Bridge-Year CAP LTER Supplement

CAP LTER:
Land-Use Change and Ecological Processes in an Urban Ecosystem of the Sonoran Desert (DEB-9714833)

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PROJECT SUMMARY

CAP LTER focuses on an arid-land ecosystem profoundly influenced, even defined, by the presence and activities of humans and is one of only two LTER sites that specifically studies the ecology of an urban system. In this large-scale project, biological, physical, and social scientists are working together to study the structure and function of the urban ecosystem, to assess the effects of urban development on surrounding agricultural and desert lands, and to study the relationship and feedbacks between human decisions and ecological processes. The primary objectives of this accomplishment-based renewal is to further develop the CAP LTER research program to understand both the patterns and mechanisms of change in ecological conditions *and* the feedbacks to the social system. In this seventh, "bridge" year between the first phase of CAP LTER and its expected renewal in November 2004, the research strategy is to continue the elements of the research that have achieved "long-term status", to phase out the shorter-term, pilot projects that have characterized much of the first award period, and to gradually add new elements and organization. Reorganization of existing and planned projects, monitoring, and teams will be done under six new integrative project areas: 1) past, current, and future land-cover and land-use transformations; 2) human activities and biodiversity; 3) biogeochemical linkages of air, land, water, and groundwater; 4) nature and interactions between ecosystem health and human health; 5) local climate change and socio-ecosystem response; and 6) ecological, economic, social, and political aspects of urban water systems. These more integrative project areas are intended to foster greater interdisciplinary involvement. Thus, the interim year provides an opportunity to phase in these changes and allow participating scientists to find their new niche within the reorganized thematic structure. The broader impacts of the CAP LTER lie in its role as a catalyst and data source for emerging outreach programs to decision-makers and the wider community, as a model for interdisciplinary integration, including significant research training efforts at the post-doctoral, graduate, and undergraduate levels, and in its highly successful "Ecology Explorers" K-12 education program, reaching over 50 schools.

Project Description

Overview

Almost six years ago we tackled the enormous challenge of a comprehensive study of the rapidly growing metropolitan region of central Arizona, including Phoenix and four of the five next-largest cities in Arizona. Added to the expected LTER challenges of understanding the patterns and processes that underlie long-term changes in ecosystem structure and function, an urban ecosystem involves the complexities of intense human participation in the system – with attendant economic and social drivers, radically altered land cover, accelerated cycling of materials, and heretofore un-researched ecological impacts of a built environment. As at the traditional LTER sites, interdisciplinary collaboration of ecologists, biogeochemists, earth scientists, and climatologists is fundamental, but we add to the mix sociologists, geographers, economists, political scientists, urban planners, anthropologists, civil and environmental engineers, mechanical and chemical engineers, and numerous community partners who share our zeal for understanding the urban ecosystem.

Our research strategy for CAP-I was to begin with many initial projects and to winnow these down over six years to fewer projects of five types: long-term research at 200 survey sites (Hope et al. 2003) and a few permanent monitoring sites; a major data-mining effort to create an urban environmental database; aided with significant leveraged funding to our data laboratory (McCartney et al., NSF-BDI, NSF-ITR). We also have used these mined monitoring data to establish parameters for our models of urban ecosystem structure and function. Two long-term experiments have been underway for 2-4 years (Stabler and Martin In review), and we have engaged in several cross-site comparisons (Brazel et al. 2000), including a new, separately funded project (NSF Biocomplexity, Redman et al.) comparing agrarian landscape change at several LTER sites, study of N retention in urban streams (part of LINX-2, NSF-IRCEB, P. Mulholland, N. Grimm, et al.), and work on bird diversity as a function of socioeconomic setting (P. Warren et al., unpublished).

In this seventh, "bridge" year between the first phase of CAP LTER and its expected renewal in November 2004, our strategy is to continue the elements of the research that have achieved "long-term status", to phase out the shorter-term, pilot projects that have characterized much of our first award period, and to gradually add the new elements and organization of our research that have arisen as a result of our team's preparation of the renewal proposal (initial work on the proposal began in May, 2002). Briefly, because we believe that projects must be interdisciplinary from the outset, we have modified our research teams away from the prior organization of "core areas + 2 social science areas" employed in CAP-I, toward more integrative project areas that demand interdisciplinary involvement. Thus, we view this interim year as an opportunity to phase in these changes and allow participating scientists to find their new niche within the reorganized thematic structure.

To enable review of past accomplishments, we provide six reprints (Grimm et al. 2000, Baker et al. 2001, Hope et al. 2003, Wu and David 2002, Martin and Stabler 2002, Brazel et al. 2000 OR Bolin et al. 2002). Information on human resources development at the post-doctoral, graduate, and undergraduate levels is provided along with other details of the broader impacts of the CAP LTER project in the section that follows.

Objectives, Significance, and Broader Impacts

Research on the CAP LTER has been directed at answering a central research question that still guides us today:

> *How do the patterns and processes of urbanization alter the ecological conditions of the city and its surrounding environment, and how do ecological consequences of these developments feed back to the social system to generate future changes?*

In the past six years, we have identified many of the ecological consequences of urbanization, but we are only beginning to understand how those consequences feed back to the social system and generate future changes. **Our primary objective during this bridge year, and in the renewal period, is to further develop our research program to understand both the patterns and mechanisms of change in ecological conditions *and* the feedbacks to the social system.** We will do this in the context of three interpretive themes linking field projects to our central research question: scales and periodicities of ecological and human phenomena; human impact and control of variability in space and time; and resilience of socio-ecological systems. In addition, we will begin to reorganize projects, monitoring, and teams under six new integrative project areas: 1) past, current, and future land-cover and land-use transformations; 2) human activities and biodiversity; 3) biogeochemical linkages of air, land, water, and groundwater; 4) nature and interactions between ecosystem health and human health; 5) local climate change and socio-ecosystem response; and 6) ecological, economic, social, and political aspects of urban water systems.

Ecological theory developed over the past century with limited reference to the massive and pervasive alterations of natural ecosystems made by *Homo sapiens.* The two urban LTER sites provide a remedy for this omission. Their scientific significance lies in their potential to reconceptualize and revitalize ecology by considering the integration of new elements into ecological theory. Although not all ecological theory must be refined, nor will all changes be radical, given the pervasive presence and impact of humans on all global environments our minds must be open to change. Urban ecosystems, because of the clearly dominant influence of people, institutions, and the built environment, offer the best laboratory for examining possible refinements.

In terms of its broader impacts, CAP LTER has served as a catalyst for many new developments, both in Arizona and nationwide. CAP-I had over 500 participants, of which more than 100 were community volunteers, in its first 6 years. Aside from the many published (or in press) works (>110 journal articles, book chapters, and reports), CAP LTER has consistently been in the news locally and nationally. We work very hard on our outreach, but also have been able to benefit greatly from the establishment of linked projects, the explicit purpose of which is to provide community and governmental outreach. For example, the GP-2100 project is engaged in using CAP LTER data to help policy-makers and others envision the future of the greater Phoenix (GP) region in the year 2100. Our Information Management team plays a leadership role in developing new IT tools for handling ecological data.

CAP LTER is an important focal program for both social and natural scientific research at ASU, and is the prime example for this university of how fostering interdisciplinary interactions can yield success. Students in our Integrative Graduate Education and Research Training (IGERT) program in urban ecology are forging new paths to interdisciplinarity, bringing the faculty along with them. A monthly All Scientist Council meeting, open to all faculty members, students, and community partners, is regularly attended by 60-80 individuals. Aided in part by leveraged funding, CAP LTER personnel have led the way nationally in crafting

the arguments for social science-natural science integration (Kinzig et al. 2000, Kinzig 2001, Harlan et al. 2003, Redman et al. in review)

From an initial collaboration with 12 schools in 1998, Ecology Explorers, our education outreach program, has expanded to include 77 teachers at 54 public schools (encompassing 22 school districts), 3 charter schools, and 2 private schools. In addition, over 20 community partners are substantively involved in the CAP LTER, such as Salt River Project, Maricopa Association of Governments, the US Geological Survey (USGS), the Gila River Indian Community, the Salt River Pima Indian Community, and Motorola. During our bridge year, we intend to keep all of these activities going, as we begin to initiate other outreach activities.

Contributions to human resources development at the post-doctoral, graduate, and undergraduate levels have been significant. We have supported 15 postdoctoral research associates, 90 graduate students, and 67 undergraduate students since 1997. These numbers include 30 completed and xx (6?) in-progress M.S. and Ph.D. theses directly supported by CAP LTER in nine different programs as disparate as Mechanical and Aerospace Engineering and Sociology, and 18 REU students attracted not only from ASU's undergraduate programs but from schools across the US. One of our early REU students from elsewhere is returning to ASU for his graduate studies. Our post-docs have important roles in the long-term project but also develop significant independent projects in the context of the urban research program. Moreover, with students at all levels we stress collaboration and interdisciplinary cooperation, aided in large measure by our IGERT in Urban Ecology.

Proposed Research

The following narrative lists, for each of our existing research areas, objectives for the coming year.

Interdisciplinary Long-Term Monitoring: Year seven will entail a major effort in re-locating and obtaining permission for sampling the 200-survey plots established in 2000, in anticipation of the 2005 sampling. Although some landowners will not have changed, there may be substantial turnover. In 1999, it took nine months for the permissions to be obtained for the spring 2000 survey! We do not anticipate major changes in our established protocols, but we do expect to add some variables that we suspect are important based on our current data analysis. Data analysis for the 2000 survey is ongoing, with 4-5 papers in preparation or in review.

We will continue to set up new permanent plots for intensive monitoring. We hope to have 8-10 of these plots in place by the end of the year.

Long-Term Experiments: Two experiments that have been underway for several years will be continued. This year, we will be investing much of our effort in establishing a new long-term experiment. The "suburbosphere" is a set of mini-neighborhoods that will be created with different yardscapes: mesiscape, xeriscape, oasis, and native vegetation, each with an associated watering regime (flood, drip, sprinkler/drip, none). When the landscaping has been completed, we will establish our plots, microclimate monitoring stations, and protocols for access of these yards (since they will be occupied by renters). This exciting opportunity, afforded us by the creation of the new ASU East campus (which owns the rental properties), will allow us to evaluate –with greater replication and over a large area that is actually occupied by residents – effects of yardscape design and watering regime on primary productivity, microclimate, biodiversity, insect communities, human perceptions and attitudes, human water use decisions, biogeochemical processes, and many more.

Geophysical Context: Research in this area will continue to be directed at establishing land-cover changes by analyzing satellite and other remote imagery. These efforts have been

greatly expanded to other regions of the world in the "100 Cities Project", part of ASU's new Center for the Study of Rapidly Urbanizing Regions (CSRUR). In addition, projects have begun in the past year to determine how human modification of flowpaths has altered rivers and streams and thereby may have changed biogeochemical function. We are focusing on several small watersheds in the Phoenix area, many of which have or plan to begin stream-riparian restoration projects. This contextual information will be useful in detemining why restoration succeeds or fails in this region, how this important type of land-use change affects aquatic ecosystem function, and what feedbacks exist to the social system that will drive further change.

Primary Production, Populations, and Biogeochemical Processes: Research under these traditional LTER core areas has been conducted at several scales ranging from the individual lot to the whole ecosystem. We have successfully co-located many studies in all three areas, which has allowed us a better understanding of the controls over these ecological variables. In year 7, while we continue established projects, we will be working to determine how these traditional ecological studies can be enriched with information from the social sciences. For example, long-term research on trace N gas fluxes and the effects of elevated N deposition will soon begin at the permanent plots and in sites we are establishing upwind, in the core, and downwind from the city. NOx is an important ozone precursor that is produced in abundance in this automobile-driven city. Thus there are complex and important feedbacks to study between human behavior (driving cars), the N cycle (NOx production, sources, and sinks), air quality (consequence of the interaction of these two factors), and ultimately, human well being.

Human Dimensions of Ecological Research: The major projects currently being conducted by this team include a study of the spatial distribution of environmental risk (from toxic release sites), the Phoenix Area Social Survey (Harlan et al. 2003), and the Parks Project (A. Kinzig and others, unpublished). Although these projects will continue during the next year, we hope to begin to fully integrate them more fully into the new integrative project areas. Modeling: Based on the hierarchical patch dynamics paradigm (Wu and Loucks 1995) and the scaling ladder concept (Wu 2001), we have developed a spatially hierarchical modeling approach to studying complex urban landscape systems, and a hierarchical modeling platform (HPD-MP) - a software package - from which multi-scale ecological models can be developed and integrated in an efficient and coherent manner. Refining the ecosystem models and integrating them with land use change models using HPD-MP is the focus of our current research. Further, we will continued work on climate models and the air transport and nutrient deposition models (Grossman-Clarke et al. 2003 (in revision)).

Cross-Site Integration: Efforts during Year 7 will include continued urban stream experiments (with LINX) and development of a potential collaboration with Sevilleta LTER regarding a new, research-oriented housing development to be established south of Albuquerque. We expect additional collaborations to arise from the ASM.

Information Management: Major efforts this year will be devoted to getting all of our own datasets available on line, through a series of PI-IM meetings. We have now made it a requirement of CAP LTER support that each PI discuss their database needs *before* initiating any research (or in the case of ongoing projects, before new funds are released).

K-12 Education: Ecology Explorers will continue to grow, develop new elements, attract more and more teachers, and to attract attention nationally. This year, the model of Ecology Explorers was used as an example of what might be done in a NEON Observatory in the area of K-12 education (AIBS White Paper). Ecology Explorers has no plans to make any major changes, and we hope to integrate even more of our research areas into this important activity.

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