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

RE: 2009 Combined Supplements Request for NSF Grant # DEB-0423704

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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, Anthony Brazel, and Chad Johnson

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 schoolyard ecology. 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.

In 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. Our summer internships and workshops have always been in high demand. Recently, we have begun working directly with school districts and local informal environmental education providers to co-offer these workshops/internships. For example, last summer we offered a one-week summer internship for high school teachers from the Deer Valley Unified School District and a day-long workshop for elementary school teachers in the Kyrene Elementary School District. This summer we will offer a workshop for middle-school teachers in association with the Office of Youth Preparation on the ASU campus, and we are exploring the possibility of offering joint workshops with several local environmental education groups. We have developed a relationship with one local school (Navajo Elementary School) that entails activities directly linked with climate and water projects of CAP LTER. First, we are delivering classroom programs that the school's science coordinator has suggested meet a curricular need. We also are installing a weather station, flow-metering equipment, and collectors for capturing stormwater runoff from school grounds, including parking lots, roofs, and drainage channels. Data from the weather station and the flow meters will be available for classroom activities that are designed by Ecology Explorers staff and graduate students in partnership with the science coordinator. We continue to support an after-school science club that targets low-income students. We have developed several lessons based specifically on CAP LTER data and projects. These will be tested in classrooms and then placed on a redesigned Ecology Explorers website.

To meet our CAP LTER education goals, we strive to continue to make connections between CAP LTER research and the education community. In this supplement proposal, in addition to

the workshops we continue to offer, we also request funding for two new projects. The effects of the urban heat island (UHI) on local climate and the urban ecosystem continue to be a major research focus in CAP LTER, and we have developed some education materials on this topic in the past. Building upon our current experience working with Navajo Elementary School, we plan to develop an education module on the UHI for another low-income school closer to the Phoenix urban core, in collaboration with recently funded UHI studies based in low- and middle-income neighborhoods of the central city (NSF-CNH; Dr. Sharon Harlan, PI/PD, Dr. Anothony Brazel and others, Co-PIs). Both Harlan and Brazel are CAP co-PIs. Dr. Brazel will work with our education team to expand activities and teaching kits, so that graduate students and/or advanced undergraduate students can take them into the classroom. He will assist in recruitment of these students through his graduate seminar on the UHI and his undergraduate climatology courses. He and our CAP LTER education staff will also visit the school and conduct in-classroom activities. A 2008 GK-12 application included activities on the UHI with high school students. If this is funded, we will establish synergies between this effort and the elementary school activities described above.

As part of the Ecology Explorers program, we have developed a pitfall trapping protocol for schoolyards. Spiders are frequently caught in these traps, and we have the opportunity to work with Dr. Chad Johnson to capitalize on the requests we have received over the years for more information about local spiders. Dr. Johnson has studied urban black widow behavior with support of the CAP LTER, and he would like to take this research to the classroom by piloting an education module investigating black widow behavior in a local school. He has identified both the school and an interested middle-school teacher. Topics in this pilot module will include urban-desert ecology with emphasis on adaptations to each habitat, spider diversity, the natural history of black widows, and black widow behavior. Students will observe black widow behavior in a safe, controlled environment in the classroom and be mentored by Dr. Johnson and his students to develop questions that can be answered by the test of a clear hypothesis and prediction. The students will have the opportunity to design a behavior protocol, collect and analyze data, and share their results with classmates and their school through science fair posters. Spider safety will also be addressed, and students will never work around spiders without supervision from their teacher, Dr. Johnson or one of his staff. Dr. Johnson and the middle school teacher will work with the CAP LTER Education team to further refine the lessons for the Ecology Explorer website. Additionally, Dr. Johnson and the CAP Education team will develop a field guide for local spiders, especially those commonly found in the urban environments. We plan to offer a teacher workshop in summer 2010 to share these activities and link with the current Ecology Explorer pitfall trapping protocols.

LTER SCHOOLYARD SUMMARY BUDGET

Personnel, undergrad	$1,500
Fringe Benefits (4%)	60
Equipment	
Weatherbug	8,000
IR themometers	600
Digital thermometers/wind/humid.	2,500
Spider study equip.	600
Travel	1,375
Participant Costs	
Stipends	4,000
Travel	320
Subsistence	300
Other	500
Other Direct Costs	
Consultants	2,000
TOTAL Direct Costs	21,755
F&A (26%)	2,245
TOTAL	**$24,000**

B. SOCIAL SCIENCE SUPPLEMENT REQUEST: LINKING DATA COLLECTION AND ANALYSIS AT THE PIE, CAP, BES, AND FCE SITES

Investigators: Kelli Larson, Sharon Hall, and Nancy Grimm

The proposed research activities reflect a coordinated cross-site proposal for the PIE, CAP, BES, and FCE LTER sites.

Problem Statement

The conversion of agricultural and forested lands to residential use represents the greatest contemporary source of habitat fragmentation and ecosystem decline in the United States. This transformation is well underway in each of the PIE, CAP, BES and FCE study sites. Yet the political, social and economic processes driving this transformation emerge from differing socio-ecological contexts. A growing body of integrated social-ecological science research – led by the BES and CAP LTER sites – suggests that lawns are an important lens for understanding (a) how suburban U.S. residential landscapes evolve across space and time, and, by extension, (b) the social drivers and ecological consequences associated with the land-use/-cover changes (Hope et al. 2003; Larson et al. in review; Pickett et al. 2007; Robbins 2007). Further research is needed, however, to systematically assess which mid-level social science theoretical perspective(s) – population density, social stratification, lifestyle characteristics, property regimes – provide the richest explanation(s) for the spatio-temporal evolution of U.S. residential landscapes across diverse geographic contexts (cf. Parker et al. 1999). These four theoretical domains direct attention to different scales of analysis, which is appropriate given the range of scales (household, neighborhood, municipal, national) associated with influences on urban and suburban form. These theories also provide, respectively, a comparative foundation for understanding within and among sites the relative influence of population patterns, differences in

social status and control of resources, cultural values and preferences, and urban form on ecological structure and household management practices in residential areas.

Ideally, research that tests these social theories would draw from a high-resolution dataset, standardized across multiple locations. We are aware of few, if any, instances of integrated socio-ecological research that has produced and analyzed such a dataset, which is the goal of this project. We shall employ multiple methods (land-use/-cover mapping, observational surveys, homeowner interviews, census and market segmentation data analysis) to test the power of these theories, using spatially explicit models of suburbanization and land management practices in four LTER sites. Our comparative framework will allow us to identify the conditions under which these processes produce common/convergent patterns while considering the specific environmental and social contexts that produce divergent place-based patterns. With a focus on the social drivers of land cover and the ecological structure of residential yards, the following question will guide the proposed work: *How and why does landscape structure and management vary within and across metropolitan regions of the U.S. as a function of the composition of and interactions among households and social groups?*

Team Background

The research proposed here would extend and expand a thriving collaboration among a set of social and ecological scientists at four LTER sites: CAP, BES, FCE, and PIE. This group (led by, respectively, Larson at CAP, Grove at BES, Ogden and Roy Chowdhury at FCE, and Polsky at PIE) has been collaborating since June 2008. The group has given a coordinated set of presentations at a scholarly meeting, met at the PIE social science hub (Clark University), to begin writing a scholarly, peer-reviewed article on our collaborations, and organized a February 2009 LTER meeting (at ASU-CAP), the goal of which is two-fold: (1) to advance network-wide socio-ecological science, and (2) to develop a November 2009 NSF-CNH grant proposal with a minimum of the four above-noted LTER sites. As each site brings a slightly different and complementary set of scientific approaches, this group offers a strong promise of advancing the LTER ISSE goals – a whole greater than the sum of its parts. In addition, the proposed work supports the goals of the broader cross-site LTER supplement request submitted by Gary Kofinas et al. (Maps and Locals – MALS) project by offering a model for integrating local knowledge into our quantitative and largely map-based analyses; our efforts are similar in motivation and focus, but differ principally in terms of temporal focus. Our project has a contemporary focus; the MALS project has a historical focus. Nevertheless, we will communicate and collaborate with this broader group to share research questions and methods appropriately applied for the distinctive but related initiatives.

Research Plan

In this proposal, we are requesting funds for the period September 2009 – December 2010 to launch the next phase of our exciting and productive cross-site socio-ecological research. Our overarching research objective is to analyze a standardized, high-resolution socio-economic-biophysical dataset for geographic similarities and differences in the processes generating residential landscapes across the four LTER sites. The work is divided into three Research Tasks.

Research Task 1: For the period September 2009 – April 2010, FCE and CAP will send PIE (at Clark University) their remotely-sensed imagery, and PIE (with technical assistance from BES

researchers at the University of Vermont) will derive the data from the imagery. PIE and BES will, in parallel, continue the processing of their remotely sensed data, such that all four data products are standardized. The product of this effort will be, for all four LTER sites, a similarly-produced (objected-oriented), high-resolution land-use/-cover classification focused on contemporary residential landscapes with a primary interest in lawns. Simultaneous with the classification effort, PIE will coordinate with each site to ensure a targeted and consisted collection of demographic (Census), property (Tax Assessor), and other socio-economic (e.g., CLARITAS PRIZM market segmentation) data at each site.

Research Task 2: Beginning in January 2010, PIE will coordinate the cross-site planning of the summer 2010 field-based data collection. The PIE-based PI and Research Assistants will work with all sites to refine and standardize for all sites the existing pilot household-level data collection protocols from CAP and BES. The field data will characterize ecological structure, land management, and yard-use practices (e.g., lawn cover/quality estimates, maintenance practices, human activities) based on observations of front yards visible from sidewalks. In summer 2010, the PIE leaders will implement these protocols at PIE, and will coordinate with the PIs at the other sites to ensure similar progress is being made with the aid of local research assistants. In addition to the observational data collected at selected households in each region (n = ~200/site), in-depth interviews (n = ~8/site) will be conducted at a sub-set of households with similar attributes (e.g., yard/lawn characteristics) across sites. This small-*n*, qualitative approach complements social survey data and associated quantitative analyses underway at 3 sites (CAP, BES, PIE), by producing information that cannot be obtained via the other data collection approaches. Accordingly, the cross-site team will have gained a richer basis for (a) understanding the social processes in question, and (b) interpreting the multivariate statistical analysis produced in Task 3.

Research Task 3: The datasets produced in the first two tasks will be processed and descriptively analyzed by August 2010. For the period September – December 2010, the datasets will be correlated in a multivariate explanatory framework. The dependent variables (ecological structure and lawn characteristics) will be measured using the imagery (Task 1) and observational surveys (Task 2), and the independent variables (population, socio-economic, lifestyle, property characteristics) will be operationalized and measured with the Census, PRIZM and Tax Assessor datasets (Task 1) building on the statistical analysis employed in Grove et al. (2006), Troy et al. (2007), and Zhou et al. (forthcoming). Particular attention will be paid to identifying which important factors are shared among the sites and which are unique to a subset of the sites, with qualitative analysis of the interviews to further validate and explain the quantitative findings. We anticipate that these efforts will produce several scholarly, peer-reviewed papers; topics include assessments of the social theories evaluated in each site and across sites; a commentary on the challenges and opportunities of cross-site data collection and processing; and a methodological paper outlining new techniques developed to specifically address emerging needs in the nascent field of integrated social-ecological research.

Budget Justification

Funds are requested to support the management and execution of the data collection and analysis in the four LTER sites, with PIE serving as hub. We propose to reduce costs by following CAP's successful model in their 2008 social science supplement proposal: to request funds for each site

but to designate one site to serve as the hub and to distribute to the hub some of the funds that might have been awarded to the other sites. Thus, instead of each site requesting approximately $20k, the hub is requesting $35k and the other sites ~$15k each, for a four-site total request of $80k. Polsky at Clark University (PIE's social science PI) is will coordinate these proposed activities. All of the funds requested by PIE will be directed to support a Postdoctoral Fellow or PhD student based at PIE-Clark, depending on the success of a national search for a postdoc. Polsky at PIE will support the PhD student/postdoc with existing funds for the period September through December 2010.

CAP is transferring $5,000 of its possible social science supplement funds to PIE; these are reflected in PIE's budget. For the remaining $15,000, CAP is requesting funds to support two undergraduate researchers to assist with the observational studies during summer 2010. As this is an ongoing effort at CAP, we anticipate that other students, paid under CAP's funding, will become involved in this research. CAP scientist Kelli Larson will supervise the undergraduates and interface with the PIE-based research coordinators. Funds are requested to cover gasoline for the CAP field vehicles that the student field technicians will use. Additional monies will be used to fund travel for training activities associated with this project, in particular the transfer of knowledge about CAP's observation protocol to the other sites.

SOCIAL SCIENCE SUMMARY BUDGET

Personnel, Undergrad	$7,680
Fringe Benefits (4%)	307
Travel	2,000
Misc. Materials & Supplies	1,918
TOTAL Direct Costs	11,905
F&A (26%)	3,095
TOTAL	**$15,000**

OTHER REQUESTS SHOULD FUNDING BECOME AVAILABLE

Investigators: Corinna Gries, Stevan Earl, Nancy Grimm

Should funding become available, we request monies to support three initiatives: 1) to improve spatial data management in CAP LTER through programming efforts; 2) to augment our stormwater sampling through the purchase of two ISCOs, and 3) to enable a CAP researcher to participate in a meeting for the Mapping and Locals (MALS) project.

Improving spatial data management

Currently, CAP maintains its spatial data, documented by EML and accessible as zip files from the file system. This approach is efficient for simple downloads and subsequent local use of the data. However, it does not allow for efficient spatial searches for available data and partial downloads (i.e. if only a small part of an otherwise very large file is needed), and thus it is cumbersome and sometimes time-consuming to use. To start building a functionality for rapid, efficient access to spatial data, we are proposing to take a first step in the development of a new data-management tool that we call "JEarth." The Mars Space Flight Facility (MSFF

www.mars.asu.edu/) at Arizona State University has developed JMars (http://jmars.asu.edu) over the last few years. JMars is now a mature, online facility to search, preview, analyze, and download desired Mars scenes. Several NASA missions, including Mars Odyssey, Mars Global Surveyor, Mars Reconnaissance Orbiter, and the up-coming Lunar Reconnaissance Orbiter use this system for mission planning and scientific data analysis. Building on these developments and experiences, the goal now is to duplicate and adapt this concept to Earth-related data. Clearly the scope of a project like JEarth is beyond the current proposal. However, this proposal will establish the collaboration between CAP LTER and the Mars lab by preparing our data for inclusion into JEarth. Moving from JMars to JEarth means new paradigms for data storage, access and sharing will have to be developed with the vastly larger amount of data available for the Earth than for Mars and the vastly larger user community. JEarth must draw on remotely stored data, hook into already existing networks, and leverage developments by other groups (e.g. GEON).

Accordingly, the first step toward this collaboration will be to set up a PostGIS database to hold all spatial data currently maintained by CAP. This step alone will allow local and remote researchers to directly access the data from within several mapping applications, including ArcGIS, and manipulate them before downloading, so that they download only what they really need. It will further allow us to directly link other collected data to locations and to more readily analyze long-term monitoring data in a spatial context. Currently, location shape files are stored separately from the data database; postGIS would allow us to access both simultaneously. PostGIS provides data in standard format ingestible by several mapping applications including Google Earth and Google Maps. The latter will be used to develop simple online applications to enhance CAP's web presence and outreach.

In a second step under this funding, we will install and configure an open source GeoServer to allow online preview of CAP's spatial data. GeoServer is an Open Geographic Consortium compliant server written in Java that allows users to share and edit geospatial data. Designed for interoperability, it publishes data from any major spatial data source using open standards (http://geoserver.org/display/GEOS/Welcome).

PostGIS and GeoServer are basic components on which future major programming efforts will build to eventually develop the functionality envisioned for JEarth. We request funding to hire a graduate student programmer for one semester to work on these products.

Stormwater research at the CAP LTER

Urbanization dramatically modifies hydrologic and biogeochemical templates of ecosystems that dictate the processing and movement of materials. Markedly peaked hydrographs and elevated contaminant loads are well documented for stormwater runoff within urban systems. However, coarse measures of urbanization (e.g., urban/undeveloped) or percent impervious cover typical of most urban stormwater studies do not adequately reflect the complex structure of urban catchments that influence stormwater hydrology and water quality. Further, most stormwater studies have addressed conditions in the more mesic eastern United States and are inappropriate for the unique seasonal storms of the arid Southwest. As such, complex dynamics among catchment characteristics, storm attributes, and runoff in highly urbanized settings of the Southwest are poorly understood. These limitations impair our ability to mange stormwater

effectively, and the efficacy of best management practices (BMPs) implemented locally but dictated at the national level is unclear. Impaired runoff quality has implications for downstream systems. In the arid Southwest, runoff from urban areas increasingly is managed as a source of active and/or focused recharge to limited groundwater resources, with consequences for groundwater quality.

CAP LTER investigators seek to understand the complex relationships between urban development patterns and stormwater runoff specific to the arid Southwest. Specifically, investigators are studying how sources, transport, and fate of contaminants in storm runoff vary with degree and form of urbanization. To facilitate this research, we seek funds for the purchase of automated stormwater sampling systems (ISCOs). We will deploy the ISCOs, supplemented by additional units from Grimm's laboratory, at the outflow of select watersheds spanning a gradient of land-cover characteristics typical of the greater Phoenix Metropolitan area. We will integrate stormwater sampling into our long-term monitoring to assess relationships between watershed characteristics and storm attributes, and to evaluate response of stormwater variables to future development and redevelopment. Sample collection, processing, and data management will be an extension of CAP LTER's Water Monitoring Program, which follows protocols developed by the US Geological Survey's NAWQA program. Student involvement is an essential component of the proposed research; participating graduate and undergraduate students will gain valuable field and lab experience, and contribute to dissemination products.

Participation in the MALS initiative

CAP LTER supports the Maps and Locals (MALS) proposal submitted by Kofinas et al. Here, we request minimal funds to allow a CAP researcher to attend a proposed meeting for this initiative. We will support this effort internally until additional funding becomes available. Specifically, we intend to:

- Conduct preliminary work, with Drs. Billie Turner and Luc Anselin, to identify map resources for the historical map comparisons initiative. This work is closely related to ongoing and planned research in CAP LTER.
- Capitalize on synergies between the residential landscaping work already underway at CAP, BES, PIE, and FCE (see information in supplement request above) and the proposed work on complementary social data analysis. We will contribute to this analysis through other, on-going social data analysis activities, such as the landscape fragmentation work funded through a 2008 social science supplement and analyses underway using the Trends datasets.
- Contribute information from a new research initiative on urban agriculture and backyard ecologies headed by Dr. Amber Wutich to the local knowledge insights work.

OTHER SUMMARY BUDGET

Personnel, Grad	$9,250
Fringe Benefits (7.22%)	668
Tuition Remission	6,777
Supplies, ISCO	3,690
Travel	885
TOTAL Direct Costs	21,240
F&A (26%)	3,760
TOTAL	**$25,000**

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