



# Central Arizona–Phoenix Long-Term Ecological Research (CAP LTER)

## Ninth Annual Poster Symposium

January 10, 2007  
Carson Ballroom, Old Main  
Arizona State University



# Central Arizona – Phoenix Long-Term Ecological Research (CAP LTER)

Ninth Annual Poster Symposium  
January 10, 2007, 8:00 am-3:30 pm  
Carson Ballroom, Old Main

- 8:00 am      **Continental Breakfast**
- 8:30 am      **Welcome and Introduction**  
*Charles Redman, Co-Director, CAP LTER; Director, Global Institute of Sustainability; Interim Director, School of Sustainability*
- 8:35 am      **Biodiversity in Urban Areas: Patterns and Mechanisms**  
*Stan Faeth, School of Life Sciences*
- 9:05 am      **The Secret Life of Xeriscapes:  
Hot Spots and Hot Moments on the Urban Land-Use Palette**  
*Sharon Hall, School of Life Sciences*
- 9:35 am      **Modeling Fluxes of Water and Salt Through the Urban Infrastructure**  
*Paul Westerhoff, Ira A. Fulton School of Engineering*
- 10:05 am     **Legacy Effects on Environmental Equity in Baltimore and Phoenix:  
A Cross-Site Analysis**  
*Christopher Boone, School of Human Evolution and Social Change; School of Sustainability*
- 10:35 am     **Coffee Break**
- 10:50 am     **Panel Discussion: The Value of Long-Term Research**  
*John Briggs, Nancy Grimm, Sharon Harlan, Kelli Larson, Chris Martin*
- 12:00 pm     **Lunch**
- 1:00 pm      **Introduction of Keynote Speaker**  
*Sander van der Leeuw, Director, School of Human Evolution and Social Change*
- 1:10 pm      **Insights in Linking Forests, Trees, and People  
from the Air, on the Ground, and in the Lab**  
*Elinor Ostrom, Arthur F. Bentley Professor of Political Science and Co-Director of the Workshop on Political Theory and Policy Analysis, Indiana University; Founding Director, Center for the Study of Institutional Diversity and Professor, School of Human Evolution and Social Change, ASU*
- 2:20 pm      **Poster Session #1**  
Coffee, tea, and refreshments
- 3:30 pm      **Poster Session #2**  
Coffee, tea, and refreshments

**ELINOR OSTROM** is Arthur F. Bentley Professor of Political Science and co-director of the Workshop in Political Theory and Policy Analysis, Indiana University. She is also founding director of the Center for the Study of Institutional Diversity and Professor at the School of Human Evolution and Social Change, ASU. She is a member of the American Academy of Arts and Sciences, the National Academy of Sciences, and the American Philosophical Society, and a recipient of the Frank E. Seidman Prize in Political Economy, the Johan Skytte Prize in Political Science, the Atlas Economic Research Foundation's Lifetime Achievement Award, and the John J. Carty Award for the Advancement of Science. She has authored or



co-authored many books, including: *Governing the Commons* (1990); *Rules, Games, and Common-Pool Resources* (1994); *Local Commons and Global Interdependence: Heterogeneity and Cooperation in Two Domains* (1995); *Trust and Reciprocity: Interdisciplinary Lessons from Experimental Research* (2003); *The Commons in the New Millennium: Challenges and Adaptations* (2003); *The Samaritan's Dilemma: The Political Economy of Development Aid* (2005); and *Understanding Institutional Diversity* (2005).

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## **Abstract**

### **Insights on Linking Forests, Trees, and People from the Air, on the Ground, and in the Lab**

Governing natural resources sustainably is a continuing struggle, and major debates occur over what types of policy “interventions” best protect forests. Ostrom synthesizes the findings from a long-term, interdisciplinary, multiscale, international research program that analyzes the institutional factors affecting forest management. This program analyzes satellite images, conducts socioecological measurements on the ground, and tests the impact of structural variables on human decisions in experimental labs. Results support a new research frontier and move the debate beyond the boundaries of protected areas into larger landscapes where government, community, and co-managed protected areas are embedded.

# Speaker Abstracts

## **Legacy Effects on Environmental Equity in Baltimore and Phoenix: A Cross-site Analysis**

*Boone, C., and B. Bolin*

Environmental equity patterns differ markedly between Phoenix and Baltimore. In Phoenix, Latino populations are more likely than whites to live near Toxics Release Inventory (TRI) sites, while in Baltimore, white communities are more likely than black communities to live near these disamenities. This presentation uses a variety of spatial analytical methods within a GIS to measure environmental inequity patterns. Using research on Baltimore and Phoenix, we demonstrate that a long history of racial and ethnic discrimination produced very different results in the distribution of neighborhoods and TRI sites. The results underscore the importance of a long-term perspective and value of cross-site research for understanding social and land use dynamics in urbanizing regions. We conclude with some comments on how a coupled environmental equity and ecology framework can add to the LTER planning effort.

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## **Biodiversity in Urban Areas: Patterns and Mechanisms**

*Faeth, S.<sup>1</sup>, E. Shochat<sup>2</sup>, P. Warren<sup>3</sup>, and W. Marussich<sup>4</sup>*

Human activities dramatically change abundances, diversity, and composition of species. However, little is known about the mechanisms by which the most intense human activity, urbanization, alters biodiversity, food webs and trophic structure in biological communities. Studies of the Phoenix and Baltimore LTERs, reveal some surprising patterns in biodiversity and abundances and alterations in control of trophic dynamics. Conversion of wildlands into agricultural and urban ecosystems increases site productivity and resource abundance. However, similar to human societies, the increase in productivity results in an unequal share of resources among species, with a minority of invasive species consuming most of the resources, and thus competitively excluding other species. This increasing inequality changes the community profile and suggests "taxing the maximum wages" of the "novo-rich" invasive species as a conservation strategy for increasing biodiversity in human-managed environments. In terms of control of trophic dynamics, manipulative experiments in the Phoenix CAP LTER show that in contrast to outlying deserts where limiting resources dominate, predation by birds becomes the dominant force controlling arthropods on urban plants. Reduced predation risk on birds elevates abundance and alters foraging behavior such that urban birds exert increased top-down effects on arthropods. Shifts in control of food web dynamics are likely common in urban ecosystems, and influenced by complex socioeconomic forces and feedbacks.

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## **The Secret Life of Xeriscapes, our Domesticated Deserts**

*Hall, S. J., and Rachel Davies*

Residential landscaping with water-intensive lawns is common in urban areas across the country, but in arid, western US cities, desert landscaping is a popular, growing practice for its perceived water-conservation and aesthetic benefits. Xeriscaped yards are often planted with drought-tolerant vegetation and are designed to look similar to natural, arid landscapes, but do they replicate the functioning of the desert ecosystems they seek to mimic? We have begun several studies to explore the ecology of these unique, urban ecosystems. Our initial findings show that managed, xeric landscapes bear key resemblances to both lawns and native deserts by capturing the temporal and spatial dynamics of both ecosystems with respect to below-ground resources and exchange of gases between soils and the atmosphere. Active human manipulation of vegetation, soils, and water in xeriscaped gardens creates a domesticated desert community that is more homogeneous and resource-rich than its native analogues.

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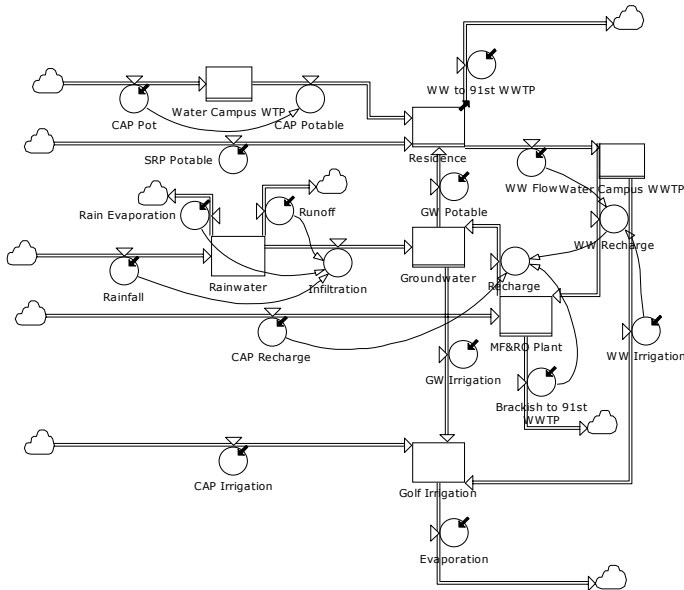


## **Modeling Fluxes of Water and Salt Through the Urban Infrastructure**

*Westerhoff, P., P. Zhang, and J. Crittenden*

The Water Integrated Project Area supported a project to undertake activities written in the CAP LTER renewal proposal. Whereas previous water-research efforts at CAP LTER have focused upon water and landscape management and a preliminary water budget for the metro area, we recognize a need for a more complex hydrologic cycle, with natural variability altered by the need to supply water for human activities and protect from floods. Controlled management activities shift the characteristic spatial and temporal variability of the system, leading to ecological consequences, human perceptions of change, and further institutional responses. This pattern can lead to vulnerabilities and unanticipated ecological consequences, inability to recognize key processes, and reduced capacity to withstand perturbations. The project is modeling the hydrologic cycle and salt fluxes. The model is based upon the same platform as used by the Decision Center for a Desert City (PowerSim) with the intent to be able to integrate the models to provide a spatially explicit understanding of water and salt fluxes. The project team decided to focus on a single municipality (City of Scottsdale) which has all the components of a modern arid-region urban water infrastructure system: supply of water from Colorado River through Central Arizona Project (CAP), groundwater, surface water (Salt River Project [SRP]), rainfall, runoff, wastewater, and reclaimed water. Data mining and generalized models are currently being integrated to support the model (Figure 1).

Figure 1 - Modeling Platform for City of Scottsdale



- Legend:**
- Cloud shape represents source or sink.
  - Arrow with double line represents water flow.
  - Arrow with single line represents information flow.
  - Bold arrows in the up-right of circles represent data input and output.
  - Sub-models are hidden within circles.

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## 2007 CAP LTER Symposium

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Toke & Arrowsmith (9)	Walker (8)
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Tobias Finke, Susan Moran, and Steve Yool. *Satellite-Derived Roughness Data for Hydrology Applications in Areas Affected by Urbanization*

Kris J. Gade. *Ecological Paradigms and Landscape Plantings Along Freeways: A Case Study from Melbourne, Australia*

Chris Martin and Jean Stutz. *Long-Term Monitoring of Tree Size Condition Across Nonresidential Patch Types in Phoenix, Arizona*

Soe W. Myint. *Quantifying Impervious Surfaces in the Phoenix Metropolitan Area using Multiple Endmember Spectral Mixture Analysis*

Kaesha Neil and Jianguo Wu. *Historical and Current Patterns of Flowering Phenology in the Phoenix Metropolitan Area*

Jason Walker. *Money Grows Trees: A Socio-Ecological Path Analysis*

## CLIMATE-ECOSYSTEMS INTERACTIONS

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Darren Ruddell and Sharon Harlan. *Phoenix as a Human Habitat in Summer: Exposure and Resources to Cope with Extreme Heat*

Ken Sweat, Thomas Zambo, and Thomas Nash III. *Geographic Patterns of Mercury Deposition Using Xanthoparmelia in Maricopa County, Arizona, USA*

Nathan Toke and J Ramon Arrowsmith. *Investigation of Dryland Geomorphic Response to Urbanization*

Scott Yabiku, David Casagrande, and Elizabeth Farley-Metzger. *Effect of Weather on Neighborhood Human Activity*

Xiaoding Zhuo, Panjai Prapaipong, and Everett Shock. *Factors that Contribute to Distribution Patterns of Trace Elements in Maricopa County*

## FLUXES OF MATERIALS AND SOCIO-ECOSYSTEM RESPONSE

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Rachel Davies and Sharon Hall. *Alteration of Belowground Ecosystem Function in Phoenix*



Carrie M. Durward and Kristin J. Gade. *Dry Nitrogen Deposition on the Highway Verge*

Daniel A. Gonzales and Jonathan O. Allen. *Dry Deposition of Aerosol Nitrogen and Organic Carbon in the CAP Area*

Megan Kelly and Hilairy Hartnett. *Temporal Compositional Changes in DOC in Tempe Town Lake*

Elisabeth K. Larson, Kayla L. Graham, and Nancy B. Grimm. *Comparison of Soil Biogeochemical Characteristics in Grassy and Xeriscaped Stormwater Retention Basins in the Phoenix Metropolitan Area*

Kathleen A. Lohse, Diane Hope, Ryan A. Sponseller, Jonathan O. Allen, and Nancy B. Grimm. *Spatial and Temporal Patterns of Wet and Dry Deposition of Nutrients in a Desert City*

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#### **HUMAN CONTROL OF BIODIVERSITY**

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Bony Ahmed, Kathleen A. Lohse, Ryan A. Sponseller, and Nancy B. Grimm. *Food Web Dynamics in Above-Ground Desert Remnant and Xeric Residential Landscapes*

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H. Bobby Fokidis and Pierre Deviche. *Variation in Avian Blood Parasite Prevalence, Insect Vectors and Haematology Associated with Recent Colonization of a City*

Susannah B. Lerman and Paige S. Warren. *Landscape Design and Bird Community Structure in Phoenix, Arizona: Management Implications*

Anandamayee Majumdar, Corinna Gries, Jason Walker, and Nancy Grimm. *A Nonstationary Spatial Generalized Linear Mixed Model Approach for Studying Plant Diversity*

Erica Schwartzmann and Jason Walker. *The Shadowing of Avian Diversity*

Eyal Shochat, Jose Lobo, J. Martin Anderies, Paige S. Warren, Stanley H. Faeth, and Charles H. Nilon. *Productivity, Inequality, and Biodiversity Loss in Human-Dominated Ecosystems*

Laura Taylor-Taft and Stanley Faeth. *Neighborhood Effects on Arthropod Diversity and Food Webs*

#### **HUMAN DIMENSIONS OF ECOLOGICAL RESEARCH**

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Heather E. Campbell, Laura R. Peck, and Michael K. Tschudi. *The Location of Toxic Release Inventory Facilities in Maricopa County: Economics, Collective Action, and Being Asian*

Juan Declat, Bob Bolin, and Christopher Boone. *Environmental Inequity in the Phoenix Metropolitan Statistical Area, 1980 and 2000*

Scott E. Ingram. *Social Transformations and Climate Variation in the Prehistoric U.S. Southwest*

Maya L. Kapoor, Ann P. Kinzig, and Charles Perrings. *The CAP LTER Ecosystem Services Assessment: Preliminary Findings and Next Steps*

Erin Lyons, Peng Zhang, Miles Costanza, Ke Li, and John Crittenden. *Life Cycle Assessment of Two Water Supply Systems: Importation vs. Reclamation*

Tischa A. Muñoz-Erickson. *Incorporating Social Elements into the Long-Term Ecological Research Program: Institutional Lessons from the LTER Network*

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#### **INFORMATION MANAGEMENT, OUTREACH, AND EDUCATION**

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Monica Elser and Charlene Saltz. *Teacher Perceptions on the CAP LTER Ecology Explorers Summer Teacher Internship Program*

Edward Gilbert, Corinna Gries, Leslie Landrum, Elizabeth Makings, and Robin Schroeder. *New Biodiversity Informatics Model for Identifying Plants*

Subhrajit Guhathakurta, Janet Holsten, Yoshihiro Kobayashi, Tim Lant, Mookesh Patel, John Crittenden, Thomas Morton, Goran Konjevod, Paul Torrens, Ke Li, Dan Stanzione, Karthikeya Date, Peyman Nayeri, Luke Shillington, Robert Pahle, Reid Baker, Steffen Eikenberry, and Chris Grasso. *Digital Phoenix: A Multidimensional Journey through Time*

Darren Julian, J. Moore, and Tom Hildebrandt. *Using GIS to Display and Predict Human-Wildlife Conflicts*

Darren Julian, Joseph Yarchin, M. Stewart, and Tom Hildebrandt. *An Integrated Approach to Resolving Urban Wildlife Conflicts by Using Public Education and Community Involvement*

Ray Quay, Khanin Hutauwatr, and K. David Pijawka. *Visualization of Sustainability Indicators: A Conceptual Framework*

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#### **DECISION CENTER FOR A DESERT CITY**

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Bethany Cutts. *Water Landscapes: Representing the Effort Distribution Multiple Outreach Organizations*

Netra Chhetri, Lori Hiding, Mark Neff, Megan O'Shea, Aliya Buttar, and Uven Chong. ***Decision Making Under Uncertainty: Ranking of Multiple Stressors on Central Arizona Water Resources***

Meredith Gartin, Tim Lant, Amber Wutich, Dave White, Susan Ledlow, and Pat Gober. ***WaterSim: A Study of Water-Related Decision-Making Under Uncertainty***

Subhrajit Guhathakurta, Patricia Gober, and Jamie Patterson. ***The Impact of Housing Characteristics and Surface Heat Islands on Water Use in Single-Family Residences: The Case of Phoenix Metropolitan Area***

Annie Gustafson, Kelli Larson, Paul Hirt, and Jagadeesh B. Chirumamilla. ***Water Conservation Policy in an Arid Metropolitan Region: A Historical and Geographical Assessment of Phoenix, Arizona***

Seung Jae Lee, Robert Balling, and Patricia Gober. ***A Soft Geostatistical Application in Urban Climate Research***

Claire Smith, Lilah Zautner, Kelli Larson, and Bob Bolin. ***Water Vulnerability on the Urban Periphery: Buckeye, Carefree and Cave Creek, Arizona***

## ABSTRACTS

All abstracts are listed alphabetically by first author.



### **Food Web Dynamics in Above-Ground Desert Remnant and Xeric Residential Landscapes**

*Ahmed, B.<sup>1,2</sup>, K. A. Lohse<sup>1</sup>, R. A. Sponseller<sup>1</sup>, and N. B. Grimm<sup>1,2</sup>*

Due to urbanization, the Central Arizona-Phoenix region has undergone major land transformations. In the 1990s, Phoenix's rate of growth prompted the Environmental Protection Agency to launch several water conservation campaigns. These campaigns led many Phoenixians to remove mesic landscapes and to install xeric landscapes in their yards. Although the structure of xeric landscapes is similar to undisturbed desert landscape, several human management factors such as plant watering and fertilization make it unclear as to whether or not these landscapes differ functionally. In this study, I contrasted the two landscapes to determine whether human influences in xeric residential landscapes generate differences in nutrient availability in above-ground primary producers and consumers. I hypothesized that xeric landscapes would have greater amounts of nitrogen (N), phosphorus (P), and water availability than desert remnants. If this was true, and N and P were more rich at xeric sites, I hypothesized that there would be greater abundance of primary consumers (herbivores) at these sites compared to desert sites and thereby change food web dynamics. The results supported both hypothesis and showed an increase in the abundance of herbivores but also a large increase in diversity of herbivores.

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### **Modeling Trophic Dynamics in the CAP Area**

*Bang, C.<sup>1</sup>, S. H. Faeth<sup>1</sup>, and J. M. Anderies<sup>2</sup>*

Water is usually the limiting resource for plant productivity in the Sonoran Desert. In the Central Arizona-Phoenix (CAP) area, urbanization generally leads to increased and more stable water availability, resulting in increased plant productivity. Several research projects are presently underway that explore how this changing water availability affects ecological communities, with emphasis on plant productivity, arthropod and bird species diversity, and composition. We explore these issues using simple mathematical models. These models will be later integrated and validated with data from CAP empirical studies. The simplest model is a tri-trophic Lotka-Volterra system with a linear functional response on herbivore and predator level. In the second model, we use a type II functional response on the same levels, with bird predation on both herbivores and predators. The models assume water as the limiting resource, thereby directly influencing plant carrying capacity. The models are compared using bifurcation analysis, focusing on plant carrying capacity and predation by birds. The dynamics of these models are discussed in relation to how classic community ecology theories are expected to fit to varying degrees of urbanization. This work provides a good foundation for integrating empirical data from the CAP urban ecosystem.

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## **Spatiotemporal Patterns of Primary Production Across Different Land Uses in Central-Arizona Phoenix LTER**

*Buyantuyev, A., and J. Wu*

The prevalence of impervious surfaces and the destruction of native vegetation in urban environments can have profound effects on native biodiversity and ecosystem functioning. Urbanization generally has been thought of as a process that decreases primary production, but for desert cities this may not be the case because of highly productive patches of irrigated green spaces and croplands. While the growth of native desert communities depends strongly on the amount and timing of precipitation, the growth of urban vegetation is decoupled with precipitation due to human ameliorations. To better understand this issue, we attempted to quantify the overall losses and gains of primary productivity due to urbanization in the Phoenix metropolitan region. We used satellite data (250 m MODIS NDVI) to assess the spatiotemporal patterns of primary production and vegetation responses to interpolated climate variables that were correlated with NDVI on different time scales, with several urban and non-urban land cover classes considered. Our results show that native desert at lower elevations is less productive than upland communities, and that riparian ecosystems encompassing perennial streams are the most productive. Cultivated grass that occupies less than 0.5% of the area has a productivity level comparable to that of riparian vegetation. Urban vegetation and agricultural lands have intermediate levels of primary production. Unlike desert communities, urban vegetation and croplands are least affected by climatic fluctuations. As expected, the primary production of native desert vegetation is tightly coupled with precipitation, but with a time delay of a few months. Our work provides insights into the interactions among vegetation growth, climate variability, and urbanization.

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## **The Location of Toxic Release Inventory Facilities in Maricopa County: Economics, Collective Action, and Being Asian**

*Campbell, H. E.<sup>1</sup>, L. R. Peck<sup>1</sup>, and M. K. Tschudt<sup>2</sup>*

Using measures of race and ethnicity, and factors controlling for the likelihood of collective action and standard economic and compensation costs including nearness to infrastructure, we use multivariate regression to analyze the factors that explain Toxic Release Inventory facilities' (TRIF's) locations.

An ongoing question in environmental justice research is whether the disproportionate co-location of environmental disamenities with minority residents is due to efficient workings of the market, or something more invidious. One difficulty in sorting this out is the often-limited availability of data on population characteristics at the time of the disamenity-producing entity's location. Researchers often must rely on population characteristics at some point after location, meaning that current co-location may be due to market-based decisions of residents, rather than entity decisions.

The paper provides evidence directly relevant to this problem. Starting with TRI data for 401 separate facilities, the researchers found location data for 222. This allows analysis of residential characteristics before TRIF location, ensuring that findings do not indicate the movement of residents into the TRIF's ambit, but location of the TRIF among the residents.

Statistical analysis indicates that it is spatially random whether data are available on a TRIF's location date.

The analysis finds that, even controlling for other factors, there is environmental injustice based on race. Several economic costs matter and the potential for collective action does decrease the likelihood of TRIF location, but the rate of poverty does not seem to be important in these data.

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### **Decision Making Under Uncertainty: Ranking of Multiple Stressors on Central Arizona Water Resources**

*Chhetri, N., L. Hidingar, M. Neff, M. O'Shea, A. Buttar, and U. Chong*

We apply a multiple stressor analysis as support for decision making under uncertainty associated with water management policy in the Central Arizona region of the southwestern United States. More specifically, we assess the significance of a variety of stressors in their relations with the vulnerability of water supply systems and generate a ranking of the stressors through a weight-of-evidence approach in the Phoenix Active Management Area (AMA). Based on the causal links between stressors and their effects on water resources, the stressors on Phoenix AMA water resources are broadly placed in three categories: municipal, agricultural, and biophysical. Our analysis shows that water used for outdoor irrigation for single-family resident accounts for the most important stressor of water resources. Ranked second is the loss of water due to rise in temperature and simultaneous reduction in precipitation due to global warming in the Colorado and Salt/Verde River basin. This is closely followed by the stress on water resources resulting from inefficient agricultural practices. Indoor water use is ranked fourth among the stressors. The relatively low ranking of indoor water use is not surprising given the implementation of efficiency standards and innovation of technologies in plumbing fixtures. Higher residential water demand due to increased night time temperature in the urban area is a distant fifth. Analysis and ranking of multiple stressors in the water resources of Phoenix AMA reveals that outdoor water use and agriculture practices are comparably fertile targets for efficiency gains from technical and management perspectives.

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### **Water Landscapes: Representing the Effort Distribution Multiple Outreach Organizations**

*Cutts, B.*

Many organizations provide public outreach yet evaluation rarely considers interactions between organizations. Issue perception and engagement with knowledge may be partially explained by the way outreach sources provide access to programs. For environmental issues like water, understanding the differences in outreach availability across neighborhoods may reveal systemic patterns in under service that contribute to recognition, procedural, and outcome injustice. Receiving lower education effort could decrease public participation in decision making across a variety of scales. The diversity of outreach program structures means that researchers must pay careful attention to the methods they use to categorize program reach.

From June to October 2006 I collected program information using interviews and existing evaluation documents for 43 organizations. Here, I compare the results of spatial analysis using points, buffered points, and area-counts to represent education programs. While some general patterns hold across analysis methods, there are differences in the areas defined by each method. The analysis from this study will be used to look for patterns in education provision across demographic variables. Future research will determine the relative role of geographic and population-based discrepancies in access to outreach.

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### **Alteration of Belowground Ecosystem Function in Phoenix**

*Davies, R., and S. Hall*

Urbanization influences the main drivers of biogeochemical cycles by manipulating hydrology, atmospheric chemistry, nutrient cycles, land use and land cover. Yet the impacts of these changes on ecosystem function are not fully understood. Soil nutrient pools and fluxes integrate the effects of human management (as irrigation and fertilization), the urban atmosphere, plant growth, and microbial activity. We compared outlying desert sites to urban desert patches and xeriscaped yards with a history of intense human management for agriculture and lawn maintenance. Soil nitrate and organic matter are elevated inside Phoenix both in xeriscaped yards with an agricultural past and urban desert patches. Similarly, potential nitrogen processing rates are somewhat higher in urban desert than outlying desert. These results are consistent with previous work that the urban atmosphere supplies the Central Arizona-Phoenix ecosystem with excess nitrogen, a key limiting nutrient in the Sonoran Desert. However, these soil resources are decoupled from soil moisture which is increased by human management, but not proximity to the urban core. Furthermore, despite elevated soil nitrogen, net potential nitrogen processing rates are even lower in xeriscaped yards than in the outlying desert. This could be due to improved nitrogen removal by plants or microbes. This implies that xeriscaped yards, though they appear similar to desert, have an enhanced ability to remove excess soil nutrients supplied by the urban atmosphere.

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### **Environmental Inequity in the Phoenix Metropolitan Statistical Area, 1990 and 2000**

*Declat, J., B. Bolin, and C. Boone*

In this research, we explore the spatial distribution of toxic facilities and decadal change in environmental inequities in the Phoenix, Arizona metropolitan area. A Geographic Information System is used to map Toxics Release Inventory (TRI) facilities and socio-demographic indicators in 1990 and 2000. We employ both traditional and novel techniques to assess change in the pattern of environmental inequity. Statistical comparisons between host/non-host Census Tracts and Tracts with our Hazards Density Index (HDI) score provides an introductory analysis. We complement the analysis by examining the relationship of HDI scores to race and class through Geographically Weighted-Regression, a spatial analysis technique.

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## **Dry Nitrogen Deposition on the Highway Verge**

*Durward, C. M., and K. J. Gade*

Because nitrogen is a limiting nutrient in the desert, the dry deposition of nitrogenous gas pollutants from car exhaust to the highway verge has serious implications for plant density and species composition. The high temperature of fuel combustion causes nitrogen from the air to combine with oxygen and form nitrogenous gas pollutants, which are released in car exhaust. In an arid environment, these pollutants can settle along the roadside through dry deposition. Our research was conducted to determine the pattern of nitrogen dry deposition to the soil of the highway verge. Surface soil samples from the highway verge were collected from 20 sites and analyzed for plant available nitrate content. One site was sampled intensively (103 samples over 200 m<sup>2</sup>) to further explore the localized pattern of nitrogen deposition. In the large-scale study, the average soil nitrate was found to be significantly higher closer to the highway (ANOVA using log surface soil concentration;  $F=5.556$ ,  $P=0.005$ ). However, more variation was found in the intensive sampling. The concentrations ranged from 0.6 mg/kg dry soil to 155.5 mg/kg dry soil and the standard deviation was 29.2 put in units. The 2005 CAP LTER 200-point survey recently found that the average soil concentration of plant available nitrate in the Sonoran Desert is 7 mg/kg dry soil, while the average for urban sites was 46 mg/kg dry soil. Kriging, a statistical model that interpolates data from a known set of sample points to a continuous surface, was used to help understand the pattern found in the intensive sampling. The results support the hypothesis that dry deposition of nitrogenous pollutants to the roadside causes elevated nitrogen levels near the highway's edge. These findings may help explain patterns of plant growth and migration along roadsides including increased plant density near the road.

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## **Teacher Perceptions of the CAP LTER Ecology Explorers Summer Teacher Internship Program**

*Elser, M.,<sup>1</sup> and C. Saltz<sup>2</sup>*

Pre- and post-internship surveys from 2003-2005 were analyzed to gain insight into the effectiveness of CAP LTER Ecology Explorers summer teacher internship program. The guiding questions for the analysis presented in this poster were:

- What did the teachers perceive as important outcomes from attending the internship?
- Were the outcomes met at the completion of the internship?
- Did the teachers accomplish what they thought they would during the school year?
- What content from the internships did the teachers actually use during the school year?

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## **Satellite-Derived Roughness Data for Hydrology Applications in Areas Affected by Urbanization**

*Finke, T.<sup>1</sup>, S. Moran<sup>2</sup>, and S. Yool<sup>1</sup>*

Surface roughness is an important watershed parameter. It influences erosion, infiltration and runoff amount and speed. Urbanization alters surface roughness by creating smooth, impervious surfaces that impair infiltration processes. Such changes influence stream flow and groundwater recharge. Remotely sensed data can measure and monitor changes in surface roughness, thus help assess impacts of urbanization on watershed parameters. Our study compares roughness data derived from satellite radar images with roughness values created with conventional methods based on vegetation data. Vegetation data are used in the KINEROS rainfall/runoff model within the widely used AGWA GIS package. Results of this study were mixed for a 150 km<sup>2</sup> semiarid watershed in southeast Arizona: On a sub-watershed scale the two datasets showed no correlation, possibly due to the limited range of roughness values. On a watershed scale, however, the two roughness maps showed similar features. This outcome supports use of satellite data, to monitor surface roughness at the regional scale for studies of urban hydrology.

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## **Variation in Avian Blood Parasite Prevalence, Insect Vectors and Haematology Associated with the Recent Colonization of a City**

*Fokidis, H. B., and P. Deviche*

Urbanization negatively impacts many avian species, but some species survive and prosper in these novel habitats. One factor contributing to the success of these species in urban environments may be the lessened presence of parasite-transmitting vectors in urban than rural areas (a component of the enemy-release hypothesis). An alternate explanation for such differences may be variability in the innate immune response to infection, resulting from differences in exposure to "stressful" stimuli associated with urban living. We examined patterns of hemoparasite prevalence, biting insect occurrence, granulocyte and mononuclear white blood cells (WBC) distributions in sedentary songbirds (four native and one introduced species) that vary in their tolerance to urbanization. These birds were found to host three types of hemoparasites (*Trypanosoma* sp., *Haemoproteus* sp., and Microfilariae). The prevalence of the two former parasite types varied at a microgeographic scale, across species, and across seasons. For three native species, heterophil, lymphocyte, and eosinophil WBCs varied between urban and rural sites. Urban collection sites showed a decreased abundance of both sand flies (Ceratopogonidae) and mosquitoes (Culicidae), which may account for differences in the occurrence of parasites between habitats. Potential explanations for observed patterns will be discussed in the context of consequences of city colonization by native wildlife.

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## **Ecological Paradigms and Landscape Plantings Along Freeways: A Case Study from Melbourne, Australia**

*Gade, K. J.*

How much do individual preferences influence the design and ecological characteristics of urban areas? As part of a larger study of plant migration along freeway corridors, a series of interviews were undertaken with project managers, environmental officers, and landscape architects associated with VicRoads in Victoria, Australia. The purpose of the interviews was to gather information on how personal views influence the selection of planting designs, plant selection, and maintenance regimes for freeways. These choices impact directly on the plants that are able to survive and reproduce within the freeway corridors. The interviews included two different Q-sorts, one of photos of an assortment of plants and the other of an assortment of landscape designs for a freeway verge. A standard Likert scale, the New Ecological Paradigm (NEP) was also included, as well as collection of general information on age, gender, and educational background. Factor analysis of the results of the Q-sorts shows general trends in likes and dislikes of plants and designs for use along freeways; these trends are correlated with ecological worldviews (taken from the NEP Likert scale results), educational background, and current employment to analyze trends across the individuals that were interviewed.

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## **WaterSim: A Study of Water-Related Decision-Making under Uncertainty**

*Gartin, M.<sup>1</sup>, T. Lant<sup>2</sup>, A. Wutich<sup>2</sup>, D. White<sup>3</sup>, S. Ledlow<sup>2</sup>, and Pat Gober<sup>2, 4</sup>*

The Decision Center for a Desert City (DCDC) has developed an interactive model designed to facilitate decision-maker interactions around long-term water supply and demand in Maricopa County, Arizona. The model titled, "DCDC WaterSim" is designed for interactive display and serves as a boundary object to inform water-related decision-making on issues of long-term sustainability in central Arizona.

The WaterSim project employs perspectives from modeling, geography, anthropology, and psychology to understand the process of decision making under uncertainty. The research objectives are designed to (1) determine the extent to which stakeholders can use the model for decision making, (2) elicit feedback from stakeholders to reincorporate in the model, (3) examine stakeholder discourses around Arizona water decisions and decision making, and (4) examine the decision-making dynamics that foster the expression of dissent and the building of consensus.

The data collection consists of a series of 12 focus groups held at the Decision Theater at Arizona State University. The focus group sessions were held with three kinds of water decision-making groups: policymakers, data analysts, and consultants. Focus group discussions were collected in audio and video format, and transcribed into text form. Once the transcripts have been coded, the researchers will use a variety of text analysis methods to analyze the data. Coding of these transcripts fall across four major themes related to the interface of science and policy: (1) the model's credibility, saliency, and legitimacy, (2) the reconciliation of supply and demand of information between scientists and policymakers, (3) uncertainty, and (4) modernity.

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## **New Biodiversity Informatics Model for Identifying Plants**

*Gilbert, E.<sup>1</sup>, C. Gries<sup>1</sup>, L. Landrum<sup>2</sup>, E. Makings<sup>2</sup>, and R. Schroeder<sup>2</sup>*

Scientists are predicting historic levels of mass extinction within this century. It is imperative that we develop better tools to aid taxonomists, field biologists, and environmental educators in order to increase the rate of biological inventories. Furthermore, it is crucial to steer youth toward becoming our future scientists. Symbiota web-tools strive to integrate biological community knowledge and data in order to synthesize a network of databases and tools that will aid in increasing overall environmental comprehension.

The Symbiota Identification Key is a PHP/MySQL platform-independent web application that integrates a number of previously established datasets to aid plant identification. The user first creates a species list based on a combination of geographical and taxonomic criteria. Once an initial checklist is assembled, the application analyzes morphological character data in order to determine which character attributes will further differentiate that particular species subset. This gives the user a practical means of further limiting the possibilities based on morphological characteristics (e.g., habit, leaf arrangement, flower color). Final identifications are determined through browsing images and additional descriptive data. Data entry and management is controlled through a password-protected web interface allowing for widespread collaboration.

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## **Dry Deposition of Aerosol Nitrogen and Organic Carbon in the CAP Area**

*Gonzales, D. A.<sup>1</sup>, and J. O. Allen<sup>1,2</sup>*

In urban areas high emissions of nitrogen and organic carbon species cause an increase in atmospheric aerosol formation. These aerosols are eventually removed from the atmosphere by wet or dry deposition, with dry deposition often accounting for more than half of the total. Deposited materials augment the available pools of nitrogen and carbon for soil ecosystems, possibly altering nutrient cycling in urban and near-urban deserts where plant and soil systems may respond differently to external inputs.

The inferential method can be used to estimate aerosol dry deposition fluxes from measured aerosol concentrations and modeled deposition velocities. Filter and denuder bank samplers were used to measure the concentration of gas and particle phase nitrogen and organic carbon at urban desert remnant and downwind desert sites in the Central Arizona-Phoenix area. A simple parameterization was developed to estimate deposition velocities at desert sites using experimental eddy correlation measurements. The inferential method was then used to estimate dry deposition fluxes of nitrogen and organic carbon to urban-influenced desert sites. The results will be used to evaluate hypotheses about ecosystem response to anthropogenic inputs in the CAP study area.

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## **The Impact of Housing Characteristics and Surface Heat Islands on Water Use in Single-Family Residences: The Case of Phoenix Metropolitan Area**

*Guhathakurta, S.<sup>1</sup>, P. Gober<sup>2</sup>, and J. Patterson<sup>2</sup>*

The effect of heat islands in Phoenix has been an increase in summer nighttime temperatures of about 3.9°F while afternoon temperatures have risen 1.1°F (Balling and Brazel 1986a, b; Brazel et al. 2000). Although microclimatic effects resulting from changes in land use and land cover have caused overall increases in temperatures in all months and all hours of the day, a spatial variation in changes in nighttime temperatures can be observed in localized areas. In this paper, we examine whether the spatial variation in summer nighttime temperatures as a result of urban heat island also impact the amount of household water use. A cross-sectional analysis of a spatially referenced June 1998 dataset of water use reveals an average increase of 647 gallons for a typical single-family unit for each degree Fahrenheit rise in nighttime temperature. This result suggests a significant impact of rising temperatures on water use in Phoenix. The poster will present the analysis and data from this research and illustrate the significant findings.

Balling, R. C., Jr. and S. W. Brazel. 1986a. "New" weather in Phoenix? Myths and realities. *Weatherwise* 39:86-90.

Balling, R. C. and S. W. Brazel. 1986b. Temporal analysis of summertime weather stress levels in Phoenix, Arizona. *Archives for Meteorology Geophysics and Bioclimatology, Series B-Theoretical and Applied Climatology* 36 (3-4):331-342.

Brazel, A. J., N. Selover, R. Vose, and G. Heisler. 2000. The tale of two climates: Baltimore and Phoenix urban LTER sites. *Climate Research* 15(2):123-135.

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## **Digital Phoenix: A Multidimensional Journey through Time**

*Guhathakurta, S.<sup>1</sup>, J. Holster<sup>2</sup>, Y. Kobayashi<sup>2</sup>, T. Lant<sup>3</sup>, M. Patel<sup>2</sup>, J. Crittenden<sup>4</sup>, T. Morton<sup>2</sup>, G. Konjevod<sup>5</sup>, P. Torrens<sup>6</sup>, K. Li<sup>4</sup>, D. Stanzione<sup>3</sup>, K. Date<sup>2</sup>, P. Nayer<sup>5</sup>, L. Shillington<sup>6</sup>, R. Pahle<sup>3</sup>, R. Baker<sup>2</sup>, S. Eikenberry<sup>3</sup>, and C. Grasso<sup>2</sup>*

The Digital Phoenix project is a multiyear project aimed at developing a realistic digital representation of the Phoenix metropolitan area through space and time that can be experienced in Arizona State University's Decision Theater. A significant objective of this project is to create an environment for querying, researching, and visualizing critical issues confronting our rapidly urbanizing area about urban sustainability. By creating a multidimensional virtual model of Phoenix from a variety of data sources, we will be able to visualize patterns of growth and development, as well as their consequences, that emerge across the continuums of space and time. The modeling of future environments will enable the assessment of policy scenarios that enable desired future urban-environmental patterns. A digitally constructed model of the city will also allow us to discover what Phoenix could have been like, starting with historical data as the basis for projecting to the present and into the future.

The poster will illustrate some of the main themes of the Digital Phoenix project and provide examples of how the tools developed in this project can be used for scenario generation and policy analysis. The illustrations will include visualization of richly textured immersive environments in downtown Phoenix, scenarios of future patterns of development in Maricopa County based on policy parameters, consequences of such development for air quality, material use, and sprawl, and visual representations of the evolution of transportation and land use patterns in various parts of Phoenix.

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## **Water Conservation Policy in an Arid Metropolitan Region: A Historical and Geographical Assessment of Phoenix, Arizona**

*Gustafson<sup>1</sup>, A., K. Larson<sup>2,3</sup>, P. Hirt<sup>1</sup>, and J. B. Chirumamilla<sup>2</sup>*

Using the 1980 Groundwater Management Act as a starting point, this poster documents shifts in residential water conservation policy that have resulted from the implementation of the Act's three consecutive management plans in the Phoenix Active Management Area (AMA). A combination of historical and geographical methods is used to examine water conservation policy trends in the ten most populous municipalities in the greater Phoenix region. Information on residential water conservation policies and programs across municipalities is evaluated using GIS maps, a water conservation policy typology, qualitative information from interviews, and historical narrative. While GIS maps document chronological changes and geographic patterns in water conservation policy, the water conservation typology (created from municipal web pages and policy documents) summarizes policy efforts aimed at reducing regional water demand through regulations, incentives, and information-based approaches. Additionally, information obtained from approximately ten interviews with water conservation specialists reveals the perceived success of these policy tools. Collectively, the typology, maps, interviews and historical research document periods of greater and lesser attention to conservation, acknowledge shifts in the types of policy tools used to reduce water demand over time, and demonstrate geographic patterns in conservation policy within the greater metropolitan region.

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## **Social Transformations and Climate Variation in the Prehistoric U.S. Southwest** *Ingram, S. E.*

The prospect of global-scale climate change makes understanding the relationship between climate variation and human behavior increasingly important. Humans have a long history of coping with climate variation and its effects on food production. This history can inform our efforts to understand, anticipate, and prepare for climate variations in the future. Archaeological research in the U.S. Southwest has documented periods when prehistoric societies appear to have undergone social transformations. These transformations involved some combination of changes in settlement patterns, public and private architecture, social networks, material culture, mortuary practices and other dimensions of social, economic, and religious life. Tree-ring based climate studies have documented more than 2,000 years of climate history in the Southwest. This poster presents a preliminary effort to examine the climatic context of several social transformations in the Phoenix basin (Hohokam), southwest New Mexico (Mimbres), and east-central Arizona/west-central New Mexico (Zuni). Climatic conditions from A.D. 900 to 1500 are examined in each location. A characterization of the

climatic context of the social transformations is a first step toward assessing whether or not a relationship between the climatic conditions and the social transformations may have existed.

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### **Using GIS to Display and Predict Human-Wildlife Conflicts**

*Julian, D., J. Moore, and T. Hildebrandt*

When wildlife and humans live in close proximity there is always a potential for conflict. The ability to identify “hot spots” is a key element in predicting areas where high-profile human-wildlife conflicts may occur. Arizona Game and Fish Department (AGFD) has created a method to use GIS software to spatially display the location of wildlife calls by animal type. Using our Human Wildlife Interaction Database to document the coordinates of conflict calls, we can then use the data in a GIS program to visually display the location of conflicts by animal type. Currently, “hot spots” are in close proximity to golf courses, dry washes, mountains, construction sites and the urban-open space interface. AGFD is currently updating the Human Wildlife Interaction Database to be able to further categorize conflict calls in accordance to our Wildlife Conflicts Policy. Conflicts are assigned a number from 1-3 based on the nature of the call. Once this information is included, the GIS maps will give AGFD a tool to more accurately predict areas of potential human-wildlife conflicts for species of management concern. These hot spots will let us know where to concentrate our attention and efforts and be proactive with education or active removal of wildlife.

Arizona Game and Fish Department, Mesa Region, 7200 E University Ave, Mesa, AZ 85207



### **An Integrated Approach to Resolving Urban Wildlife Conflicts by Using Public Education and Community Involvement**

*Julian, D., J. Yarchin, M. Stewart, and T. Hildebrandt*

The urban oasis of the greater Phoenix area, with its abundant resources, makes life easier for wildlife and also allows more animals to exist in smaller areas. Because wildlife is living in close proximity to humans, conflicts are inevitable. A large part of these conflicts can be related to human activities such as active or inadvertent feeding, and indifference or tolerance that leads to habituation. The Arizona Game and Fish Department (AGFD) have adopted an Integrated Management Approach (IMA) for coexistence with wildlife in the urban setting. “Coexistence” is an active term; it takes effort, ranging from increasing one's knowledge, to being responsible citizens and assisting with resolution. The mission of the IMA is to organize public awareness, education, communication, and coordination for management of urban wildlife and conflict issues by giving the responsibility for animal behavior to the community. AGFD provides educational material to the community through homeowner's associations, municipalities, or other active community groups. These groups or entities are then responsible for disseminating this information by using a variety of resources to get everyone “on the same page” with wildlife issues. AGFD manages escalating conflicts by providing support, solutions, and/or lethal removal of wildlife that poses a threat to public safety. Four large communities in the Phoenix metropolitan area have adopted this approach and created their own individual Integrated Management Plans. Although the IMA is in its infancy, early

reports indicate the effort is a success that is leading to other communities wanting to implement their own plans.

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### **The CAP LTER Ecosystem Services Assessment: Preliminary Findings and Next Steps** *Kapoor, M. L.<sup>1</sup>, A.P. Kinzig<sup>2</sup>, and C. Perrings<sup>3</sup>*

Beginning last fall, an interdisciplinary team of social and natural scientists conducted a pilot study to assess the ecosystem services provided within the CAP LTER boundaries. Here we present some of our preliminary findings and describe our next steps. Our goal was to identify the ecosystem services provided within the CAP LTER that were most highly valued; most threatened by human activity; and most irreplaceable through technological substitutes. We expected that our findings could inform policy decisions within the Phoenix metropolitan area regarding ecosystem services, and guide research objectives within the CAP LTER by highlighting gaps in our knowledge about the functioning and valuing of ecosystem services. The basis for our study was the Millennium Ecosystem Assessment. The sources for our assessment were varied and include published literature, professional knowledge, and unpublished data from the city of Phoenix. We found that in general, the ecosystem services that have degraded in the CAP LTER in the last 25 years have been provisioning and some regulating services, while support services and other regulating services have been enhanced. We struggled with quantifying changes in the provisioning and valuation of cultural services, with the exception of recreation. Our findings were informed by the scale at which we considered ecosystem services. One important next step is identifying the ecosystem services for which there are no technological substitutes. Other potential future directions include refining our list of critical services; performing a cross-sight comparison with other urban systems; and reviewing the process that we developed for conducting this interdisciplinary study.

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### **Temporal Compositional Changes in DOC in Tempe Town Lake** *Kelly, M.<sup>1</sup>, and H. Hartnett<sup>1,2</sup>*

We evaluate the concentration and composition of dissolved organic carbon (DOC) in Tempe Town Lake in order to investigate temporal patterns in the source and character of the DOC. Our data set extends from January 2005 through the present and includes measurements of pH, conductivity, dissolved oxygen, and dissolved organic carbon. The DOC concentrations range from ~3 mg/L to ~17 mg/L; the highest carbon concentrations occur during the winter rainy period and during the summer monsoon. Understanding the source and reactivity of DOC requires knowing not only how much carbon is present but also what kinds of organic compounds are present. We hypothesize that the DOC composition will be different throughout the year because sources vary seasonally (terrestrial vs. riverine carbon) and a range of processes (photosynthesis, respiration, photooxidation) can control the DOC cycling in the lake. Electrospray ionization mass spectrometry is an analytical tool that provides molecular-level analysis of the compounds present in DOC. We have analyzed selected samples representative of each season of each year. Preliminary ESI-MS work shows that the majority of compounds present in the system during the early summer are have a molecular weight range of 30-200 atomic mass units (amu) and basic character. A much smaller percentage

of the compounds have acidic character. Samples from Tempe Town Lake will also be compared with samples from Lake George, an urban lake in Saint Cloud, Minnesota, to evaluate differences in DOC composition in arid and mesic regions.

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### **Comparison of Soil Biogeochemical Characteristics in Grassy and Xeriscaped Stormwater Retention Basins in the Phoenix Metropolitan Area**

*Larson, E. K.<sup>1</sup>, K. L. Graham<sup>1</sup>, and N. B. Grimm<sup>1,2</sup>*

Because urbanization increases the amount of storm runoff, many developed areas have created stormwater retention basins designed to receive local drainage. These basins are common feature in the CAP LTER region. The Arizona Department of Water Resource requires stormwater detention and retention for all almost all new developments. Basins in the Phoenix area differ in terms of vegetative cover (grassy or xeriscaped) and the presence or absence of a dry well. Researchers have found that retention-basin soils in mesic climates effectively remove stormwater pollutants within the top few centimeters, but the filtration capacity of basins in arid areas has not been fully investigated. We collected soil cores from 32 different basins in the Phoenix area (8 each from the 4 types of basins) and analyzed them for extractable nitrate, ammonium and dissolved organic carbon pools, and determined denitrification rates. Potential denitrification in xeriscaped basins was very low and appeared to be limited by organic matter and water. These results indicate that the suite of ecosystem services provided differs by basin type and could influence planning and management strategies.

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### **A Soft Geostatistical Application in Urban Climate Research**

*Lee, S. J.<sup>1</sup>, R. Balling<sup>2</sup>, and P. Gober<sup>1,2</sup>*

The pressing problem of Phoenix's urban heat island (UHI) has spawned numerous academic studies of the spatiotemporal nature of this physical process and its relationship to energy and water use, urban design features, and ecosystem processes. Critical to these studies is accurate representation of the UHI over space and time. This poster is concerned chiefly with accurately representing the UHI by using the Bayesian Maximum Entropy (BME) method of modern geostatistics to account for data uncertainty of soft data. We successfully applied BME to the UHI in Phoenix by retrieving and mapping minimum temperature observations over time from historical weather station networks, then testing our mapping accuracy compared to traditional maps that do not account for data uncertainty. The results demonstrated that BME led to substantial increases of mapping accuracy (up to 35.28% over traditional linear kriging analysis) and provided high spatiotemporal resolution of estimated minimum temperatures. Resulting maps of the UHI can be integrated with other data about human and environmental processes in future studies of urban sustainability.

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## **Landscape Design and Bird Community Structure in Phoenix Arizona: Management Implications**

*Lerman, S. B.<sup>1</sup>, and P. S. Warren<sup>2</sup>*

Urbanization, as it transforms natural biotic systems into human-dominated landscapes, has become recognized as one of the greatest threats to bird diversity. Although most urban development alters the natural landscape, urban areas are also mosaics, where certain landscape designs may provide mini-refugia within urban areas, enabling the persistence of a natural bird community. Residential landscape design in Phoenix, Arizona, is dominated by mesic and xeric yards. If fine-scaled vegetation structure within the residential yards differs between mesic and xeric, bird community structure should also differ between these two forms of landscape design. We tested this hypothesis by quantifying vegetation in residential landscape along 150-m × 40-m transects around 26 of the bird monitoring locations at the Central Arizona–Phoenix Long-Term Ecological Research study area. We classified transects into predominantly mesic and predominantly xeric according to ground cover: grass versus gravel/dirt, respectively. We classified trees into four groups according to leaf structure and height, and recorded their abundance and presence along each transect. Mesic transects were dominated by broad-leafed deciduous, broad-leafed evergreen, and coniferous trees (all predominantly non-native species), and trees taller than 20 m. By contrast xeric transects were dominated by thin-leafed evergreen trees (predominantly native or drought-tolerant species). Bird communities significantly differed within the fine-scaled vegetation structure but not between mesic and xeric designs. Future studies will address mechanism and behavioral cues responsible for distinct bird assemblages within different human-dominated landscapes. If particular landscape designs and vegetation structures support higher degrees of native bird communities, then development plans could incorporate these designs into future projects.

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## **Spatial and Temporal Patterns of Wet and Dry Deposition of Nutrients in a Desert City**

*Lohse, K. A.<sup>1</sup>, D. Hope<sup>1</sup>, R. A. Sponseller<sup>1</sup>, J. O. Allen<sup>2</sup>, and N. B. Grimm<sup>1,3</sup>*

Atmospheric deposition is an important source of nutrient inputs to many ecosystems, particularly in arid environments. Urbanization is significantly enhancing atmospheric deposition of both nutrients and pollutants in cities as well as in downwind recipient ecosystems on regional scales. Despite this trend, there are relatively few studies of the spatial patterns in atmospheric deposition of nutrients and major ions across urban areas. We examined spatial patterns in wet and dry deposition chemistry over a four-to-six year period across the Central Arizona–Phoenix region, the site of one of the two urban programs within the National Science Foundation’s Long-Term Ecological Research network. While annual mean fluxes of wet and dry nitrogen deposition were relatively low and did not differ significantly across sites, wet and dry deposition of dissolved organic carbon (DOC) were significantly elevated in the urban and downwind desert compared to the upwind sites. Dry loads of phosphorus and potassium and wet loads of calcium were significantly elevated in the core urban sites. Measured loads of DOC to the urban core (14.9 kg C/yr) were half

those predicted by atmospheric models (37 kg C/yr). Lower than predicted dry deposition of nitrogen to the urban core may be explained by the dominance of gaseous-phase nitrogen in hot, arid environments and volatilization of dry deposition from surrogate surfaces. These possibilities are being further explored with detailed measurement of deposition velocities and aerosol and gas concentrations in the atmosphere.

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## **Life Cycle Assessment of Two Water Supply Systems: Importation vs. Reclamation**

*Lyons, E., P. Zhang, M. Costanza, K. Li, and J. Crittenden*

Water importation and indirect wastewater reuse are two options commonly used to address the water availability problems in areas where local supplies are not sufficient, and the City of Scottsdale, Arizona, adopts both options. The Central Arizona Project (CAP) carries water from the Colorado River to Scottsdale through canals, and meanwhile in Scottsdale aquifer storage and recovery (ASR) wells are used to reclaim high-quality treated wastewater. In this study, the overall environmental impacts were compared for two water-supply systems in Scottsdale. Life Cycle Assessment (LCA) was employed to quantify the overall impacts of the two water-supply scenarios, and SimaPro<sup>®</sup> 6.0, a state-of-the-art LCA modeling tool, was chosen for the assessment. Based upon life-cycle inventories, the endpoint impacts on natural resource, ecosystem quality and human health were quantified using Eco-Indicator 99, a life-cycle impact assessment method within SimaPro 6.0. It was found that the overall impacts of the water reclamation were lower than those of the water importation, and the environmental impacts from the facility operations are significantly higher than those from the construction phase and dominate the overall impact for both scenarios. Due to the high impacts associated with the energy consumption during plant operations, different energy mixes were analyzed for their capabilities to lower the overall environmental burden.

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## **A Nonstationary Spatial Generalized Linear Mixed Model Approach for Studying Plant Diversity**

*Majumdar, A.<sup>1</sup>, C. Gries<sup>2</sup>, J. Walker<sup>3</sup>, and N. Grimm<sup>2,3</sup>*

For studying the distribution of plant species and plant diversity in the fast-growing urban landscape of Phoenix, we analyzed the spatial distribution of plant species richness, based on data from three different kinds of landuse - urban residential, urban non-residential, and desert. We model this data using a Spatial Generalized Linear Mixed Model (SGLMM). Here plant species counts are assumed to be correlated within and among the spatial locations. Using a Bayesian approach, we implement the Metropolis within Langevin-Hastings Hybrid algorithm. Using a generalization of a spatial log-Cox Gaussian model, the log-intensities of the species richness follow Gaussian distributions.

The purely spatial component corresponding to the log-intensities are modeled using a cross-convolution approach, in order to depict the cross-correlation structure for different types of landuse. We obtain predictions of various measures of plant diversity at observed locations. We also obtain a prediction framework for plant-preferences in urban plots.

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## **Long-Term Monitoring of Tree Size and Condition Across Nonresidential Patch Types in Phoenix, Arizona**

*Martin, C., and J. Stutz*

Trees in cities are exposed to a complex array of abiotic and biotic factors, yet little is known about how these factors might alter annual rates of change in urban tree size or tree health. This is a first report of a continuing long-term assessment of changes in tree size, and measures of tree health and mortality within the CAP LTER study region. In 2001, 50 sites across a gradient of seven zones from urban core to fringe in Phoenix, AZ, were selected to begin monitoring long-term changes in tree trunk cross-sectional area. Gradient zones were based on a preliminary study of near-surface atmospheric CO<sub>2</sub> concentrations and air temperatures across an urban core to fringe gradient. The 50 sites encompassed a variety of non-residential land use types that were replicated within each of the seven gradient zones. Land use types in which the sites were located included commercial residential, industrial, institutional, transportation, barren, and desert. There were a total of 65 tree and palm taxa at the 50 sites. Each site had an average of  $7 \pm 0.5$  trees or palms with a range of between 2 and 18 individuals. Consistent measurements of trunk diameter were made during each winter using a hand-held steel tape. Calculations of trunk cross-sectional area were made assuming a rounded to oval trunk shape factor. Increases in trunk cross sectional area were species specific. Incidences of tree mortality were most related to urban construction activities.

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## **Chemical Fluxes in Semi-Arid Managed River Systems**

*McLean, B.<sup>1</sup>, and E. Shock<sup>1,2</sup>*

Recent storm events throughout the Salt and Verde watersheds allow us to modify mixing equations, derived by other researchers through studies of natural systems, and apply them to an arid-climate managed watershed. Their binary and multi-component mixing equations were derived using a limited number of conservative constituents in river waters to extract percentages of flow from surface and subsurface sources (Pinder and Jones 1969, Tardy et al. 2004). We have adapted these equations to identify management effects manifest as pulses of dissolved concentrations. Using these management effects we can calculate downstream concentrations and use them to understand solute transport in a managed river system. Water management decisions resulted in storage along the Salt River reservoirs and significant release along the Verde River. This is evident in stable isotope measurements of  $\delta^{18}\text{O}$  and  $\delta\text{D}$  downstream. Also, we have identified Central Arizona Project water ( $>80$  mg/l) evacuated into the Salt River during storm events from high concentrations of sulfate. Elevated nitrate concentrations downstream from the confluence are likely the result of permitted effluent ( $30$  mg/l  $\text{NO}_3^-$ ) from the Mesa Northwest recharge facility. Using the nitrate and sulfate concentrations as constraints, we can model downstream chemistry by iteratively solving continuity equations. Preliminary results indicate that infiltration is necessary to balance the loads of major solutes downstream of the mixing zone. It may be possible to identify additional urban fingerprints from stormwater drainage using heavy metal

concentrations and quantify the infiltration of these pollutants as they seep into the shallow aquifer during storms.

Pinder, G., and J., Jone. 1969. Determination of the ground-water component of peak discharge from the chemistry of total runoff. *Water Resources Research* 5(2):438-445.

Tardy, Y., et al. 2004. Geochemistry applied to the watershed survey: Hydrograph separation, erosion and soil dynamics. A case study: The basin of the Niger River, Africa. *Applied Geochemistry* 19:469-518.

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### **Incorporating Social Elements into the Long-Term Ecological Research Program: Institutional Lessons from the LTER Network**

*Muñoz-Erickson, T. A.*

Incorporating the social sciences in the LTERs has become a priority for the LTER Network and was a central aspect in the funding planning workshops held at the recent All Scientists Meeting in Estes Park. Numerous LTER sites, concerned over increasing human influences within and around their sites, are also taking the initial steps in engaging social scientists into their long-term research programs. This poster was initially motivated by an interest from the Luquillo LTER to incorporate social sciences into their site but seeking guidance as to how to begin this process. I conducted a qualitative review that expands on the lessons of four LTER sites presented in a recent issue of *Society and Natural Resources*, including the Central Arizona–Phoenix, Baltimore Ecosystem Study, Coweeta, and the Northern Template Lakes, to draw lessons on the institutional opportunities and challenges from LTERs already conducting integrative research. The lessons presented in this poster are relevant to all LTERs, especially those seeking to gain from the experiences of other LTERs conducting social science research.

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### **Quantifying Impervious Surfaces in the Phoenix Metropolitan Area Using Multiple Endmember Spectral Mixture Analysis**

*Myint, S. W.*

Urban impervious surface areas (e.g., cement parking lots, asphalt roads, shingle rooftops) can only be recorded as either present or absent in each pixel when using traditional per-pixel classifiers. Sub-pixel analysis approaches that can provide the relative fraction of surface covers within a pixel may be a potential solution to effectively identifying urban impervious areas. Spectral mixture analysis approach is probably the most commonly used approach that models image spectra as spatial average of spectral signatures from two or more surface features. However, spectral mixture analysis does not account for the absence of one of the surface features or spectral variation within pure materials since it utilizes an invariable set of surface features. Multiple endmember spectral mixture analysis (MESMA) approach addresses these issues by allowing endmembers to vary on a per pixel basis. The MESMA technique was employed in this study to model Landsat TM reflectance in the Phoenix metropolitan area. Field spectra of vegetation, soil, and impervious surface areas collected with the use of a fine-resolution Quickbird image and pixel purity index tool in ENVI software were modeled as reference endmembers in addition to photometric shade that was

incorporated in every model. This study employs 30 endmembers and 600 spectral models to identify impervious areas in the Phoenix metropolitan area. Results from this study suggested that the MESMA approach is reliable and the algorithm picked the signatures effectively.

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## **Historical and Current Patterns of Flowering Phenology in the Phoenix Metropolitan Area**

*Neil, K., and J. Wu*

Research of the effects of urbanization on flowering phenology has shown that many spring flowering plants are blooming earlier in urbanized areas than in the surrounding rural areas. Researchers have hypothesized the urban heat island (UHI) effect is the primary cause for these changes. The observational studies suggesting the UHI hypothesis have been conducted in temperate, Mediterranean, and boreal regions of North America, Europe, and Asia where the temperature-photoperiod interaction is widely accepted as the primary trigger of floral development. While moisture and temperature are considered the primary triggers for most arid plants, flowering phenology in arid urban areas has yet to be studied. A preliminary study of *Parkinsonia microphylla* and *Larrea tridentata* at different land-use types and across an urban-rural gradient in the Phoenix metropolitan area suggests (1) land use affects spatio-temporal flowering patterns of some plants, (2) both may be sensitive to temperature, and (3) changes in flowering phenology may affect seed production and success. Moreover, historical data from the Arizona State University Herbarium indicates a potentially significant advancement of blooming over time during the last century. These results help improve our understanding of how plants and ecosystems respond to changing environmental conditions induced by urbanization.

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## **Visualization of Sustainability Indicators: A Conceptual Framework**

*Quay, R.<sup>1</sup>, K Hutauwatr<sup>1</sup>, and D. Pijawka<sup>2,3</sup>*

As sustainability becomes integrated into public policy decision making, comprehensive and easily accessible sustainability information will be needed to assist policy analysis. As visual analytics emerges as a major tool of policy analysis, sustainability information, particularly sustainability indicators, will need to be structured to work with visualization methods and tools. Numerous models for defining and organizing sustainability indicators have been published but there is limited literature on defining a theoretical framework for organization of such data so that it can be easily analyzed using visual analytic tools. This project is developing a framework for organizing and visualizing hierarchical based sustainability indicators within three scales, topical, spatial, and temporal. This will include quantitative and qualitative concepts and methods for analyzing large sets of sustainable data. Desktop and Internet based Visual Analytic tools are being developed that will allow interactive analysis and exploration of the indicators at the various scales.

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## **Phoenix as a Human Habitat in Summer: Exposure and Resources to Cope with Extreme Heat**

*Ruddell, D.<sup>1</sup>, and S. Harlan<sup>2</sup>*

Exposure to excessively warm weather is a global threat to human health and well-being, according to assessments of major impact studies on climate change. Extreme summer heat events increasingly cause illness and death in cities that are climatically diverse. As rapid urban development continues, the impacts of temperature extremes on human health and comfort are also expected to increase as threshold temperatures of human tolerance are crossed more frequently and for longer periods of time. Phoenix is an ideal setting for studying human vulnerability to high temperatures. It has a naturally warm climate and over the past 50 years, the average daily temperature has increased by more than 3°C. The Center for Disease Control recently reported that Arizona led the nation in heat-related deaths from 1993-2002. A study of the 2001 Phoenix Area Social Survey (PASS) neighborhoods used a temperature/dew point logger system and a human comfort simulation model to estimate spatial variability in summer temperature and human thermal comfort in Phoenix. Findings showed that predominantly lower socioeconomic and minority neighborhoods were warmer, exposed to greater heat stress, and had fewer social and material resources to cope with extreme heat. Using data from the 2006 PASS, this poster will continue this line of inquiry, analyzing respondents' perceptions of and experiences with summer weather in Phoenix. Variation across key social and geographic characteristics will be examined, including typical outdoor activities in the summer, self-reported maximum tolerable temperature, heat-related symptoms and illnesses, and access to resources for coping with high temperatures.

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## **The Shadowing of Avian Diversity**

*Schwartzmann, E.<sup>1</sup>, and J. Walker<sup>2</sup>*

In this study we analyzed the scalar effects of vegetation coverage on avian density across the CAP LTER study region, encompassing desert and urban ecosystems. In the study area, bird diversity and density were surveyed at 40 sites quarterly during 2003. We aggregated these datasets to capture an annual estimate of avian densities. Buffers were constructed to fit these points, each with an area of approximately 700 km<sup>2</sup>. Within these buffers, vegetation coverage was generated by an object-oriented remote sensing classification scheme conducted on high-resolution (0.6m<sup>2</sup>) aerial photography captured in April 2003. This classification was subset at a variety of scales in order to determine which scale of vegetation best determines area abundance.

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## **Productivity, Inequality, and Biodiversity Loss in Human-Dominated Ecosystems**

*Shochat, E.<sup>1</sup>, J. Lobo<sup>1</sup>, J. M. Anderies<sup>2</sup>, P. S. Warren<sup>3</sup>, S. H. Faeth<sup>4</sup>, and C. H. Nilon<sup>5</sup>*

Although declining biodiversity owing to urban and agricultural development is an established global pattern, its cause remains unclear. To date, habitat fragmentation has been suggested as the major reason for this phenomenon. However, because in urbanization one habitat is being replaced with another, the expected result is more likely to be a change in community composition, rather than reduction in diversity. We propose competitive exclusion of native species by human-commensals as a theory for this phenomenon. Conversion of wildlands into agricultural and urban ecosystems increases site productivity and resource abundance. As in many human societies, the increase in productivity results in inequality and a “winner-take all” situation. Food is shared unequally among species, with a minority of invasive species dominating most of the resources. As a result, many subordinate native species become extinct. We show how this increasing inequality changes the community profile and suggest “taxing the maximum wage” of the “*novo-rich*” invasive species as a conservation strategy for increasing biodiversity in human-managed environments.

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## **Water Vulnerability on the Urban Periphery: Buckeye, Carefree and Cave Creek, Arizona**

*Smith, C.<sup>1</sup>, L. Zautner<sup>2</sup>, K. Larson<sup>2</sup>, and B. Bolin<sup>1</sup>*

With an ongoing drought approaching a decade in Arizona, scholars, water managers and decision-makers have heightened attention to the availability of water resources, especially in rapidly growing regions where demand may outgrow supplies or where conflicts might erupt over competing demands for water. The physical and social characteristics of a place reflect individuals' and communities' vulnerability to hazards such as drought, in addition to their ability to cope with potential water shortages and other water- and climate-related risks such as flooding. Our ongoing case study research in Buckeye and Carefree/Cave Creek, Arizona investigates water management issues in the context of unprecedented growth in the greater Phoenix region. Once a small agricultural town in the West Valley, Buckeye is now planning for massive development to accommodate 325,000 new residents by 2025. Amid desert hills and near Tonto National Forest in the North Valley, Carefree and Cave Creek are upscale residential communities where water use exceeds 300 gallons per capita per day (GPDC). This poster will illustrate comprehensive assessments of water related vulnerability, with focus on the unique physical and social factors that increase the potential for losses in each area. In this context, public perception is explored to better understand awareness and beliefs about risks, and implications for adaptation and responses to mitigate losses.

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## **Geographic Patterns of Mercury Deposition using the Lichen *Xanthoparmelia* in Maricopa County, Arizona, USA**

*Sweat, K., T. Zambo, and T. Nash III*

Geographical patterns of atmospheric metal deposition in Maricopa County, Arizona, were assessed using 2006 collections of the epilithic lichen *Xanthoparmelia* spp. This study is a re-sampling of the 28 locations used in an earlier investigation by Zschau and Nash in 1998, along with two new locations sampled to increase spatial resolution. Lichens were removed from the rock substrate, cleaned and homogenized. Initially the homogenized samples were analyzed for mercury [Hg] with a mercury analyzer and will be wet digested and analyzed by high resolution ICP-MS for a suite of up to 40 elements. Spatial Hg patterns are plotted with ArcGIS software to identify potential "hot spots". Potential sources of these high Hg levels, such as power generation facilities, were sought at or in the vicinity of these hot spots.

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## **Neighborhood Effects on Arthropod Diversity and Food Webs**

*Taylor-Taft, L., and S. Faeth*

Recent studies in the CAP LTER region using the native Sonoran Desert plant, brittlebush (*Encelia farinosa*) have indicated that desert remnants behave more like urban mesic yards than the outlying desert and urban habitats exhibit a reduction in species diversity and altered species composition. Consequently, urbanization results in changing the food web structure and dynamics in urban areas. Here, we investigate whether local neighborhood landscaping affects biodiversity and food web structure and function of arthropod communities. North Desert Village has four residential landscape types including mesic, oasis, xeric and native. Each of these neighborhoods have been supplemented with six brittlebush plants. Plant productivity, arthropod diversity, abundance and biomass will be assessed monthly. In addition, herbivory damage will be assessed monthly by randomly selecting branches and quantifying leaf damage. Species diversity and abundance of the trophic guilds will then be compared across landscape types. Food web structure and dynamics at this local scale will be compared to brittlebush in outlying desert areas and desert remnants from complimentary studies of brittlebush. This study will be one of the first to investigate human impacts on trophic structure and dynamics at the spatial scale of entire neighborhoods in a human manipulated landscape.

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## **Investigation of dryland geomorphic response to urbanization**

*Toke, N., and J R. Arrowsmith*

Aridland fluvial systems are significantly different than their temperate and humid counterparts. Dryland channels are often ephemeral, braided, and tend to have more roughness than temperate channels. Dryland channels are also wider than their temperate counterparts because they are shaped by infrequent, but high flow and energy runoff events. Differences in climate and landscape also lead to alternative choices in urban morphologies (urban development patterns) in young dryland cities like Phoenix, AZ. We are initiating investigations into how urban development affects the relationships and feedbacks among urbanization, hydrology, and geomorphic response on fluvial and alluvial geomorphic surfaces in dryland environments. In this poster we present observations and ideas for research into



this problem and address the following questions: How do landscape changes affect the total infiltration capacity of desert surfaces? Desert pavements decrease infiltration capacity with increasing age, but are these pavements more or less effective at infiltration than the moderately dense urban patchwork of Phoenix? What are the fates of ephemeral desert channels? Do these channels see an increase or reduction in runoff and sediment? How do channel morphologies change? It is important to address and answer these geomorphic questions because they have implications for plant and animal ecosystem function and may provide a basis of knowledge to make informed development decisions in similar arid landscapes.

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### **Improving the Keyword Search over Ecological Datasets using a Relational Data Model**

*Vadrevu, S.<sup>1</sup>, C. Gries<sup>2</sup>, and H. Davulcu<sup>3</sup>*

With the information explosion that the area of ecology has experienced in recent years, efficient means of organizing and searching this information are necessary. Since the availability of structured information in the form of domain ontologies is limited, statistical modeling of data and semi-structured data extraction are very useful in analyzing the available information. In this work, we propose a co-occurrence based relational model from various data sources including partial ontologies, related publications, text books and online sources. This relational model can be used to guide the keyword search of an ecologist by helping in navigating through the search results and narrow down the focus of the search. We provide experimental results to demonstrate the efficacy of our approach with diverse data sources.

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### **Money Grows Trees: A Socio-Ecological Path Analysis**

*Walker, J.*

This study analyzed the interplay among socioeconomics, patterns of urban development, and their effect on vegetation dynamics in the Phoenix metropolitan area. I hypothesized that income is the driving factor primarily affecting neighborhood characteristics, which in turn have the largest influence on vegetation coverage. However, income's direct effect on vegetation coverage (a) is minimal, but negatively correlated. This may seem counter-intuitive; but can be explained by a tendency of richer families having some preference towards desert landscaping which would reduce total vegetation coverage. Within Phoenix, income and neighborhood age (d) appear to be negatively correlated. As Phoenix is a young urban development neighborhood age is a logical predictor of vegetation coverage (b). As Phoenix has developed land has become more expensive, resulting in higher housing density which should be next best predictor of vegetation coverage (c). As more housing structures are on the landscape, there is less available growing space and thus less vegetation. Housing density is also likely a function of house size. The conceptual model for Phoenix was tested via structural equation modeling (SEM), a statistical evaluation of the hypothesized path model and the empirical data. This analytical procedure allowed the direct and indirect effects of economic and housing variables to be incorporated and tested within a single hypothetical model, which explicitly accounts for the interdependence of dependent variables. Results from

the SEM analysis for the Phoenix metropolitan area indicate that the hypothetical model appropriately fit the data. However, income was positively, not negatively, correlated with vegetation indicating that there either there is not a relationship between income and desert landscaping, or that desert landscaping does not limit urban biomass, as is commonly thought.

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### **Effects of Weather on Neighborhood Human Activity**

*Yabiku, S.<sup>1</sup>, D. Casagrande<sup>2</sup>, and E. Farley-Metzger<sup>3</sup>*

On 33 days between January and May 2004, systematic observations of human activity were taken at the North Desert Village neighborhood on the Arizona State University Polytechnic campus. These observations noted the precise time, location, and nature of the activity, as well as characteristics of the people involved. In total, 1073 activities were cataloged. We correlate these activities with weather data from nearby Williams Gateway Airport to examine what types of activities and which individuals are influenced by factors such as temperature, humidity, and wind.

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### **Factors that Contribute to Distribution Patterns of Trace Elements in Maricopa County**

*Zhuo, X., P. Prapaipong, and E. Shock*

We have generated patterns of trace element distributions across Maricopa County from trace elemental analysis of 200 surface soil samples (upper 10 cm) collected during the CAP LTER 200-point survey in 2005. Samples were digested with mixtures of concentrated acid, solutions were analyzed with inductively coupled plasma mass spectrometry (ICP-MS), and trace elemental data were plotted with geographic information system (GIS) using kriging methods of spatial analysis. The distribution patterns of trace elements vary from strong correlations with automobile and industrial emissions (Pb, Cd, and Cu) to random patterns that probably reflect the natural geological background of the desert (Ni, Mn, and V). Currently we are working to establish the transport routes that each element takes. Local toxic release inventories obtained from the EPA website indicate that, rather than industrial air emissions, local automobile emissions are important source for anthropogenic trace elements. However, more work needs to be done to distinguish the geological background and adsorption capacities of different soils. Ultimately, the goal is to identify sources and sinks in the environment, whether the trace elements are transported from the surrounding desert to the urban area, whether their toxicity and bioavailability change during transport, and whether contaminated soils can become local sources of aerosols containing trace elements.

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