potential to contribute to disturbance theory

in ecology.

Flood is the other major disturbance on which CAP LTER will focus. In collaboration with the USGS, we have begun a study to examine the transport of materials from urban patches to waterways during the intense, localized storms that characterize this region. Their existing data, plus new studies initiated in summer 1998, will form the basis for comparison of urban, suburban, and desert catchments in terms of their yields of nutrients, organic carbon, and metals.

Human-environment feedbacks: Land restricted for the protection and preservation of native plants and animals, termed open-space land, has become an increasingly important part of urban environments providing benefits to individuals through its value as an amenity. The purpose of the initial project in human feedbacks was to provide empirical estimates of the economic value of open-space land. Since individual valuations underlie all market prices, this study attempts to determine individuals' willingness to pay for the amenities associated with open-space areas through an analysis of the primary factors that determine land prices. The main problem that arises in undertaking such an investigation is that it is difficult to determine the value of individual site characteristics, since these characteristics are not separately traded nor are they priced in explicit markets. Results indicate that open-space land has a positive and highly significant impact on the per acre price of residential parcels located near the McDowell Mountain Regional Park. That is, individuals living near this area are willing to pay a premium to do so.

III. Progress in Information Management

The CAP LTER has an established data policy that conforms with that of the LTER network, and is in the process of retraining its scientists to think about data accessibility and sharing. Several data sets are under development and some are on line (see VII. Products).

A CAP LTER web page (http://caplter.asu.edu/) is in place and is undergoing continual development. Components of this include an introductory page, a news and events page, a research page, and an education/outreach page. The research page provides access to project descriptions, on-line datasets, and a visual overview of GIS data. An internal site has discussion groups and memoranda from Project Directors and the Executive Committee.

IV. Progress in Integration

Integration of the diverse group of activities described above will be achieved in some cases through internal dissemination of results and naturally evolving collaborations among project scientists. However, we recognize that some deliberate steps to encourage integration will be necessary. To this end, we held a 1-day workshop this summer, entitled “The CAP LTER Summit on Human-Ecosystem Interactions”. Over fifty attendees discussed potential for social science-natural science integration in working groups organized around the existing LTER projects. The CAP LTER also hosted lectures and discussion groups (involving social and natural scientists) with visiting scientists Steward Pickett (October 1997) and Robert Costanza (April 1998), both of the Baltimore LTER. Finally, in October 1999, several CAP LTER scientists will participate in a workshop, “Developing a modeling paradigm for spatially explicit urban ecology”, at the National Center for Ecological Analysis & Synthesis.

Integration also will be accomplished by modeling. Modeling activities during year 1 have focused on development and refinement of the hierarchical patch dynamics modeling (HPDM) framework for the CAP LTER, and hierarchical analysis of the CAP landscapes based on land cover

and land use data. Upon reviewing a wide range of existing models of arid and semiarid ecosystems, we have identified the most suitable process-based ecosystem model as a starting point for development of the CAP LTER HPDM model: Patch AridLand Simulator, PALS. PALS is a process-based ecosystem model that takes into account variations in patch type, plant characteristics, soil resources, and climatic factors, and is the only well-published ecosystem model that explicitly considers the island of fertility - a common and essential phenomenon in arid ecosystems worldwide. It was developed and validated extensively for the southwest desert ecosystems of US by the Jornada LTER modeling team led by J. F. Reynolds. PALS will be modified and linked with other component models of the CAP HPDM. Because of the similarities in vegetation and many basic ecosystem processes, a significant advantage of adopting PALS is that many model parameters can be estimated based on existing and on-going field investigations at the Jornada LTER. This may also lead to interesting comparative studies between the two desert LTER sites with contrasting human influences. As a part of the CAP HPDM, we have also developed the mathematical and simulation scheme for an integrated spatial Markovian and cellular automata model for landscape pattern dynamics, which will be implemented immediately when historical data on land use/cover and related information become available.

V. Outreach Activities

The CAP LTER education program, "Ecology Explorers", is developing into an exciting opportunity for K-12 students and teachers to partner with scientists of the CAP LTER. In June we offered a three-day teacher workshop to eleven participants representing nine elementary, middle and high schools in the Phoenix area. The workshop was facilitated by five LTER scientists (representing plant, insect and bird studies) working with two LTER education team members. The workshop modeled an inquiry-based teaching approach as scientists presented their LTER investigations. A primary workshop goal was to develop ways that these investigations can effectively be translated into K-12 classroom experiences, using schoolyards and backyards as research sites.

A second group of five teachers from five schools have been working for the past four weeks as interns on the CAP LTER ground arthropod study. They work with the principal investigators, postdoctoral researchers, technicians, and university students in the full suite of research activities from data sampling to analysis. The primary internship goal, like the workshop, is for teachers to translate CAP LTER research into a classroom project implemented during the upcoming school year.

From the workshop and internship, the CAP LTER has established an initial set of twelve LTER schools with which we will continue to work closely as we further develop and implement program components. Teacher participants in the workshop and those in the internship came in with a commitment to implement research projects in their schools during the 1998-99 school year, relying on LTER for guidance and ongoing communication.

The CAP LTER is able to offer guidance and ongoing communication by tapping into an existing program, called "Science Connections", offered by one of our community partners, the Southwest Center for Education and the Natural Environment (SCENE). Through Science Connections, teachers can request an LTER graduate student/scientist to visit their classrooms, introducing a research project and demonstrating sampling protocols. The graduate student will return to the classroom periodically to help kids analyze data and develop testable hypotheses. Funding for this program comes from Motorola, another one of our community partners, and supports the addition of an Environmental Educator to the LTER education team. In another facet

of our partnership with SCENE, high school students are being invited to apply for internships in ASU scientists' labs, some of which will place students in CAP LTER research labs.

In addition to scientist visits to K-12 classrooms, Ecology Explorers will include an interactive Web site that leads students through the scientific process as they select and map out their research site, carry out sampling protocols, analyze data, and develop testable hypotheses. The Ecology Explorers Web site will be developed in three phases, with the first phase slated for completion by the end of September, the second phase in November, and the third phase in February 1999. Phase One development includes instructions for mapping out the research site and sampling protocols for vegetation survey, ground arthropod investigation, bird survey, and plant/insect interaction studies. The database will be constructed as students send in data. Also during phase One, two threaded-discussion forums, one for teachers, "Teachers Talk", and one for students, "Kids Talk", will be in place. And, an "Ask-A-Scientist" email address will be available. Phase Two development will include guidelines for analysis and developing hypotheses. Phase Three will add sampling protocols for water, soil, and climate studies. All the schoolyard projects also will be included as PDF files on the Web site, so that teachers may download hard copies for easy reference as they plan their curricula.

In addition to getting kids involved in real scientific research, Ecology Explorers has been developed to meet national and state science education standards. We have a graduate student from the College of Education who will make the correlation of our program with the standards explicit on the PDF files for teachers. Program development also has been based on interviews with teachers, administrators, scientists and researchers. We began with a list of possible program components that were culled and streamlined based on feedback regarding which program components would be most useful to teachers, would likely be used in classrooms, would garnish support from administrators, and would spark interest among scientists and researchers.

We are fortunate to have a dynamic group of education partners and an enthusiastic education advisory team that includes representatives from teacher-training and teacher in-service programs as well as individuals from informal education institutions including the Phoenix Zoo, the Arizona Science Center, and the Desert Botanical Garden. At our last advisory team meeting, each member introduced ways that the LTER education program might be incorporated in existing programs at each of these formal and informal organizations. Now that Ecology Explorers is more fully defined, we can refine these partnering ideas so that more teachers, teachers-in-training, scientists, and K-12 students can benefit from the myriad programs including and related to Ecology Explorers.

VII. Products

Publications in refereed journals

In Press: Hostetler, M. E. 1998. Scale and birds in urban environments. *National Wildlife Magazine*.

Submitted: Graf, W. L. Locational probability for an urbanizing river. *Environmental Management*.

Hostetler, M. E. and C. S. Holling. 1998. Detecting the scales at which birds respond to landscape structure in urban habitats. *Oikos*.

Wu, J. Hierarchy and scaling: Extrapolating information along a scaling ladder. *Canadian Journal of Remote Sensing*.

Wu, J. and J. F. Reynolds. Developing models across multiple scales based on hierarchy theory. *Ecological Modelling*.

Publications - book chapters (submitted)

Gober, P., E. K. Burns, R. Walton, and K. Knowles-Yanez, Rural to urban land conversion in metropolitan Phoenix. Book chapter, in J.S. Hall, editor. *Arizona Policy Choices.*

Publications - other (submitted)

Holloway, S. Union Hills Quadrangle and New River SE Quadrangle. Open-File Reports, Arizona Geological Survey (AZGS). (geologic mapping)

Publications in Preparation

Grimm, N.B., S.T.A. Pickett, C.L. Redman, J.M. Grove, and S.G. Fisher. Ecology of urban areas: integrated approaches to long-term studies. Intended for *BioScience.*

Hostetler, M. E. An empirical method to address the scales at which birds respond to urban landscape structure. Intended for *Urban Ecosystems.*

Stefanov, W. L., and Ramsey, M. S., Using multispectral, multispatial remote sensing data of Phoenix, AZ to identify and monitor urban land cover changes. Intended for *Remote Sensing of the Environment*.

Grant awards and proposals submitted

Awarded:

ASU Executive on Loan to City of Phoenix, 1998-1999, through the ASU Office of the President. E.K. Burns.

Summer 1998 Undergraduate Research funding for Lisa Lauver, senior in Civil and Environmental Engineering, through the WISE program in the College of Engineering and Applied Sciences. NSF Women in Science and Engineering Program. E.K. Burns and L.A. Baker.

Four Supplements to CAP LTER: "CAP LTER Schoolyard Ecology Supplement" ($15,000); "CAP LTER Curation Supplement" ($50,000); "CAP LTER General Supplement" ($50,000); "CAP LTER REU Supplement" ($15,000). Long Term Studies Program,

National Science Foundation, 1998-1999. N.B. Grimm & C.L. Redman, Co-PIs.

"Scientist/Teacher Partnerships for the Environment" ($50,000 cash; $50,000 in kind (equipment and services)). Funded by Motorola Corporation.

Submitted:

"Regional Earth Science Application Center: Human Processes in Arid Urban Environments". ($2,549,000) Earth Science Applications Center Program, NASA, 1999-2002. P. Christensen, PI/PD, C.L. Redman, Co-PI. Other LTER participants: A. Brazel, J. Elser, N. Grimm, S. Houston, M. Ramsey.

"Dynamics of an Urban Carbon Dioxide Dome." ($500,000). NSF Urban Initiatives Program, 1998-2001. R. Balling, PI/PD, P. Gober, Co-PI. Other LTER participants: A. Brazel, J. Klopatek, J. Fernando, E. Wentz.

"Urban Core Sustainability." ($500,000). NSF Urban Initiatives Program, 1998-2001. P. Gober, Co-PI. Other LTER participants: K. Knowles-Yanez, M. Ramsey, P. McCartney.

"Integrated graduate education and research training in urban ecology." ($2,654,939 for 5 years). IGERT Program, National Science Foundation, 1999-2004. (Pre-proposal). S. Fisher, PI/PD, N.B. Grimm & C.L. Redman, Co-PIs. Other LTER faculty participants: R. Arrowsmith, P. Christensen, J. Elser, W. Graf, S. Houston, A. Kinzig, T. Nash, D. Pijawka, S. Pyne, P. Westerhoff.

"EMPACT." ($600,000). Submitted by Maricopa County Environmental Services Department Environmental Monitoring for Public Access and community Tracking: HEAR (Healthy Environment for Area Residents) Environmental Protection Agency. C.L. Redman, Co-PD (With Al Brown, Director, Environmental Services Department, Maricopa County). Other LTER participants: L. Kuby, P. McCartney, J. Fry, D. Pijawka; CAP LTER partners involved: Maricopa Association of Governments, Arizona Department of Environmental Quality, City of Phoenix, Earth's 911 Environmental Hotline

Presentations at Regional, National and International Conferences

Presented:

Edmonds, J.W., Grimm, N.B., Westerhoff, P., & Fisher, S.G. Spatial variation in organic matter quality in natural ecosystems: a determinant of microbial decomposition rates. Annual Meeting, North American Benthological Society, Prince Edward Island, June 1998.

Grimm, N.B., and C.L. Redman. Human and ecological sciences at the urban crossroads: central Arizona - Phoenix Long-Term Ecological Research. To be presented, special LTER Session on Urban Ecosystems, Annual Meeting, Ecological Society of America, Baltimore, Maryland, August 1998.

Grimm, N.B. Opportunities and challenges in urban ecological research. International LTER meeting, Taipei, Taiwan, November 1997.

Grove, J.M., C.L. Redman, S.T.A. Pickett, and N.B. Grimm. An hierarchical, patch dynamics approach to the long term study of urban ecological systems. Seventh International Symposium on Society and Resource Management: Culture, Environment, and Society. Columbia, Missouri, May 1998.

Hope, D., N.B. Grimm, and C.L. Redman. The Central Arizona-Phoenix (CAP) LTER: a new opportunity for urban ecological research. To be presented, Urban Ecosystems session, Annual Meeting, Ecological Society of America, Baltimore, Maryland, August 1998.

Hostetler, M. E. Scale and the Design of Urban Landscapes for Birds: A Potential to Integrate

Planning and Design with the Natural Sciences. Contributed paper for the Shire Conference: teaching ecology in landscape design and planning programs - from theory to practice. July 15 - 19, 1998.

Ramsey, M. S. Urban remote sensing analysis: The Phoenix LTER project, 15th ASTER Science Team Meeting, Tokyo, Japan, 22-26 June, 1998.

Redman, C.L. Humans as part of ecosystems. 125th Anniversary Symposium, yellowstone National Park, Bozeman, MT, May 1998.

Wu, J. and J. F. Reynolds. 1998. Developing models across multiple scales based on hierarchy theory. Presented at the International Conference on Complex Systems Modeling, New Orleans, July 13-17, 1998.

Wu, J. and O. L. Loucks. 1998. Hierarchical patch dynamics and scaling. Presented at the International Workshop on Scaling & Modelling in Forestry: Applications in Remote Sensing & GIS, Universite de Montreal, March 19-21, 1998.

Forthcoming:

Baker, L., organizer. "Urban ecosystems" special session for the 1999 annual conference of the Water Environment Federation (the call for papers is out).

Hostetler, M.E., organizer. "Designing Urban Landscapes for Animals" special session for the Arizona Planning Association Annual Conference, Flagstaff, Arizona, October 1998.

Knowles-Yanez, K., E. K. Burns, and P. Gober. Urban fringe morphology of metropolitan Phoenix. Abstract accepted for Arizona Planning Association Annual Meeting, Flagstaff, AZ, October 1998.

Moreau, J. M., Morrisey, G. E., Graf, W. L. GIS Analysis of Channel Changes in the Upper Rural Reach of the Salt River. Arizona Geographic Information Conference, Phoenix, August, 1998.

Ramsey, M. S., Stefanov, W. L., and Christensen, P. R. Monitoring world-wide urban land cover changes using ASTER: Preliminary results from the Phoenix, AZ LTER site, submitted to the 13th Annual Applied Geologic Remote Sensing Conference, 1-3 March, 1999.

Robinson, S., Arrowsmith, R., Granger, and Phillips. Using remote sensing and cosmogenic nuclides to determine spatial variability and timing of alluvial fan deposits. Abstract submitted, Annual Meeting of the Geological Society of America.

Community Outreach, Non-Standard Publications, and other Miscellaneous Activities

An article about the urban bird surveys for a local community paper - The Dobson Ranchers' Roundup - titled "Ranch part of survey to keep track of fine feathered friends". More such articles are planned for other community papers to recruit volunteers and to educate the general public about the LTER project.

Several presentations (about the bird project) were given to community groups and local clubs (Maricopa Audubon Society, the Birders Anonymous Club, and to a birding group from the Sportsman Club).

Hosted visit and field trip of Neal Lane (NSF Director) to study site (LTER participants: Grimm, Arrowsmith, Ramsey, Edmonds)

Presentation of work to various municipal and state agencies, governments, corporations, etc. (Redman, Grimm, Arrowsmith, others)

Internal Publications and Presentations

R. Arrowsmith taught two courses that were inspired by and contributed to CAP-LTER research and student training: Advanced Field Geology, Spring 1998 (http://www.public.asu.edu/~arrows/advfield/flyer.html) and Desert Surface Processes and Quaternary Geomorphology seminar, Fall 1997 (http://www.public.asu.edu/~arrows/DesertGeomorphflyer.html).

W. L. Graf and 14 others. Recent Channel Changes in the Salt River, Phoenix, Arizona. Tempe: Center for Environmental Studies, 107 p.

Graf, W. L. and 14 others, Channel Change in the Salt River. LTER All-Scientists Meeting, May 14, 1998.

Redman, C.L. Phoenix: The Ecology of a City. Tuesday, March 31, 1998. Leadership Breakfast, College of Liberal Arts and Sciences, ASU Downtown Center

Data Sets

Dataset	Source[1]	Description	Status[2]
Statewide coverage of Indian reservation land in Arizona	ASLD	GIS cover	on line
Geologic fault formations in Arizona	ASLD	GIS cover	on line
Geologic formations in Arizona	ASLD	GIS cover	on line
Bureau of Mines Minerals Availability System data set	ASLD	GIS cover	on line
Spring locations in Arizona	ASLD	GIS cover	on line
Major soils and some minor soils groups	ASLD	GIS cover	on line
Point locations of various cities and towns	ASLD	GIS cover	on line
Township and range grid lines	ASLD	GIS cover	on line
Census blocks for the State of Arizona	ASLD	GIS cover	on line
Incorporated city boundaries	ASLD	GIS cover	on line
U.S. Congressional Districts	ASLD	GIS cover	on line
Arizona Actual Vegetation, 1993	ASLD	GIS cover	on line
Arizona's natural vegetation	ASLD	GIS cover	on line
Hydrologic unit code areas	ASLD	GIS cover	on line
Interstate highways	ASLD	GIS cover	on line
Irrigated lands in Arizona in the early 1960's	ASLD	GIS cover	on line
Lakes in Arizona	ASLD	GIS cover	on line
Public Land Survey system data (Township, Range and Section), land Ownership and county	ASLD	GIS cover	on line
Point data for the Census landmarks	ASLD	GIS cover	on line
Arizona's natural vegetation	ASLD	GIS cover	on line
7.5 minute quadrangle boundaries	ASLD	GIS cover	on line
Riparian vegetation associated with perennial waters	ASLD	GIS cover	on line
School Districts	ASLD	GIS cover	on line
Hydrography consisting of linear features, i.e. streams	ASLD	GIS cover	on line
U.S. Census Bureau street segments extracted from 1992 TIGER files	ASLD	GIS cover	on line
Linear data representing railroads	ASLD	GIS cover	on line
Roads, streets, trails, pipelines, transmission, railroads and	ASLD	GIS cover	on line

miscellaneous transportation			
Census 1990 Urbanized Area Code	ASLD	GIS cover	on line
Bureau of Land Management, U.S. Forest Service, National Park Service and Fish & Wildlife Service Riparian Natural Conservation areas, Wilderness Study areas and Wilderness or Primitive areas	ASLD	GIS cover	on line
1995 Land Use inventory	MAG	GIS cover	on line
1:250000 scale Digital Elevation Model	USGS	DEM	on line
1:24000 scale Digital Elevation Model	USGS	DEM	on line
1993 Landsat cover	USGS	Remote sensing	on line
Remote sensing data	various	Remote sensing	U.D.
Land use/land cover classification maps	LTER 2	Patch topology-spatial	U.D.
Locational probability maps for Salt River	LTER 5	GIS	U.D.
Aerial photo record of Salt River	LTER 5	photographs	U.D.
Quaternary geomorphology maps	LTER 6	spatial	CD-ROM
1:100,000 geological maps for study area (western half)	AZGS	spatial/ maps	CD-ROM
Landsat mosaic for LTER area (AZ)	AZLIS	remote sensing	CD-ROM
7.5-minute quad DEMs for Phx basin, converted to std DEM format	AZGS	DEM	CD-ROM
Groundwater N and salt concentrations	ADEQ	data matrix	acquired
Wastewater reuse, recharge, and discharge	ADEQ, LTER 7	data matrix	acquired
Spatial distribution of dairy farms	LTER 7	spatial	created
GIS database of fertilizer inputs	LTER 7	GIS cover	U.D.
Water chemistry monitoring	LTER 8	data matrix	created
Arthopods	LTER 10	data matrix	created
Phoenix flora	LTER 11	species list	U.D.
Plant communities of remnant desert patches	LTER 11	data matrix	created
Bird censuses	LTER 12	data matrix	created
100-year climate data set	LTER 16	data matrix/ spatial	created
Historic land use data set	LTER 19	spatial/ maps	U.D.

[1] ASLD - Arizona State Land Department; MAG - Maricopa Associated Governments; AZGS - Arizona Geological Survey; USGS - US Geologic Survey; AZLIS - Arizona Landsat Image Server; ADEQ - Arizona Department of Water Quality; LTER# - data generated by LTER initial project (#).

[2] On-line – available at http://caplter.asu.edu/ Acquired – data set acquired from agency or organization; data not yet on line, metadata not complete, or data entry incomplete. Created – data set designed and documented by Data Manager, currently in data entry. U.D. – under development: investigators have initiated discussions with Data Manager. CD-ROM- A CD-ROM database of geological data is being prepared (from the Quaternary Geomorphology Project) and will contain GIS, mapping, and remote sensing data. Much of our effort has involved establishing a GIS and remote sensing databases for the CAP-LTER project. Others not listed currently reside in individual departments.

Bibliographies

Urban ecology (result of graduate seminar, Fall 1997)
Urban climatology (result of graduate seminar, Spring 1998)
Urban heat island (compiled by W. Thomas, climatology project)

Theses and dissertations in progress

Kevin Clark (M.S., Biology, Ohmart): Vertebrate species composition of desert islands in urban Phoenix

Dixie Damrel (M.S., Plant Biology, Pinkava): An Horticultural Flora of the ASU Arboretum

Jennifer Edmonds (PhD., Biology, Grimm): Understanding linkages between dissolved organic carbon quality and microbial and ecosystem processes in Sonoran Desert riparian-stream ecosystems

Stephen Holloway (M. S., Geology, Arrowsmith): Proterozoic and quaternary geology of Union Hills, Arizona

Brooke McDowell (M.S., Plant Biology, Martin): Mycorrhizal Effects on Sonoran Desert Landscape Plants

Nicole McPherson (M.S., Civil and Environmental Engineering, Baker): Fate of 50 years of fertilizer N applications in the Phoenix ecosystem

Michelle Oleksyszyn (M.S., Plant Biology, Stromberg): Native-exotic vegetation interactions in abandoned agricultural fields

Martin Roberge (Ph.D., Geography, Dorn): Desert Urban Hydrology: Human encroachment onto hillslope and channel systems

Sarah Robinson (Ph.D., Geology, Arrowsmith and Christensen): Understanding Quaternary landscape development in the Phoenix area using remote sensing and cosmogenic dating

William L. Stefanov (Ph.D., Geology, Christensen): Investigation of semiarid hillslope soil development using mid-infrared spectroscopy

Art Stiles (Ph.D., Plant Biology, Scheiner): Influence of urbanization on vascular plant species diversity within desert remnant patches

Erin Vining (M.S., Plant Biology, Day): Plant-microclimate interactions

Ying Xu (Ph.D., Civil and Environmental Engineering, Baker): A spatial model of N cycling within the Phoenix metropolitan ecosystem

Collections

Urban arthropod collection (under development, M. Tseng)
Flora of Phoenix (herbarium)