Ecosystem Services in Sustainable Planned Communities: Do they Deliver?

V. Kelly Turner and Christopher Galletti

School of Geographical Sciences and Urban Planning, Arizona State University

I. Abstract

Developers in the United States and abroad have begun to implement the principals of sustainable urbanism in planned community design. Sustainable urbanism seeks to minimize negative biophysical impacts associated with urbanization and to maximize ecosystem service delivery through best practices in urban form. This research investigates the connection between urban design and ecosystem services at the neighborhood scale using the planned community of Civano in Tucson, Arizona as a case study. Specifically, we focus on the following ecosystem services: (1) micro-climate regulation, (2) provisioning of water resources, and (3) primary productivity. We utilize fine-scale spatial data to compare our case-study of interest to a neighboring community in order to determine if adjustments in urban form create registered differences in the provisioning of ecosystem services.

II. Sustainable Urbanism Case Study Communities

Civano is a planned community in Southeastern Tucson built on state trust land with the explicit goals of reducing water consumption, temperature, and water demand through sustainable urban design. Phase I involved multiple developers and homebuilders while Phase II was solely developed by Pulte Homes. The comparison community is a suburban development with no explicit sustainability goals.

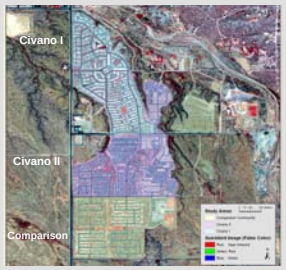

Figure 1: Study Area

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Table 1: Civano I, II, and Grand Opening Date, Size, and Number of Households

III. Data and Methods

- The albedo data set was estimated from a Quickbird scene, acquired on June 13, 2010, by converting the raw digital numbers to reflectance and summing the squares of the reflectance values for each band on a per pixel basis
- The temperature data set was estimated by using the sixth band (thermal infrared) of a Landsat 5 TM scene acquired on June 22, 2011.
- Soil Adjusted Vegetation Index, or SAVI, was calculated from the Quickbird scene by taking the difference of band four and three and multiplying it by 1.5 and then dividing that value by the sum of band four, band three, and 0.5.
- A multinomial logistic regression was used to find the significant difference amongst the biophysical (temperature and SAVI) and social (potable water consumption, non-potable water consumption, and full cash value of the plot) covariates. Unlike a standard logistic regression that uses a dichotomous dependent variable, MLR uses a dependent variable that has more than two classes. Our study used the three development associations (Civano I, Civano II, and the Comparison Community) as the three classes for our dependent variable, with Civano I being the reference category for comparison. The analysis was divided into two MLR's so that the social and biophysical covariates could be analyzed separately to keep model development parsimonious.

Table 2: Ecosystem Service Indicator Data

Service	Indicator	Data Source	Scale
Climate Regulation	Temperature	Landsat	60 m
	Albedo	Quickbird	2.4 m
Primary Productivity	Soil Adjusted Vegetation Index (SAVI)	Quickbird	2.4 m
Water Provisioning	Potable Consumption	City of Tucson	City block
	Non Potable Consumption	City of Tucson	City block
Affordability	Home Full Cash Value	Pinal County Assessor	Parcel

IV. Differences in climate regulation, primary productivity, and water provisioning between study areas

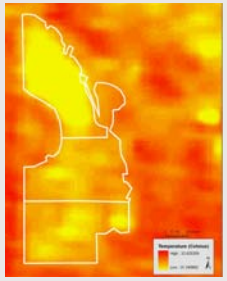

Figure 2: Temperature (c)

The mean temperature in Civano I was cooler than in Civano II and the Comparison.

Figure 3: Albedo

Mean albedo was highest in Civano I and lowest in Civano II.

Figure 4: SAVI

Mean SAVI was highest in Civano I and lowest in Civano II.

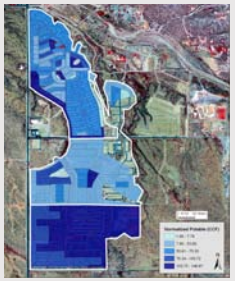

Figure 5: Normalized Potable Consumption

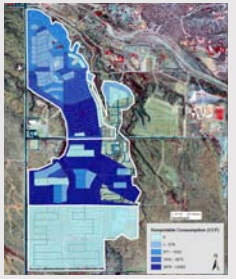

Figure 6: Normalized Non Potable Consumption

The mean normalized potable water consumption was lowest in Civano II and highest in the comparison community.

Total non potable water consumption was highest in Civano II. The comparison community did not use any non potable water.

Total water consumption—normalized potable and non potable—was highest in the comparison community and lowest in Civano II.

Table 2: Multinomial Regression of biophysical variables

		Beta	Significance
Comparison	Intercept	-812.251	0.003
	SAVI	-2.038	0.812
	Temperature	25.485	0.003
Civano II	Intercept	-828.735	0.005
	SAVI	-22.638	0.038
	Temperature	26.141	0.005

*Civano I is the reference category.

Lower temperature blocks were more likely to be located in Civano I as opposed to Civano II or the comparison community.

Highly vegetated blocks were more likely to be located in Civano I as opposed to Civano II, but vegetation was not a significant predictor that a block was in Civano I as opposed to the comparison community.

Relationship between Climate and Albedo

Linkages between high albedo roof material and temperature are clearly visible. Figure 7 shows that high albedo blocks are a good predictor of low temperature. The highest albedo blocks are concentrated in Civano I.

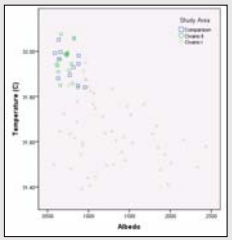

Figure 7: Correlation Scatterplot between Temperature and Albedo

Table 3: multinomial regression of water consumption and full cash value

		Beta	Significance
Comparison	Potable Norm	0.045	0.026
	NonPotable Norm	-10.444	NA
	Full Cash Value	-0.227	0.061
Civano II	Potable Norm	0.019	0.135
	NonPotable Norm	0.003	0.041
	Full Cash Value	-0.177	0.003

*Civano I is the reference category.

Blocks with less potable water consumption were more likely to be located in Civano I as opposed to the comparison community, however, blocks with fewer potable water consumption were not significantly more likely to be located in Civano I than Civano II.

Blocks with high non potable water use were slightly more likely to be located in Civano II than in Civano I. The comparison lacked non potable water connections.

Higher full cash value blocks were more likely to be located in Civano I than Civano II. Differences in full cash value were not significant between Civano I and the comparison community.

V. Discussion and Conclusions

The findings suggest that the principles of sustainable urbanism can be utilized to deliver key ecosystem services but also imply that urban design alone does not necessarily generate desired outcomes. Although Civano I and Civano II explicitly implemented design features to meet environmental goals, differences in urban form and ecosystem functioning emerged. In some instances, the comparison community delivered more desirable outcomes than Civano II.

Many of the differences in environmental outcomes may be explained by institutional differences:

•Vegetation: Civano I salvaged 80 percent of the native vegetation during construction, while Civano II used new plantings that have not yet matured.

•Climate: Civano I entered a contract with the City of Tucson to create a solar village under strict environmental controls which had softened by the time Civano II began construction. Additionally, Civano II was relatively quickly developed by national builder Pulte Homes, while Civano I was a multi year collabroation between public and private partners.

•Water: Civano II was developed five years later than Civano I and capitalized on advances in irrigation and other water technologies.

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