Seasonal Variations in the Determinants of Outdoor Residential Water Consumption in Yuma, Arizona

Brian J. Pompeii & Elizabeth A. Wentz

Decision Center for a Desert City, ASU, PO Box 878209, Tempe AZ

School of Geographical Sciences & Urban Planning, ASU, PO Box 870104, Tempe, AZ

Overview

Yuma, Arizona - a desert city located at the meeting grounds of the Arizona, California, and Mexico borders – is facing a shift in its water-use pattern from agricultural to semi-urban and residential. This transition, coupled with population growth and an uncertain climatic future, necessitates a better understanding of the new determinates of water consumption. Studies conducted in a nearby sprawling desert city – Phoenix – have shown that up to 60-70% of residential water consumption is determined by outdoor uses (Wentz & Gober 2007). Outdoor residential water consumption varies seasonally and reflects the presence of pools, landscaping type, and lot size. This study uses household level water consumption data from 2005 to 2009 to map variations over time and space**. Specific results answer the following research questions:**

1. What is the relationship between residential consumption and variations in temperature?

2. How are these variations reflected in specific determinants of residential demand such as pools and lot size?

Map 1. Study Area

The Rapid Urbanization of Yuma

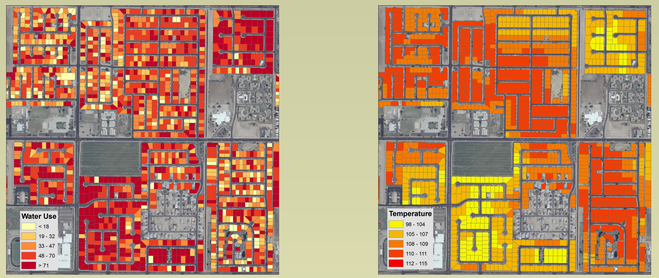
According to a Brookings Institute Report (2001), Yuma was the fifth fastest growing metropolitan area by percent change in urbanized land between 1982 and 1997. The cities population in 2000 was 77,115, and current projections estimate a population of over 90,000.

Rank	Place	Increase in Urbanized Land
1	Las Cruces, NM	784.9%
2	Pueblo, CO	763.9%
3	Naples, FL	153.3%
4	Decatur, AL	139.1%
5	**Yuma, AZ**	**130.4%**

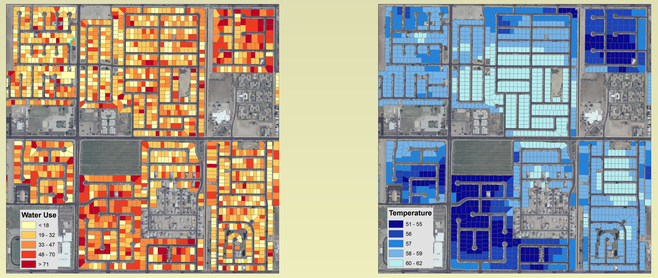
This material is based upon work supported by the National Science Foundation under Grant No. SES-0345945 Decision Center for a Desert City (DCDC). Any opinions, findings and conclusions or recommendation expressed in this material are those of the author(s) and do not necessarily reflect the views of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

Water and Surface Temperature

Summer 2009



Winter 2009



Map 2. The sample maps above represent approximately 2,000 of the 16,598 single family residential households analyzed. The left side displays water usage in Cubic Feet per Minute (CFM) for Summer months (July and August) and Winter months (January and February). The right side displays surface temperature averages from July & August and January & February derived from Landsat TM data. **Households with high water usage are significantly clustered in cooler areas throughout the city.**

Month	Avg. Temp (°F)	Water Use (CFM)	Sig.	Relationship
Jan. 2006	66.97	32.21	(-.093)**	1 unit of water usage can decreases temp. by .005 F
Jan. 2007	55.02	32.12	(-.101)**	1 unit of water usage can decreases temp. by .003 F
Jan. 2008	61.23	31.07	(-.073)**	1 unit of water usage can decreases temp. by .004 F
Jan. 2009	57.84	28.39	(-.079)**	1 unit of water usage can decreases temp. by .004 F
Aug. 2005	90.2	62.2	(-.286)**	1 unit of water usage can decreases temp. by 0.01 F
Aug. 2006	94.47	64.19	(-.283)**	1 unit of water usage can decreases temp. by .009 F
Aug. 2009	110.36	52.81	(-.290)**	1 unit of water usage can decreases temp. by .016 F

Table 2. The months of January and August are used to display the trend difference in correlation. Calculated using Pearson's two-tailed bivariate test and linear regression analysis. CFM is cubic feet per minute and is equivalent to 7.48 gallons per minute . ** denotes a significant correlation.

• **Winter:** The average water usage will decrease the local surface temperature from **.09 to .16** degrees Fahrenheit

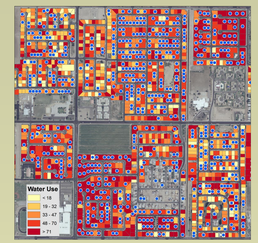
• **Summer:** The average water usage will decrease the local surface temperature from **.48 to 1.03** degrees Fahrenheit

Pools, Water, and Temperature

• In the **Winter** (Jan.-Feb.) the presence of a pool can increase household water consumption between **10.47 to 17.31 CFM,** and decrease the local surface temperature between **.38 to 1.01 ºF**

• In the **Summer** (Jul.-Aug.) the presence of a pool can increase household water consumption between **19.52 to 31.76 CFM and** decrease the local surface temperature between **1.2 to 1.67 ºF**

•The presence of a pool is positively correlated with water usage and negatively correlated with surface temperature. Pools are significantly spatially clustered with areas of high water usage and cooler temperatures.



Map 3. The blue points represent pools. This is an example from August of 2009 displaying the clustering of pools in high water usage areas.

Water and Lot Size

Pearson Correlation Values		
	Winter	Summer
2005	.081**	.140**
2006	.128**	.172**
2007	.147**	.171**
2008	.117**	.198**
2009	.119**	.156**

Table 3. Lot size had t he least impact on water usage and displayed the least amount of seasonal variation.

In the **Winter** (Jan-Feb) every 100 Sq. Ft. of Lot Size can increase water consumption up to **.1 CFM**

In the **Summer** (Jul-Aug) every 100 Sq. Ft. of Lot Size can increase water consumption between **.1 to .3 CFM**

Conclusions, Further Work, and Informing Decision Making

•Warmer temperatures increase water usage and increasing outdoor water usage decreases local temperature. A threshold exists where a collective increase in outdoor water use could actually decrease household water usage.

•Surface temperature, pools, and lot size are all significantly correlated with outdoor residential water consumption and more so in the Summer than in the Winter.

•Preliminary test results show that the presence of a pool is the largest influence on outdoor residential water consumption in Yuma, AZ in the winter and summer, followed by local surface temperature and lot size.

• Future research will include the addition of air temperature, vegetation, and indoor water consumption variables.

•The applicable result of this work is the creation of a system that allows water managers and decision makers in a water scarce region to understand water-use patterns with better precision.

Sources

The Brookings Institution. 2001. Who Sprawls Most? How Growth Patterns Differ Across the U.S. Center on Urban & Metropolitan Policy. 1-23.

Wentz, E. and P. Gober. 2007. Determinants of Small-area Water Consumption for the City of Phoenix, AZ. Water Resource Management, 21(11):1849-1863.