Abstract

The Central Arizona–Phoenix (CAP) LTER study area covers more than 6,400 km^2 and includes the rapidly expanding Phoenix metropolitan area, home to more than three and a half million people, as well as surrounding agricultural and undeveloped desert lands. Survey200 is an extensive field survey designed to provide a snapshot of broad-scale spatial variations in key ecological variables across this diverse and ever-changing landscape. Beginning in 2000 and repeated every 5 years, the survey constitutes one of the central elements in the CAP LTER's monitoring of ecosystem change over time. In addition, the long-term plots provide a framework of common study sites for other CAP research projects. A dual-density, randomized, tessellation-stratified design was used to identify the 206 study plots distributed throughout the study area. Variables quantified at each 900-m^2 study plot include: plant species and corresponding size, soil texture and chemistry, mycorrhizal diversity, plant-associated insect diversity and abundance, and the distribution of built structures and land cover. To date, Survey200 data have been used for analyses of regional vegetation patterns, soil nutrient pools and predictions of soil nutrient concentrations, the distribution of trace elements, relationships between ecological and social variables, the legacy effect of historic land use changes, and ground truthing of remote-sensing analyses. Overall we found that spatial correlation between sites in the desert does not exist in urban sites for plant diversity or soil nutrient concentrations. Historic land-use changes have a memory effect on both biodiversity and soil nutrient concentrations, and family income positively influences plant richness. More plant species and higher soil nutrient concentrations were found in the urban area. When arbuscular mycorrhizal fungal diversity was compared for desert sites and urban sites with non-native and native plants, species composition was similar between desert and urban sites. Trace element distribution varies between elements, with Pb and Cd having highest concentrations in the urban center, V and other elements being evenly distributed in the region, while Ni, As and some other elements seem to have multiple sources. Preliminary comparisons of 2000 and 2005 survey data suggest a marked expansion of the Phoenix urban area with consequences for plant and insect communities and material distributions.

Survey200: CAP LTER's approach to extensive field monitoring

Christofer Bang[1], Robert Bills, John Briggs[1,2], Maria DiIorio, Laura Dugan, Roy Erickson[2], Stevan Earl[2], Stan Faeth[1], Martin Feldner, Corinna Gries[2], Nancy Grimm[1,2], Eric Holmes, Diane Hope, Jason Kaye[3], Ann Kinzig[1], Cathy Kochert[1,2], Ananda Majumdar[4], Charles Redman[2], Everett Shock[5], Quincy Stewart[1,2], Jean Stutz[6], Maggie Tseng[1,2], Jason Walker[1], Sean Whitcomb, Xiaoding Zhuo[5]

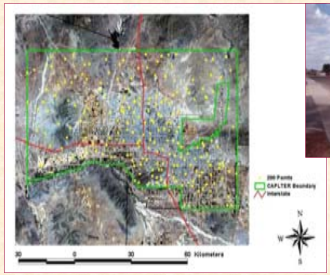
[1]Arizona State University, School of Life Sciences; [2]Arizona State University, Global Institute of Sustainability; [3]Penn State, Department of Crop and Soil Sciences; [4]Arizona State University, Department of Mathematics and Statistics; [4]Arizona State University, School of Earth and Space Exploration; [6]Arizona State University, Department of Applied Biological Sciences

"To what extent do human variables contribute to explaining spatial variation in the basic ecological properties of an urban ecosystem, and how do these relationships change through time?"

Study Design

Field survey

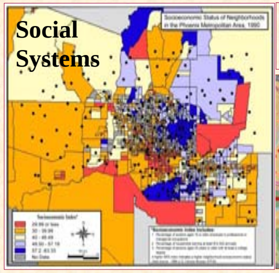
Field sampling scheme: We used a dual-density, randomized, tessellation-stratified design (see point distribution at right) to obtain a spatially dispersed, representative and unbiased sample of the study area. Sampling density inside the developed urban core was 3x that outside. Our application of probability-based sampling at this scale across an urban area is unique.



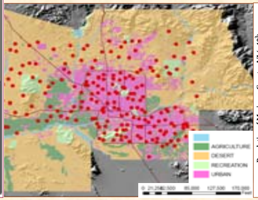
Typical survey sites

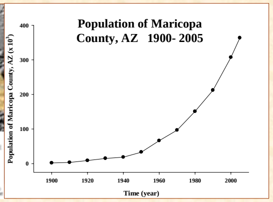
A synoptic integrated field inventory of key biotic, abiotic, and some human variables is carried out in 30x30m field plots (n≈200) over a 3-month period. Beginning in 2000, surveys are conducted every 5 years.

Additional data



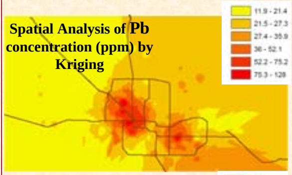
Geographic and socioeconomic variables are obtained from existing CAP LTER databases and from other sources, such as the US Census block group immediately surrounding each of the survey sites.

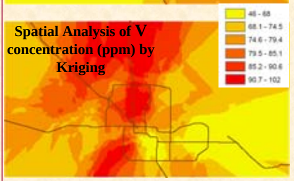


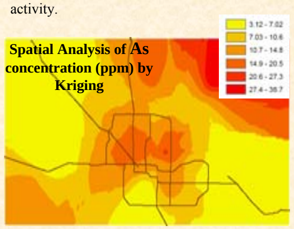


Soil chemistry: Heavy metals

Soil samples (top 10 cm) were analyzed by inductively coupled plasma mass spectrometry for concentrations of trace elements, and the results were plotted with GIS. Elements such as Pb, Cd, Cu, Ag show strong urban influence while V, As, Zn, Mn might have complex sources from geology and human activity.



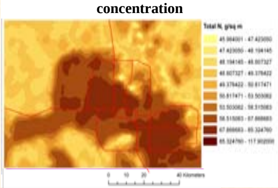




Soil chemistry: nutrients

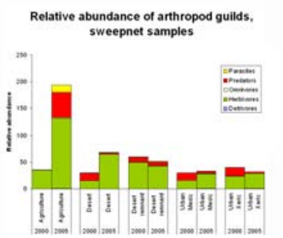
- **Surface soil (0 – 10 cm depth) was sampled to determine whether a legacy of past agricultural use is detectable in the soil chemistry of contemporary residential lawns**
  - Organic matter, carbon, nitrogen, and soluble ion concentrations were twice as great in yards that were previously farmed as in yards that were developed from desert, and the pools remained elevated 40 y after urbanization.
  - Nitrogen accumulation rates (1.5 g m^{-2} y^{-1}) in residential soils were not affected by prior land use, suggesting that home owners do not adjust rates of residential fertilizer application to account for the high fertility of previously farmed soils.
  - Bioavailable, inorganic phosphorus (P) was elevated in soil with a recent agrarian past, but this signal disappeared after 10-30 y of residential use because P accumulated in yards developed on native desert soils.
  - Our results suggest a "direct agrarian legacy," wherein agricultural impacts on soil chemistry endure urbanization, more so than an "indirect legacy," wherein contemporary land management is shaped by prior land use.

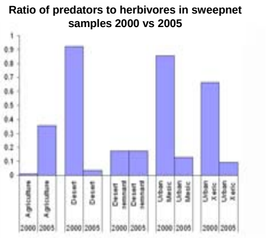
Hierarchical spatial modeling was employed to map surface-soil nutrient concentration



Arthropods: 2000 to 2005

Although this is a long-term study and we can only compare two sampled years so far, we find three interesting results. First, the urban sites, particularly the desert remnants, appear much more stable from 2000 to 2005 compared to the desert sites, which fluctuated widely. Differences in productivity and rainfall provide a reasonable explanation for the fluctuations: 2000 was a drought year whereas 2005 which received much rainfall during the winter. The result lend further support to the hypothesis that urban sites are buffered from seasonal or yearly fluctuations in productivity owing to human management.

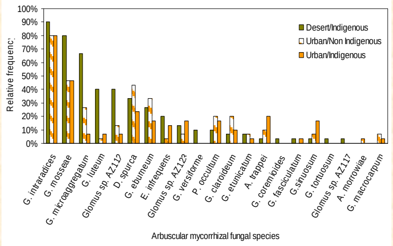




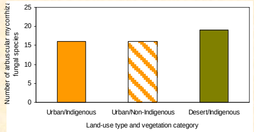
Arbuscular mycorrhizal fungi

A selected subset of Survey 200 sites were sampled for AM fungi. Soil samples were taken at from the roots systems of plants at 10 sites of each of the following types: urban, non-indigenous plants; urban, indigenous plants; and desert, indigenous plants. Trap cultures initiated from these soil samples were used to obtain AM fungal spores for identification.

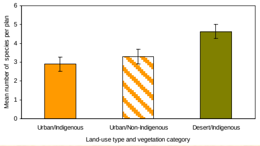
Relative Frequency: There were differences between desert and urban sites in the relative frequency of some AM fungal species. Desert sites had more species with a relative frequency > 50%. Three relatively common species at desert sites (*Glomus microaggregatum*, *G. luteum* and *Glomus sp.* AZ112) were detected less frequently at urban sites.



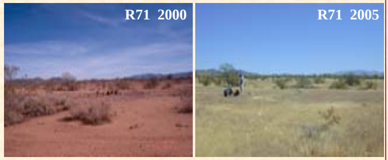
Species Composition: 21 AM fungal species were detected (urban=17, desert=19). Roughly 70% of the species were detected at both urban and desert locations. Four species were only detected in the desert and two species were only detected in the urban sites.



 # species/sample: A greater number of AM fungal species per plant detected at desert vs. urban sites (F=5.874, df=2, P=0.004). There were no significant differences between the two types of urban sites which differed in types of vegetation.



Vegetation: 2000 to 2005



Annuals

Annuals were not quantified in 2000 but visual inspection suggests considerable differences between assemblages of annuals at survey sites in 2000 and 2005. These differences may reflect above-average precipitation in the winter of 2004/2005.

Perennials

- Differences among compositions of perennial plants in 2000 and 2005 were assessed by calculating pair-wise, ecological dissimilarities (Sorenson distance metric) between sites.
  - Assemblage structure of perennial plants was highly variable across both urban and desert sites but pair-wise ecological dissimilarities were significantly greater ($p < 0.001$) for urban sites, suggesting that there was a greater change in perennial plant assemblages at urban sites compared to desert sites.
  - Changes in community composition at desert sites were generally correlated to soil characteristics whereas changes in community composition at urban sites were more closely associated with anthropogenic characteristics.
- Indicator Species Analysis (Dufrene and Legendre 1997) suggests that a higher proportion of members of the genus *Sphaeralcea* in 2005 contributed to differences in assemblages at desert sites; a higher proportion of members of the genus *Lantana* contributed to differences at urban sites.

Significant correlates to changes in composition of perennial plants between 2000 and 2005 at desert and urban sites

	p	r
Desert sites		
Extractable phos.	0.019	0.285
Organic carbon	≤ 0.037	≥ 0.253
Slope	0.004	0.347
Urban sites		
Dist. to urban center	0.042	0.236
Population density	0.030	0.251

Arizona State University
CAP LTER Central Arizona Phoenix Long Term Ecological Research
Global Institute of Sustainability Arizona State University
LTER
NSF