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Building an Interdisciplinary Research Program in Water Conservation: Approach, Preliminary Findings, and Next Steps

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EFFICIENT 2011- BUILDING AN INTERDISCIPLINARY RESEARCH PROGRAM IN WATER CONSERVATION:
APPROACH, PRELIMINARY FINDINGS, AND NEXT STEPS

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ABSTRACT

Effective urban water conservation programs must harness a synergy of new technologies, public policies, social cost pricing, information dissemination, citizen engagement, and coordinated actions across decision making scales. Together, these factors affect the volume of water an individual user ultimately saves and the overall success of a conservation program or programs. Over the past 18 months, we have started building an interdisciplinary research program in urban water conservation to quantify and assess the effects of these interconnected factors to motivate citizen engagement. We have interviewed water utility managers and conservation coordinators across the state of Utah, held focus groups with different water user groups, and tested our ability to recruit households into a future, multi-year water conservation study. Preliminary results suggest:

1. Nearly all households we recruited agreed to enroll in the future study;
2. Differences in enrollment were statistically insignificant across the different methods we used to interact with participants; and,
3. Participants expressed interest in a broad range of information, technology, financial, and community conservation programs.

In developing our research program, we have also identified the importance of:

- Broadly conceiving motivators, contexts, and scales (e.g. household or community) that may influence water use and conservation behavior;
- Developing integrated cyber-infrastructure and computing capabilities to collect and organize data, process it into site-specific, contextualized information, share it as feedback with participants, and subsequently measure its effects;
- Differentiating household capacity to conserve (comparing water use to need) from stated willingness-to-conserve and conservation actions;
- Involving household participants as collaborators through participatory action research;
- Training and delegating responsibilities to graduate student researchers; and,
- Collaborating with local water utilities.

We are pursuing funding to run a large, multi-year study that will allow us to investigate the separate and cumulative effects of various water conservation programs on household water use. As part of the study, we also seek to test whether presenting households with estimates of their capacity to conserve can effectively motivate willingness-to-conserve and conservation actions. The study will elucidate the contextualized factors that shape residential water use and people's conservation actions.

Introduction

Cities worldwide are struggling to deliver water in the face of growing demand for water-intensive services and associated increases in the social and ecological costs to develop new supplies. Growing demands and costs have motivated water managers to shift from maintaining and securing supplies to reducing (or altering the timing of) demand. Forty years of urban water research and empirical estimates suggest the effectiveness of various price, education, and other public policies and programs to reduce household water demand (Dalhuisen et al. 2003; Espey et al. 1997; Howe and Linaweaver 1967; Nieswiadomy 1992) and have helped inform local, regional, and U.S. policymaking. Yet inefficiencies and inequities persist in urban water use and suggest needs to further develop urban water conservation science and practice (Brookshire et al. 2002; Inman and Jeffrey 2006).

These needs relate to better understanding ways water use data are collected and managed, how data are packaged into information and delivered to users, meanings and knowledge users derive and construct from the content and transfer of that information, and how resulting knowledge informs public policy and citizen decision making. Knowing and making sense of water use to encourage greater efficiency and equity requires new integrated perspectives, computing, and visualization tools that can organize data, deliver information, and promote a more holistic, interactional, and interdisciplinary paradigm to promote water conservation. Integrated perspectives must move beyond the individual technology, data collection, consumer, environmental psychology, stimulus-response, and information transfer paradigms specific to the fields of engineering, economics, psychology, and science policy that have characterized current and prior water conservation research (Hurlimann et al. 2009; Jackson 2005; Mayer et al. 2004).

Here, we describe the approach our team has taken over the past 18 months to work towards integration. We present some findings from preliminary research activities and discuss next steps for a larger, longitudinal research program.

Interdisciplinary approach

Our team consists of researchers from the colleges of Engineering, Natural Resources, and Agriculture at Utah State University (USU) who represent the fields of water resources management, water policy, social science, and economics. Since fall 2008, we have regularly met to formulate an integrated water conservation research plan. This plan draws on theory, experimental methods, and analysis techniques from each of our fields to answer the overarching question: "What motivates and empowers conservation behavior?" We envision running a controlled, longitudinal field experiment with a large number of water users to test the individual and cumulative effects of numerous water conservation programs and interventions that influence users' access to information, construction of knowledge, conservation behaviors, and attitudes towards conservation.

Since June 2009, we have used USU seed funding to develop, test, and extend our research plan through three structured activities. Funding also allowed us to hire and involve graduate research assistants in the activities. First, we interviewed 32 water managers and conservation coordinators who work for 10 cities and 6 water conservancy districts (wholesale water providers) across the state of Utah (Figure 1). These interviews provided opportunities for us to hear the challenges Utah water providers currently face, their past and current experiences with water conservation, and receptivity to different,

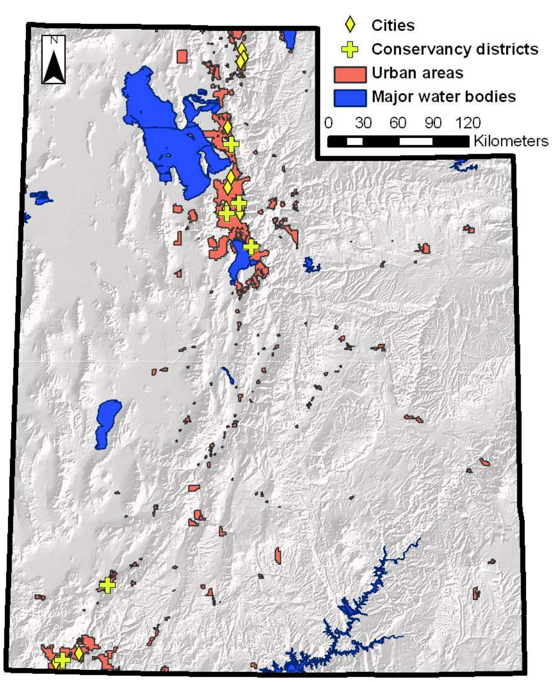

Figure 1. Locations of Utah cities and water conservancy districts we interviewed.

information, technical assistance, price, and community conservation programs we had in mind to test through a subsequent, larger research project. The interviews also allowed us to start building collaborative relationships with cities and conservancy districts with whom we hoped to partner, would contribute water use billing data, and implement experimental conservation programs as part of a larger field experiment.

During a second set of structured activities, we held focus groups with 30 people from five different water user groups during fall 2009 and winter 2010 in Logan, Utah (located in northern Utah and home to USU). We asked groups of residential homeowners, renters, landscapers, institutional landscape managers, and mangers/landlords of rental properties about what water conservation meant to them, their prior experiences with conservation programs, constraints and limitations that have prevented them from taking conservation actions, their reactions to proposed experimental conservation programs, and their suggestions for additional programs and motivators to encourage water conservation.

Focus group responses informed our third structured activity which was developing and testing protocols to recruit participant households into a subsequent (still to be funded) longitudinal field experiment and simultaneously collect data from them. We pilot tested recruitment and data gathering procedures in summer 2010 with 41 households in Logan, Utah. We random sampled from four household strata representing differing capacities to conserve (CTC) where existing estimated CTC for each property location in Logan was derived by dividing estimated landscape water use by water need estimated from evapotranspiration and remotely sensed landscape vegetation coverage (Farag et al. In press; Glenn 2010). For the High CTC group, estimated landscape water use was consistently higher than estimated water need over multiple years. Households in the Low CTC group showed use consistently less than need. Use fluctuated above and below need from year to year for households in the Variable group. We combined all other households into a Residual group.

We then mailed occupants letters inviting them to participate in activities that culminated in them choosing whether to enroll in a subsequent (still to be funded) multi-year research project. The activities involved data gathering and sharing, building rapport, providing participants assessments of their water use for the past three years, and allowing participants to choose conservation programs in which to participate. Recruitment activities allowed us to test several logistics related to the field experiment, including whether we could: (i) recruit a sufficient number of participants; (ii) recruit and collect data of sufficient quality using different methods to interact with potential participants such as in-person, drop-off/pick-up, postal mail, and E-mail; (iii) verify our initial estimates of CTC; and (iv) learn participant's stated preferences for conservation programs.

Next, we present preliminary findings for these and other issues related to the interdisciplinary research design.

Preliminary findings

Through pilot-testing recruitment, we filled our quota of 40 pilot households with a diverse and representative set of households. 35 households completed each of the data gathering and information sharing activities and 33 households subsequently agreed to enroll in the larger proposed study (Table 1). Differences in responses were statistically insignificant across the different interaction methods (p-values for Fisher's Exact tests of the (null hypothesis of no) relationships between Interaction Method and Completed and Enrolled, respectively, were 0.258 and 0.438 when calculated using Stata IC/11.0 for Windows 32-bit).

We allowed a subset of households to choose their interaction method; most chose mail survey, which contributed to (statistically insignificant) lower enrollment from this group. Otherwise, interaction methods were comparable in terms of cost and accuracy. However, in-person interactions provided the richest information for understanding household context and decision-making.

Some households expressed interest to participate in each of the proposed experimental conservation programs, with stated preferences generally highest for the information and technical assistance programs (Table 2; note percentages in each column do not sum to 100 because households could choose multiple programs). A large number of households expressed willingness to participate in an individual water savings contest that would pay them a lump sum

Table 1. Household recruitment by interaction method. Percentages are fractions of registered households.

Interaction Method	Registered	Completed	Enrolled
In-person	10	10 (100%)	10 (100%)
Drop off/pick up	6	5 (83%)	5 (83%)
Postal mail	10	7 (70%)	7 (70%)
Email	7	6 (86%)	6 (86%)
Participant chooses	8	7 (88%)	5 (63%)
Total	***41***	***35 (85%)***	***33 (80%)***

Table 2. Household stated preference to start experimental conservation programs in Year 1 of a subsequent study. Percentages are fractions of households that completed recruitment.

Category / Program	All	Estimated Capacity-to-Conserve			
		High	Low	Variable	Residual
Information					
Additional billing information	77%	80%	80%	100%	67%
Internet information	43%	40%	40%	60%	40%
Smart meter	74%	80%	60%	100%	67%
Child education	14%	10%	20%	40%	7%
Technical					
Water audits	71%	90%	40%	100%	60%
Rebates	63%	60%	80%	80%	53%
Financial					
Community water saving contest	14%	20%	40%	0%	7%
Summer water saving contest	11%	30%	0%	0%	7%
Individual water saving contest	37%	50%	40%	40%	27%
Conservation savings account	26%	40%	40%	20%	13%
Community-based					
Environmental stewardship	20%	20%	40%	20%	13%
Social networking	20%	20%	40%	40%	7%
Do-it-yourself	29%	20%	40%	20%	33%
Completed recruitment (count)	***35***	***10***	***5***	***15***	***5***

($400) up front to participate in the program, then raise the price of water by 50% for water use above a threshold and lower the price paid by 50% for use below the threshold. We set the threshold at 10,000 gallons (37.9 m^3) per month, which is the current break point in Logan's two-block (tier) residential rate structure.

Preliminary results suggest that households we initially estimated with high or variable CTC had statistically significant and stronger preferences for the water audit conservation program than the sample as a whole (the Fisher Exact p-value for water audit—based upon the frequency distribution underlying the percentages presented in Table 2—was 0.085; whereas for the remainder of the programs, the associated p-values were each greater than 0.10). This stronger preference may have resulted from information we shared with participants as part of the recruitment activities. We showed participants time series graphs of their billed water use, estimated indoor and outdoor water use, and estimated indoor and outdoor water need. Participants could related this information to derive the estimated volume of their overuse.

As part of our proposed longitudinal project, we plan to work with a larger sample size and exercise better experimental control to say whether this information sharing approach and the other results presented in Tables 1 and 2 are statistically significant. Beyond the quantitative results discussed above, our preliminary research activities yielded several important qualitative findings.

For example, a policy dilemma was revealed when several city water managers we interviewed stated that water conservation programs reduce both use and utility revenues, and are therefore problematic. Other managers and conservation coordinators disagreed with this statement. They noted they could simultaneously adjust rate structures to encourage conservation and maintain revenues despite reduced water use.

We learned that how we frame a conservation program can influence people's receptivity to the program. For example, we wanted to test the effect of a financial program that would significantly increase the price participants pay for water. We had simply called the program a "price increase" program and were challenged to provide suitable incentives to encourage voluntary household participation (a U.S. requirement for research involving human subjects). We crafted incentives that offered fixed compensation at the beginning of the study (individual financial) or a variable, mean compensation amount dependent on other participants' actions at the study end (community and summer financial programs). Still, we were met with significant resistance and skepticism during interviews and early focus groups. However, during a focus group, as we explained the different compensation mechanisms for each financial program, one participant noted the programs sounded like “contests,” this participant “liked contests,” and reported willingness to participate in such an activity. Other focus group participants agreed. We subsequently emphasized the contest (individual, community, and seasonal water savings) aspects of these programs and saw improved interest among our pilot households, as shown in Table 2.

During recruitment testing we also noted two district groups of respondents to an open-ended question where we asked, “Why are you interested in participating in this research?” One respondent group was interested in water conservation and a second group was only interested in the money paid as compensation to complete recruitment activities. Many respondents in the second group gave blanket responses (e.g., yes to everything) and marked checkboxes, but gave no comments on open-ended questions to illuminate their reasoning. While the former blanket responses can help with some quantitative analysis, they may hinder qualitative analysis aimed at better understanding reasons why conservation actions were (or were not) undertaken.

Finally, and importantly, we heard and received strong interest in and support for the research from the cities and conservancy districts where we interviewed people. Two cities signed commitments to collaborate in the subsequent, longitudinal, multi-year research. Together, the quantitative and qualitative results from our preliminary research activities have informed the design of and verified our ability to carry out a much larger longitudinal research effort.

Next steps

Our principal next step is to secure funding to conduct the longitudinal, multi-year conservation field experiment with a much larger sample, develop cyber-infrastructure and computing capabilities to support the experiment, and verify plus extend findings from our preliminary work. We are currently responding to research solicitations released by large, national funding agencies such as the U.S. National Science Foundation that could fund the entire, integrated effort for up to 1,000 participant households. Additionally, we are considering how to package the research into smaller, separate pieces that would qualify for national, state, and local solicitations that offer smaller funding amounts. We are also continuing to propose, develop, and work with collaborating cities and interested water utilities on smaller projects to advance and test parts of the larger proposed research. This multi-pronged and scaled approach allows us to target a wide range of funding opportunities to advance the interdisciplinary research agenda.

As funding materializes, we will recruit and train an interdisciplinary team of graduate and undergraduate student researchers to participate in our research program. Student participation will span all project phases including recruiting households, administering the field experiment, and analyzing data. During extended data-collection trips, students will embed and work in cities and water utilities. These trips will provide students with theses and capstone research experiences that, upon graduation, they can use to launch careers in the municipal sector or conservation fields. Here, student-focused research that delegates research responsibilities to students and provides rich field experiences will help train the next generation of water managers, conservation coordinators, and planners to approach conservation from interdisciplinary perspectives.

With funding, we will also develop the cyber-infrastructure and computing capabilities to collect, organize, process, visualize, and deliver the numerous primary (survey) and secondary (water use billing and landscape) data we will collect through the longitudinal study. This infrastructure and computing will serve as the back-bone to the field experiment and will allow us to process collected data into information (such as CTC), share information with participants, observe their interpretation of that information, provide participants access to several experimental conservation programs (such as internet information and social networking), log participants' online actions in response to these programs, and format collected data to use in engineering modeling, program and policy evaluation, and econometric, case study, and qualitative analyses. Interdisciplinary analysis will only be possible with cyber-infrastructure and computing capabilities that are fully integrated with the conservation field experiment.

Conclusions

Over the past 18 months, we have interviewed numerous water managers across Utah, held focus groups with different water users, and pilot-tested recruitment to develop and inform the design of a larger, longitudinal field experiment. This experiment draws on theory, data collection methods, and analysis techniques from multiple fields to answer the overarching question "what motivates and empowers conservation behavior?"

Our preliminary results suggest that it is possible to recruit a sufficient number of participants, interact with participants in several ways to collect the required data, and that participants have preferences for many information, technology, price, and community conservation programs. We look forward to discovering whether these results manifest with a larger sample and whether participants' expressed preferences for programs will motivate information seeking, knowledge construction, conservation actions, and ultimately, more appropriate water use.

We are now pursuing funding to run the longitudinal field experiment; with funding, we will hire a talented student researcher team and develop the cyber-infrastructure and computing systems to support the field experiment and make collected data available in various formats for interdisciplinary analysis. Together, these activities have and will continue our efforts to build an interdisciplinary research program in water conservation.

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