**Central Arizona–Phoenix Long-Term Ecological Research: Phase 2**
RE: 2010 Combined Supplements Request for NSF Grant # DEB-0423704
Nancy B. Grimm and Charles L. Redman, CAP LTER Project Co-Directors

CAP LTER researchers are engaged in integrative science that involves partnerships among disciplines to conduct research, detect change, examine impacts, and devise appropriate solutions to problems in rapidly urbanizing regions. Having adopted a modification of the Integrative Science for Society and Environment (ISSE) conceptual framework to guide our research, we continue to explore the dimensions of social–ecological interaction while focusing on urban ecological pattern and processes. Further, we are actively seeking opportunities to expand our studies in space and time, and to collaborate with others to more effectively use comparative approaches to understand socioecological systems. In this spirit, we propose a set of education and research projects to further this agenda within CAP LTER.

## A. EDUCATION SUPPLEMENT REQUEST

Investigators: Monica Elser, Heather Bateman, Chad Johnson, Robert Ziemba and others

### Schoolyard-Related Activities

Environmental education and outreach activities are woven throughout CAP LTER. We reach out to the K-12 community in a program called Ecology Explorers that engages teachers and students in urban and field ecology. Through previous Schoolyard supplements we have targeted both the teaching community through teacher workshops and internships, and students through after-school programs and in-classroom activities.

Through an NSF-funded Teacher Professional Continuum grant, we developed and tested a one-week teacher workshop on Urban and Field Ecology, incorporating major aspects of the Ecology Explorers program and CAP LTER science. We are working with individual school districts to offer this workshop to their teachers. We would like to continue in 2010-2011 to offer this high-demand program twice to our partner school districts, as well as to provide follow-up classroom visits, using a teacher consultant to assist in classroom implementation.

We were able to offer one of these workshops with a community partner, the Chandler Environmental Education Center (CEEC). The success of this workshop has spurred their interest in establishing Ecology Explorers monitoring sites on their property and engaging children in after-school urban ecology programs. We will identify a CAP LTER graduate student interested in outreach and ecology education, who will work with the CEEC as a "visiting scientist" for after-school classes and mentor local high school students on potential ecological studies at the CEEC. We believe this pilot program could be expanded to other urban environmental education centers in our area.

Finally, we would like to include more dynamic material on the newly updated Ecology Explorers website. The CEEC has also offered their location as a site to collaborate with local high school students to create videos of Ecology Explorers sampling protocols. Dr. Heather Bateman, a CAP senior scientist working with herpetofauna, will develop an educational video/webinar on urban herpetofauna that would be appropriate for K-12 school-age children. The 15 to 20-minute video is planned to include sections on how to identify local amphibians and reptiles, how scientists conduct herpetological sampling, and instructions for students on what to do if they encounter an unfamiliar reptile. We will work with a local children's author to create an appropriate script for this video. We will explore other potential video projects, including the black-widow spider project that CAP senior scientist Dr. Chad Johnson is currently bringing to area schools.

### Research Experience for Undergraduates

We propose to engage undergraduates in our research on urban-ecological systems. Students will participate in a sequence of activities. They will begin with an assigned *question* through developing a research proposal that outlines *hypotheses, predictions,* and *tests,* proceed to collect and analyze *data,* and

then present their *results* in a summer-research symposium. Our program builds upon our 20 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 undergraduate students.

CAP LTER PIs, senior scientist, or post-doctoral scholars will supervise REU students. REU students will be responsible for their own projects, but these projects will interface closely with CAP research groups. 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. CAP REUs will also interact with other undergraduate researchers at ASU though workshops, symposia, and informal social activities.

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. We contribute to advancing affirmative action objectives by aggressively seeking women and minority candidates and providing an opportunity for both female and male students of ecology to interact with female ecologists at faculty member, postdoctoral, and doctoral levels. We will aim our recruitment efforts toward groups underrepresented in ecology and related disciplines, particularly Latino, American Indian, African American, and female students. Our School of Life Sciences currently has a 25% minority enrollment in its undergraduate program, evidence of an increasing ability to reach and attract students traditionally underrepresented in the discipline. Notably, this year ASU established a SEEDS chapter (SEEDS is a program of the Ecological Society of America intended to increase the participation of minority students in ecology), and we will recruit from this group of motivated students for our program.

Table 1**. Demographic composition of Summer REU applicant pool and fellowships awarded; 1990-2009.** "Minority" 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 | Majority | TOTAL |
|---|---|---|---|---|---|---|
| **Applicants** | 336 (61) | 214 (39) | 87 (16) | 217 (39) | 246 (45) | 550 (100) |
| **Fellowships** | 74 (65) | 40 (35) | 14 (12) | NA | 100 (88) | 114 (100) |

NA= Not applicable or not available

Below is a list of individual projects we will offer students. Each project will feature a question that can be answered within the timeframe available. In addition, we will encourage students to help each other in their field and lab work, broadening their experience and instilling a sense of camaraderie.

- Project 1: The Impact of City Structure on Urban-Induced Rainfall
- Project 2: The Effect of City Zoning Codes on Urban Form
- Project 3: Impacts of Urbanization on Small Mammals and Herbivory in an Urban, Arid Ecosystem
- Project 4: Impacts of Infrastructure Design on Urban Lake Biogeochemistry

**Research Opportunity Award**

The expansion of urban areas around the world will have immediate and long term consequences. One particularly understudied aspect of ecological disturbance via urbanization is the effect it has on patterns of genetic variation in populations of urban wildlife. Here we propose a collaborative research project between CAP senior participant Dr. Chad Johnson (ASU West) and Dr. Robert Ziemba (Maricopa Community Colleges) on the effects of urbanization on genetic variation in populations of the Western black widow spider, *Latrodectus hesperus*, in the greater Phoenix area. Investigating the impact of urbanization on genetic variation in black widows will increase our understanding of the ability of this venomous species of medical importance to adapt to an urban landscape and achieve high levels of

population growth (often resulting in urban infestations) and help us predict the long-term outcome of adaptations characteristic of urban pests.

Johnson's research program focuses on behavioral/ ecological variables that make urban black widows distinct from their Sonoran Desert counterparts. Perhaps the most striking ecological difference observed is that urban widow populations are more dense than desert populations. Anecdotal evidence also suggests that urban spiders are less aggressive and significantly less fecund than desert spiders. One hypothesis to explain these differences is that reduced genetic variation underlies differences between urban and desert populations. The proposed ROA research will bring together Johnson's behavioral and ecological expertise and Ziemba's molecular genetics expertise to address genetic structure of the populations.

Surveys of DNA variations can provide insight into the level of genetic variation within populations and can be used to estimate the degree of dispersal between populations. By comparing frequencies of genetic markers among populations in the urban matrix and in rural areas outside of Phoenix, we will determine the effects of known ecological differences between these areas on genetic variation. We propose to sample 20 individuals from each of 10 populations found both in heavily urbanized and rural areas. Using techniques and equipment in the Johnson laboratory at ASU's West campus, researchers will amplify regions of DNA known to be variable on small geographic scales in this and other species of spiders. Frequencies of unique sequence variations will be calculated for each population and used to estimate levels of genetic variation and test the prediction that gene flow among urban populations has been curtailed such that urban populations are less variable and more fragmented compared to desert populations.

Dr. Robert Ziemba is a faculty member in the Maricopa Community College District. Ziemba will work in Johnson's laboratory from 6/1/10 until 5/31/11, applying his expertise in molecular genetics while obtaining experience working on urban arthropod populations. As an instructor of non-majors biology courses, this experience will provide Ziemba with opportunities to enrich his teaching, especially on topics related to the interactions between humans and the urban environment. The field work will also provide Ziemba with an opportunity to learn more about the flora and fauna of the Southwest deserts, further enhancing his catalog of case studies for use in class. Finally, working on this project will allow Ziemba to answer an important question of interest to the urban LTER site in the Phoenix area and present an opportunity for him to publish his research. This project will be equally beneficial to the CAP research of Johnson, bringing expertise in molecular genetics to his research program focused on urban and behavioral ecology. Johnson and Ziemba plan to further develop this collaboration in a grant proposal to the NSF, to be submitted in July. ROA funding for this collaboration will provide the investigators with publishable pilot data that will further strengthen future grant submissions.

| **Education Supplement Budget** | |
|---|---|
| **Personnel** | |
| Student worker | $2,400 |
| Fringe (1%) | $24 |
| **Travel** | |
| Domestic | $2,000 |
| **Participant Costs** | |
| Stipends | $17,000 |
| Travel | $2,000 |
| Subsistence | $3,150 |
| Other | $6,000 |
| **Other Costs** | |
| Materials & supplies (lab supplies) | $4,150 |
| Non-capital equipment (video equipment) | $830 |
| Consultants (summer salary & teacher consultant) | $6,905 |
| Other (lab costs & incentives) | $10,252 |
| **Total Direct Costs** | $54,811 |
| **Indirect Costs (26%)** | $8,406 |
| | |
| **TOTAL** | **$63,217** |

**B. SOCIAL SCIENCE SUPPLEMENT REQUEST: PHOENIX AREA SOCIAL SURVEY 2011: IMPROVING RESPONSE OF HARD-TO-REACH GROUPS**

Investigators: Sharon Harlan, Nancy Grimm, Kelli Larson, Kerry Smith, Paige Warren, and Amber Wutich

We request support to improve the response of underrepresented minorities and persons with low educational attainment in the Phoenix Area Social Survey (PASS), CAP LTER's long-term monitoring program of social attitudes and behavior. In 2001–2002, we conducted a pilot study of 302 households in 8 neighborhoods. In 2006, we administered the second wave of PASS to 808 randomly selected households in 40 strategically selected neighborhoods, funded through NSF supplements to CAP LTER and the DMU-funded Decision Center for a Desert City. Summary survey reports can be found at http://caplter.asu.edu/research/research-projects/pass. To date, 13 peer-reviewed journal articles and book chapters using PASS data have been published or in press, 2 articles are under review, and several more are in preparation.

The goal of PASS is to increase understanding of how human behavior shapes urban socioecological systems and how changes in local ecology and ecosystem services affect people. PASS addresses important questions about how: 1) human communities form, adapt, and function in an urbanizing region; 2) human behaviors transform the preexisting ecosystem into an urban landscape; 3) spatial variations in ecosystem characteristics relate to social-class inequalities and cultural differences; and 4) changes in social, economic, and environmental systems affect the quality of life and vulnerability to environmental hazards for diverse human populations. Each time the survey is repeated, we create a more valuable legacy for future CAP LTER scientists who will analyze change in the socioecological system over long time spans.

**PASS 2006 Response Rates**

Through hard work and creativity, the research team achieved a 51% response rate for PASS 2006, which is above most surveys today (Curtin 2005). Low response has become a chronic problem in survey research due to ubiquitous marketing surveys, lack of public trust in poll takers, time pressures in households, and increasing use of cell phones rather than land lines for which phone numbers can be accessed through databases. In Arizona, we have the additional problem of extreme sensitivity to migration status among Hispanics, a situation that is worsening with the recent passage of a state law that criminalizes being in Arizona illegally. With our multi-method system of survey administration in PASS 2006—Internet, telephone, and home visits—and some bilingual interviewers, we were able to achieve our high-response rate. However, Table 1 shows that we fell short of proportionate representation of respondents in ethnic minorities and persons with lower educational attainment. Although this is characteristic of most surveys, **with additional resources to target hard-to-reach groups, we can do much to improve the response rate and representativeness of PASS 2011.**

**PASS Methods**

Sample neighborhoods for PASS 2006 were selected from among 204 long-term ecological monitoring sites (CAP LTER's Survey 200). We assembled Census demographic data for all 94 sites in residential areas, and cross-classified these census block groups (CBGs) by median household income and location into 7 groups: low-income core; low-income suburban; middle-to-high income core; middle-income suburban; low-to-middle income fringe, high-income suburban, and high-income fringe. As shown in Figure 1, we chose 5 neighborhoods of each type and added 5 retirement communities because of the importance of this demographic in the Phoenix area (n=40). A random sample of 40 households was drawn from each CBG and one adult resident per household was randomly selected to respond. Survey efforts continued until at least 20 responses were obtained in each of 40 neighborhoods (N=808, response rate=51%). We then georeferenced each survey location to enable CAP researchers to link social and biophysical contextual data with responses and use spatial statistics.

Our research plan is to create a long-term panel study. PASS 2011 will re-contact the 2006 sample residences and repeat questions about community sentiment and perceptions of social, built, and

biophysical environments. We will track residences in which occupants have changed, and replacement sampling will be used for nonrespondents. This study design will permit us to use statistical techniques that measure change in attitudes and behavior over survey intervals.

**Proposed Methods for Targeting Hard-to-Reach Groups**

We propose to use additional funding to enhance survey responses among hard-to-reach groups in two ways. First, we will add 2 additional high-minority neighborhoods to our sample. The PASS 2006 CBGs have somewhat higher proportions of non-Hispanic whites (69% vs. 62%) and somewhat higher median incomes ($63,887 vs. $48,124) compared to all CBGs in the Phoenix metro region (Table 1). Among the CAP LTER Survey 200 sites, we have 8 additional low- and middle-income CBGs with over 30% minority residents (mostly Hispanic) that were not included in PASS 2006. We will select 2 of these neighborhoods to add to the PASS 2011 sample (n=42), which will help to represent minorities more proportionately to the region's population.

Second, we will increase the number of bilingual interviewers who make in-person visits to all 42 neighborhoods in our sample, particularly to those households in low-income areas.

We are more likely to find residents with low-educational attainment, underrepresented in our previous surveys, in these areas. The PASS 2006 sample CBGs mirrored the educational attainment of CBGs in the region. Nevertheless, people with a less-than-high-school education were underrepresented among respondents (and correspondingly, people with a college degree and graduate education were overrepresented). Although adding 2 neighborhoods to the 2011 study will increase the number of individuals with low educational attainment in the respondent pool, we need additional measures to ensure their participation.

In summary, we believe Hispanics and people with low-educational attainment (all ethnicities) were underrepresented in our surveys partly because the CBG profile of our sample did not match the regional profile and partly because potential respondents had difficulties with the language and literacy skills required to participate in surveys. Those with low literacy skills and a less-than-high-school education are likely to need an interviewer walk them through the questionnaire. People with low literacy skills are found in all ethnic groups in Arizona and are likely to have additional issues, such as not speaking English (or English as second language), disabilities, work nontraditional work shifts, and have less access to computers and telephones (Pew Internet and American Life Project 2010). Therefore, we propose to add 2 neighborhoods and additional bilingual interviewers.

Support for this reasoning is found in the response modes of PASS 2006 participants: 59% of respondents completed the survey on the Internet; 34% completed a telephone survey; and 7% completed an in-person survey with an interviewer present in their home. However, only 18% of PASS respondents with a less-than-high-school education completed the web version of the survey compared to 63% of respondents with at least a high-school education completing the web version. In-person interviews were used by 22% of PASS respondents without a high-school education compared to 6% of respondents with at least a high-school education. The pattern was the same for Hispanic respondents, who used the in-person option more frequently than non-Hispanic whites.

**Significance**

Collection of high quality and representative data is essential to publish in top refereed journals.

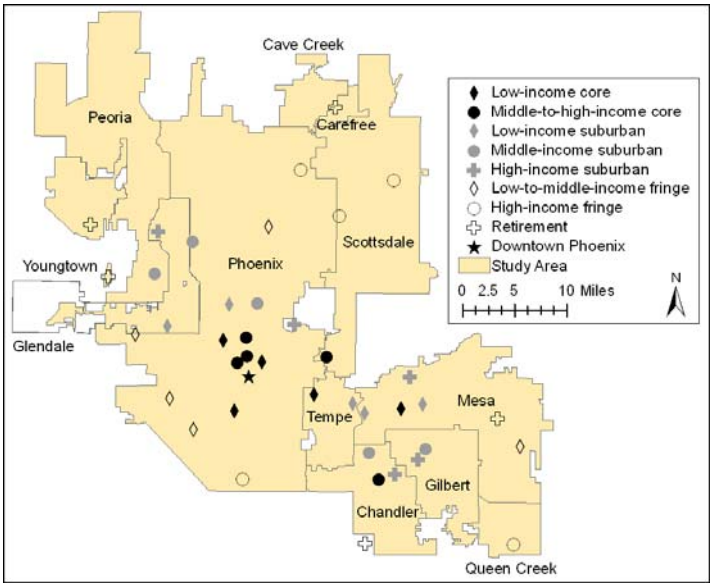
The PASS response rate (51% of contacted households completed the survey) is extremely good compared to national and local surveys, and we have published in a variety of journals. Nevertheless, we continuously seek to improve our survey. Additional resources will make PASS more representative of the region and include groups whose opinions are seldom heard on socioecological issues.

In addition, the expansion of the PASS neighborhood sample will strengthen the comparative research with other urban surveys with similar research designs, drawing on the PASS questionnaire. For example, University of Nevada sociologists have published results of the first Las Vegas Metropolitan Area Survey, which was modeled on PASS (http://strata.unlv.edu/docs/LVMASS.pdf). The University of Kansas is also

**Table 1.** Comparison of PASS 2006 Respondents' Demographic Characteristics with Population Profiles for All Census Block Groups in the Phoenix MSA and the 40 Census Block Groups in PASS 2006 Sample.

| | Phoenix MSA | PASS CBGs | PASS Respondents |
|---|---|---|---|
| **Population** | 3,805,123 | 83,402 | 808 |
| **Ethnicity** | | | |
| % White | 61.9 | 69.0 | 73.1 |
| % Latino/Hispanic | 29.5 | 24.0 | 19.2 |
| % African American/Black | 3.7 | 2.7 | 2.9 |
| % American Indian | 1.9 | 1.5 | 1.1 |
| % Asian, Hawaiian, Pacific Islander | 2.7 | 2.2 | 2.3 |
| **Education level** | | | |
| % <12 years | 15.8 | 15.5 | 7.2 |
| % a school graduate | 24.6 | 19.6 | 27.9 |
| % Some college | 33.0 | 31.3 | 18.3 |
| % Bachelors degree | 17.4 | 22.8 | 30.8 |
| % Graduate school | 9.3 | 10.8 | 15.8 |
| **Income** | | | |
| Median household income | $48,124 | $63,887 | $60,001-$80,000 |
| % <$40,000 | - | - | 35.8 |
| % $40,000–$80,000 | - | - | 28.6 |
| % >$80,000 | - | - | 35.6 |
| **Age** | | | |
| Median | 33.5 | 37.6 | 48.2 |
| % 18–64 years old | 84.6 | 78.7 | 79.2 |
| %> 65 years old | 15.4 | 21.3 | 20.8 |

**Figure 1.** Location of 40 Census Block Groups in the PASS 2006 sample.




proposing a neighborhood survey in Kansas City modeled on PASS concerned with similar socioecological issues in low-income neighborhoods.

### Work Plan

Sharon Harlan, associate professor in the School of Human Evolution and Social Change at Arizona State University, will lead the PASS 2011 study. Harlan directed the previous PASS studies. Many other CAP LTER investigators will contribute to designing the study and analyzing the results, including ecologist Nancy Grimm, geographer Kelli Larson, economist Kerry Smith, ecologist Paige Warren, and anthropologist Amber Wutich. A professional survey organization and staff trained at ASU in conducting door-to-door surveys in low-income households will handle the survey administration.

| **Social Science Supplement Budget** | |
|---|---|
| **Personnel** | |
| Student worker | $8,400 |
| Fringe (1%) | $84 |
| Field supervisor | $1,050 |
| Fringe (34.5%) | $362 |
| **Travel** | |
| Domestic | $1,602 |
| **Other Costs** | |
| Non-capital equipment (computer) | $1,370 |
| Other (incentives) | $3,000 |
| **Total Direct Costs** | $15,868 |
| **Indirect Costs (26%)** | $4,126 |
| | |
| **TOTAL** | **$19,994** |

## C. SUPPLEMENTS FOR INTERNATIONAL ACTIVITIES

Investigators: Nancy Grimm, Charles Redman, Hallie Eakin, Daniel Childers

We request funds to develop two international collaborations, in China and Mexico. The Chinese collaboration will build upon the Joint Center for Urban Sustainability (JCUS), established in 2006 by the administrations of Arizona State University (ASU) and the Chinese Academy of Science (CAS) by providing opportunities for PIs and a graduate student to work in Beijing in association with the Beijing Urban Research Station. The Chinese collaborator is CAS scientist Dr. Zhiyun Ouyang, Director of the State Key Lab of Urban and Regional Ecology and the Beijing Urban Research Station.

**Ecosystem Services and Urban Water Systems: Beijing, China and Phoenix, USA**

Water availability is a major challenge confronting China's cities and is an increasing cause for concern in the arid and semi-arid Southwest of the USA. The northwestern Chinese megacity (17 million inhabitants), Beijing, is situated in a semiarid climate zone and faces severe water scarcity that threatens future development (UNEP 2009). For the past eleven years Beijing has been in a state of climatic drought associated with a 28% decline in precipitation from historic averages (Probe 2008). In response to the water demand of its large population, dams, reservoirs, and other hydrologic manipulations have been put in place. Due to the gravity of Beijing's water issues, the Beijing municipal government is developing several programs focused on ecosystem services. Our Chinese collaborator was asked by local authorities to lead a comprehensive assessment of Beijing's water ecosystem services. The Key Lab of Systems Ecology recently completed a preliminary analysis, and is interested in expanding their study in collaboration with international scientists who specialize in examining ecosystem services in an urban context.

Like Beijing, the Phoenix metro area in central Arizona (4 million inhabitants) experienced extended climatic drought conditions until very recently, and has extensively modified upstream water sources over the past 100 years to serve its rapidly growing population. Moreover, the rapid population growth in this southwestern city puts burgeoning demand on a collision course with an anticipated hotter, drier future climate (Barnett et al. 2008).

Institutional responses, infrastructure development, and ecosystem impacts in the two cities are likely to differ due to different government structures, national developmental and/or economic contexts, and cultural norms. Therefore, a comparison of the benefits that people in Beijing and people in Phoenix derive from their rivers (i.e., water ecosystem services) may yield insight into the socioecological controls on ecosystem services—specifically, the role of governance and infrastructure design. Further, the temporal changes in ecosystem services as well as the ecosystem processes that underpin them may reveal how different temporal patterns of urbanization have affected river and riparian ecosystems in the two regions. These observations compel us to ask,

- *What ecosystem services do river-riparian ecosystems provide for Beijing and how does this compare with Phoenix?*
- *How have ecosystem processes and thus services associated with river-riparian ecosystems changed with watershed urbanization in the two regions?*
- *What features of the two regions best explain differences in ecosystem service delivery and change over time?*
- *How do the institutional arrangements and recognition of ecosystem services by decision-makers differ between the two cities?*

The research proposed will take advantage of the foundation laid by the Joint Center for Urban Sustainability (JCUS), an initiative between the Chinese Academy of Sciences and Arizona State University, and also funding received by graduate student Christina Wong under the EAPSI program to work in Beijing during summer 2010. Wong is Grimm's Ph.D. student and her initial work in Beijing will kick off her dissertation research, which will focus on quantifying water ecosystem services in Beijing and Phoenix. In this summer period Wong will refine the list of ecosystem services that area of relevance to both cities, develop and test a set of indicators of those services (i.e., measurements of ecosystem

processes or structures that directly or indirectly affect services), and acquire the remote imagery, background information, and detailed site information for Beijing. From this foundation, we will design a parallel study in Phoenix with close interaction (web- based conferencing) with our Beijing collaborators during fall 2010. We plan a short visit for PI and graduate student to Beijing, followed by a more extensive stay to continue the research initiated in 2010 and informed by experience in Phoenix.

***Collaborators:*** In 2006, ASU and CAS established the JCUS, which has since featured a few additional visits of Chinese delegations to ASU and US delegations to CAS, but has not yet spawned a comparative research project in urban ecology. Ouyang and Grimm have exchanged information about research approaches since 2003, when the CAS State Key Lab of Urban and Regional Ecology started examining Beijing's ecology under the leadership of Ouyang. Both Grimm and Ouyang participated in initial JCUS meetings, and Ouyang now oversees the CAS section of the center. This year, Wong will spend two months of summer 2010 in Beijing, and will be the graduate student who will return to China for an additional 2-month period during the next 12-18 months. Other CAP scientists may also participate in this initiative through web-based conferences, including Co-PI and wetland scientist Dan Childers, post-doc Laura Turnbull, and senior scientist and riparian ecologist Heather Bateman.

| **International Supplement Budget - China** | |
|---|---|
| **Travel** | |
| Foreign & in country – student | $3,000 |
| Foreign & in country – faculty | $2,200 |
| **Participants** | |
| Subsistence & housing - student | $2,800 |
| Subsistence & housing - faculty | $1,715 |
| **Other Costs** | |
| Materials & supplies | $1,000 |
| **Total Direct Costs** | $10,715 |
| **Indirect Costs (26%)** | $2,786 |
| | |
| **TOTAL** | **$13,501** |

**D. EQUIPMENT SUPPLEMENT REQUESTS**

Investigators: Stevan Earl, Nancy Grimm

**Air-quality sampling equipment**

Desert ecosystems are driven by pulsed inputs of the key limiting resource, water, but are also subject to limitations by nitrogen (N) and organic matter. Cities have diverse effects on the atmosphere, altering microclimates and emitting compounds that can potentially alleviate these limitations in local and downwind desert systems. Over the past four years, CAP LTER investigators have studied the impact of anthropogenically-mediated, elevated N deposition on protected Sonoran desert ecosystems in (desert remnants) and around the greater Phoenix Metropolitan area. We found that N deposition is enhanced by human activities in desert remnants within the city core, where inorganic N pools are 30-40% larger compared to outlying deserts soils. However, despite impacts to the atmosphere and soils, we found that primary production of annual and perennial desert plant communities appears relatively resistant to the city environment, even during relatively wet years when water is available and the limiting nutrient is expected to be N.

A lack of response to fertilization combined with a positive urban effect during the cooler season of the year suggests some other urban variable (higher temperature, $CO_2$) may be interacting with water availability to influence production of perennial shrubs in this desert ecosystem. Indeed, urbanization is a multi-factorial process—effectively, a global change experiment—whereby several potentially limiting resources and modulating factors are increased ($CO_2$, N, temperature), while potentially adverse environmental conditions are also induced ($O_3$). Recent multi-factor global change experiments show that these environmental factors can have complimentary or contradictory effects on ecosystems that may change over time. To explore (and deconstruct) the combined effects of urban atmospheric modification on Sonoran desert ecosystems, we intend to expand our assessment of potential ecological drivers. We will measure microclimate and atmospheric concentrations of $CO_2$, $O_3$, $NO_x$, and $NH_3$ across our 15 previously established desert study sites and relate these factors to long-term patterns of plant and soil

processes that are being measured by CAP LTER. Funds are requested here to purchase three Ogawa passive samplers (and supplies) that we will deploy at each site to measure ambient concentrations of $O_3$, $NO_x$, and $NH_3$ for one week, 2x/month, over one year (1.5 m height) at each of the experiment sites. These passive samplers have been validated against active monitoring methods in numerous studies in both remote and polluted environments, and represent a relatively low-cost method for measuring spatial heterogeneity of air quality. CAP LTER general funds are to be used to cover analysis costs. At these same locations, temperature and ambient concentrations of $CO_2$ will be measured using existing CAP LTER equipment and sensors to be purchased from general funds.

**Computer hardware for urban watershed delineation and analyses**

We request funds for computer upgrades to support applications related to the stormwater monitoring program that is being established with combined funds from CAP, Childers's start-up account, and an Ecosystems grant to Grimm and Earl. We have selected a series of nested catchments that differ in terms of the type of stormwater drainage infrastructure (e.g., pipes vs. washes vs. retention basins), and our analysis of catchment characteristics will require extensive land-cover analysis work. In addition, we will import classified imagery from the overall CAP land-cover classification effort as well as Census, parcel ownership, and other available data to establish a series of GIS layers that can be used to explain patterns in stormwater hydrology and biogeochemistry.

| **Equipment Supplement Budget** | |
|---|---|
| **Other Costs** | |
| Materials & supplies (filters & sampler housing) | $14,640 |
| Non-capital equipment (computers & samplers) | $5,200 |
| **Total Direct Costs** | $19,840 |
| **Indirect Costs (26%)** | $5,158 |
| | |
| **TOTAL** | **$24,998** |

## E. INFORMATION/DATA MANAGEMENT REQUEST

### Investigator: Philip Tarrant

The presentation of quality data for external consumption is one of the key goals of Information Management within the LTER community. Today, the people responsible for preparing these data for publication have very little input during the data definition and collection phase of a research project. This results in a "back-end" loading on the process, as substantial effort is often required to massage datasets and to prepare EML compliant metadata in a form that is compatible with the data management infrastructure.

By considering the nature of the data (both content and structure) to be collected during the life of a project, in conjunction with the desired end result (output datasets and EML compliant metadata), it is possible to reduce the overhead associated with both data collection and post project data processing. If this consideration is given at an early stage in the project then it is less likely that either the project team or the information manager will be faced with the need for retrospective data manipulation. Ideally, we would like to standardize as many aspects of data collection as possible for CAP projects to reduce the need to recreate data structures and project related documentation each time a project is initiated.

With this goal in mind, it is our intention to focus on streamlining the data collection process used by CAP researchers. In order to achieve this goal we intend to develop a data collection management system that will be a combination of simple processes, clearly defined standards, and productivity tools. These components are intended to improve the initial quality of data collected during CAP projects and thus reduce the need for post processing and quality checking. This is particularly pertinent in light of our

ongoing collaboration with the J-Earth development team at Arizona State University. We are currently in the early stages of supplying data for inclusion in the J-Earth environment (supported by a 2009 supplement). Consequently, we are re-visiting our existing data archival methods to ensure that our data are available in a format suitable for inclusion in J-Earth. Changes in data storage formats may be necessary to accommodate J-Earth's requirements.
The funds requested will be used to:

1. Create a dialog with faculty and researchers to determine ways to increase the level of standardization in data collection, processing and storage methods. A small number of process workshops involving faculty, researchers and information management team members will be conducted to collect these requirements.
2. Define and document a common data collection process using input from these "user" workshops. This common process definition will be shared with other LTER sites to look for additional synergy and commonality in data collection methods.
3. Within the agreed process framework we intend to develop tools, standards and data templates to support the process. The tool development phase of this project will aim to use technologies in common use within the LTER community (PHP and MySQL) in order to maximize potential opportunities for sharing the CAP solution with other sites. We anticipate that this solution will enable researchers to define EML compliant project metadata during the early stages of their project.
4. Provide education to the CAP research community to increase their knowledge of LTER data requirements, EML metadata standards, and the contribution these standards make to the effective distribution of our data. We believe this will assist with adoption of common standards for data collection, processing and storage. We currently envisage that new researchers joining CAP will receive this education as part of their induction into the organization. This education package will also be made available to any other sites who wish to utilize these data tools and standards.

In order to facilitate sharing the tools and processes developed during this project with other LTER sites support is also requested for travel. Funds will be used to send an IM team member to two information management meetings related to this work and to support the preparation of associated materials such as documentation. Additionally, to foster and optimize cross-site collaboration, we request funds to organize and participate in a co-development activity that includes support for either one team member to visit another site or to host another information manager at our site. These are unique, targeted professional development opportunities that provide venues for dialogue and learning within a community of practice as well as for coordinating cross-site and network-level activities.

We expect the deliverables from this project to be:

- A documented on-line data collection process with associated standards and documentation templates.
- Tools for defining data formats and EML compliant metadata as close to project inception as is feasible.
- An education package for training researchers on the process and tools available to support the process.

| **Information Management Supplement Budget** | |
|---|---|
| **Personnel** | |
| Student worker | $16,640 |
| Fringe (1%) | $166 |
| **Travel** | |
| Domestic (cross-site collaboration) | $3,750 |
| **Other Costs** | |
| Materials & supplies (workshop) | $100 |
| Other (workshop costs) | $400 |
| **Total Direct Costs** | $21,056 |
| **Indirect Costs (26%)** | $5,475 |
| | |
| **TOTAL** | **$26,531** |

## References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