14th Annual CAP LTER Poster Symposium

Friday, January 13, 2012

Skysong

LTER

ASU Global Institute of Sustainability
Arizona State University

NSF

CAP LTER Fourteenth Annual Poster Symposium and All Scientists Meeting January 13, 2012 Skysong, Scottsdale, Arizona

January 13, 2012
Synthesizing Urban Systems Research

8:30 am Registration, coffee, and tea

9:00 am **Welcome**
Dan Childers, Lead PI and Director, CAP LTER; Professor, School of Sustainability

9:15 am **Rethinking Urbanization and Sustainability: Lessons from China and India**
Karen Seto, Associate Professor, School of Forestry and Environmental Studies, Yale University

10:15 am **CAP Synthesis Efforts**
Charles Redman, Professor, School of Sustainability; Virginia M. Ullman Professor, Natural History and the Environment, School of Human Evolution and Social Change

10:30 am **Climate, Ecosystems and People: Updates and Discussion**
Sharon Harlan, Associate Professor, School of Human Evolution and Social Change
Benjamin Ruddell, Assistant Professor, Department of Engineering, College of Technology and Innovation

11:00 am **Water Dynamics in a Desert City: Updates and Discussion**
Dan Childers, Lead PI and Director, CAP LTER; Professor, School of Sustainability
Ray Quay, Research Professional, Decision Center for a Desert City

11:30 am **Poster Session #1**

12:00 pm Lunch (for participants who have RSVPed)

12:45 pm The Global CO_2 Problem and Some Possible Solutions: What It All Means for Cities
Wallace Broecker, Newberry Professor of Earth and Environmental Sciences, Columbia University, Lamont-Doherty Earth Observatory

1:45 pm Biogeochemical Patterns, Processes, and Human Outcomes: Updates and Discussion
Christopher Boone, Professor, School of Sustainability; Professor, School of Human Evolution and Social Change
Sharon Hall, Associate Professor, School of Life Sciences

2:15 pm Human Decisions and Biodiversity: Updates and Discussion
Heather Bateman, Assistant Professor, Department of Applied Sciences and Mathematics, College of Technology and Innovation
Paige Warren, Associate Professor, Natural Resources Conservation, University of Massachusetts-Amherst

2:45 pm Education Updates and Discussion
Monica Elser, Education Manager, Global Institute of Sustainability

3:00 pm Information Management Updates and Discussion
Philip Tarrant, Director of Information Technology Services, Global Institute of Sustainability

3:15 pm Coffee break

3:30 pm Poster Session #2

4:30 pm Adjourn for happy hour at Papago Brewing

2012 CAP LTER Symposium

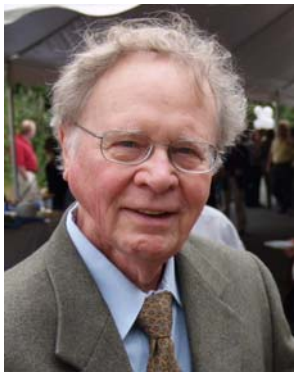
Posters are listed alphabetically by first author with poster location number in parentheses.

Poster Session #1 Climate, Ecosystems and People Land Use, Land Cover and Land Architecture Water Dynamics in a Desert City	Poster Session #2 Human Decisions and Biodiversity Biogeochemical Patterns, Processes and Human Outcomes
Bausch et al. (1)	Arnold and Stutz (20)
Bleasdale et al. (2)	Aronson et al. (21)
Brumand (3)	Beebe et al. (22)
Connors and Galletti (4)	Cook et al. (23)
Childs and Koyama (5)	Davies et al. (24)
Earl (6)	Gifford and Westerhoff (25)
Epshtein et al. (7)	Hale et al. (26)
Hodzic et al. (8)	Hamilton and Hartnett (27)
Kaplan and Myint (9)	Marusenko et al. (28)
Martin and Ruddell (10)	Miles et al. (29)
Middel et al. (11)	Ramirez et al. (30)
Nzengya (12)	Ripplinger and Franklin(31)
Pincetl et al. (13)	Schmoker et al. (32)
Sampson and Quay (14)	Still and Johnson (33)
Sanchez et al. (15)	Stromberg et al. (34)
Tuccillo et al. (16)	Trubl and Johnson (35)
Turner and Galletti (17)	Volo et al. (36)
Vins et al. (18)	Warkus et al. (37)
Zhang et al. (19)	Weaver and McGraw (38)
Ferry (40)	Weller et al. (39)

Speaker Bios

Karen Seto

Dr. Karen Seto is an Associate Professor at the School of Forestry and Environmental Studies at Yale University. Prior to joining Yale, she was on the faculty of the School of Earth Sciences at Stanford University for eight years. Dr. Seto studies the human transformation of land and the links between urbanization, global change, and sustainability. A geographer by training, her research includes understanding urbanization dynamics, forecasting urban growth, and examining the environmental consequences of land-use change and urban expansion. She is an expert in satellite remote-sensing analysis, applied econometrics, urban growth modeling, and has pioneered methods to reconstruct historical land-use and to develop empirical models to explain and forecast the expansion of urban areas. Dr. Seto is Co-Chair of the IHDP (International Human Dimensions Programme on Global Environmental Change) Urbanization and Global Environmental Change (UGEC) Project, and a Coordinating Lead Author for the chapter on "Human Settlements, Infrastructure, and Spatial Planning" of Working Group III of the *IPCC Fifth Assessment Report*. She also serves on the U.S. Carbon Cycle Scientific Steering Group, the U.S. National Research Council Committee to Advise the U.S. Global Change Research Program, the U.S. National Research Council Geographical Sciences Committee, and the U.S. National Research Council Committee on Needs and Research Requirements for Land-Change Modeling. Professor Seto is Executive Producer of *10,000 Shovels: Rapid Urban Growth in China*, a documentary film that integrates satellite imagery, historical photographs, and contemporary film footage to highlight the urban changes occurring in China. Professor Seto is an Aldo Leopold Leadership Fellow and recipient of a NASA New Investigator Program Award, a U.S. National Science Foundation Career Award, and a National Geographic Research Grant.



Wallace Smith Broecker

Dr. Wallace Smith Broecker received his undergraduate degree in physics at Columbia College in 1953 and his Ph.D. in geology from Columbia University in 1958. Dr. Broecker joined the Columbia faculty in 1959 and since 1977 has held the title of Newberry Professor of Earth and Environmental Sciences at Columbia's Lamont-Doherty Earth Observatory. For more than half a century, his major research interest has been the ocean's role in climate change. He was among the pioneers in radiocarbon and isotope dating – the quintessential processes for creating maps of the Earth's past climate fluctuations since as early as the Pleistocene period. He was also the first person ever to recognize the Ocean Conveyor Belt (which he named), arguably the most important discovery in the history of oceanography and its critical relation to climate. Dr. Broecker's research interests center on climate systems, especially as they involve the role of oceans in climate change. He places strong emphasis on utilizing isotopes in investigating physical mixing and chemical cycling in the ocean and the climate history as recorded in marine sediments. In 2008 FSG Books published *Fixing Climate: What Past Climate Changes Reveal About the Current Threat and How to Counter It*, which he co-authored with Rob Kunzig. His most recent book, *The Great Ocean Conveyor: Discovering the Trigger for Abrupt Climate Change*, was published in spring of 2010 by Princeton University Press. In 1979, Dr. Broecker was elected to membership in the National Academy of Sciences. He is also a member of the American Academy of Arts and Sciences, a Fellow of both the American and European Geophysical Unions and a Foreign Member of the Royal Society. The many honors he has received over the last few decades include: the Roger Revelle Medals of the American Geophysical Union, 1995; the National Medal of Science, conferred on him by President Bill Clinton in 1996; the Asahi Glass Foundation's Blue Planet Prize, 1996; the Tyler Prize for Environmental Achievement, 2002; the Ben Franklin Award from The Franklin Institute and The Crafoord Prize in Geosciences from the Royal Swedish Academy of Sciences, 2007; the Balzan Prize from the Balzan Foundation, 2008; Frontiers in Knowledge Award in Climate Change from the BBVA Foundation, 2009; and an Honorary Degree (Doctor of Science) from the University of Cambridge, 2009.

List of Posters

BIOGEOCHEMICAL PATTERNS, PROCESSES, AND HUMAN OUTCOMES

Cook, Elizabeth M., Sharon J. Hall, Ryan Sponseller, David P. Huber, Stevan R. Earl, and Nancy B. Grimm. ***Atmospheric nitrogen deposition in arid Phoenix, Arizona: A comparison of sampling approaches.***

Gifford, Mac, and Paul Westerhoff. ***Making biofuel renewable: Sustainable phosphorus recovery from microbial biomass***.

Hale, Rebecca, Laura Turnbull, Stevan Earl, and Nancy Grimm. ***Effects of urban stormwater infrastructure and spatial scale on nutrient export and runoff from semi-arid urban catchments.***

Hamilton, Alex, and Hilairy Hartnett. ***Black carbon in surface soil and subsequent black carbon photo-oxidation.***

Marusenko, Yevgeniy M., Karl A. Wyant, Sharon J. Hall, and John L. Sabo. ***Dynamics of urban biogeochemical cycling coupled with the interactions between soil microbial communities, the belowground food web, and land-use type in an arid ecosystem.***

Weller, Nicholas, Laura Turnbull, and Dan L. Childers. **The influence of storm characteristics and catchment structure on particulate organic matter transport in an arid city.**

CLIMATE, ECOSYSTEMS, AND PEOPLE

Martin, Elizabeth, and Benjamin Ruddell. ***Managing the effects of climate change on water and energy resources in the western U.S. using embedded resource accounting.***

Middel, Ariane, Anthony J. Brazel, Shai Kaplan, and Soe W. Myint. S***ummer cooling efficiency of landscapes in Phoenix, AZ.***

Pincetl, Stephanie, Michael Chester, Mike McCoy, Giovanni Circella, Paul Bunje, Zoe Elizabeth, Dan Flaming, Dan Gallagher, and Janet Ferrell. ***Complementing urban metabolism with life-cycle assessment for a Los Angeles energy baseline.***

EDUCATION

Bernier, Andrew, and students. ***Ecology Explorers: K-12 student contributions to the CAP LTER project.***
Hale, Taylor, and students. ***Ecology Explorers: K-12 student contributions to the CAP LTER project.***

Lansdowne, Kimberly, and students. ***Ecology Explorers: K-12 student contributions to the CAP LTER project.***

HUMAN DECISIONS AND BIODIVERSITY

Arnold, Susanne, and Jean Stutz. ***Impact of restoration practices on mycorrhizal inoculum potential in a semi-arid riparian ecosystem.***

Aronson, Myla F. J., Madhusudan Katti, Frank A. La Sorte, Charles H. Nilon, Paige S. Warren, Mark Goddard, Christopher Lepczyk, and Nicholas S. G. Williams. ***What concrete jungle? A global analysis of urban biodiversity.***

Beebe, Shaneen, Heather Bateman, and Kiril Hristovski. ***Burrowing Owl habitat selection in urban southeast Phoenix, Arizona.***

Davies, Scott, Kirsten Heller, Kyle Waites, and Pierre Deviche. ***The influence of urbanization on the reproductive phenology and morphometrics of the Abert's Towhee.***

Ferry, Lara. ***Food webs in urban fish "communities" from the Salt River Project canals.***

Miles, Lindsay, Robert Ziemba, J. Chadwick Johnson, and Brian Verrelli. ***A population genetic approach to investigate effects of urbanization and habitat fragmentation on the western black widow spider,* Latrodectus hesperus.**

Ramirez, Brenda, Yevgeniy Marusenko, and Sharon J. Hall. ***Characterizing ammonia oxidizing communities under legumes and non-legume plants in the Sonoran Desert.***

Ripplinger, Julie, and Janet Franklin. ***CAP LTER plant species diversity responds to land use and landscape aesthetics.***

Schmoker, Michelle K., Elizabeth M. Cook, Stephanie Amaru, Jennifer K. Learned, Scott L. Collins, and Sharon J. Hall. ***Bottom-up vs. top-down regulation of desert annual plants in an urban arid ecosystem.***

Still, Megan, and J. Chadwick Johnson. ***Predator-prey dynamics between urban, exotic crayfish and the threatened Sonoran Desert pupfish: The role of chemical communication.***

Stromberg, Juliet, Heather Bateman, Elizabeth Makings, Nico Franz, Helen Rowe, Stacie Beute, Amanda Suchy, Dustin Wolkis, Brenton Scott, and Rebecca DePuydt. ***Inventory and monitoring of the Salt River in Phoenix.***

Trubl, Patricia, and J. Chadwick Johnson. ***The urban stoichiometry of an arthropod pest, predator-prey system across metropolitan Phoenix.***

Volo, Thomas J., Enrique R. Vivoni, Chris A. Martin, and Stevan Earl. ***Modeling soil moisture and plant stress under irrigated conditions in semi-arid urban areas.***

Warkus, Erica, Dana Nakase, Sharon J. Hall, Osvaldo Sala, and Jennifer K. Learned. ***Spatial associations between nurse rocks and succulents in the Agua Fria National Monument.***

Weaver, Melinda, and Kevin McGraw. ***Response of urban and rural House Finches to predator scent.***

LAND USE, LAND COVER, AND LAND ARCHITECTURE

Bleasdale, Thomas H., and Sharon L. Harlan. ***The formation of an urban food desert: Struggle for a just food system in Phoenix, Arizona.***

Brumand, Jaleila. ***The effects of formal and informal institutions on residential land management in the Phoenix metropolitan area.***

Connors, John P., and Christopher S. Galletti. ***Characterizing spatial structure in Phoenix and its implications for ecosystem services.***

Childs, Cameron, and Curtis Koyama. ***Power, learning, and institutions in an emerging adaptive co-management collaboration.***

Tuccillo, Joseph, Abigail York, Briar Schoon, and Bob Bolin. ***Zoning, land-use fragmentation, and environmental injustice in early Phoenix.***

Turner, V. Kelly, and Christopher Galletti. ***Ecosystem services in sustainable planned communities: Do they deliver?***

Zhang, Sainan, Christopher G. Boone, Susannah Lerman, and Abigail M. York. ***A multi-scale study of the relationship among land composition, land fragmentation, and bird biodiversity in the Phoenix area.***

WATER DYNAMICS IN A DESERT CITY

Bausch, Julia C., John P. Connors, Cathy Rubinos, Hallie Eakin, Rimjhim Aggarwal, and Abigail York. ***Agriculture around a desert city: Perspectives on decisions for water, land, and livelihood.***

Earl, Stevan. ***Ecosystem metabolism in an effluent-derived, arid-land river estimated from diurnal dissolved-oxygen profiles.***

Epshtein, Olga, Laura Turnbull, and Stevan Earl. ***Modeling runoff response of pervious pavement systems at a catchment scale.***

Hodzic, Mirna, Meredith Gartin, Alyson Young, Amber Wutich, and Alexandra Brewis. ***Ethno-etiologies of water-borne disease: Global divergences and convergences.***

Kaplan, Shai, and Soe W. Myint. ***Estimating outdoor water consumption in a coupled human-environment system using remote sensing.***

Nzengya, Daniel. **Attitudes and perceptions of urban households in sub-Saharan Africa on water sources, threats and sustainability: A preliminary study in Bondo, Kenya.**

Sampson, David A., and Ray Quay. ***An application programmer's interface (API) to WaterSim; WaterSim 5.0.***

Sanchez, Chris, Dan L. Childers, Laura Turnbull, and Nicholas Weller. ***The contribution of evapotranspiration to the water budget of the Tres Rios constructed wastewater treatment wetland.***

Vins, Holly, Melissa Beresford, Alissa Ruth, Christopher Roberts, Alexandra Brewis, and Amber Wutich. ***The Science of Water Art: A citizen science project.***

Abstracts

All abstracts are listed alphabetically by first author. * indicates student poster.

Arnold, S., and J. Stutz. *Impact of restoration practices on mycorrhizal inoculum potential in a semi-arid riparian ecosystem.

Mycorrhizae are soil fungi that form symbiotic relationships with plant roots. Mycorrhizal fungi play a functional role in riparian ecosystems by increasing nutrient availability to plants, improving soil stability and improving drought tolerance of plants with which they form associations. Mycorrhizal inoculum potential was measured at three stages of an urban riparian restoration project which involved the mechanical removal of *Tamarix* spp.(tamarisk, salt cedar) and grading prior to re-vegetation. Soil samples were collected at the Tres Rios Ecosystem Restoration and Flood Control Project located at the confluence of the Salt, Gila and Agua Fria Rivers in three areas: pre-restoration, soil banks with chipped tamarisk, and in areas that had been graded. Bioassay plants (*Zea mays* var. *saccharata* for arbuscular fungi and *Populus fremontii* for ectomycorrhizal fungi) were grown in the soil samples and roots analyzed for mycorrhizal infection percentage. It was hypothesized that the restoration process would reduce mycorrhizal inoculum potential due to disruption of fungal hyphal networks. Preliminary findings are that arbuscular mycorrhizal inoculum potential was not affected by the restoration activities. Our results should contribute to an understanding of the resilience of riparian mycorrhizal fungi to mechanical disturbance and could have implications for riparian restoration practice by determining if inoculation with mycorrhizal fungi is needed during revegetation.

Department of Applied Sciences and Mathematics, Arizona State University-Polytechnic, Mesa, AZ 85212

Aronson, M. F. J.[1], M. Katti[2], F. A. La Sorte[3], C. H. Nilon[4], P. S. Warren[5], M. Goddard[6], C. Lepczyk[7], and N. S. G. Williams[8]. *What concrete jungle? A global analysis of urban biodiversity.*

Despite increasing evidence that urban areas support a wide variety of species, they continue to be perceived as concrete jungles of limited conservation value, and little is known about the global patterns and drivers of urban diversity. Here we show, using the largest global database to date of 149 cities, that urban areas house a large proportion of the world's plant and especially bird diversity. Of the world's total known species, ca. 20% of birds and 5% of vascular plants occur in urban areas, which represent conservative global estimates. Contrary to homogenization concerns, urban areas tend to contain unique assemblages of species. The majority of urban bird species are native whereas a smaller proportion of plant species are (94% and 70% on average, respectively). Only a small number of plants and animals display cosmopolitan distributions, the most common bird being *Columba livia* (rock pigeon) and plant *Poa annua* (annual meadow grass), found in 94% and 96% of urban areas, respectively. Species richness of cities is not only correlated with climate and topography, but also with human population size, city age and urban land cover characteristics, indicating that urban anthropogenic history can play a role in defining urban diversity patterns. Despite worldwide biodiversity loss, cities are not depauperate concrete jungles that only promote global change but have the potential to conserve aspects of regional diversity that can be used to promote greater biological awareness.

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Integrative and Comparative Biology, Miall 9.20, Faculty of Biological Sciences, University of Leeds, Leeds LS2 9JT; [7]Department of Natural Resources and Environmental Management, University of Hawaii at Manoa, Honolulu, HI 96822; [8]Department of Resource Management and Geography, Melbourne School of Land and Environment, The University of Melbourne, Burnley Campus, 500 Yarra Boulevard, Richmond VIC 3121.

Bausch, J. C.[1], J. P. Connors[2], C. Rubinos[1], H. Eakin[1], R. Aggarwal[1], and A. York[3].** ***Agriculture around a desert city: Perspectives on decisions for water, land, and livelihood.

Climate change and population growth have far-reaching implications for water resources in the arid American Southwest. Despite the rapid pace of urbanization in Arizona, agriculture accounts for around 70% of total water use in the state. This study is based on interviews conducted with a wide range of stakeholders in agriculture from July-December 2011 to get multiple cross-scale perspectives on the historical and current stresses on agriculture in the Phoenix metropolitan area and the role of irrigation institutions in influencing agricultural water use. The analysis explicitly considered how recent events, such as the recession and boom in commodity prices have influenced farmers' decisions. The results illustrate that while irrigation infrastructure has largely buffered farmers from inter-annual variability in water availability, interviewees noted several other stresses related to development pressures, labor availability, air quality regulations and energy costs. On one hand, the expansion of agricultural acreage and water demand in since 2007 demonstrates the vitality of agriculture in central Arizona. On the other hand, it alerts us to the limitations of irrigation institutions and infrastructure in conveying the right signals about future water scarcity. Looking forward, uncertainties in water availability, urbanization pressures, and U.S. farm policy challenge the long-term viability of agriculture in central Arizona. This analysis underscores the complexity of the farm decision environment, suggesting that if farmers are to play specific roles in central Arizona's water future, policy makers will need to understand the factors that underlie farmers' decision making and the circumstances that maintain farm viability around the metropolitan area.

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Beebe, S., H. Bateman, and K. Hristovski.** ***Burrowing Owl habitat selection in urban southeast Phoenix, Arizona.

Burrowing Owls (*Athene cunicularia*) have experienced significant population declines over the last 100 years in parts of the United States and Canada. This decline may be associated with urbanization; however, owls may also occupy urbanized environments. To determine habitat selection in the southeast valley of Phoenix, Arizona, we conducted visual surveys for owls during summer 2011 and measured microhabitat and landscape characteristics in 23 agricultural fields (fields) and along 15 canal right-of-ways (trails). We estimated occupancy rate and detectability using Program MARK. We identified microhabitat selection using chi-square and z-tests and used logistic regression to related owl occurrence to landscape variables. Occupancy rate was 32% in both fields and trails and owls had greater detectability along trails. Where owls occurred, they preferred perches on the ground in fields and in vegetation along trails. Owls used shorter perch heights in fields compared to trails. Burrowing Owl occurrence was similar in fields with varying conditions (e.g., undisturbed, cultivated, vegetated, or harvested) and types (e.g., corn, hay, soil, etc.). In both fields and trails, owl occupancy was positively associated with soil type and water

presence, but was not influenced by urbanized landscape cover. These findings suggest that Burrowing Owls are able to live in urbanized environments provided that water and suitable soils are available. Additional research is needed to determine if Burrowing Owl translocation can be successful using these habitat criteria.

Department of Applied Sciences and Mathematics, Arizona State University-Polytechnic, 6073 S Backus Mall, Mesa, AZ 85212.

Bernier, A., and students. ***Ecology Explorers: K-12 student contributions to the CAP LTER project.***

In fall 2011, sophomore students from The Center for Research Engineering Science and Technology in Paradise Valley employed Ecology Explorers protocols to conduct independent research projects for their Sustainability class. Select posters will be presented.

CREST Paradise Valley High School, 3950 E Bell Rd, Phoenix, AZ 85069-7100.

Bleasdale, T. H., and S. L. Harlan.** ***The formation of an urban food desert: Struggle for a just food system in Phoenix, Arizona.

Understanding urban food desert formation is an increasing priority for low-income communities, academics, and institutions such as the United States Department of Agriculture (USDA). Food deserts are areas in wealthy nations where healthy food is hard to obtain. This work presents a materialist-based history of three economically disadvantaged, minority-based, urban communities whose historical trajectories were deeply interwoven in Phoenix's early agriculture-based economy, but have been recently classified by USDA, and other independent researchers, as urban food deserts.

The central research question is "what local socio-economic and political processes led these once agriculturally rich rural farming communities to become urban food deserts?" The social and political mechanisms explored in this work include restrictive covenants, absentee land ownership, city disinvestment, urbanization and economic policies favoring elite exploitation of labor within these communities.

A historical comparative analysis is undertaken to analyze the processes that contribute to modern food desertification within the communities. The range of time addressed is the 1890s through present and broken into phases. Each phase explores a causal mechanism leading to food desertification and illustrates the study areas as actively made, functional landscapes of injustice both normalized and hidden within structural, institutional and social relationships.

School of Human Evolution and Social Change, Arizona State University, PO Box 872402, Tempe, AZ 85287-2402.

Brumand, J.** ***The effects of formal and informal institutions on residential land management in the Phoenix metropolitan area.

Residential land management practices are often studied from a purely ecologic perspective to gain understanding of the implications for surrounding ecosystems. However, to really be able to understand and shape sustainable land management with both ecological and social benefits, it is necessary to understand the driving forces behind why people make decisions. This research endeavors to understand how institutions influence land management practices in different residential contexts, and how formal (codified) rules and informal (non-codified) norms interact in neighborhoods to influencing landscaping practices.

While various authors like Paul Robbins (2001) have conducted studies examining chemical applications and groundcover patterns in residential settings, including the influence of demographic and attitudinal factors in decision-making, the actual institutions that constrain or affect these decisions are not well understood. Land management norms are thought to reinforce neighborhood aesthetics and appearance, which could stimulate residents to water, fertilize, and apply pesticides more frequently than yard care experts recommend.

With a better understanding of the effects that neighborly relations and organizations have on yard maintenance, knowledge about norms and social institutions can ultimately help improve water quality as well as enhance other sustainable practices (Nielson and Smith 2005). Further, this study examines how norms do or do not influence and reinforce groundcover and plant choices as well as maintenance practices through residents' held beliefs and exerted pressures among particular social groups and neighborhood HOAs. Understanding these implications is vital for the furtherance of sustainable communities and to understand the interplay between these sometimes-conflicting institutions.

Nielson, L., and C. Smith. 2005. Influences on residential yard care and water quality: Tualatin watershed, Oregon. *American Water Resources Association* 41(1):93-106.

Robbins, P., A. Polderman, and T. Birkenholtz. 2001. Lawns and Toxins. *Cities* 18(6):369-380.

School of Geographical Sciences and Urban Planning, Arizona State University, PO Box 875302, Tempe, AZ 85287-5302.

***Childs, C.[1], and C. Koyama[2]. *Power, learning, and institutions in an emerging adaptive co-management collaboration*.**

Collaborative management techniques are emerging to address complex socio-ecological problems that cut across boundaries. One such approach is adaptive co-management which emphasizes learning-by-doing and broad stakeholder participation. In the early stages of such collaborations, participants must learn how to work together toward common objectives within a predetermined institutional arena. However when collaboration between agency and non-agency stakeholders is mandated, rigid institutions may hinder participation and adaptability. Power imbalances contribute to these challenges, but are often left out of institutional analyses.

This case study investigates an emerging co-management arrangement in Arizona as it unfolds during the first year. Three government agencies and non-government stakeholders have agreed to develop a coordinated resource management plan for two small grazing allotments (70,000 acres) north of Phoenix. Resource priorities include riparian areas, uplands, wildlife, and cultural resources.

We first outlined the pre-existing institutional structure then track participant interactions through the first phase of co-management: establishment, stakeholder engagement, and goal setting. Throughout these stages, we specifically investigated how institutional rigidity, power, and learning influence the evolution of this co-management process. Qualitative data was gathered through field observation, stakeholder interviews, and a series of three participatory workshops. The insights from this case study will contribute to co-management literature by identifying "rules of thumb" for small-scale natural resource collaborations in early phases. Cooperation, learning, and power play important roles in any team setting. These insights may be applied to other collaborations working to address multifaceted problems in social-ecological systems.

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Connors, J. P., and C. S. Galletti.** ***Characterizing spatial structure in Phoenix and its implications for ecosystem services.

In recent years, there has been a growing effort to characterize the range of goods and services provided by nature to people, i.e., ecosystem services. Research in this area has found spatially explicit modeling to be a powerful tool to quantify the values (both monetary and non-monetary) of ecosystem services. Land-use and land-cover data are a primary input to these models as they are considered to be a main driver of ecosystem services. However, studies have yet to examine how the spatial configuration of the landscape mosaic affects the provision of ecosystem services. Nonetheless, research in the field of landscape ecology has revealed that ecological function is closely tied to landscape structure. This study considers the relationships among an array of biophysical variables and landscape structure in the Central Arizona-Phoenix (CAP) Long Term Ecological Research (LTER) site. Using high resolution satellite imagery obtained by the Quickbird sensor, we quantify an array of landscape metrics and their correlation to field and satellite measurements. Building upon this analysis, we conduct a cluster analysis to identify characteristic groupings of ecosystem services and also compare these to landscape metrics. This analysis reveals the relationship between urban form and ecosystem services in the Phoenix metropolitan area. These results are important for understanding synergies and tradeoffs among ecosystem services, and how spatial structure influences these relationships. Improved understanding of spatial dynamics of ecosystem services will contribute to improved valuation methods and land use management.

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Cook, E. M.[1], S. J. Hall[1], R. Sponseller[2], D. P. Huber[1, 3], S. R. Earl[4], and N. B. Grimm[1].** ***Atmospheric nitrogen deposition in arid Phoenix, Arizona: A comparison of sampling approaches.

Cities occupy a small land area globally, yet atmospheric compounds generated from human-dominated ecosystems have significant impacts on protected lands. Atmospheric nitrogen (N) deposition alters ecosystems, including biogeochemical cycling, primary production, and community composition. In arid urban ecosystems, considerable uncertainty surrounds estimates of atmospheric N inputs due to variable precipitation and difficulties in quantifying dry deposition. We compared multiple approaches to quantify N deposition at locations within, upwind, and downwind of Phoenix, AZ, using the Community Multi-scale Air Quality (CMAQ) model (for year 1996; Fenn et al. 2003), wet-dry buckets (2000-2005; Lohse et al 2008), ion-exchange resin (IER) collectors (bulk and throughfall, 2006-2011), and inferential methods using passive samplers (atmospheric N concentrations x deposition velocity; 2010-2011). In addition, we examined the sensitivity of each approach to uncertainty in order to quantify the best methods for characterizing N deposition in aridlands. We found that rates of N deposition estimated with resin collectors, passive samplers, and wet-dry buckets (0.1-4.1 mgN m^{-2} d^{-1}, median 0.8 mgN m^{-2} d^{-1}) are significantly lower than CMAQ model estimates (1.1-3.2 mgN m^{-2} d^{-1}). Contrary to CMAQ model predictions with high deposition within and downwind of Phoenix, inferential methods show elevated N deposition is restricted to the urban core. Inconsistencies between approaches reveal how uncertainties related to quantifying site characteristics and deposition velocities can easily confound accurate N deposition estimates. Overall, our findings highlight the need for and benefit of mixed methods to quantify N deposition in arid systems and its ecological consequences.

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Davies, S., K. Heller, K. Waites, and P. Deviche.** ***The influence of urbanization on the reproductive phenology and morphometrics of the Abert's Towhee.

To successfully breed, birds must time their seasonal reproductive activity to coincide with peak food abundance. A mistiming between reproduction and peak food availability can have severe fitness costs. Consequently, the timing of reproduction (reproductive phenology) is considered one of the major life-history traits reflecting the adaptation of birds to local environmental characteristics. The strongest, most consistent pattern emerging from studies of the effects of urbanization on birds is that urbanization is associated with advancement of reproductive phenology. We tested the hypothesis that urbanization of Phoenix, AZ advances the onset of seasonal breeding in urban Abert's Towhees, *Melozone aberti*. We measured testis volume and cloacal protuberance width, a secondary sexual characteristic, of adult male towhees caught in urban localities of the Phoenix metropolitan area and outlying desert localities. We also measured body mass, tarsus length, and fat stores to investigate whether urbanization is associated with morphological differences in towhee populations. The data suggest that urbanization of Phoenix is not associated with differences in body mass, tarsus length, or fat stores. However, testis volume and cloacal protuberance suggest that urbanization of Phoenix is associated with an advancement of reproductive phenology of urban towhees. The mechanism responsible for this difference is unknown and requires further study. We are currently testing the hypothesis that this difference in reproductive phenology is a result of greater food abundance in urban areas, and will present data from a captive study supporting this hypothesis.

School of Life Sciences, Arizona State University, PO Box 874501, Tempe, AZ 85287-4501.

Earl, S. ***Ecosystem metabolism in an effluent-derived, arid-land river estimated from diurnal dissolved-oxygen profiles.***

The redistribution of water in the Phoenix metropolitan area has altered greatly the ecological structure and function of the region. Affected particularly are formerly aquatic and riparian systems that have been dewatered. Numerous projects have been undertaken to 'restore' these systems through reintroducing water. At the same time, many riparian areas have been created as a result of unintended water introduction. While the addition of water, either intentional or inadvertent, has typically immediate and profound results, the effects on ecological processes are not always clear.

Receiving wastewater from several municipalities, the 91st Avenue wastewater treatment plant is among the largest in the Valley. Effluent generated by the plant serves multiple uses, one of which is to provide water to the Buckeye Irrigation District. Effluent is diverted to a network of canals approximately 10 km below the plant with the remainder lost to evaporation; this discharge provides perennial flow to an otherwise dry reach of the Salt River before entering the canal system.

Diurnal dissolved oxygen (DO) profiles collected over an approximately 6-year period at several locations downstream of the plant were used to estimate ecosystem metabolism (production and respiration) in the river. Preliminary analyses reveal relatively minute changes in diurnal DO concentration immediately below the plant with a gradual increase reflective of a more 'natural' river system with distance downstream. This pattern suggests a complex dynamic between ecosystem structure (water addition) and function. Relationships among maximum and minimum DO concentrations, and other ecosystem properties (e.g., water chemistry) are also explored.

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Epshtein, O.[1], L. Turnbull[2], and S. Earl[2]. *Modeling runoff response of pervious pavement systems at a catchment scale.

Urbanization of the American Southwest continues to transform aridlands into dynamic, expanding metropolitan centers. Maturing regional development inversely couples Total Impervious Area to infiltration rates, with subsequent increase in runoff generation. Intensified runoff magnifies urban flooding and transport of contaminants. As urban surface drainage networks concentrate flow along roads, the capacity of pervious pavements to simultaneously increase infiltration directly at locations of greatest runoff and mitigate inflow effects from remote points has compelling potential as a hydrologic and urban systems engineering tool.

Previous research into pervious pavement systems has consisted primarily of laboratory prototypes or small-scale field testing of parking lots – precluding analysis of variable traffic load and land-use patterns. In this study, we explore the effectiveness of pervious pavements in increasing infiltration, thus decreasing runoff volume during summer monsoonal and winter convective rainfall events, over a 0.08 km^2 residential catchment in Scottsdale, Arizona. Hydrologic response is modeled using MAHLERAN (Model for Assessing Hillslope-Landscape Erosion, Runoff and Nutrients), a spatially explicit, event-based model parameterized at a spatial resolution of 0.25 m^2. Parameterization data were derived from analysis of urban land cover surface and soil properties, and a Digital Elevation Model (DEM) constructed from field-based GPS data. The model is being calibrated to discharge monitored at the catchment outlet.

We will model various pervious pavement scenarios, which will provide insight into the net effect of pervious pavement application at a catchment scale. Model development will contribute to methodologies for using MAHLERAN as an effective urban hydrologic modeling tool.

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Ferry, L. ***Food webs in urban fish "communities" from the Salt River Project canals.***

Urban fish communities are established in a myriad of ways, not least of which is that associated with water delivery to populated areas. In Arizona, much of our water is delivered by canals. It is well known that these canals house many species of fish, form the source waters, and from bizarre introductions by the general population. Given that many, if not most, of the bodies of water within Arizona are highly altered in some way by human activities, understanding the fish communities that persist within these artificial waterways is fundamental to a larger understanding of the region's aquatic ecosystems. As a first look at the canal community, we used stable isotope analysis for detecting long-term diet signatures. We seek to determine if the diet is canal-based, meaning the fishes have potentially established residency in the system. During 2010 and 2011 fish samples were collected from Salt River Project canals through planned 'drain-downs', whereby SRP dams back a portion of the water and drains a section of the canal. The fishes left behind in the canal were identified and frozen. For stable isotope analysis, tissues were collected from the white muscle on the dorsal surface following brief defrosting. Tissues were oven-dried, ground finely, and placed in tin capsules for analysis which was performed at the Goldwater Environmental Laboratory. Stable isotope values suggested that the food chains/webs in the canal are shorter than is typical of other Arizona bodies of water that have been studied. There was also lower diversity in isotopic signatures among species than reported for those same waterways. This reduced diversity suggests the diet of canal fishes overall is not very

rich, and is not different from species to species. This holds true when comparing canal data with either highly invaded, disturbed, or restored systems. While this finding is not surprising, it suggests that canal fishes have a community structure that is, perhaps, overlooked from an ecological perspective. We hypothesize that many of the species are resident in the canals, and even reproducing there. These fishes have their own community that is maintained over long periods of time, ranging from months to even years (depending on the persistence of water). Therefore, we hope to gain an understanding of how these fishes interact with one another and the unique physical environment created by the canals. These fishes will continue to be sampled in order to investigate a number of different aspects of this urban community including genetics (to determine relatedness of canal fishes to stocks in natural and semi-natural waterways), metrics of pollution load (as they affect animal reproduction, growth, behavior and morphology), and eventually laboratory studies of live fishes to quantify behavior and functional morphology (to determine exactly how these fishes interact).

Division of Mathematical and Natural Sciences, Astate University-West, Glendale, AZ 85306-4900.

Gifford, M., and P. Westerhoff.** ***Making biofuel renewable: Sustainable phosphorus recovery from microbial biomass.

Global climate change and fossil fuel depletion indicate that future energy must come from biofuel. Biodiesel from photosynthetic microorganisms such as cyanobacteria and microalgae does not compete with terrestrial crops for food or arable land, but does require nutrient input. Unfortunately phosphorus (P) is also a depleting resource. Therefore, P recycling is an important step in ensuring the overall sustainability of photosynthetic microbe biofuel production. This poster presents preliminary results of a proof of concept P recycling process integrated with biofuel production.

Cyanobacteria are found to contain 4% P, much of which is located in RNA. A mass balance of P through lipid extraction shows that a majority of P remains in the primary residual in a complex organic matrix. This P is oxidized into a bioavailable form. It is then concentrated and captured using ion exchange resins. Two commercially available resins are compared for sorption capacity and elution recovery ability. One is found to able to adsorb 99% of influent P through the first 50 bed volumes treated, then 60% of that may be recovered through elution. This pure, concentrated, bioavailable P may then be used to grow subsequent cultures for further biofuel stock production.

P recycling for biofuel production is an interdisciplinary effort requiring collaboration with microbiologists, biofuel production specialists, sustainability scientists, and process engineers. The research aims to provide green energy by developing a carbon neutral technology and conserve natural resources through fossil fuel and P ore preservation. Broader applications may include wastewater treatment and eutrophication mitigation.

School of Sustainable Engineering and the Built Environment, Arizona State University, PO Box 875306, Tempe, AZ 85287-5306.

Hale, R[1], L Turnbull[2], S Earl[2], N Grimm[1,3].** ***Effects of urban stormwater infrastructure and spatial scale on nutrient export and runoff from semi-arid urban catchments.

There has been an abundance of literature on the effects of urbanization on downstream ecosystems, particularly due to changes in nutrient inputs as well as hydrology. Less is known, however, about the nutrient transport processes and processing in urban watersheds. Previous research has focused on land cover and land use, but engineered drainage systems are apt to play a significant role in controlling the transport of water and

nutrients downstream. Furthermore, variability in drainage systems within and between cities may lead to differences in the effects of urbanization on downstream ecosystems over time and space. We established a nested stormwater sampling network with 12 watersheds ranging in scale from 5 to 17000 ha in the Indian Bend Wash watershed in Scottsdale, AZ. Small (<200ha) watersheds had uniform land cover (medium density residential), but were drained by a variety of stormwater infrastructure including surface runoff, pipes, natural or modified washes, and retention basins. In addition to collecting discharge and precipitation data, we sampled stormwater for dissolved and particulate nitrogen (N), phosphorus (P), and organic carbon (oC).

Urban drainage infrastructure is characterized by a range of hydrologic connectivity. Piped watersheds are highly connected and respond linearly to rainfall events, in contrast to watersheds drained with retention basins and washes, which exhibit a nonlinear threshold response to rainfall events. Runoff and nutrient loads from piped watersheds scale linearly with total storm rainfall. Because of frequent flushing, nutrient concentrations from these sites are lower than from wash and retention basin drained sites and total nutrient loads exhibit supply limitation, e.g., nutrient loads are poorly predicted by storm rainfall and are strongly controlled by factors that determine the amount of nutrients stored within the watershed, such as antecedent dry days. In contrast, wash and retention basin-drained watersheds exhibit transport limitation. These watersheds flow less frequently than pipe-drained sites and therefore stormwater has higher concentrations of nutrients, although total loads are significantly lower. Nutrient loads from these sites exhibit a strong exponential relationship with storm size. However, nonlinearities in rainfall-nutrient loading relationships for the wash and retention basin watersheds suggest that these systems may become supply limited during large rain events. We show that the shape of the hydrologic network is an important mediator of terrestrial-aquatic linkages. Specifically, we see that increased hydrologic connectivity, as in the piped watershed, actually decreases the importance of hydrology with regard to nutrient export as highly connected systems are frequently flushed, leading to lower concentrations of nutrients during storm events, and higher variability in nutrient concentrations driven by antecedent dry days.

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Hale, T., and students. ***Ecology Explorers: K-12 student contributions to the CAP LTER project.***

Students from across the Phoenix metropolitan area have been collecting population data in their schoolyards. Students from Taylor Hale's high school ecology classes at Highland High School in Gilbert collected and analyzed arthropod pitfall trap data in fall 2011. Select posters from the five classes will be presented.

Highland High School, 4301 E Guadalupe Rd., Gilbert, AZ 85324.

Hamilton, A.[1], and H. Hartnett[1,2].** ***Black carbon in surface soil and subsequent black carbon photo-oxidation.

Black carbon (BC) is the product of incomplete combustion of fossil fuels and biomass. Little is known about BC in a terrestrial urban setting; however, it is known that BC is a significant portion of the organic carbon in central Arizona soils (31%). Black C could, therefore, play a major role in organic biogeochemical processes in this area. Black C enters the soil column from atmospheric deposition. We hypothesize that surface soil (top 5 cm)

contain a larger percentage of BC than deep core (top 15 cm) soil. Laboratory experiments show that on average surface soil contains 1.2 g of BC/kg soil more than deep core soil. This difference is entirely controlled by desert soils ($p<0.05$) because they are less mixed than agricultural soil and urban soil.

Since the BC global budget is unbalanced with respect to sources and sinks, we propose that BC is undergoing bio-, chemical-, or photo-degradation in soil. Photo-degradation of black and organic carbon in a desert and urban soil was monitored in a solar simulator for 191 hours and under mercury (Hg) lamp for 24 hours. The solar simulator experiment showed no statistical change in BC or OC concentration over time regardless of land use classification. Mercury lamp experiment showed a statistical decrease in organic carbon for both desert and urban soil and in black carbon for urban soil only. These results indicate that BC oxidation via photo-oxidation is possible and that BC in a desert/urban ecosystem might be more reactive than previously thought.

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***Hodzic, M.[1], M. Gartin[1], A. Young[2], A. Wutich[1], and A. Brewis[1]. *Ethno-etiologies of water-borne disease: Global divergences and convergences*.**

Using interviews conducted with 468 adults in nine different global locations, we tested for commonalities in how people culturally understand water-disease connections. Based on consensus analysis we find evidence of shared cultural ideas about the causes and solutions to waterborne disease both within and across all locations. Causes of water-related illness with the highest salience in the different countries were comparable across sites as well, and mapped reasonably onto public health understandings. Comparison of specific items (statements) of public health and lay cultural knowledge about the causes and solutions to waterborne disease overall showed a high level of agreement. We suggest a straightforward, cohesive approach to water-health messaging in public health campaigns could often be the most effective point of departure, and that sophisticated cultural tailoring may be less important in regard to global waterborne disease prevention efforts than might be expected.

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Kaplan, S., and S. W. Myint. *Estimating outdoor water consumption in a coupled human-environment system using remote sensing.

Outdoor water use in the Phoenix metropolitan area is a key to achieve sustainable development and ensure water security. Evapotranspiration (ET) can be used as a proxy for outdoor water consumption. As traditional methods for ET estimation are point based and data intensive, remote sensing is the only feasible and reliable methodology for estimating ET at a regional scale coupled human environment system. The objectives of this research are to use remote sensing to quantify outdoor water consumption by different land use land cover types within the urban settings, and compare the spatio-temporal variation of water consumption between drought and wet years. A new remote sensing energy balance model (S-ReSET) was developed and applied using a series of Landsat images to estimate daily and seasonal ET for the CAP LTER region. To validate the model, the ET estimations were compared against urban parks water use and showed good agreement, explaining 71% of the variance. Results indicate that ET varies with land cover types. Seasonally, active agriculture shows high ET (>500 mm) for both wet and dry conditions, while the desert and

urban land cover experienced lower ET during drought (<300 mm). Within the urban settings, some areas retain their ET values (400-500mm) during drought, implying the considerable use of irrigation to sustain their green space. Other urban areas show significant difference between the years, suggesting a more xeric landscape. This study demonstrates that S-ReSET model can be used effectively to estimate and map water consumption in a coupled human environment system.

School of Geographical Sciences and Urban Planning, Arizona State University, PO Box 875302, Tempe AZ 85287-5302.

Lansdowne, K., and students. ***Ecology Explorers: K-12 student contributions to the CAP LTER project*****.**

Students from The Herberger Young Scholars Academy on the ASU West campus used various Ecology Explorers protocols to measure populations of organisms on their campus in fall 2011. Based on their results, students made recommendations and created designs for new sustainable campus buildings. Select posters and exhibits will be presented.

Gary K. Herberger Young Scholars Academy, PO Box 37100, Phoenix, AZ 85069-7100.

Martin, E.[1], and B. Ruddell[2].** ***Managing the effects of climate change on water and energy resources in the western U.S. using embedded resource accounting.

As population and industry in urban areas continue to grow, resource demands increase and become more spatially concentrated - especially demands for electrical energy. Energy production accounts for the largest percentage of gross water withdrawals in the U.S., placing water resources at the focal point of the climate change - energy - water nexus as an important and climate-sensitive constraint on electrical energy production.

Reallocation of water supplies in addition to redistribution of the production of electrical energy and other resources will be necessary to adapt reduced supplies to meet increasing and spatially concentrated resource demands. The relocation of existing water resources often involves prohibitive infrastructure costs, energy costs, and legal barriers. However, there is a significant amount of water embedded in electrical energy production. Therefore, the remote production and virtual transmission of this resource provides a powerful management solution for an efficient reallocation of water resources. Embedded water resource accounting combined with economic analysis provides a method for the evaluation of proposed electrical energy production adaptations.

This study evaluates the water intensity of thermo-electric power plants in the eleven Western states included within the Western Electricity Coordinating Council region, and combines this information with retail electricity sales to estimate the economic value per gallon of water embedded in electrical energy production and trade within and across the region. The results of this embedded resource analysis are presented as a network of production and trade in electrical energy and associated embedded water volumes throughout the Western United States.

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Marusenko, Y. M., K. A. Wyant, S. J. Hall, and J. L. Sabo. *Dynamics of urban biogeochemical cycling coupled with the interactions between soil microbial communities, the belowground food web, and land-use type in an arid ecosystem.

Cites transform ecosystems by changing the landscape to mesic and xeric environments, resulting in fundamental changes to soil moisture, temperature regimes, organic matter content, and nitrogen (N) inputs. However, there is little evidence of how these changes affect belowground microorganisms (e.g., bacteria and fungi) and fauna (e.g., consumers of microorganisms and their predators) in urban areas. This study seeks to a) differentiate the different groups of soil microbes and fauna, and to b) elucidate possible energy and nutrient transfers, via feeding interactions, in belowground communities from urban soils in four different sites (mesic, xeric, native, native + N). In the summer of 2011, we collected a series of 60 soil cores, split between the dry and monsoon seasons, in metro Phoenix. Soils were processed for flora and fauna, nutrient dynamic quantification, and microbial community molecular analyses. Our results indicate that mesic lawns harbor increased soil moisture over two seasons (dry and monsoon) relative to xeric and native desert sites. Furthermore, mesic soils have increased counts of fungivorous and predatory soil microarthropods. Measurements of net N nitrification and mineralization were the highest in mesic lawns, with highly variable rates in xeric sites. In addition, preliminary data show that archaea, not bacteria, dominate ammonia oxidation in the desert soils sampled here. This research will innovate urban biogeochemistry research by coupling organismal activity at different scales of the soil community with observations of N cycling patterns across a mosaic of human dominated landscapes.

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Middel, A.[1], A. J. Brazel[2], S. Kaplan[2], and S. W. Myint[2]. *Summer cooling efficiency of landscapes in Phoenix, AZ*.

The summer cooling-water use tradeoff is investigated for different landscapes in Phoenix, Arizona using calculations of atmospheric energy fluxes from a model called the Local-Scale Urban Meteorological Parameterization Scheme (LUMPS, after Grimmond and Oke, 2002) and a cooling efficiency concept after Shashua-Bar et al. (2009). We examined two summer days in 2005 to analyze the cooling efficiency of different land cover mixes in the urban core. LUMPS model results were correlated to surface temperatures from Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) imagery and reference evapotranspiration values from a meteorological station for validation. Cooling efficiency was estimated from daytime sensible and latent heat flux differences of the LUMPS raw fluxes for urban surfaces and the desert. Results indicate that cooling at night is strongly influenced by the heat storage capacity of different land cover types and by the amount of vegetation. Efficiency index results suggest that overall, the Phoenix urban core is slightly more efficient at cooling than the desert, but efficiencies do not increase much with wet fractions higher than 20%. Industrial sites with high impervious surface cover and low wet fraction result in negative cooling efficiencies compared to the desert. Findings indicate that low to moderately dry neighborhoods with heterogeneous land uses are the most efficient landscapes in balancing cooling and water use in Phoenix. However, further factors such as energy use and human vulnerability to extreme heat waves have to be considered in the cooling-water use tradeoff, especially under the uncertainties of future warming of the climate.

Grimmond, C. S. B., and T. R. Oke. 2002. Turbulent heat fluxes in urban areas: Observations and a local-scale urban meteorological parameterization scheme (LUMPS). *Journal of Applied Meteorology* 41(7):792-810.

Shashua-Bar, L., D. Pearlmutter, and E. Erell. 2009. The cooling efficiency of urban landscape strategies in a hot dry climate. *Landscape and Urban Planning* 92(3-4):179-186.
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Miles, L.[1,3], R. Ziemba[2], J.C. Johnson[3], and B. Verrelli[1]. *A population genetic approach to investigate effects of urbanization and habitat fragmentation on the Western black widow spider,* Latrodectus hesperus*.

Urbanization causes a sudden and drastic change to the landscape, fragmenting habitats, leading to a disruption in dispersal, potentially impacting gene flow of the organisms living in these new urban habitats. Due to the variable effects caused by urbanization, it is important to understand the genetic variation if we wish to understand why some organisms thrive in urban environments and become pest species. We test the hypothesis that urbanization and habitat fragmentation restricts gene flow in urban black widow populations and therefore may cause urban populations to exhibit patterns of genetic diversity consistent with fragmentation, isolation, and recent colonization relative to desert black widow populations. Preliminary results indicate urban populations may not only be recently derived but that isolation has been established for some time given the significant divergence between them and surrounding desert samples.

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Nzengya, D. *Attitudes and perceptions of urban households in sub-Saharan Africa on water sources, threats and sustainability: A preliminary study in Bondo, Kenya.

A survey was conducted in Bondo town, Kenya, during June 2011 to examine how attitudes and perceptions of urban residents on water sources, threats and sustainability affect their participation in town-level water interventions intended to increase access to safe drinking water. During the survey, women from 307 households were interviewed in five urban and peri-urban neighborhoods within the Bondo Township. Data was analyzed using cross tabulation, chi-square and logistic regression methods. Results of the study show that the majority of urban residents consider unimproved drinking water sources such as ponds and water from vendors to be very important compared to improved sources such as public stand pipes. Households in Bondo consider droughts and more people migrating to the town to be greater threats to households' water sources compared to activities that worsen water quality. Results of this study reveal marginal participation by women in town-level water activities and interventions; only 2.3% of women of the total households interviewed belong to a water group, 4.2% had attended a water meeting during the last six months prior to survey, 13.4 % had participated in water treatment training, and 9.1% had participated in hand-washing training. This does not bode well for policy because women's participation in water interventions has been shown to improve health outcomes and sustainability. Future studies will need to identify barriers to women's participation in urban water interventions, and ways to increase women's involvement with the aim of improving health outcomes, particularly in the reduction of diarrheal illness.

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Pincetl, S.[1], M. Chester[2], M. McCoy[3], G. Circella[3], P. Bunje[1], Zoe Elizabeth[1], Dan Flaming[4], Dan Gallagher[5], and Janet Ferrell[2]. *Complementing urban metabolism with life-cycle assessment for a Los Angeles energy baseline.*

A rigorous understanding of Los Angeles' energy consumption and environmental effects is needed to craft effective policies for meeting California climate change and sustainable community goals. Urban metabolism (UM), the preeminent framework for understanding resource use and effects in cities, should be combined with life-cycle assessment (LCA) for comprehensive evaluation of sustainable community policies (we call this combined framework UM2.0). This research, still in its early stages, aims to build a comprehensive energy, water, waste, and air emissions inventory of Los Angeles, including cradle-to-grave ancillary and supply chain effects beyond the city's borders.

The energy baseline will include manufacturing, services, and activities, as well as infrastructure processes in Los Angeles, ultimately including social equity metrics. Manufacturing and consumption of goods, services, and utilities will be evaluated by joining economic input-output models with corresponding environmental indicator intensities. Transportation propulsion, vehicles, and fuels will be evaluated by combining travel demand models with life-cycle inventories for Los Angeles-specific passenger and freight travel. To understand land use effects, materials-based life-cycle inventories will be developed for 18 building classes and joined with utility data on building operational energy consumption. The building inventories will be complemented by life-cycle inventories of asphalt and concrete paved surface effects. These city sectors capture many of the high-impact energy demands in cities. The Los Angeles energy baseline UM2.0 model will provide an accounting of energy and environmental flows into and out of regions and will be designed for informing urban sustainability policies, programs and investments to reduce ecological footprints.

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Ramirez, B., Y. Marusenko, and S. J. Hall. *Characterizing ammonia oxidizing communities under legumes and non-legume plants in the Sonoran Desert.

Microorganisms are ubiquitous and essential to earth system functioning. As catalysts of the nitrogen cycle, specialized microbes oxidize inorganic nitrogen compounds (ammonia to nitrite, and to nitrate) during the process of nitrification, creating different forms of available nutrients for plants. Nitrogen-fixing plants, such as legumes, increase ammonium availability in soil. However, it is unclear how nitrification is affected by natural inputs compared to anthropogenic inputs. In this research, we asked how the bacterial and archaeal ammonia oxidizing communities and their activities differ in soil under legumes and non-legume plants.

Preliminary data depicts there is no significant differences in ammonia oxidizing rates between nitrogen fertilized and legume soil. Prospect experiments will include the collection of soil from additional sites to explore heterogeneity across arid, urban soil under legumes and non-legume plants. Additionally, we are using molecular detection techniques to characterize the microbial communities in these soils.

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Ripplinger, J.[1], and J. Franklin[1, 2]. *CAP LTER plant species diversity responds to land use and landscape aesthetics.

A tradition of investigating landscape-level ecological patterns and processes exists among landscape ecologists, yet the spatial variability of social-ecological patterns and processes challenges our understanding of drivers of plant community patterns and modeling of urban social-ecological dynamics. We are addressing these issues as part of our collaboration with Central-Arizona Phoenix Long Term Ecological Research (CAP LTER). The overall objective of our research is to examine spatial patterns and important drivers of plant community patterns in a coupled social-ecological system. Survey 200 data collection was carried out in 2000, 2005, and 2010 on 30x30-m plots overlaid on a systematic random sampling grid. Each of the 200 sites was categorized into broad regional land-use (agriculture, desert, urban), then finer-scale residential 'landscape aesthetic' categories (xeric, mesic, oasis) for multi-scale analysis. In 2010, as was previously found for 2005, plant species richness varied by regional land-use and decreased significantly from desert to urban to agriculture. Land-use also affected community composition, though unlike in 2005, the 2010 species composition of desert sites was unique while species composition of urban and agriculture sites were indistinguishable from each other. This aberration may indicate a shift between 2005 and 2010 in social-ecological processes driving plant community patterns. Future work will investigate differences in plant communities and drivers on a site-by-site basis. Our results are beginning to help us answer questions about how vegetation patterns in space and time feed back to key urban ecosystem functions, important to stakeholders, CAP LTER, and the scientific community.

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Sampson, D. A., and R. Quay. *An application programmer's interface (API) to WaterSim; WaterSim 5.0.*

Our mission at the Decision Center for a Desert City (DCDC) is to "conduct climate, water, and decision research and to develop innovative tools to bridge the boundary between scientists and decision makers in order to put our work into the hands of those whose concern is for the sustainable future of Greater Phoenix." The WaterSim water policy and management model represents one of the core tools created, updated, and maintained by DCDC. We use WaterSim to examine the potential impact of uncertainties in climate and policies on water supply and demand. The newest version of WaterSim-WaterSim 5.0-represents a radical departure from previous versions. Our newly released, provider-level model (individual water providers are modeled separately but evaluated in the aggregate) includes: 1) a city infrastructure model that simulates the movement of water through a standard city system including the water use chain starting from water supply and treatment to delivery to residential and commercial users and, eventually, effluent production and the possible pathways of reclaimed and recycled water; 2) a hierarchical demand-based water supply module; and 3) an open source API and associated documentation which enables others to freely use the WaterSim model for their own research, education, and outreach. This poster presents the programmatic structure and function of WaterSim 5.0 and highlights the potential applications of the model for the decision-making arena.

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Sanchez, C.[1], D. L. Childers[2], L. Turnbull[3], and N. Weller[2]. The Contribution of *Evapotranspiration to the water budget of the Tres Rios constructed wastewater treatment wetland.

One of the most important aspects of any wetland is the water budget. Quantifying how evaporation and evapotranspiration contribute to water residence time is crucial to understanding the cycling of biogeochemically active and non-active solutes through the water column, plants and soils-particularly in arid climates. We measured evapotranspiration and evaporation rates in the Tres Rios constructed treatment wetland during Summer 2011. Our primary objectives were: 1) to measure the rates of wetland evaporation and evapotranspiration bi-weekly using a handheld infrared gas analyzer, and; 2) calculate a whole-system summer water budget using these rates plus inflow and outflow data. The primary drivers of variation in evapotranspiration were PAR, air temperature, and relative humidity. We used data from a nearby meteorological station, and plant biomass data, to scale our leaf-specific rates to the entire system. Daily evapotranspirative losses ranged from 3.7 to 6.5 cm day^{-1}; values that are 5-10 times higher than published results from mesic wetlands. This loss represented roughly 6-8% of the total effluent inflow to the system. Bi-weekly measurements of conductivity showed increases of up to 25% along transects within the wetlands from open water to the shoreline, suggesting that evapoconcentration of nutrients and solutes is occurring. We are continuing this sampling on a bimonthly schedule and will calculate a more rigorous annual water budget in Summer 2012, once we have collected a year of data, which will enhance understanding of the ability of wetlands in arid climates to deliver ecosystem services related to water treatment.

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***Schmoker, M. K.[1], E. M. Cook[1], S. Amaru[2], J. K. Learned[1], S. L. Collins[3], and S. J. Hall[1]. *Bottom-up vs. top-down regulation of desert annual plants in an urban arid ecosystem*.**

The productivity and diversity of desert annual plants is regulated by multiple bottom-up and top-down factors such as precipitation, soil inorganic nitrogen (iN), and consumption by herbivores. In this study, we examined the relative importance of regulating factors of winter annual plants across an urban-rural gradient in the rapidly growing city of Phoenix, AZ. We measured precipitation, soil iN pools, above-ground plant production, and community composition at sites in desert remnant parks (i.e., urban) and the surrounding Sonoran Desert (i.e. non-urban). Total plant growth and community composition were quantified within exclosure plots (excluding vertebrate herbivores) and control plots. Results from our study indicate that precipitation is the most significant predictor of total plant growth across the region, followed by herbivory, and soil iN is not significantly related to plant growth when water is limiting. Total production and diversity of annual plants were found to be significantly greater in the surrounding desert, and plant growth was greater in plots that excluded herbivores. Overall, we concluded that while herbivory has a significant impact on total plant biomass, the rate of herbivory does not change the production or diversity of winter annual plants in urban vs. non-urban sites. Desert annual plants provide vital ecosystem services. This and other studies can help urban planners and conservation biologists determine how urbanization may influence the relative importance of regulating factors of annual plant growth, and therefore the services that these plants provide.

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Still, M., and J. C. Johnson.** ***Predator-prey dynamics between urban, exotic crayfish and the threatened Sonoran Desert pupfish: The role of chemical communication.

Urbanization alters the structure, productivity, and composition of waterways. This disturbance may explain the general finding that species diversity is compromised following urbanization, at the expense of explosive population growth for a handful of urban-adapted taxa. Here, we investigate the predator-prey relationship between the Northern crayfish (*Orconectes virilis*), an invasive, omnivorous predator that has been introduced across the Phoenix valley, and the native endangered desert pupfish (*Cyprinodon macularius*). Using chemical cues alone, we tested the behavioral response of each species to i) heterospecific cues, ii) conspecific alarm cues (i.e., injured conspecifics), and iii) the combination of conspecific and heterospecific cues. The latter treatment allowed us to look for synergistic, negative impacts of these chemical cues on the behavior of the threatened pupfish. An understanding of the predator-prey dynamics between urban exotics and threatened native species will allow us to identify the mechanisms responsible for losses in species diversity following urbanization. Future work will determine if variables such as the degree of urbanization (e.g., percent of urban cover, water quality, native species richness) and the community composition influence the abundance of non-native crayfish species in central Arizona.

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Stromberg, J.[1], H. Bateman[2], E. Makings[1], N. Franz[1], H. Rowe[1], S. Beute[1], A. Suchy[1], D. Wolkis[1], B. Scott[1], and R. DePuydt[1]. ***Inventory and monitoring of the Salt River in Phoenix*.**

Need for research: Riparian areas provide important ecosystem services including habitat provisioning and water quality purification. The Salt River in the Phoenix metropolitan area is highly modified as a result of upstream damming, flow diversion, stream channelization, and floodplain conversion to urban lands. The Salt River has been the site of several active and passive restoration efforts, but additional research is needed to assess restoration success and to identify effective ways to restore ecosystem services to degraded riparian lands.

Experimental design: We have selected sites along the Salt River that i) have undergone active restoration in recent years; ii) that remain degraded but are targeted for restoration in the near future and iii) distant future; iv) that have revegetated in response to discharge of water from urban storm drains, and v) are located upstream of the urbanized region. This spatial distribution of river sections presents an opportunity to answer: 1) How do levels of ecosystem services vary among passively and actively restored urban river sites? 2) How quickly are ecosystem functions restored, following restoration actions?

Methods: As a first step, we are conducting multi-taxa inventories of biota at the riparian site types delineated above. We are striving to encompass many taxonomic groups, including insects, birds, small mammals, herpetofauna, and aquatic and riparian plants. Once the inventory is underway, we will develop long-term monitoring protocols, and actively engage citizen scientists in the collection of data.

Opportunities: We invite collaborators to join us at this early stage of research design.

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Trubl, P.[1], and J. C. Johnson[2]. *The urban stoichiometry of an arthropod pest, predator-prey system across metropolitan Phoenix.

Understanding the impacts of 'human-induced rapid ecological change' (HIREC) has recently been described as a 'grand challenge' for ecologists. For example, the effects of urban disturbance are critical to understand as the majority of the world's population now resides in urban centers. Notably, urbanization often leads to reduced species diversity at the expense of a few urban-adapted taxa. However, it remains unclear why some taxa thrive following human disturbance and others do poorly. Both the western black widow spider, *Latrodectus hesperus*, and its most common prey item in urban Phoenix, the decorated cricket (*Gryllodes sigillatus*) thrive in disturbed, urban habitat-often forming dense aggregations (i.e., infestations). Indeed, we have recently shown that the body mass and population density of urban *L. hesperus* is well predicted by their foraging success on *G. sigillatus*. Here we report on the stoichiometry of this predator-prey relationship. Specifically, we collected spiders and crickets from ten different locations across the greater Phoenix metropolitan area and analyzed the C:N content of 10 spiders and 10 crickets from each locale. Our results will shed light on the predator-prey dynamics of these urban pests and perhaps inform integrated pest management strategies.

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Tuccillo, J.[1], A. York[1], B. Schoon[1,2], and B. Bolin[1]. *Zoning, Land-Use Fragmentation, and Environmental Injustice in Early Phoenix.*

Little attention has been paid to the role of early land-use institutions on development patterns, the creation of disamenity zones of environmental injustice, and the promotion of space-consuming suburban development. In this study, we use historic Sanborn Fire Insurance Maps and spatial analytic techniques to expose zoning's tendency to spread disamenities and disperse heterogeneous, incompatible land-uses in early Phoenix. Although the stratification of land-uses enabled by Euclidean Zoning upon its adoption by Phoenix appears decidedly organized on paper, analysis at a finer scale using Sanborn Maps reveals that zoning decisions in Phoenix tended to promote further land-use fragmentation, especially disamenity zones that targeted poor, minority neighborhoods. We find two seemingly oppositional forces of land development in Phoenix--careful protection of new suburbs and leniency in commercial and industrial districts--that suggest a mechanism allowing Boosterism to thrive. Zoning encouraged the expansion of industry while attracting residents to newly developed suburbs with guaranteed protection from blight. For residents of General Commercial and Light Industrial zones, ignored by these zoning designations, rezoning decreased the availability of services and amenities by imposing automotive and rail-oriented districts, rather than promoting compact, walkable neighborhoods. The institutional imperative to commoditize space outstripped a desire to account for social equity within Phoenix. As a result, the city continued to expand at the expense, rather than the inclusion, of low-income and minority residents.

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Turner, V. K., and C. Galletti.** ***Ecosystem services in sustainable planned communities: do they deliver?

Developers in the United States and abroad have begun to implement the principals of sustainable urbanism in planned community design. Sustainable urbanism seeks to minimize negative biophysical impacts associated with urbanization and to maximize ecosystem service delivery through best practices in urban form. This research investigates the connection between urban design and ecosystem services at the neighborhood scale using the planned community of Civano in Tucson, Arizona, as a case study. Specifically, we focus on the following ecosystem services: (1) micro-climate regulation, (2) provisioning of water resources, and (3) primary productivity. We utilize spatial data including fine-scale remotely sensed imagery and block level municipal water data to compare our case-study of interest to a neighboring community in order to determine if adjustments in urban form create registered differences in the provisioning of ecosystem services. Preliminary results indicate that the principles of sustainable urbanism generate lower temperatures, higher albedo, more vegetation, and lower water consumption in the older phase of the development but not necessarily in the newer phases. This finding suggests that urban form can be manipulated to achieved environmental goals, however, the differences between development phases indicate the relevance of socio-ecological factors beyond urban form. This research constitutes a pilot-study for a comparative project empirically examining the capacity of sustainable planned communities to deliver ecosystem services in the context of environmental change and future uncertainty.

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Vins, H., M. Beresford, A. Ruth, C. Roberts, A. Brewis, and A. Wutich.** ***The Science of Water Art: A citizen science project.

The Science of Water Art project is a collaborative work that brings together professionals, community members, college students and children to think about the role that water plays in each of our lives. Using a sample of 4th grade classrooms in Maricopa county, over 3000 drawings of children's perception of water today and in the future were collected. The 9-11 year olds were asked to draw pictures of 1) how they saw water being used in their neighborhood today (T1), and 2) how they imagined water would be used in their neighborhood 100 years from now (T2). The artwork was then collected and coded for nine different themes, including: vegetation, scarcity, pollution, commercial sources of water, existing technology, technology innovation, recreational use, domestic use, and natural sources of water. Statistically significant differences were found between T1 and T2 all codes and between boys and girls for vegetation, existing tech, and technological innovation. This project allows for a look into how climate change and water insecurity is viewed by younger generations and gives a voice to children so that they may share their outlooks on this vital resource.

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Volo, T. J.[1], E. R. Vivoni[1,2], C. A. Martin[3], and S. Earl[4].** ***Modeling soil moisture and plant stress under irrigated conditions in semarid urban areas.

Climatological and hydrological models typically ignore anthropogenic irrigation, despite its notable effects on water, energy and biomass conditions. This omission is noteworthy in semiarid cities, such as Phoenix, Arizona, where native and exotic vegetation in urban landscapes are well watered, inducing changes in their phenology and productivity. To our

knowledge, the impact of irrigation on urban ecohydrology has yet to be addressed in a quantitative fashion, partially due to a general lack of appropriate soil moisture data from irrigated areas. Thus a rare and valuable opportunity for new avenues of research in urban ecohydrology is presented by the extensive soil moisture data from the North Desert Village neighborhood, funded by CAP-LTER: soil moisture observations have been collected at the site for several years under multiple landscape and irrigation treatments. This study adapts a point-scale model of the soil water balance and plant stress, utilizing nearby daily records of potential evapotranspiration and rainfall as well as metered irrigation data as model forcing, calibrated using the available soil moisture data. The calibrated model will then be used as a basis to study the sensitivity of soil moisture and plant stress on such factors as soil classification, vegetative cover, meteorological forcing, and irrigation amounts and schedules that are representative of the conditions found in the broader Phoenix metropolitan area. Our results are intended to inform water and landscape managers in making decisions regarding the relationship between water use rates and plant response for different landscape treatments, based on a quantitative model.

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Warkus, E., D. Nakase, S. J. Hall, O. Sala, and J. K. Learned.** ***Spatial associations between nurse rocks and succulents in the Agua Fria National Monument.

In arid and semi-arid ecosystems, facilitative "nurse" associations that ameliorate temperature fluctuations, increase soil water availability and protect against physical disturbance have been shown to aid seedling establishment. Nurse plant associations have been well studied (e.g., leguminous trees and saguaro seedlings), but little research has explored the potential abiotic facilitation of plants by rocks. Surface rocks are known to significantly affect soil moisture and temperature and were manipulated for these purposes and others by prehistoric dryland agriculturalists. In this study we assessed the frequency and strength of spatial associations between succulents and nurse rocks in grasslands within the prehistorically active landscapes of Agua Fria National Monument. Specifically, we measured the distribution of succulents relative to surface rocks compared to an expected frequency based on randomly assigned points. Preliminary data show greater spatial associations between rocks and succulents than expected by chance, suggesting the presence of a nurse rock association. Succulents grow preferentially within a two-centimeter buffer zone around surface rocks, and the number of succulents decreases as distance from the nurse rock increases. These initial results support a spatial association between succulents and facilitative nurse rocks and indicate that rock cover is a significant factor affecting succulent community composition and distribution. The potential implications of our preliminary conclusions may be that surface rock heterogeneity such as differential cover on hilltops versus hillsides as well as rock cover manipulation by prehistoric agriculturalists may have a previously unrecognized effect on succulents.

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Weaver, M., and K. McGraw.** ***Response of urban and rural house finches to predator scent.

The world's wildlife currently faces an unprecedented challenge. The year 2008 marked the first time in history that more humans resided in cities than rural areas (United Nations

Population Fund 2007). Urban areas pose novel environmental challenges to organisms, such as exposure to nonnative predators, destruction of native flora, and unfamiliar noise and light pollution (Partecke et al. 2006). Many species have been displaced by these changes, while others have adapted and persist in made-made ecosystem. We considered one aspect of adaptation to urban ecosystems by testing the response of both urban and rural house finches (*Carpodacus mexicanus*) to urban predator scent. House finches captured from one of four sites labeled either urban or rural based on distance from the Phoenix center were placed in an outdoor aviary cage with one of three scents: cat (predator), hamster (nonpredatory mammal) and water (control). The scents were created from a slurry of the animal's feces and placed under a feeder in a box that blocked visual cues but allowed scent to pass (Roth et al, 2008). Reaction to scent was determined by scoring length time before approaching feeder, time spent on the feeder and percent time spent eating vs vigilance when on feeder. As hypothesized, urban birds were faster to approach the feeder than rural birds but length of time to approach feeder varied by which scent with which the bird was presented; however, the correlation wasn't as strong with rural birds, which took longer overall to approach the feeders but may not be as familiar with urban predators.

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Weller, N.[1], L. Turnbull[2], and D. L. Childers[1]. *The influence of storm characteristics and catchment structure on particulate organic matter transport in an arid city.

In urban landscapes, flood infrastructure and altered surface permeability influence the movement of stormwater. Stormwater is an important carrier of biotic nutrients and sediments. Thus, factors influencing stormwater dynamics influence materials transport and retention within urban catchments. Our goal is to understand how the structure of urban catchments controls material transport in an arid, urban landscape to build a more thorough understanding of urban ecohydrological processes. We focused on particulate organic matter (POM) dynamics.

Water samples and basic hydrologic data were collected during storm events from October 5, 2010-April 9, 2011 at three sites in the Indian Bend Wash watershed of Scottsdale, Arizona and one site in Tempe, Arizona. Water samples were filtered and the filters were dried, then ashed to quantify POM content. Particulate organic matter flux was calculated and statistical models were used to extrapolate discrete measurements of POM concentration across the entire storm hydrograph to determine event-based POM export from the catchments.

Across all sites, POM export was highly variable within and between catchments. For a catchment with street drainage infrastructure, POM export was highest (18.65 kg) for a high rainfall (14.99 mm) event and lowest (2.27 kg) for a low rainfall (6.10 mm) event. Several factors including antecedent conditions, catchment connectivity and land cover, and catchment size and infrastructure appear to influence export. The exact relationships between these factors and POM export remains unclear due to the complex nature of urban hydrology.

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Zhang[1], S., C. G. Boone[1,2], S. Lerman[3], and A. M. York[2]. *A multi-scale study of the relationship among land composition, land fragmentation, and bird biodiversity in the Phoenix area.

Land fragmentation is known to have a significant influence on global biodiversity, but knowledge about how it impacts biodiversity in an urban setting, where there is intense interaction between humans and nature, is limited. This study explored the effects of land composition and land fragmentation on bird biodiversity in the Phoenix metropolitan area, a rapidly growing urban region in central Arizona. Fragmentation was calculated based on the 2001 National Land Cover Dataset. Metrics were selected to reflect the fragmentation level from the angles of land patch, edge, shape and connection. Bird biodiversity data of 52 sites surveyed in 2001 were acquired from the Central Arizona Phoenix Long Term Ecological Research Project. We evaluated bird species richness, evenness, and abundance, using the maximum bird count among three surveys in the Spring season. Pearson correlation and multiple regressions were conducted to build models of bird biodiversity based on land composition and fragmentation at multiple scales, using buffering areas with 90 m to 2760 m side-length around each site. To strengthen the models, surface indices such as NDVI (Normalized Difference Vegetation Index) and Built-up index computed from the remote sensing images, as well as social-economic factors extracted from census tract data are also applied. From preliminary results, different bird groups (urban exploiters, urban adaptors, and urban avoiders) present variant preferences on land types and sensitivities to land fragmentation. Results of the study will add information to help link urban forms and bird biodiversity protection.

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