Environmental Tradeoffs in a Desert City: An Investigation of Water Use, Energy Consumption, and Local Air Temperature in Phoenix, AZ

Darren Ruddell, Elizabeth Wentz, Anthony Brazel, Juan Declet, P. Grady Dixon, Patricia Gober, Susanne Grossman-Clarke, Sharon L Harlan, and Scott Kelley

INTRODUCTION

A recent initiative among municipalities within the Phoenix, AZ metropolitan area is to reduce water consumption by subsidizing homeowners to convert their yards from turf grasses to drought-resistant landscapes. Likely outcomes of this policy are:

- Intensification of urban heat island effect – increased nighttime temperatures – which threatens human health and well-being [1].
- Increased energy demands for residential cooling which is highly water intensive and is increasing as regional temperatures rise.

This study examines water, energy, vegetation, and microclimate profiles of 16 neighborhoods within the City of Phoenix to investigate environmental tradeoffs which are critical for long-term urban planning.

Figure 1: Predominant Land Cover Types within Metropolitan Phoenix

Research Hypotheses:

H1: Neighborhoods comprised of Dry Landscapes (Desert and Mesic) conserve water;

H2: Increased residential water consumption correlates with less residential energy use at the neighborhood level.

METHODS

Study Area

This study examined 16 Census Block Groups (2000) within the City of Phoenix to investigate tradeoffs between vegetation cover, microclimate temperature, and water and energy consumption.

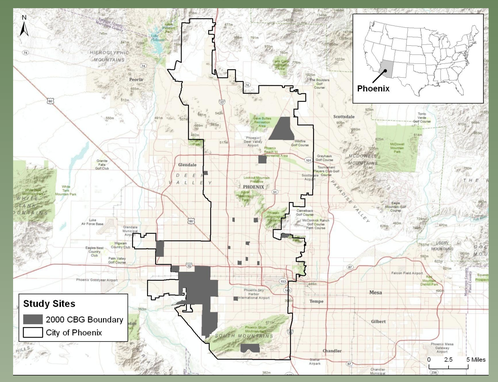
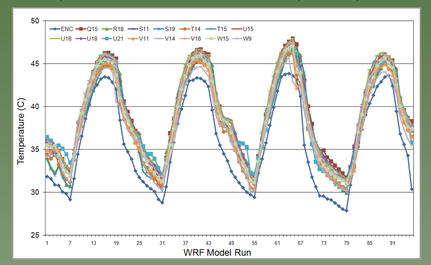


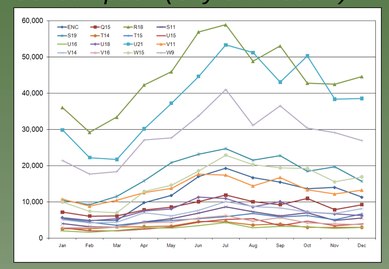
Figure 2: Study Area: 16 Census Block Groups within City of Phoenix, AZ

Data

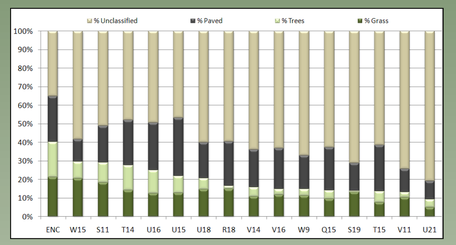
Temperature Simulations (WRF)



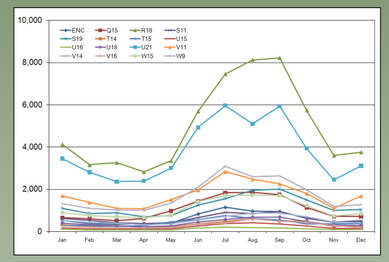
Water Consumption (City of Phoenix)



Vegetation (OBIA Classification)



Energy Use (SRP and APS)



RESULTS

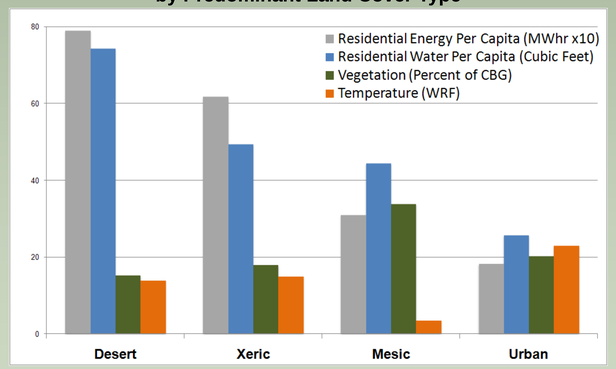
Table 1: Panel Data Analysis GLS Random-Effects Model

Independent Variables	Coef	SE	Z	Sig
Residential Water Use	**0.105**	**0.007**	**15.40**	**0.000**
Vegetation Cover	**21.06**	**22.06**	**0.97**	**0.360**
Temperature	**214.1**	**136.1**	**1.57**	**0.116**
Social Characteristics				
Household Income	**-0.009**	**0.005**	**-1.92**	**0.055**
Household Size	**-102.12**	**174.2**	**-0.59**	**0.558**
Housing Characteristics				
Age of Housing	**12.18**	**9.06**	**1.34**	**0.179**
Size of House	**-0.027**	**0.051**	**-0.53**	**0.596**

Dependent Variable: Residential Energy
R-square: within: 0.47; between: 0.95; overall: 0.85
Significant at 95% confidence level

- Residential Water Use is a significant, positive predictor of Residential Energy Consumption;
- Household Income is a significant, negative predictor of Residential Energy Consumption;
- Vegetation Cover and Neighborhood Temperature do not report statistically significant correlations with Residential Energy Consumption.

Figure 3: Integrated Analysis of Energy Use, Water Consumption, Vegetation Cover, and Microclimate Temperature by Predominant Land Cover Type



- Neighborhoods comprised of dry landscapes (Desert and Xeric) consume the greatest amount of water and energy resources;
- Mesic landscapes provide neighborhood cooling while using considerably less water and energy resources, relative to Desert and Xeric;
- Urban neighborhoods have the lowest energy and water demands but also report the warmest temperatures.

CONCLUSION

- Research Observations:
  - Water Consumption, Energy Use, Vegetation Cover, and Microclimate Temperature are highly variable among the 16 sites examined in this study;
  - Residential consumption of water and energy resources are tightly coupled;
  - Drought-resistant landscapes (Desert and Xeric) consume significantly more water and energy resources (per capita) compared to Mesic and Urban neighborhoods.
- Implications on the literature:
  - Environmental and resource tradeoffs require extensive and long-term research efforts to inform and direct policy makers;
  - Municipalities within metropolitan Phoenix need to further evaluate the costs and benefits of the current landscape conversion policy.
- Future Research:
  - Examine finer spatial scales of analysis, such as parcel level data which would enable analyses at the household level;
  - Investigate wider temporal scales of analysis;
  - Increase the sample size to include neighborhoods throughout metropolitan Phoenix, and build a water/energy model.

Acknowledgement

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References

[1] Harlan, SL, Brazel A, Prashad L, Stevanov WL, Larsen L. (2006). Neighborhood microclimates and vulnerability to heat stress. *Social Science and Medicine* 63:2847-2863.