Evaluating the Performance of Non-Price Residential Water Conservation Programs Using Quasi-Experiments

Tatiana Borisova and Pilar Useche
Department of Food and Resource Economics,
University of Florida
P.O. Box 110240 IFAS
Gainesville, FL 32611-0240

Selected Paper prepared for presentation at the Agricultural & Applied Economics Association's
2013 AAEA & CAES Joint Annual Meeting, Washington, DC, August 4-6, 2013.

EVALUATING THE PERFORMANCE OF NON-PRICE RESIDENTIAL WATER CONSERVATION PROGRAMS USING QUASI-EXPERIMENTS

Tatiana Borisova and Pilar Useche
Department of Food and Resource Economics, University of Florida

Key words: non-price demand management, effectiveness, residential irrigation

Introduction

Non-price approaches (such as rationing and outreach programs) are widely used by agencies to manage residential water demand and to reallocate limited water resources to the activities with the highest values (Olmstead 2010). While past studies have examined the determinants of residential water demand on city-wide or regional scales, they have largely failed to estimate the impacts of specific non-price programs (e.g., Kenney et al. 2008, Syme et al. 2000, Michelsen et al. 1999).

The few studies that have focused on evaluating specific non-price programs have employed randomized experiments (Syme et al. 2000; Geller et al. 1983; Thompson and Stroutemyer, 1991; Fielding et al. 2013). One problem of this methodology is that randomized assignment of subjects to control and treatment groups is not feasible for many of the programs implemented by county and city government agencies, as well as outreach organizations. For example, water rationing programs target all households in a specific jurisdiction; while outreach programs are attended by self-selected community members.

As residential water use data are becoming increasingly available to researchers, it is becoming more feasible to evaluate the performance of water conservation programs in quasi-experimental settings. Quasi-experiments have been extensively used to evaluate the performance of labor market programs (e.g., Heckman and Robb 1985, Dehejia and Wahba 1999) and poverty and development programs (e.g., Baker 2000, Ravallion 2005), but not non-price water demand management programs. Non-price programs are unique in their targeting criteria, which also require distinct methods to identify the individuals to be included into a control group. Furthermore, labor and poverty program studies largely rely on repeated cross-sectional or panel data spanning relatively short time periods. In contrast, for water use studies, longitudinal data tracing the individual households over extended periods of time allow comprehensive evaluation of the effectiveness of non-price programs in both the short- and the long-run time periods.

This study (1) evaluates the performance of two non-price residential water conservation programs implemented by local government agencies and Extension Service in Florida, (2) identifies how the response to water conservation programs is influenced by unique characteristics of households, proposes better targeting strategies based on these findings, and identifies data collection needs to be able to improve program evaluations and targeting, and (3) examines the short- and long run effectiveness of the programs, identifying when repeated program interventions may be warranted.

Description of Water Conservation Programs

Florida is ranked fourth in the country by the total domestic water use (Kenny et al. 2009), and up to 60% of household water use is attributed to landscape irrigation (Haney et al. 2007, South Florida Water Management District 2008). This paper focuses on two non-price programs in Florida, aimed at reduction of residential irrigation: (1) an educational program (i.e. irrigation workshops) implemented by the local government and the Cooperative Extension Service in Osceola County, central Florida; and (2) a program enforcing irrigation restrictions (through inspections and written warnings) implemented by Alachua County, north-central Florida. Below we characterize the programs in more detail.

Extension irrigation workshops. Two-hour free irrigation management workshops were offered twice per month by Osceola County Cooperative Extension (Florida) in cooperation with the local water provider, Toho Water Authority. The workshops were held at the local Cooperative Extension office, and cover three main topics: (1) adjusting irrigation system timers to satisfy local irrigation restrictions (no irrigation is allowed between 10:00 AM and 4:00 PM); (2) measuring irrigation sprinkler output (to select duration of the irrigation periods to match plants' requirements and avoid wasting water, see Dukes and Haman [2012]); and (3) operating different types of timers that control automatic irrigation systems. Presentations and demonstrations were made by the natural resource extension agent or the Toho Water Authority's water conservation coordinator, followed by a question-and-answer session and hands-on exercises. The workshops were advertised through Cooperative Extension newsletters and brochures, as well as through periodic water utility bill inserts and local newspaper advertisements. In addition, households that violated local irrigation ordinances (by irrigating at the wrong times) were sent invitations to attend an irrigation workshop as an alternative to paying the citation.

Irrigation Inspections. Since 2011, the Alachua County Environmental Protection Department (ACEPD) has been inspecting high water use residential neighborhoods in Gainesville, north-central Florida. The inspections focus on identifying the households that violate residential irrigation restrictions imposed by Alachua County Irrigation Conservation Standards and Management Practices Code. Specifically, the irrigation restrictions prohibit irrigating residential lawns between 10 am and 4 pm, and designate the allowed irrigation day(s) based on odd or even numbered addresses. Generally, irrigation is allowed twice a week during the Daylight Saving Time period and once a week during the Eastern Standard Time period. If violations (or indicators of) are observed, a warning letter is mailed by ACEPD to the property owner.

The two water conservation programs examined in this study have many characteristics in common. Both programs focus on reducing outdoor water use, employ non-price demand management strategies and are implemented in conjunction with the irrigation restrictions imposed by local governments. However, while the Extension irrigation workshops audiences include both households that violate irrigation restrictions and those that are voluntarily attending the workshops, the warning letters target specifically those who are violating irrigation restrictions. Despite this difference, both programs can be described as quasi-experiments since the households participating in the programs were selected non-randomly. Such non-random selection of the households makes the task of identifying the program effects (as opposed to seasonal variations in water use) more challenging. For example, it is possible that water-use patterns are different for those who are interested in water conservation, as opposed to those trying to avoid citations or those wanting to learn about new irrigation systems. While information about the reasons for workshop attendance that would allow differentiating categories of attendees was unavailable, our estimation method will control for these differences in attitudes when they are constant over time.

Method

Following the standard difference-in-difference approach, to evaluate the effectiveness of the two programs, we compare water use over time for two groups of households: those that participated in the programs (referred to as 'participants' or 'treatment group'; includes those who attended the irrigation workshops in Osceola County or received the warning letters from ACEPD), and those that did not (referred to as 'non-participants' or 'control group').

The average effect of the two non-price programs is evaluated using a fixed effect regression model on our panels of data. The regression model allows examining the changes in water use over time, and comparing program participants' water use before and after the workshop, as well as the water use of non-participants. A fixed-effect model is a linear regression model in which a unique intercept is estimated for each household in a sample (Allison, 2006). A fixed effect model with the household as a unit in fact examines changes in water-use time trends, making the differences in absolute water usage levels irrelevant in the estimation. The model controls for the effect on water use of both observed and unobserved household characteristics that generally do not vary over time (such as the size of the lawn, income level, household composition, or attitudes towards water conservation), since it compares a household to itself (first difference). Furthermore, it also controls for time-varying factors through the comparison with a group of non-participants that was exposed to similar environmental factors (second difference). And finally, the possibility of applying the DD approach within a framework of multiple time periods is particularly important, because the researcher can control for heterogeneity in observed characteristics or environmental conditions over a multi-period setting, additionally to controlling for time-invariant unobserved heterogeneity.

The panel fixed-effects regression model can be presented as follows:

$$y_{it} = u_i + \boldsymbol{x}'_{it}\beta + \boldsymbol{z}'_{it}\gamma + \varepsilon_{it} \quad (1)$$

where y_{it} denote the irrigation water use by household i in month t. Matrix $\boldsymbol{x_{it}}$ denotes dummy variables indicating the periods before and after the water conservation program intervention (the subscript i indicates that intervention dates can vary across households, for the same program). Matrix $\boldsymbol{z_{it}}$ identifies explanatory variables that are used to account for factors that may influence water use patterns over time, but which are unrelated to workshop attendance (e.g., seasonal or weather variables). In turn, u_i is a household-specific parameter that integrates all time-invariant characteristics of the households (Allison, 2005). Finally, ε_{it} is a random variable, assumed to be normally distributed, with the mean of zero and variance of σ^2.

Applying this fixed effect regression model requires addressing the following key challenges.

Selecting the control group. Applying difference-in-difference methodology requires defining the control group to evaluate the changes in behavior over time in the absence of the program. However, in the quasi-experiment setting, residential households cannot be randomly assigned to the control and treatment groups. In contrast, the program participants are usually different from non-participants, and this difference is used to identify households to be included into the program. For example, participation in extension irrigation workshops is open to all interested households, and the households that self-select for workshop attendance are likely to be different from the households not attending the workshops. In turn, the households that received warning letters were identified through the Alachua county inspection program as those violating irrigation restrictions, while program "non-participants" were compliant with the restrictions.

Defining the time periods over which the program's effect can be evaluated. Applying difference-in-difference methodology to measure effect of a water conservation program requires comparing water use before and after the program participation. There are two challenges associated with the definition of the "before" and "after" periods. First, different households can participate in the programs at different times. For example, some households may attend irrigation workshops in April, while others may do that in September. And while this difference still allows defining before and after periods for the treatment group, it significantly complicates the definition of the periods for the control group. Second, the length of the time period over which the effect of the workshop should be measured is also not clearly defined. The effect of the conservation program can be strong in the first months after the program participation, but the effect likely reduces over time (Fielding et al. 2013). In addition, the water use can deviate from a "typical" pattern before the program participation, complicating the definition of the "before" period to be used as a basis for measuring the program effects.

Accounting for water prices. Majority of the utilities in Florida use inclining block rate price structures, in which the increase in water use leads to the increase in both the total bill and the per-unit price. In other words, residential households define water price and quantity simultaneously, which complicates the econometric estimations of the price effect on water use. The water rate structures can be further complicated by the wastewater fees set for the use of “minimum” volumes of water (which are defined differently by different utilities), and extra charges for those residing outside city limits.

In this study, these challenges are addressed in the following way. The households in the control group are selected from the same neighborhoods as the programs’ participants to insure the similarity between the households in the treatment and control groups in terms of the house and yard characteristics, as well as income categories. Given that controlling for households’ neighborhoods does not completely address the participants’ self-selection / endogeneity problem, we use two different techniques: (a) introduce dummy variables into the fixed effect regression model to explicitly account for different seasonal and annual time patterns of program participants and non-participants; and (b) select a sub-sample of program participants and non-participants whose water use prior to the conservation program exhibit similar patterns.

It is important to note that we do not control for potential information leakage between the households in the treatment and control groups. For example, it is possible that the participants of irrigation extension workshops share water conservation techniques with other households in the neighborhood. Alternatively, households that received the warning letters may warn their neighbors about the inspection program. No studies have been found that examine the effect of social networks on neighborhood level on the effectiveness of non-price water demand programs. We expect that if the information leakage exists, it would reduce the difference in water use behavior between the households in the treatment and control groups, leading to under-estimation of the effectiveness of the non-price water conservation programs. In other words, the estimated effectiveness reported in this paper can interpreted as a lower bound on the real effect of the programs examined.

To examine the sensitivity of the program effectiveness estimations, we experimented with different lengths of the time periods before and after the water conservation program effectiveness. Finally, the water price information was not available in the analysis of the extension irrigation workshops. In turn, for the irrigation inspection program, water bill for an average household was used as a proxy of the water price variable.

Data

The analysis utilizes two panel datasets of monthly household water use provided by water utilities in Osceola and Alachua counties. The datasets cover the periods 12 – 36 months before and 2 – 12 months after the implementation of the water conservation programs, and include the water use for the households that participated in the programs (i.e., the treatment group), and the households that did not participate (i.e., the control group). The control group includes households that were randomly from the same subdivisions as the households in the treatment group. Data for each of the programs is described in more detail below.

Extension Irrigation Workshops

Monthly irrigation water-use data were provided by the Toho Water Authority water conservation coordinator (Ms. Elizabeth Block) for 57 Florida households which participated in one of the irrigation workshops conducted between April 2007 and March 2010, and for which irrigation water use was metered separately from the indoor water use with irrigation or reclaimed water meters.[1] In this panel dataset, monthly irrigation water-use information is available for each household for 12 months prior to the date of the workshop, the month of the workshop, and 12 months after the workshop. Given that the workshops were conducted in 2007–2010, the number of water-use observations for 2006 and 2011 is relatively small (Table 1). Monthly household water use was measured in thousand gallons and rounded to the closest integer. Overall, the monthly irrigation water use ranged from zero to 52 thousand gallons (Table 1).

[1] The original sample included 74 households. In this sample, two households were recorded with the same identification numbers, and twelve households had water meters that did not allow for a separate analysis of indoor and outdoor water use. These fourteen households were excluded from further analysis. Three additional households were excluded from further analysis as outliers based on the home certified values and the estimated irrigated areas.

Table 1. Information about workshop participants

Household Characteristics	Mean	Median	Minimum	Maximum
House monthly irrigation water use, Thousand gallons (N=1425)	8.1	6.0	0	52.0
Home certified value, thousand 2010 dollars (N=57)	125.8	120.8	51.8	230.5
Estimated irrigation area, square feet (N=57)	4677.5	3761.4	1104.8	12,366.2

For each household, Toho Water Authority also provided certified values of the houses acquired from the local property appraiser dataset, for the year 2010 and irrigated area of the lots (estimated via subtracting the lot areas classified as the base area, driveway area, sidewalk, and other area, from the total lot size) (Elizabeth Block, personal communications). Based on this information, the households in the sample included both relatively wealthy households with expensive houses and large lawns, as well as less affluent residents with certified home values of less than $60,000). For each household, irrigation rate (in inches per month) was estimated by dividing monthly irrigated water use by the size of the irrigated yard area, and then converting the results into inches. On average, the estimated irrigation rate of the workshop participants was low—just 3.2 inches per month; however, the maximum irrigation rate observed was 42.3 inches. For comparison, according to University of Florida researchers, an irrigation of 12 inches per month is sufficient to sustain turfgrass during extreme summer conditions (Trenholm, Unruh, and Cisar 2006).

In addition, monthly irrigation water use data were provided for 43 households that had never attended the workshops and that were selected from the same neighborhoods as those that attended the workshops. These households were selected by the Toho Water Authority Conservation Coordinator to be the closes neighbors of those who attended the workshops (Ms. Elizabeth Block, personal communications).[2] No information about the value of the houses and estimated irrigation areas was provided. Descriptive statistics for the households that never

---

[2] Six households were excluded from the dataset due to the fact that their water-use records combined indoor and outdoor use.

attended the workshops is summarized in Table 2. Note that the mean water use was higher among the households that never attended the workshop, in comparison with the participants (the difference in water use between participants and non-participants was statistically significant; Kolmogorov-Smirnov test, α=0.01).

Table 2. Information about households that never attended the workshops

Household Characteristics	Mean	Median	Minimum	Maximum
Household monthly irrigation water use, thousand gallons (N=2665)	10.2	7.0	0.0	192.0

Irrigation Inspections

Monthly water use data (measured in thousand gallons per billing cycle) was provided by Gainesville Regional Utilities (GRU) for 68 households from Gainesville's high water use neighborhoods (i.e., neighborhoods dominated by manicured turf landscapes). These households received the Alachua County Environmental Protection Division (ACEPD)'s warning letters between April 2011 and June 2012. The households had irrigation water use meters that were separate from the indoor/tap water use meters.

To create a control group, 265 households that were randomly selected from the same Gainesville subdivisions as the households in the treatment group.[3] Of the 265 households, 48 had separate irrigation water meters, and these were selected as control group.

Monthly water use was available for the households in both the treatment and control groups for the billing cycles between January 2008 and May 2012. The average water use is presented in Table 3. The average, median, and maximum monthly irrigation water use is higher in the treatment group than in control group. Interestingly, for the indoor monthly water use, the mode and the maximum monthly use is also higher in the treatment group, while the mean is

[3] Some subdivisions were aggregated

higher in the control group (the difference in the distributions of monthly water use between treatment and control groups was statistically significant for both indoor and outdoor water use; Kolmogorov-Smirnov test, $\alpha=0.01$).

In addition to water use data, water rate structure information was provided by GRU, including the information about fixed customer charges and variable per-thousand-gallon water rates for residential tap water, irrigation water, and wastewater. Nominal rates were used in this study (i.e., year-to-year inflation was not accounted for).

Table 3. Information about treatment and control groups for ACEPD irrigation inspections

Household Characteristics		Mean	Median	Minimum	Maximum
House monthly *irrigation* water use, Thousand gallons	treatment (N=3510)	15.7	12.0	0	264.0
	control (N=2467)	14.7	11.0	0	206.0
House monthly *indoor* water use, Thousand gallons	treatment (N=2845)	5.3	5.0	0	85.0
	control (N=2349)	5.8	4.0	0	71.0
Home certified value, thousand 2012 dollars	treatment (N=3710)	236.1	230.3	100.8	481.9
(based on Property Appraiser data)	control (N=2544)	235.7	227.6	93.5	537.1
Estimated *total* property area, square feet	treatment (N=3657)	22677.7	21332.6	4949.3	50918.1
(based on GRU Estimates)	control (N=2544)	25796.2	21851.7	7409.8	61584.0

Model

Fixed effect regression analysis is used (as defined in (1)), allowing for heterogeneous effects of the programs over time. To examine the effect of both programs, we used alternative specifications for model (1) to capture the seasonal and annual variations in water use, as well as defining the periods before and after the program participation. The variables considered in the alternative specifications are described in Table 4. The regression analysis was conducted using *proc panel* in statistical package SAS 9.2© and *xreg* procedure in STATA Data Analysis and Statistical Software. To account for possible similarity in water use among the households living in proximity to each other, we allow for clustering of the error term in (1), ε_{it}, by subdivisions or by the streets fronting the households' addresses.

Table 4. Variables used in alternative specifications of the regression models used to evaluate the effectiveness of the two non-price water conservation programs

Variable	**Description**	**Hypothesized effect on irrigation water use**
TEMN	Extreme minimum daily temperature for calendar month (degrees F) [1]	+ Irrigation water use is positively correlated with outdoor temperature.
sqTEMN	Extreme minimum daily temperature for calendar month, squared[1]	+/– The effect of the outdoor temperature on irrigation water use can be non-linear.
PEMX	Extreme maximum daily precipitation for calendar month (inches) [1]	– Irrigation water use is negatively correlated with precipitation.
sqPEMX	Extreme maximum daily precipitation for calendar month, squared[1]	+/– The effect of the precipitation on irrigation water use can be non-linear.
Year	Variable(s) identifying calendar years[2]	– Irrigation water is expected to decrease over time in response to overall increase in water conservation ethics and general economic conditions.
Month	A vector of dummy variables identifying calendar months[2]	+/– Irrigation water use is expected to peak in April-May, the end of Florida's dry season and the season of landscape plants' growth and planting.
Periods	A vector of dummy variables identifying the months before and after the non-price water demand management program (for treatment group only) [2]	+/– Irrigation water use is expected to decrease after the program, the duration of the effect is subject to additional analysis; the water use can increase or decrease in the months before the program.
Price	A vector of proxy variables describing average and marginal prices paid by an "average" water user[2]	+/– Irrigation water use is expected to be negatively correlated with water rates; however, the effect is expected to be non-linear.

[1] Data were downloaded from NOAA.

[2] Sensitivity of the estimation results to the alternative specifications of the variable is examined.

Alternative specifications of the lengths of the periods before and after the non-price water demand management programs were examined. Given that the total number of households included into the datasets is relatively small, the definition of the periods' length is associated with a tradeoff between the number of observations available for the period (if the period is defined as short), and the ability to identify short-term changes in water use (if the period is defined as long).

In addition, we tried alternative approaches to account for differences in water use between the treatment and control groups. The first approach was to assume that the difference in the water use is captured in the fixed effects estimated for each household, and no additional adjustments is needed. Second, the variables capturing the interactions between control group and Month and Year dummy variables were introduced to capture possible differences in seasonal water use patterns of households in treatment and control groups. Third, the propensity scores were estimated for each household based on the available property characteristics (i.e., value and area), and the households outside the common support area were excluded from the analysis. This approach was examined for one non-price water conservation program only (i.e., irrigation inspections), since for the other program (i.e., extension irrigation workshops) no information about household characteristics in the control group were available. Fourth, matching households in the treatment and control groups by their water use over several months in the observation period was used. Specifically, Euclidian distance was calculated between water use over six-month period of all households in the control groups, and all households in treatment groups. Sub-sample of households with the distance in water use below 5 thousand gallons was selected for further regression analysis as specified in equation (1). Finally, fixed-effects instrumental variables estimation (two-stage least squares, 2SLS) was used, with the average water use of the households prior to the program implementation as the primary instrument.

Alternative definitions of outliers were also examined. As can be seen from Tables 1 – 3, irrigation water use can reach up to 264 thousand gallons per month (even though the mean water use does not exceed 16 thousand gallons, and median water use does not exceed 12 thousand gallons for both treatment and control groups and in both datasets). From the distributions of monthly irrigation water use observations for the treatment and control groups, we examined top 1% and top 5% of the observations. Our hypothesis was that if the excessive water use observations represent water leaks (i.e., un-systematic deviations from water use patterns that can be disregarded from the analysis), then the households in the top 1% and 5% water use category will represent a random sample of all households in the sample. However, contrary to our expectations, a sample of several households were repeatedly observed in the top 1% and 5% categories, implying such a high water use can reflect these households' typical water use behavior. As a result, no observations were classified as outliers and removed from the dataset.

It is likely that the effectiveness of the non-price waster demand management programs depends on the water use prior to the program, as well as other household characteristics. Generally, households with low water use have fewer opportunities to achieve further water use reductions (so-called "demand hardening"). To examine the possible differences in the effectiveness of non-price programs, regression analysis was conducted for the whole group of households, as well as for sub-samples of households with relatively low and relatively high water use.

Results

Graphical and statistical (with Kolmogorov-Smirnov tests) analysis of the water use patterns prior to the program implementation shows that the patterns differ between the control and treatment groups. For program #1 (educational program), the water use was on average lower in the treatment than in the control group; in contrast, for the program #2 (inspection program) the opposite relationship was observed. Such difference can be explained by self-selection of the program participants and by the targeting strategies employed by the agencies implementing the programs. Moreover, selection of the households based on the common support region of the propensity scores does not eliminate the difference between water use patterns in the treatment and control groups (when the propensity score is based only on the households' property acreages and home building values, i.e., most readily available household characteristics). All of the former selection issues suggest that our fixed effects panel data approach is most warranted.

In Table 5, we report estimation results for one of the model specifications (the results for other model specification and various estimation methods will be presented in detail during the conference). Overall, the estimates of the program effectiveness are sensitive to the definition of the length of the time periods before and after the workshop. For example, for both non-price residential water conservation programs, monthly water use of the households in the treatment group increases in the months prior to the program participation (Period0). Hence, the estimates of the program effectiveness can depend on the assumptions about the duration of the baseline period against which the programs' performance is measured.

Furthermore, the programs are more effective in the short-run than in the long-run (see Fielding 2013 for similar findings). And hence, the estimates of the program effectiveness depend on the length of the period after the program considered in the analysis. Specifically, the effect of irrigation workshop attendance is observed only in the month of the workshop and in the following month. For the inspection program, irrigation water use gradually decreases following the receipt of the warning letter from the local government, bottoms in the 5^{th} month after the warning, and then rises in the following months. For both non-price water demand management programs, the water use returns to the level observed prior to the program, or even exceeds its level in the longer run (see coefficients for month8, month9, and Period10 for irrigation workshop program). Estimates of the length of the time periods over which the programs' impact decays can be used by the agencies and extension educators to determine the frequency of the programs' follow-ups.

Also, the programs' impacts also vary among households (the estimation results are not reported in the table), with the programs being the most effective for the households with the highest water use. This estimated heterogeneity of the programs' impacts can help better target the programs.

Table 5. Estimation results for one of the specifications of regression model

Variable Category	Variable	Description	Irrigation Workshops		Inspection Program	
			Estimate	Standard Error	Estimate	Standard Error
Periods	Period0 [a]	>3 months prior to program	-2.14	0.52***	-2.29	1.45
	month0 [a]	Month of program participation	**-1.70**	**0.76****	3.41	2.97
	month1 [a]	Month following program participation	-0.22	0.95	-0.21	2.79
	month2 [a]	2nd month after program participation	1.63	1.05	-3.67	2.38
	month3 [a]	3rd month after program participation	1.07	0.91	-3.33	2.59
	month4 [a]	4th month after program participation	**1.88**	**1.02***	**-6.22**	**2.47****
	month5 [a]	5th month after program participation	0.32	0.99	**-4.86**	**2.54***
	month6 [a]	6th month after program participation	1.31	1.01	-3.14	2.31
	month7 [a]	7th month after program participation	1.68	1.05	1.50	3.18
	month8 [a]	8th month after program participation	**1.73**	**1.03***	1.59	2.69
	month9 [a]	9th month after program participation	**2.26**	**1.00****	-2.62	2.66
	Period10[a]	More than 9 months after program participation	**2.46**	**0.67*****	0.98	3.92
Year	Year	Index of calendar year	-1.44	0.14***	-2.21	0.87**
Month	Feb[b]	Dummy variables indicating calendar month	-0.90	0.61	-3.06	0.81***
	Mar[b]	Dummy variables indicating calendar month	-0.24	0.62	-0.01	0.83
	Apr[b]	Dummy variables indicating calendar month	0.85	0.67	7.35	0.85***
	May[b]	Dummy variables indicating calendar month	2.09	0.66***	12.97	0.95***
	Jun[b]	Dummy variables indicating calendar month	1.62	0.85*	9.65	0.97***
	Jul[b]	Dummy variables indicating calendar month	-0.95	0.70	5.61	0.98***
	Aug[b]	Dummy variables indicating calendar month	-1.41	0.67**	5.44	0.96***
	Sept[b]	Dummy variables indicating calendar month	-1.26	0.66*	4.78	0.94***
	Oct[b]	Dummy variables indicating calendar month	-0.81	0.66	5.53	1.26***
	Nov[b]	Dummy variables indicating calendar month	0.86	0.69	5.17	1.25***
	Dec[b]	Dummy variables indicating calendar month	0.03	0.69	0.08	1.23
Price	AVirrP	Proxy of average price for irrigation water	NA	NA	-84.32	13.12***
	AVirrPsq	Square of the proxy of average price for irrigation water	NA	NA	12.19	1.82
F Test for No Fixed Effects (Num DF)				25.38*** (99)		29.26*** (115)

[a] water use in the period covering, 1 – 3 months prior to the program participation is selected as the base for comparioson

[b] January is selected as the base for comparison

Summary

The effectiveness of two non-price water demand management programs is examined: (1) two-hour extension workshops focused on residential water conservation, and (2) irrigation program inspections combined with warning letters for non-compliance. We used a sample of irrigation water-use data for program participants (treatment group) and non-participants (control group), and applied a fixed effect regression analysis method. The results show that the programs were effective in reducing irrigation water use; however, the effect was short-lived. Furthermore, the effect of the program attendance depended on specification of the regression model used in the analysis, and on the household sample considered (i.e., high water users vs low water users).

The following two directions for the future research have been identified.

(1) Targeting a specific neighborhood with a water conservation program (such as irrigation inspections or irrigation workshops) can alter water use in the whole neighborhood. For example, those attended irrigation workshops can share the information they learned with their neighbors, changing water use in the community as a whole. Hence, in future, it is important to explore the broader impact of the irrigation programs on the targeted communities as a whole.

(2) The characteristics and the motivations of those targeted by a program can vary. For example, attendees of extension irrigation workshops can include those who are interested in water conservation, as well as those who are required to attend the workshop to avoid irrigation citations. Moreover, the ability and willingness to change water use will depend on a variety of households characteristics, such as the average water use prior to the program, income levels, landscape characteristics, environmental attitudes, etc. To further examine the effectiveness of a non-price program for different groups of households, and to better target the programs to specific audiences in the future, better information about participating households should be collected on the program design and implementation phase.

REFERENCES

Allison, P.D. 2006. Fixed effects regression methods in SAS®. Paper 184-31, SUGI 31: Statistics and Data Analysis Section, in *Proceedings of the Thirty-first Annual SAS® Users Group International Conference*. Cary, NC: SAS Institute Inc.

Allison, P.D. (editor). 2005. Chapter 1: Introduction to fixed effects methods. In: *Fixed Effects Regression Methods for Longitudinal Data Using SAS*, edited by P.D. Allison. Cary, NC: SAS Institute. http://support.sas.com/publishing/pubcat/chaps/58348.pdf

Borisova, T., D. Adams, A. Flores-Lagunes, M. Smolen, M. McFarland, and D. Boellstorff. 2012. Does participation in volunteer-driven programs change household landscape management practices? Evidence from southern states. *Journal of Extension* 50(3):3RIB4. http://www.joe.org/joe/2012june/rb4.php.

Borisova, T., K. Giacalone, R.A. Hanahan, and E. Momol. 2011. Quick overview of extension programs to educate homeowners about environmentally friendly landscape practices in Florida, South Carolina, and Tennessee. Electronic Data Information Source (EDIS) FE892. University of Florida, Gainesville, FL. http://edis.ifas.ufl.edu/fe892

Dukes, M., and D. Haman. 2012. Operation of residential irrigation controllers. University of Florida Electronic Data Information Source (EDIS) AE220 (CIR1421). http://edis.ifas.ufl.edu/ae220

Fielding, K.S, A. Spinks, S. Russell, R. McCrea, R. Stewart, and J. Gardner. 2013. An experimental test of voluntary strategies to promote urban water demand management. *Journal of Environmental Management* 114:343-351

Florida-Friendly Landscaping™ Program. 2009. *Florida-Friendly Landscaping™.* http://fyn.ifas.ufl.edu/

Geller, S.E., J.B. Erickson, and B.A. Buttram. 1983. Attempts to promote residential water conservation with educational, behavioral, and engineering strategies. *Population and Environment* 6(2):96-112.

Haney, M.B., M.D. Dukes, and G.L. Miller. 2007. Residential irrigation water use in Central Florida. *Journal of Irrigation and Drainage Engineering*, September/October:427-434.

Hostetler, M., E. Swiman, A. Prizzia, and K. Noiseux. 2008. Reaching residents of green communities: Evaluation of a unique environmental education program. *Applied Environmental Education and Communication* 7:114-124.

Hurd, B.H. 2006. Water conservation and residential landscapes: Household preferences, household choices. *Journal of Agricultural and Resource Economics* 3l(2):173-192.

Kenney, D.S., C. Goemans, R. Klein, J. Lowrey, and K. Reidy. 2008. Residential water demand management: Lessons from Aurora, Colorado. *Journal of the American Water Resources Association* 44(1):192-207.

Kennedy, P. 2008. *A Guide to Econometrics*, Sixth Edition. Malden, MA: Blackwell Publishing.

Maddaus, M.L., and W.O. Maddaus. 2008. Using an end use model to quantify demand hardening from long-term conservation programs. In: *Proceedings of the 2008 AWWA Water Conference*, Reno, NV. http://www.awwa.org

Marella, R.L. 2009. *Water Use in Florida, 2005 and Trends 1950–2005*. Report prepared in cooperation with the Florida Department of Environmental Protection (Florida Water Management District Fact Sheet 2008–3080). Florida Department of Environmental Protection and Florida Water Management District Headquarters, Tallahassee, FL. http://www.pubs.usgs.gov/fs/2008/3080

McKenney, C., and R. Terry. 1995. The effectiveness of using workshops to change audience perceptions of and attitudes about xeroscaping. *HortTechnology* 5(4):327-329.

Michelsen A.M., J.T. McGuckin, and D. Stumpf. 1999. Nonprice Water Conservation Programs as a Demand Management Tool. *Journal of the American Water Resources Association*, 35(3): 593-602.

Natural Resources Defense Council. 2010. *Climate Change, Water and Risk: Current Water Demands Are Not Sustainable*. Natural Resources Defense Council, Washington, D.C. http://www.nrdc.org/globalWarming/watersustainability/files/WaterRisk.pdf

Nieswiadomy, M.L. 1992. Estimating urban residential water demand: Effects of price structure, conservation, and education. *Water Resources Research* 28(3):609-615.

SAS. 2012. Overview: DISTANCE procedure. In: *SAS/STAT(R) 9.2 User's Guide*, Second Edition. Cary, NC: SAS Institute, Inc. http://support.sas.com/documentation/cdl/en/statug/63033/HTML/default/viewer.htm#statug_distance_sect001.htm

South Florida Water Management District. 2008. *Water Conservation: A Comprehensive Program for South Florida*. South Florida Water Management District, West Palm Beach, FL. www.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/waterconservationplan.pdf

Syme, G.J., B.E. Nancarrow, and C. Seligman. 2000. The evaluation of information campaigns to promote voluntary household water conservation. *Evaluation Review* 24:539-578.

Thompson, S.C., and K. Stroutemyer. 1991. Water use as a commons dilemma: The effects of education that focuses on long-term consequences and individual action. *Environment and Behavior* 23(3):314-333.

Trenholm, L., J.B. Unruh, and J.L. Cisar. 2006. Watering your Florida lawn. University of Florida Electronic Data Information Source (EDIS) LH025. http://edis.ifas.ufl.edu/pdffiles/LH/LH02500.pdf

Wilby R., and K. Miller. 2009. *Water Demand Impacts and Utility Responses*. Technical Briefing Paper (8), Water Research Foundation, Denver, CO. http://waterinstitute.ufl.edu/WorkingGroups/downloads/WRF%20Climate%20Change%20DocumentsSHARE/Climate%20Change%20Briefings/(8)%20Water%20Demand%20Impacts%20and%20Utility%20Responses.pdf