The Impact of Urban Heat Islands on Water Use: The Case of the Phoenix Metropolitan Area

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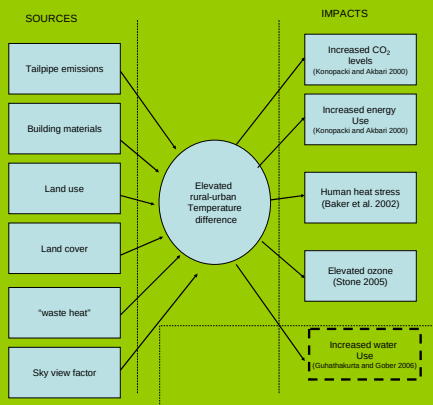
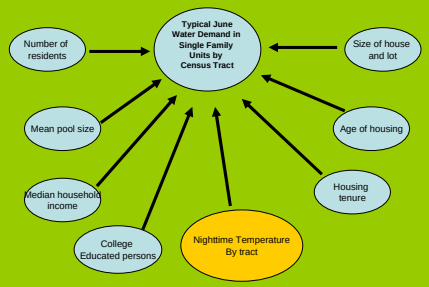
Sources and Impacts of Heat Island Effects



The Conceptual Model

What would explain the variation in water demand?



ABSTRACT

Metropolitan Phoenix's urban heat island (UHI), the phenomenon of warmer temperatures in the urban core than in the surrounding rural countryside, has been linked to an increase in summer nighttime temperatures of almost 10° Fahrenheit during the past 50 years (Baker et al., 2002; Brazel et al., 2000). Although changes in land use and land cover associated with urbanization have increased urban temperatures overall, a distinct spatial variation in nighttime minimum temperatures can be observed. The UHI effect is strongest in the urban core and declines toward the urban fringe and surrounding rural countryside (Brazel, et al., 2006). We use this spatial variation in June nighttime temperatures to examine whether the UHI affects residential water use, controlling for relevant household and housing attributes. ***Results of the statistical analysis demonstrate that a rise of 1° F is associated with an average monthly increase of 647 gallons for a typical single-family unit, all else remaining the same.***

The Data on Variation in Temperature and Water Demand by Census Tract

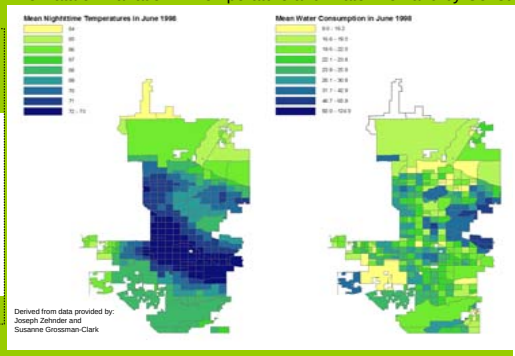
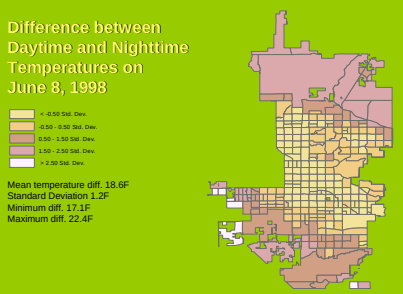


Table 1: Descriptive statistics on dependent and significant explanatory variables

	Minimum	Maximum	Mean	Std. Deviation	Source
Gallons of water per SF unit in June	7480.50	80415.38	17025.42	6711.52	Water Resources Department, City of Phoenix
mean low temp (5 am)	64.57	72.77	70.09	1.87	Grossman-Clarke and Zehnder
difference in high and low temperature	17.08	22.37	18.59	1.21	Grossman-Clarke and Zehnder
median household income in CT	.00	98007.00	41317.56	19022.89	US Census Bureau, 2000 Summary File 3
median number of people in housing unit	2.00	8.40	4.99	1.23	US Census Bureau, 2000 Summary File 3
mean lot size in CT	5257.82	83044.11	10428.40	6933.58	US Census Bureau, 2000 Summary File 3
Average pool size	0	832.00	399.54	133.17	Maricopa County Assessors Data
Average age of SF units	1.87	388.63	51.11	45.23	Maricopa County Assessors Data
Percent of SF unit with pool	0	1.00	.25	.21	Maricopa County Assessors Data
Percent of SF units with Evap. coolers	.00	1.00	.26	.28	Maricopa County Assessors Data
SFNDVI	.00	.41	.17	.11	Authors' calculations from Grossman-Clarke and Zehnder
PCTOWN	0	1.00	.6276	.25	US Census Bureau, 2000 Summary File 3
Whether in SRP supplied areas	0	1	.44	.50	Salt River Project data
mean land value in CT	7372.73	217093.63	24778.71	20516.44	Maricopa County Assessors Data

Difference between Daytime and Nighttime Temperatures on June 8, 1998



Mean temperature diff. 18.6F
Standard Deviation 1.2F
Minimum diff. 17.1F
Maximum diff. 22.4F

Empirical results

Dependent: *Log of gallons of water consumed by a typical single-family unit by census tract in June 1998*

	Model 1			Model 2		
Explanatory variables	B	Beta	t	B	Beta	t
(Constant)	5.960**		10.435	9.199**		43.708
Median household income in CT	$-1.19x10^{-6}$	-	-1.450	$-1.60x10^{-6}$	-	-1.912
Median number of people in housing unit	.075**	.314	3.214	.066**	.278	2.769
Mean lot size in CT	$1.34x10^{-5}$	.319	4.555	$1.37x10^{-5}$	.325	4.515
Average pool size	.001**	.215	4.256	.001**	.225	4.338
Mean age of SF units	.001**	.157	2.555	.001**	.203	3.263
Percent of SF units with pool	.160	.117	1.588	.211**	.155	2.062
Percent oh SF units with Evaporative coolers	.246**	.236	3.865	.288**	.277	4.456
SFNDVI (vegetation index)	.253*	.092	1.854	.357**	.129	2.544
Percent housing units owner occupied	.128	.108	1.416	.104	.088	1.125
Whether in SRP supplied areas	.032	.055	1.201	.038	.066	1.376
Mean land value in CT	$3.11x10^{-6}$	.218	2.764	$2.7x10^{-6}$ **	.192	2.377
Minimum low temp (5 am)	.038**	.243	4.818			
Difference in high and low temperature				-.031**	.127	-2.796

Note: Model 1 R^2= 0.64; Model 2 R^2= 0.62; N = 287; ** p < .05; * p < .1

- **What Matters Most**
  - Average low temperature in tract (+)
  - Average Lot size (+)
  - Average size of pool in tract (+)
  - Percent of single-family units with evaporative coolers
  - Average age of units in tract (+)
  - Median number of people per unit (+)
  - Amount of vegetation / mean single-family NDVI (+)
- **What doesn't seem to matter**
  - Age of inhabitants
  - Tract median income
  - Average size of unit in tract
  - Whether in SRP supplied areas
  - Owner occupancy

Acknowledgment

This material is based upon work supported by the National Science Foundation under Grant No. SES-0345945 Decision Center for a Desert City (DCDC). Any opinions, findings and conclusions or recommendation expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation (NSF).