NEIGHBORHOOD ECOSYSTEMS: HUMAN - CLIMATE INTERACTIONS IN A DESERT METROPOLIS

Sharon Harlan[1], Anthony Brazel[1], Darrel Jenerette[1], Nancy Jones[1], Larissa Larsen[2], Lela Prashad[1], William Stefanov[1]
[1]Arizona State University
[2]University of Michigan

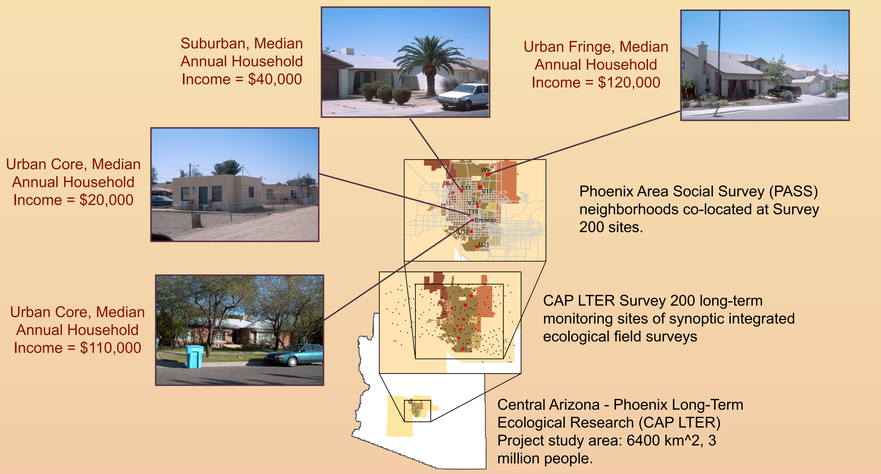
Abstract

Urban ecosystems are fragmented in ways that correspond to patterns of organized social life, and the concept "neighborhood ecosystem" anchors both ecological and sociological questions about the causes and consequences of human - environment interactions. In our NSF-funded biocomplexity project, we are creating a framework and producing evidence that will allow us to model the relationship of social and bioclimatological variables over time and space in urban ecosystems. We will demonstrate that inequalities in "neighborhood capital", comprised of economic, human, social and natural capital within small areas, determines the relative contribution of different populations to the urban heat island, the exposure of human and biological communities to climate stress, and their vulnerability to the risks of feedback from climate. Initial results of regional-scale and neighborhood-scale comparisons of remotely sensed vegetation and surface temperature patterns indicate strong correlations between population characteristics of neighborhoods (e.g., density, median household income, percent minority, age of housing), vegetation density, and surface temperature. Social surveys show that people correctly perceive that it is growing hotter in Phoenix, and that people in lower-income neighborhoods are exposed to higher outdoor temperatures.

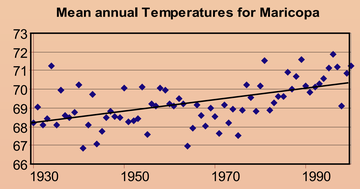
Study Area and Sample Neighborhoods

The study is located in the Phoenix, Arizona metropolitan area, a region of three million people that is growing rapidly and converting agricultural land and undeveloped native desert into upper- and middle-income residential neighborhoods on the urban fringe. This development pattern intensifies social and environmental inequalities with lower-income Hispanic communities located in the urban core and high-income Anglo communities mostly on the urban fringe. The project encompasses both a regional scale and a more intensive study of eight neighborhoods selected from among the monitoring sites of the Central Arizona - Phoenix Long-Term Ecological Research (CAP LTER). Eight Phoenix Area Social Survey (PASS) neighborhoods are defined by census block group boundaries and they represent different types of urban communities stratified by income,

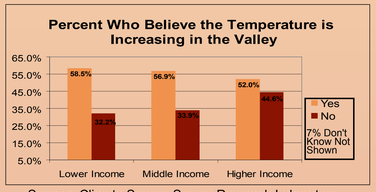
Index Maps Showing CAP LTER Study Area, Survey 200 Points, and Four PASS Neighborhoods



Significant temperature change due to urbanization and considerable variation across the region has been measured in the Phoenix area: an average of 0.33 F per decade in the 20th century.



Source: Brazel, A. "Future Climate in Central Arizona - Heat and the Role of Rapid Urbanization," Arizona State University, 2003.



Source: Climate Survey, Survey Research Laboratory, Arizona State University, 2003.

A majority of residents of the Phoenix area recognize that temperature in the region is increasing. A recent random sample survey of 587 residents showed that 56.4% think the "Valley" (local name for the region) is getting hotter, 36.5% think it is not, and 7.2% don't know. Higher income residents are significantly less likely to perceive the increasing temperature than others.

Acknowledgements

This research is supported by NSF Grant No. 0216281

CAP LTER Central Arizona-Phoenix Long-Term Ecological Research

ASU IGERT in Urban Ecology

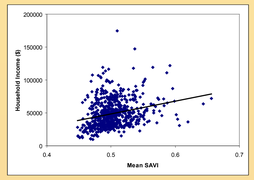
Poster designed by Lela Prashad, CAP LTER

Key Questions and Preliminary Results

Question 1. Are variations in natural capital, measured by vegetation density (SAVI), correlated with human capital and social capital?

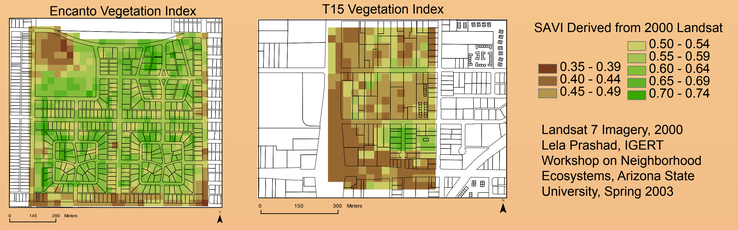
Vegetation is positively correlated with median household income of census tracts in the Phoenix region, indicating that neighborhoods with higher economic capital also benefit from greater natural capital.

Regional Correlation of Median Household Income (Current $) with Mean SAVI for 652 Census Tracts in Phoenix



Source: U.S. Census and Landsat, 2000.
G. D. Jenerette, A. Brazel, S. Harlan, N. Jones, L. Larsen, W. Stefanov. Regional Relationships Between Social and Bioclimatological Components of an Urban Ecosystem. Arizona State University, manuscript, 2003.

The lowest income PASS neighborhood (T15) has a much lower vegetation density than one of the wealthier neighborhoods (Encanto).

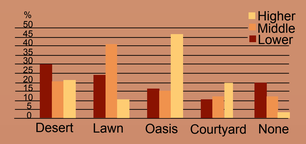


Landsat 7 Imagery, 2000
Lela Prashad, IGERT Workshop on Neighborhood Ecosystems, Arizona State University, Spring 2003

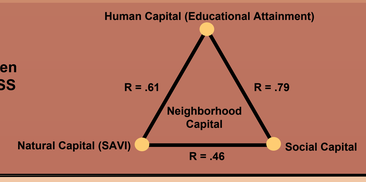
The "greenness" of backyard landscapes in residential neighborhoods is positively correlated with median household incomes in PASS neighborhoods, echoing the regional relationship.

Source: Phoenix Area Social Survey, 2002 S.L. Harlan, L. Larsen, T. Rex, S. Wolf, E. Hackett, A. Kirby, R. Bolin, A. Nelson, and D. Hope. 2003. The Phoenix Area Social Survey: Community and Environment in a Desert Metropolis. Central Arizona - Phoenix Long-Term Ecological Research Contribution No. 2, Center for Environmental Studies, Arizona State University, Tempe.

CURRENT BACKYARD LANDSCAPE BY NEIGHBORHOOD INCOME LEVEL



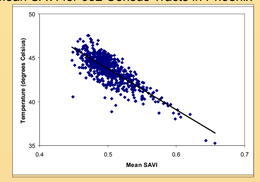
Pearson correlations between indicators of capital for PASS neighborhoods



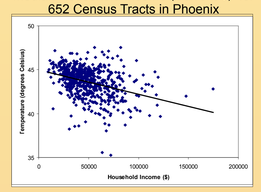
Question 2. Are inequalities in neighborhood capital related to temperature variation among neighborhoods?

Vegetation density and median income of census tracts are negatively correlated with surface temperature across the Phoenix region and these independent relationships are statistically significant when other social and topographic variables are controlled.

Regional Correlation of Temperature (C) with Mean SAVI for 652 Census Tracts in Phoenix

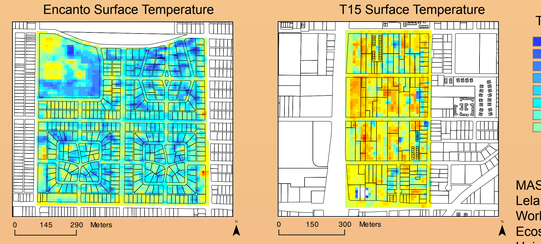


Regional Correlation of Temperature (C) with Median Household Income (Current $) for 652 Census Tracts in Phoenix



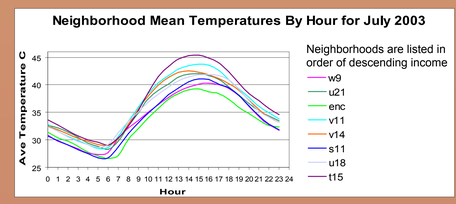
Source: U.S. Census and Landsat, 2000.
G. D. Jenerette, A. Brazel, S. Harlan, N. Jones, L. Larsen, W. Stefanov. Regional Relationships Between Social and Bioclimatological Components of an Urban Ecosystem. Arizona State University, manuscript, 2003.

The lowest income PASS neighborhood (T15) has a much higher surface temperature than one of the wealthier neighborhoods (Encanto).



MASTER Imagery, 2000
Lela Prashad, IGERT Workshop on Neighborhood Ecosystems, Arizona State University, Spring 2003

Air temperature measured at Hobo stations in the PASS neighborhoods show that the poorest neighborhood (T15) is the hottest and the wealthiest neighborhoods are the coolest. The overall correlation between median household income and surface temperature in the eight neighborhoods measured by MASTER (June 2000) is -.69.



Source: Brazel, Jones, and Prashad, Climate Monitoring of Pass Neighborhoods, 2003

Data Sources

Our sources include the U.S. decennial census (1980-2000), household surveys of PASS neighborhoods (matched with household water consumption) and the region, field observations of air temperature and land cover, historical climate records, and satellite imagery from Landsat, ASTER, and MASTER.

Question 3: Do microclimatic differences in temperature between neighborhoods expose communities to unequal levels of climate-induced stressors?

Differences in heat exposure by social class are reinforced by interviews with residents of PASS neighborhoods.

Respondent from a low-income neighborhood:

"I know that it's **cooler to sleep outside than inside**. And so a lot of families will be sleeping outside in the hot summer. . . I work with the fire department and the fire department will come over and **bring cases of water and fans and those sorts of things to help facilitate families.** The problem there is I can only do probably six or eight of them a summer. And I know there's probably sixty or eighty of the folks that are in trouble."

"Probably about a year and a half ago there was a big apartment, and the mayor of Beverly Hills was the owner of that property. That was in my community and it was a **slum lord property. . . They had no air conditioning in there.** It was the middle of summer, and I went into one complex and they had one of those little wading pools and two little babies sitting in it, pouring cold water over their heads. Just trying to keep them cool."

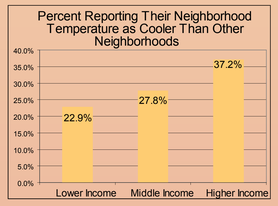
Respondents from high-income neighborhoods:

(1) "I have AC [air conditioning] and swamp coolers. My house is really well insulated. In the winter it doesn't get below 64 degrees and **in the summer it's 81 or 82 inside**. The porch makes a big difference and I have fans. I have friends that use AC and friends that use swamp. It all depends how much you want to pay."

(2) "The irrigation [lawn flood irrigation] has a cooling effect. When there's a breeze, the sprinklers create evaporative cooling. The irrigation and sprinklers in the park keeps coolness in. There's a lot of shade and we have central air [conditioning]. The older houses stay cooler because they're thick plaster and brick walls. **I go from my air conditioned house to my air conditioned car to my air conditioned office**."

Source: IGERT Workshop on Neighborhood Ecosystems, ASU. Interviews, April 17, 2003.

Social survey evidence strongly suggests that people with lower incomes are more vulnerable to the effects of summer desert heat. A random sample survey of area residents indicates that a higher percentage of high-income respondents think their neighborhood is cooler than other neighborhoods, and that the temperature in their homes are very comfortable.



Source: Climate Survey, Survey Research Laboratory, Arizona State

Future Work

We made significant progress in the first year of the project in data collection, measurement, and analyses that support basic hypothesized relationships between social, ecological, and climatological systems. In particular, we made improvements in matching the resolution of remote sensors with the scales of human communities. In the next stages of our research we are positioned to:

- Expand the measures of "capital" in neighborhood ecosystems and model the interactions and transformations of human, social, and natural capital over time;
- Establish linkages between household, neighborhood, and regional scale processes that affect the urban heat island;
- Develop strategies to assess human - climate interactions in a multicultural urban area;
- Construct parallel concepts of vulnerability to climate stressors for human and other biological communities;
- Model diversity in people's use of natural resources (water and energy consumption) to mitigate the effects of climate;
- Make cross-site comparisons with other regional bioclimatological conditions