ARIZONA STATE UNIVERSITY

Central Arizona–Phoenix Long-Term Ecological Research: Phase 2

RE: 2007 Combined Supplements Request for NSF grant # DEB-0423704
Nancy B. Grimm and Charles L. Redman, CAP LTER Project Co-Directors

A. Integrated Research and Education Supplement

Investigators: Monica Elser, Nancy Grimm, Charles Redman, John Briggs, and others

CAP LTER recognizes the need for integrative science that involves partnerships among disciplines to conduct research, detect change, examine impacts, and devise appropriate solutions to problems while exchanging knowledge with multiple user groups and stakeholders. In this spirit, we are proposing a set of education and research projects to further this agenda within CAP LTER. The *Service at Salado* program brings CAP LTER science to minority schoolchildren in Phoenix and involves one of our partner organizations, City of Phoenix, Department of Natural Resources. Our proposal to install wireless technology on climate sensors will not only ease the strain of data downloading and make our data available to CAP LTER scientists in near real time, it will also aid our REU students and teachers in their research and teaching efforts.

LTER Schoolyard Activities

Environmental education and outreach activities are woven throughout the CAP LTER project. We reach out to the K-12 community in a program called *Ecology Explorers* that engages teachers and students in a schoolyard-ecology program where students collect data similar to CAP LTER data, enter results into our database, share data with other schools, and develop hypotheses and experiments to explain their findings. We offer summer internships and school-year workshops for teachers that have been funded by previous Schoolyard supplements. Additionally, we are also working directly with ASU undergraduate students and several classroom teachers in high-minority and underserved schools through ASU's Service Learning program. In particular, one program, *Service at Salado*, which received funding through LTER and EdEn in 2005, has reached nearly 500 elementary-school aged children and 55 ASU undergraduate students over the past 3 years. *Service at Salado* received the 2006 ASU President's Medal for Social Embeddedness based on its success of linking ASU research with the local community.

This year, we request supplemental funds for the *Service at Salado* program. *Service at Salado* enables students from underserved and disadvantaged communities to gain experience in ecology and civic involvement. In the process, they practice environmental stewardship and come to see themselves as agents of change to conserve and improve their local landscape. This program targets an area of Phoenix where the population is 79% Hispanic, and 39% of the residents are under 20 years old. Family incomes average around $30K, with 31% of families below poverty level. In schools served by the program, 85% of students receive free or reduced lunch. Student achievement, based on test scores for Grades 3, 5, and 8, is below the state average for reading, writing, and math.

Service at Salado is a partnership of ASU and the City of Phoenix's Rio Salado Project. The CAP LTER education team coordinates the *Service at Salado* program. They work with the schools, the City of Phoenix, and the ASU undergraduates to create a positive learning

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environment for the children in after-school clubs. ASU undergraduates enroll in a 3-credit Service Learning class to participate in the clubs and are directly supervised at the school site by a paid undergraduate facilitator. These facilitators work with the CAP LTER education team to ensure that the active learning strategies implemented in *Service at Salado* meet national and state academic standards in science, math, language arts, and social studies. The CAP LTER education team also provides expertise in urban ecological research. CAP LTER scientists, post-doctoral associates, graduate student, and REU students have the opportunity to share their research with the children. The ASU students gain hands-on experience in establishing an environmental education program and also learn about the urban ecosystem and the many facets of restoring part of the urban landscape. Too often, the interaction of low-income and minority populations with their local environment involves existing environmental and social problems in their neighborhood: abandoned lots, industrial pollution, graffiti, and gangs. *Service at Salado* provides a positive context for involvement with the environment and urban ecology.

We evaluated the goals and outcomes of *Service at Salado* through multiple assessments to determine impacts on the schoolchildren and service-learning interns. Together with an external evaluator, we collected data through surveys, standardized inventories used by interns, and focus groups with the interns. Evaluations revealed marked improvement among middle-school students related to the project's goals. According to pre- and post-semester surveys, students exhibited greater scientific aptitude, learned how to ask relevant questions, identify patterns, and make connections to their local community.

We will continue to support our other *Ecology Explorers* programs as well. We are working with a local nonformal education association to develop more urban ecology activities for local teachers based on CAP LTER research. We would like to request funding from this supplement for technical assistance to create online activities on the *Ecology Explorers* website. We see the online urban ecology field guide as a venue for sharing data collected via wireless monitoring devices (see description below) that are proposed as additions to CAP LTER's monitoring program.

LTER Schoolyard Summary Budget

Personnel, undergraduate	11,220
Fringe Benefits (4%)	449
Travel	1,196
Participant Costs	
Stipends	800
Other	5,796
Other Direct Costs	
Copying	500
Web development	2,000
TOTAL Direct Costs	21,961
F&A (26%)	3,995
Total	**25,956**

Other: Implementation of Wireless Data Transfer from Remote Locations at CAP LTER

CAP LTER maintains a network of tower-mounted environmental sensors at several locations within the study-area boundary. Currently, one 10-m tower and one 3-m tower are located within the urban core, and a second 10-m tower is located downwind of the metropolitan area. A fourth tower to be installed later this year will be located upwind of the metropolitan area. Each tower is fitted with sensors to monitor wind speed and direction, temperature, relative humidity, incoming solar radiation, and precipitation. In addition to invaluable long-term monitoring of atmospheric properties, data collected from these towers support projects aimed at investigating (1) the urban heat island, and (2) the ecological effects of atmospheric deposition on the Sonoran desert ecosystem. Eventually, sensor data from these towers will contribute to long-term studies of annual net primary productivity (ANPP) at upwind, core, and downwind locations.

Data collected by the tower-mounted sensors currently are stored by data loggers (Campbell Scientific, Inc., Logan, Utah) that are downloaded manually to a computer at regular, frequent intervals. We request funds to establish wireless data-transfer capability between the towers and the CAP LTER database at ASU. This upgrade will include outfitting the towers with cellular modems and developing data-processing routines. Implementing wireless data-transfer is critical to maintain data collection at these remote locations when field activities co-located near the towers are reduced in the future. Further, the addition of wireless data-transfer technology will greatly reduce CAP LTER operating costs by reducing technician hours and vehicle operating expenses associated with manually downloading the data loggers. Distance between the towers is > 160 km and driving time to each location is considerable. Minimal equipment is needed for the proposed upgrade to wireless technology as the existing data loggers are capable of communicating with a cellular modem, and CAP LTER equipment funds will pay for the modems.

Funds requested will support a graduate-student programmer who will write procedures for (1) quality control of the streaming data, (2) data reduction, (3) data storage and retrieval, and (4) algorithms that send alerts when sensor maintenance is required. Quality control will include algorithms that check for outliers by comparing data among towers, the values to their neighbors within the data stream, and to upper- and lower-limits for each parameter. Streamed data will be loaded automatically into a database following initial quality checks and will be made available to CAP LTER scientists in near real-time via web services and a website. CAP LTER has adopted a web service model for climate data, following the standard established by Consortium of Universities for Advancement of Hydrologic Science (CUAHSI). The streamed sensor-data will be available to a wide audience via plug-ins for Microsoft Excel, Matlab, and other desktop applications developed by CUAHSI.

Other Summary Budget

Personnel, graduate	14,500
Fringe Benefits (41%)	5,945
TOTAL Direct Costs	20,445
F&A (26%)	4,045
Total	**$24,490**

Research Experience for Undergraduates

We propose a program of undergraduate involvement in research on urban ecological systems. Students will participate in a sequence beginning with an assigned *question* through their own development of a research proposal in which *hypotheses, predictions,* and *tests* are outlined, to collection and analysis of *data*, and then to an oral presentation of *results* in a summer research symposium. Our program builds upon our 17 years of experience in sponsoring undergraduate research in environmental biology (REU-EB), supported by multiple NSF-REU supplements but managed as a single program. The REU-EB (since 1990) and CAP LTER REU program (since 1999) have been successful in mentoring and training of undergraduate students.

CAP LTER PIs, project managers, or postdoctoral fellows are responsible for direct supervision of REU students. Each selected student is matched with a CAP LTER project, based partly on the investigator's ideas for a doable project and partly on the student's interests. The REU student will be responsible for his or her own project, but the project will interface closely with projects of the research group. It is equally important for students to learn that urban ecology must be cooperative and interactive as it is for them to gain technical skills. The existence of the University-wide Community of Undergraduate Research Scholars (COURS) program with many REU students working with IGERT in Urban Ecology Fellows, the previously mentioned summer REU-EB program, and the School of Life Sciences Undergraduate Research (SOLUR) program (with >50 student researchers) means there will be ample peer role models and opportunities to interact with other students pursuing similar paths. A formal symposium and other more informal social activities are coordinated with these programs at Arizona State University (ASU).

<u>REU recruitment</u>

As Table 1 indicates, we have had considerable success over the years in recruiting a diverse pool of applicants to the REU-EB and CAP LTER REU programs. Recruitment of REU fellows has been from primarily undergraduate colleges, ASU, and other universities. Many of these institutions have our program in their files, as we regularly receive inquiries beginning in December of each year. In addition, we have a web page and online application (http://sols.asu.edu/ugrad/reu/index.php). We update both this page and the CAP LTER home page (http://caplter.asu.edu) to promote the CAP LTER REU program. Our program contributes to advancement of affirmative action objectives by aggressively seeking women and minority candidates and by providing an opportunity for both female and male students of ecology to interact with female ecologists at faculty member, postdoctoral, and doctoral student levels. Recruiting for this summer's REU applicants is aimed at groups underrepresented in ecology and related disciplines, particularly Latino, American Indian, African American, and female students. ASU's School of Life Sciences currently has a 25% minority enrollment in its undergraduate program, evidence of an increasing ability to reach and attract students underrepresented in the discipline.

Table 1. Demographic composition of Summer REU applicant pool and fellowships awarded; 1990-2006. Minority category includes Latino/a, African American, and American Indian students; majority category includes Anglo and Asian American students. Values in parentheses are percentages of total applicants or fellowships.

Program	Female	Male	Minority	Ethnicity Unknown	Fresh or Soph	TOTAL
Applicants	286 (59)	200 (41)	72 (15)	206 (42)	na	486 (100)
Fellows	65 (64)	36 (36)	12 (12)	na	16 (16)	101 (100)

na= Not applicable or not available

Potential projects

Below is a list of projects that we will offer to students. We organize each project under a question that can be answered in our experience within the timeframe available. In addition to individual projects, the students will be encouraged to aid one another in their field and laboratory work, which gives them a broader range of experiences as well as a sense of camaraderie with their fellow REU students.

- Project 1: How does urbanization affect the isotopic composition of C and N in soils?
- Project 2: How does the dissolved organic carbon composition in Tempe Town Lake vary with season?
- Project 3: In what ways do black widow spider (*Lactrodectus hesperus*) populations from disturbed, urban habitats differ from populations from undisturbed, desert habitats?
- Project 4: How does the urban atmosphere affect the body elemental content and abundance of ground-dwelling arthropods?
- Project 5: Are long-term elemental deposition patterns changing in the Phoenix metropolitan areas as reflected by accumulation in lichens?
- Project 6: How do birds adapt physiologically to urbanization?
- Project 7: How does park ecology affect neighborhood crime and residents' perceptions of crime and park quality?
- Project 8: How does landscaping of stormwater retention basins affect soil microbial activity?

Past REU support

REU fellows during summer 2006 conducted individual research in the field of urban ecology. Shondra Seils (University of Arizona) worked with Stevan Earl to determine what characteristics of desert remnant open spaces contribute to higher species diversity and the overall presence of native species. Conclusions from this research are being used by the Arizona Game and Fish Department to evaluate appropriate methods to quantify wildlife in urban environments. Thomas Zambo (ASU) conducted research with Thomas Nash and Ken Sweat, using lichens as biological monitors of heavy metal deposition. Work conducted during the summer months has contributed to progress on this research initiative.

REU Summary Budget

Participant Costs	
Stipends	4,800
Travel	1,500
Subsistence	2,000
Other	2,500
TOTAL Direct Costs	10,800
F&A (25% stipends)	1,200
Total	**$12,000**

B. International Research Collaboration

Experimental Approach to Assess the Role of Top-Down Forces in Urban Avian Communities

Investigators: Eyal Shochat and Paige Warren

Urban community ecology research has only recently implemented a mechanistic approach, moving beyond descriptive studies. Research on trophic dynamics has revealed that the influences of top-down and bottom up forces on biotic communities are not predictable based on the distribution of predators, prey, and resources. For example, it is now widely agreed that human resource subsidies account for increases in densities of animals such as birds in urban areas, but the role of top-down forces (predation) remains unclear. Some researchers emphasize the high abundance of domestic and feral predators as evidence of increased predation pressure in cities. However, recent experiments on bird foraging behavior at the CAP LTER sites along with the broadly replicated finding of high bird densities in cities suggest that top-down control on urban birds is negligible. The best way to resolve this question is through manipulative experiments that alter risk of predation. Such experiments require skilled manipulation of predators in a field environment. Very few researchers have applied such an approach successfully.

Proposed project

We propose to collaborate with researchers from the Ben-Gurion University (BGU) of the Negev, Israel, taking advantage of their successful past experience with training birds of prey and using the birds in field ecological research. The research will be conducted in urban parks in Beer-Sheva, southern Israel, and in 'Sayeret Shaked', a desert park and ILTER site located northwest of the city.

Our past research in CAP LTER suggests that the perceived risk of predation is lower in urban sites in Phoenix as compared with Sonoran desert sites (Fig. 1). We measured perceived predation risk of birds using giving-up density (GUD) – the leftover amount of seed in artificial food patches (seed trays) in different microhabitats. The GUD has been shown previously to be sensitive to differing levels of predation risk related to microhabitat structure: GUDs are higher in open microhabitats than near bushes. Bushes reduce the cost of predation, allowing birds to quit foraging later than in the exposed open microhabitat, thereby increasing their harvest (Fig. 1). In Israel, our collaborators have found similar patterns of altered GUDs in urban parks versus wildland parks (I. Tsurim, pers. comm.).

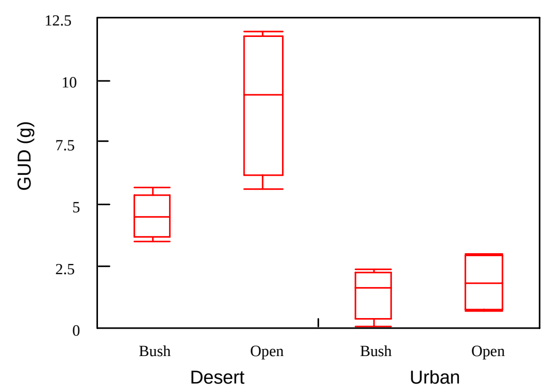

Figure 1. The effect of microhabitat (Bush or Open) on GUD. Unlike in the desert, in the urban habitat there was no microhabitat effect on GUDs. This lack of difference suggests that refuge from predators is not a primary driver of foraging behavior in urban sites. (from Shochat et al. 2004)

We hypothesize that risk of predation is lower for birds in urban habitats than in wildlands, both in Arizona and in Israel. If so, we predict that increasing the perceived cost of predation through raptor over-flights should increase GUDs to a similar level to the desert. The Israeli researchers will train Common Kestrels *(Falco tinnunculus)* during summer 2007. Susannah Lerman, a graduate student, will travel to Israel and spend 6 weeks collaborating with the Israeli researchers to conduct the experiments as part of her Ph.D. thesis (advisor: P. Warren, U. Mass-Amherst).

Methods

At each site, we will deploy two arrays of seed trays, a falconry array and a control array (Fig. 2). Arrays will consist of four stations, each having a tray in the bush (Fig. 2, orange/dark color) and a tray in the open (Fig. 2, grey/light color), measuring GUDs at all stations in a park concurrently. Analyses will use stations nested within treatment array, nested within site. Trays will be placed on stools, one close to a tree or bush, and one at a distance of three meters. Control arrays will be located out of range of over flights and out of horizontal view of experimental stations. All analyses will use stations nested within park and treatment as the units of replication. Experiments at each site will follow a nine-day course: Fly falcons once per day during Days 1-3, then alternate days with falconry flights over four more days (flights on Days 4 and 6). Responses of prey birds will continue to be measured through Day 9 in order to determine how responses to elevated predation risk persist. At each location (urban vs. desert), we will have measurements of response for a total of eight trays over five days with falconry and with four days without falconry (Days 5,7,8, and 9) and eight trays with no falconry for nine days. This will tell us whether the response to elevated predation risk is fast (on a daily basis), or whether perceived risk accumulates after a series of over flights, with a place becoming perceived as generally 'risky' over time.

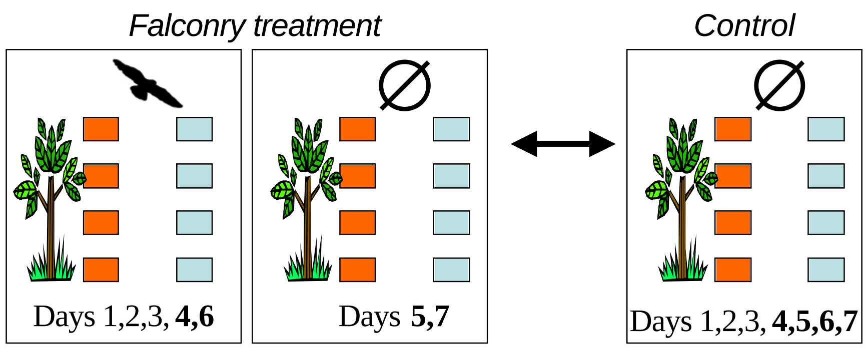

Figure 2. Planned protocol for conducting and measuring responses to falconry over flights in both urban and desert sites. The protocol allows for comparisons between falconry and non-falconry treatments both in space and in time, as well as within and among sites.

Timetable and budget

Dr. Ofer Ovadia from BGU will apply to the Israel Nature & Park Authority for permission to raise and train 10 Common Kestrels for research. The Common Kestrel has a wide distribution in Israel and will be collected from a robust population. Training the birds requires the work of two skilled technicians for 5 months. The majority of the budget will cover their salaries. Training will start in Summer 2007, and the experiment will take place in Winter 2007/08. The remainder of the budget will cover local travel and accommodation for Susannah Lerman while in Beer-Sheva, Israel. Dr. Ovadia will cover the expenses of equipment and materials (trays, millet seeds, sand etc.), and other funds will be used for Lerman's international travel.

International Summary Budget

Travel within Israel	1,100
Accommodation in Israel	535
Consultant - Technicians	6,300
TOTAL Direct Costs	7,935
F&A other (26%)	2,063
Total	**$9,998**

C. SOCIAL SCIENCE SUPPLEMENT

Untangling the Variability in Urban Ecological Processes: Socioecological Drivers of Residential Landscape Management and Ecosystem Responses

Investigators: Kelli Larson and Sharon Hall

Human management of agricultural lands is the primary driver of global-scale changes to the nitrogen cycle, and second only to fossil fuel combustion in controlling anthropogenic carbon flux to the atmosphere (Vitousek et al. 1997). Thus, research has primarily focused on the impact of agricultural practices on biogeochemical cycling. Although a relatively small area globally, intensively managed urban landscapes such as lawns are increasingly prevalent worldwide. For example, turfgrass is now the largest irrigated crop in the U.S. (Milesi et al. 2005), covering 10-16 million hectares (Robbins et al. 2001) and contributing to high rates of water and fertilizer use. Alternative residential landscapes, such as water efficient xeriscapes, are often planted with densely spaced productive species that are drip irrigated, raked, and pruned (Martin 2001). Despite the growing importance of these designed landscapes and potential policy implications, little is known about how diverse homeowner practices impact biogeochemical cycling and few studies have linked the drivers of residential land management to ecological impacts.

In the proposed research, we will combine expertise in the social and natural sciences to address: ***What are the factors that drive residential landscape management decisions, and how do these practices affect ecological processes, specifically biogeochemistry?*** We will evaluate how landscape types (xeriscape yards, turfgrass lawns), irrigation practices (technology, frequency), and the application of agrichemical products (fertilizers, pesticides) impact soil nutrients, microbial processes, and emissions of trace gases into the atmosphere. Through an integrated sampling design and field work, we aim to investigate coupled socioecological processes by explicitly linking reported landscape practices from social surveys to biogeochemical responses in the arid region of Phoenix, AZ. This integrated approach represents a step forward for CAP research, and LTER support through a Social Science Supplement grant will help leverage additional, external funds for a more extensive follow-up project.

Background research related to the work proposed

The research proposed will create a new, integrated study that builds upon existing projects in urban ecology. PI Hall and students are exploring whether residential xeric yards that are landscaped with native plants mimic the functioning of natural desert ecosystems. By sampling biogeochemical processes across an urban-rural gradient of manipulation (turfgrass lawns, xeriscaped yards, native Sonoran desert), they are finding that managed xeriscaped gardens bear key ecological resemblances to both lawns and deserts with respect to nutrient cycling and gas exchange with the atmosphere. However, the variability of ecological processes within "replicate" yard types is large, enough in some cases to blur the distinction between landscape types. This uncertainty is likely driven by residential management practices that were not incorporated into the current study.

PI Larson is currently designing a pilot survey (funded through an internal ASU grant) to identify a range of residential landscape management practices encompassing the use of water, pesticides and fertilizers. This survey will be conducted using a modified value-belief-norm (VBN) model in order to determine the theoretical drivers of these behaviors (Stern 2000), including environmental and other lifestyle values, beliefs about adverse consequences and responsibility, and perceived norms and expectations in addition to social-structural (demographic, household and property characteristics) and situational (legacy effects from past land uses, access to flood irrigation) explanations. Because this existing effort is focused on the factors driving human behavior with closed-ended questions from a survey, the existing project does not support rich qualitative explanations for heterogeneous management practices, nor does it address the ecological responses of landscape practices.

In the proposed work, we will develop an integrated study to explore the relationships between the drivers of residential landscape decisions, the diversity of these management practices, and their impacts on local and regional biogeochemical cycling. Specifically, we will link household data from Larson's survey (already funded) to new, follow-up field surveys to connect reported behavior and associated drivers with a suite of ecological response variables measured in respondent's yards. In addition, the field work will explore more fully the reasons underlying landscape management practices through complementary qualitative techniques (i.e., interviews with homeowners). Co-located with other comprehensive field work at CAP, our research will engage respondents to the social survey, which targets a random sample of homeowners (n>30) in 4 distinct neighborhoods (total n>120) ranging from low-to-high income households and predominantly mesic (grass lawns) to xeric yards. Focus on these neighborhoods allows an exhaustive case study approach that considers local context (e.g., historic, cultural, economic) and incorporates findings from past research (e.g., Harlan et al. 2006).

With a nested sampling approach, we will measure several ecological variables at all survey sites (n=120), and additional social and ecological variables at select sites (n=32), with 8 yards per neighborhood split between mesic lawns and xeriscaped yards. Within all sites, we aim to measure variables that characterize biological structure (plant community composition, distribution, biovolume) and key soil properties that drive nutrient cycling (temperature, moisture, total organic matter). The subset of sites will be selected based on field and social surveys to represent diverse management practices within each neighborhood. At the intensive sites, we will also analyze soil microbial processes (net N mineralization, nitrification), soil emissions of greenhouse gases (methane, nitrous oxide, carbon dioxide) and gases that regulate air quality (ammonia, nitric oxide). Moreover, semi-structured interviews will explore questions raised by past research about how residential landscapes reflect social identities and status (e.g., "ecology of prestige;" Grove et al. 2006), why environmental concern does not translate into pro-ecological behavior (Robbins et al. 2001), and how neighborhood norms influence landscaping behavior (Nielson and Smith 2005).

Significance and broader impacts

Our integrated socioecological study will be the first to quantify relationships between the drivers of human behavior, residential landscape management decisions, and ecological responses that affect ecosystem functioning and services. We will train a team of students (graduate and undergraduate) to assist with field surveys, interviews, sample collection and processing, and data analysis. We also plan to incorporate this research into an IGERT in Urban Ecology workshop on coupled socio-ecological research, with residential landscapes as the theme. Beyond advancing scientific research and education, the proposed project will inform policy efforts aimed at improving water conservation and environmental quality.

Social Science Supplement Summary Budget

Graduate Research Assistant	6,325
Fringe Benefits (41%)	2,593
Undergraduate Student Hourly	1,440
Fringe Benefits (4%)	58
Travel	338
Participant costs - Incentives	1,920
Supplies and analysis	4,000
TOTAL Direct Costs	16,674
F&A (26%)	3,282
Total	**$19,956**

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