MEASURING THE IMPACT OF WATER CONSERVATION CAMPAIGNS IN CALIFORNIA[1]

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Abstract. The reductions in water use achieved by urban households in California during the recent drought are well documented. What is not documented is how those reductions were achieved. In this paper, we report on survey data from the Los Angeles and San Francisco Bay Areas describing the water conservation activities undertaken. We also examine variation in water conservation activities across households and adjust statistically for social desirability biases in the self-reports.

1. Introduction

The prospect of global climate change is closely linked to the hydrological cycle, and some parts of the world may be significantly warmer and drier for a range of global warming scenarios (Cohen, 1991; Meher-Homji, 1991; Salanti and Nobre, 1991; McCabe and Wolock, 1992). Under many of these scenarios, the Western United States, and California in particular, are at substantial risk. The California economy, which is comparable in size to that of a major industrial nation, depends on a supply of relatively cheap water (Kahrl, 1979, 1982). But as Vaux (1991) notes, '[g]lobal warming raises the prospect of significant changes in the timing and magnitude of precipitation and runoff in California as well as the possibility of changes in the patterns and magnitudes of water demand.' For example, if more of the winter precipitation falls as rain rather than snow, the water will be lost as runoff rather than stored for gradual release in the Sierra snowpack. Hotter weather also implies greater demand for water from farmers and other users. In short, both the supply side and the demand side could well be adversely affected.[2]

It follows that should significant climate change materialize for California,

[1] Thanks go to UCLA's Survey Research Center for the data collection and especially to Eve Fielder, the Director, who took a particular interest in the study. We are also indebted to the Save the Earth Foundation for funding the earlier research projects that made the data collection for this paper possible. Finally, we wish to express our appreciation to three reviewers who helped us clarify a number of arguments in the paper.

[2] Analogous arguments have been made by many scholars from around the world. See in particular the two volume anthology *The Impact of Climatic Variations on Agriculture* edited by Parry, Carter and Konijn (1988), and the anthology *Climate Change and U.S. Water Resources* edited by Waggoner (1990).

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important adjustments may need to be made. Building additional water storage facilities is certainly one option, which would improve the supply side. But it may be prohibitively expensive, damaging to a number of wildlife habitats, and politically unacceptable. And should drier weather become endemic, more storage capacity will not fully solve the problem. Changing the demand for water is a second option. There are clearly a number of technological fixes that could help agricultural and industrial users. And farmers could switch to less water intensive crops (e.g., fruit trees rather than rice). Also promising, however, is water conservation efforts in households, including both technological *and* behavioral change.

For the United States at least, there is modest literature on the demand for water and water conservation (e.g., Berk *et al.*, 1981; Kindler and Russell, 1984).[3] Much of the research draws on data from California and recent events suggest that California will continue to be a focal point. By the late 1970's, a combination of economic growth and population increases laid claim to most of California's supply under the existing physical infrastructure, water use law, and institutional arrangements (Vaux, 1988; Kennedy, 1990). It was easy to project, therefore, that with little slack in the system, serious trouble lay ahead.[4]

Beginning in 1986, California experienced the longest period of sustained drought since the dust bowl era of the 1930's. With most of the State's water supply already spoken for, the dramatic precipitation shortfall that characterized 1986 through 1991 (and continuing) led to serious concerns about available supplies. An almost inevitable short-term response followed: calls for reductions in the amount of water consumed.[5] By and large, the public response was dramatic. In particular, aggressive water conservation programs apparently reduced residential water use in urban areas by as much as 28% (personal communication, Drought Information Center, Department of Water Resources, Sacramento, CA.).

While aggregate figures on urban water savings are certainly useful for a variety of public issues, they necessarily overlook the means by which water conservation was achieved. It is one thing to document how much water consumption declined and quite another to document the methods consumers employed. Were the reductions a result of new indoor technologies (e.g., low flow shower heads), changes in landscaping and water devices (e.g., drip irrigation), behavior change (e.g., full dishwasher loads), or some combination of these and other measures? The mix is important not only for understanding conservation behavior within households, but for projecting future water consumption and future responses to water shortages. For example, technological changes may well lead to long term reductions in

[3] There is also a small international literature (e.g., Grima, 1972; Darr *et al.*, 1976).

[4] For example, in 1981 we observed, 'Indeed, it is perhaps not too alarmist to assert that the energy crisis of the 1980's will be followed by the water crisis of the 1990's.' (Berk *et al.*, 1981, p. 8).

[5] There were also efforts to improve the efficiency of water distribution through market mechanisms such as the California Water Bank. However, the Water Bank was largely an experimental effort that did not redistribute large amounts of water. In collaboration with the California Department of Water Resources and the U.C. Water Resources Center, we are conducting a study of the Water Bank.

consumption, while changes in behavior may have only transient effects. But this implies that once the technological savings are achieved, additional savings from technology require *new* technology. Should that new technology not be forthcoming, behavioral change is all that remains. In any case, such processes cannot be studied using aggregate household consumption figures from households, such as those available from the routine monitoring of water meters.

In this paper, we report the results of a survey fielded in part to measure responses to the drought within urban households in the Los Angeles and San Francisco Bay areas. Against a backdrop of demonstrable declines in water consumption, we will examine the conservation means households employed. In addition, we will consider the possibility that respondents were inclined to exaggerate their water conservation efforts; we will report how these inclinations were diagnosed and how statistical adjustments were made. For some readers, these methodological issues, which have implications for all survey research on environmental matters, may be especially relevant. But the main substantive point remains: under a variety of global climate change scenarios, water conservation within households is an important policy option that needs to be better understood.

2. Background

There is ample evidence that household water use can be reduced either through changes in price or through conservation appeals. That is, one can reduce the amount of water consumed at a given level of demand by raising the price and/or shifting the demand curve to lower levels (Bruvold, 1979; Berk *et al.*, 1981; Hamilton, 1985; Maddaus, 1987). Virtually unaddressed, however, is how these savings are achieved. A priori, one can imagine households employing some mix of the following strategies:

1. technological fixes within the home (e.g., low water-use toilets);
2. technological fixes outside the home (e.g., drip irrigation);
3. behavioral change within the home (e.g., turning off the shower when soaping up); and
4. behavioral change outside the home (e.g., sweeping rather than washing down driveways).

One might also expect that the mix of strategies chosen would vary depending on household characteristics. And in this regard, four household characteristics stand out (Berk *et al.*, 1981; Luyben, 1982; Hamilton, 1985; Fujii *et al.*, 1985). First, one might anticipate that other things equal, home owners will conserve water more readily than renters. Most directly, owners have access to the information (e.g., water bills) required to monitor water use. Owners also have the control necessary to make a wider variety of changes (e.g., to make plumbing changes). Finally, owners will perhaps be more motivated to install new water saving technology insofar as the investment may be recaptured when the dwelling is sold.

Second, household income should also play some role, other things equal. For the purchase of durable goods, however, there are two countervailing tendencies (Hausman, 1979). On the one hand, with greater wealth comes the ability to invest in water saving technology. At the very least, poor households may simply not have the capital to invest. On the other hand, a diminishing marginal utility of income implies that households with higher incomes will have less incentive to save water because each marginal dollar saved provides less utility. That is, higher income households may have a greater ability to pursue water conservation through technological change, but less motivation to do so. In short, it is difficult to anticipate whether households with higher incomes will invest more in water saving technology than households with lower incomes.

The predictions are more clear for the role of income in behavior changes. Since the opportunity costs of time are higher for higher income households (Becker, 1981), behavioral changes leading to greater time investments in household chores should be less common. One would predict, therefore, that low income households would more readily adopt time consuming water saving activities (e.g., sweeping rather than hosing down driveways).

Third, adopting water saving technology and/or behavior requires (1) that the nature of the water shortages be understood; (2) that water saving options be understood as well; (3) that household members believe they can actually implement at least some of the water saving options available; and (4) that their conservation efforts will not be exploited by others (Berk *et al.*, 1981). The first three prerequisites are likely to be related to education, suggesting that other things equal, households with more highly educated members will be more likely to reduce their water use. And these reductions should apply regardless of the strategy.

Fourth, water conservation may also be related to 'life style'. In particular, higher SES households may reduce their water use because of a greater attachment to a conservation ethic and, of late, to the pro-environmental fashions of the day.[6] In other words, with higher SES is more likely to come a set of 'pro-environmental' predispositions. This suggests an across the board adoption of water saving strategies. We stress, however, that SES is at best an indirect measure of 'life style'.

3. Research Design

For well over a year, UCLA's Center for the Study of the Environment and Society has been conducting an ongoing telephone survey of households in the greater Los Angeles area. The purpose has been to monitor a variety of environmentally relevant behavior in Southern California households. Late in the summer of 1991, funding was found for a larger effort which would include the Bay Area and add a

[6] SES stands for 'socioeconomic status', and is usually operationalized as some combination of occupation, income and education.

more thorough set of items on responses to and impact of the Statewide drought. The goal was to assess what effect the drought may have had on urban households.[7]

The population was for the 'drought impact study' defined as residences with working telephones in the Los Angeles Area and San Francisco Bay Area. The former was operationalized roughly as the area served by the South Coast Air Quality Management District, enlarged a bit to include even rather distant 'bedroom communities' for Los Angeles,[8] and the latter was operationalized by the five counties including and adjacent to San Francisco.[9] Computer assisted telephone interviewing (CATI) was used, and interviews averaged about 30 minutes in length. Both Spanish and English versions were available. Telephone numbers were selected by random digit dialing, and a random adult was selected in each household. The response rate was 62%.[10]

Questionnaire content was of three broad types. There were, of course, the usual questions on the backgrounds of respondents and their households: the ages of household members, income, education and the like. Conventional formats were used.

The vast majority of items asked about conservation (water and energy), recycling, and a number of other environmentally relevant activities. In this analysis, we will focus on the water conservation items, worded to elicit responses about very recent technological and behavioral changes in response to the drought that occurred after local water conservation measures were introduced. These included questions on:

1. turning off the water when brushing teeth;
2. turning off the water when soaping up in the shower;
3. frequency of flushing the toilet;
4. frequency of taking showers;
5. installation of water saving showerheads;
6. installation of water saving toilets;
7. installation of a water dam in toilets;

[7] The ongoing survey is called the Southern California Environmental Report Card and was initially funded by the Save the Earth Foundation. The instrument was enhanced and then used also in the Bay Area as a result of funding provided by the California Department of Water Resources and the U.S. Army Corps of Engineers. The research, and several other related studies, were orchestrated by the U.C. Water Resources Center..

[8] Los Angeles County, Orange County, Riverside County and parts of Ventura County, and San Bernadino County.

[9] San Francisco County, and parts of San Mateo County, Alameda County, Marin County, and Santa Clara County.

[10] The response rate was computed by dividing the sum of completed interviews by the sum of the working, non-business telephone numbers called. It is comparable to response rates from other recent surveys in urban areas. Over the past decade, response for much of the United States has dropped dramatically, and it has become very difficult to get response rates over about 65%. However, in the Los Angeles and San Francisco areas, almost all residences have a phone, so that at least the sampling frame is representative for a study of water conservation within households.

8. checking for plumbing leaks;
9. whether dishes are washed under running water, or, alternatively, rinsed under running water before being put in a dishwasher;
10. whether the dishwasher has a water saving feature;
11. frequency of watering the lawn/garden in the afternoon;
12. use of mulch on garden/lawn;
13. installation of water saving irrigation devices;
14. letting part of the lawn/garden die to save water;
15. installing of drought tolerant landscaping;
16. frequency of hosing down sidewalks/patios/driveways; and
17. draining a pool.

Finally, there were a series of questions designed to trap respondents who were predisposed to exaggerate their water conservation efforts. It is well known that social desirability can affect how respondents answer certain kinds of questions (for recent reviews see DeMaio, 1984; and Groves 1989). In brief, respondents treat the interview like many other social interactions in which an important goal is to present oneself in the best manner possible. Socially desirable behaviors tend to be overreported and reports of socially undesirable behaviors tend to be underreported. Previous research in which efforts have been made to validate a variety of self-reports (e.g., by checking utility company bills against respondent claims of energy conservation) have shown that similar processes operate in surveys of conservation and recycling behavior (Luyben, 1982; McGuire, 1984; Hamilton, 1985; Fujii *et al.*, 1985).

Our problem was to design a method to capture social desirability artifacts when no external means of validation are easily obtained.[11] As a practical matter, external validation is irrelevant for routine survey work because if accurate external figures are readily available, there is no need to obtain survey-based estimates to begin with! That is, external validation is a methodological tool, which has no real role in 'production work'.

We adopted the strategy of including several items on fictitious conservation activities and issues (e.g., Bishop *et al.*, 1986). We assumed that respondents who claimed to undertake fictitious conservation activities, or who expressed concerns about fictitious environmental issues, would also be inclined to exaggerate water conservation activities that could have been undertaken. The fictitious items included:

1. recycling light bulbs;
2. installation of a ferronic input-out device on the water heater;
3. use of yard products with Selgar-D;
4. owning an energy saving television set;

[11] Meter readings, for example, would have been useless to validate specific behavioral changes within households.

5. hearing about efforts by California State officials to prohibit the wearing of fur;
6. hearing about government efforts to ban the cutting of Christmas trees; and
7. hearing about a proposal by State transportation officials to ban all cars from freeways during Stage II smog alerts.

For each item, we reasoned that people who answered affirmatively were a bit too anxious to sound 'green' to the interviewer. At the very least, we planned to use the fictitious items as covariates in any analysis of conservation practices.

4. Findings

Table I shows the proportions engaging in water saving behavior and employing water saving technology. The responses are coded so that in each case a higher percentage means more water conservation. Clearly, households appear to have made a substantial effort to reduce water use through a variety of mechanisms.

But, it is hard to escape the sense that the findings are too good to be true. For example, did a quarter of the households in the Los Angeles and Bay Areas really install water saving devices for irrigating lawns and gardens (among the households that had lawns and gardens)? Did over half of the households stop flushing toilets after every use? One must keep in mind that there was a lot of publicity surrounding the drought and some evidence of palpable pressure to conserve. At the

TABLE I: Responses to water conservation questions ($N = 632$)[12]

Variable	Response
Water running when brushing?	Never = 58%
Water running when soaping up?	Never = 15%
Flush toilet after each use?	No = 55%
More than one shower per day?	No = 80%
Recently purchased water saving shower head?	Yes = 43%
Recently purchased water saving toilet?	Yes = 12%
Water dam in toilet?	Yes = 37%
Recently searched for water leaks?	Yes = 49%
Rinse or wash dishes under running water?	No = 18%
Water saving feature on dishwasher?	Yes = 5%
Water garden/lawn in afternoon?	Never = 71%
Use mulch on garden/lawn?	Yes = 42%
Installation of water saving irrigation?	Yes = 26%
Let part of lawn/garden die?	Yes = 55%
Recently installed drought tolerant landscape?	Yes = 32%
Hose down sidewalks/patios?	No = 56%
Drained pool?	Yes = 10%

[12] The percentages reflect the base that is relevant. For example, the 10% who claim to have drained their swimming pools applies only to the subset of respondents who have a pool.

extreme, for example, 7% of the households claimed to have been fined for using too much water. Perhaps more important, some respondents were taking the drought so seriously that they were 'turning in' their neighbors; 3% of our respondents claimed that over the previous 12 months they had reported someone for overwatering. It is reasonable to assume that many others, who may not have reported infractions, nevertheless, made their concerns about water conservation apparent to others. In short, there is a real possibility that social desirability of water conservation practices has inflated the figures in Table I.

Table II shows the responses to the items meant to gauge each respondent's concerns about appearing 'green'. Clearly, far less than a majority were taken in by any single item, but well over 20% were caught by at least one. At the very least, Table II should raise concerns about the credibility of responses to questions about socially desirable environmental activities and more important, provide the raw material with which some adjustments may be undertaken. In particular, if the items in Table II are positively related to self-reports of environmental activity, they may be used as covariates to adjust downward the self-report activity.

Since some of the single social desirability items had little variance, we could not effectively work with all of the items individually. So, we simply summed the seven items as a first approximation of a social desirability index. The histogram in Figure 1 shows the result. Over 25% of the respondents endorsed at least one item and about 15% endorsed more than one. It was the second group that was of particular interest since many respondents could have easily endorsed one of the items by mistake.

As an exploratory device, we then estimated the parameters of logistic regression models in which each water conservation item was regressed in the social desirability index.[13] In all but two cases, the relationship was positive; higher scores on the social desirability index were associated with greater odds of conserving water.[14] One exception was the toilet flushing item. Respondents who scored higher on the social desirability index were *more* likely to flush the toilet after each use. Post hoc, we reasoned that norms of personal hygiene perhaps made the water

TABLE II: Responses to social desirability items ($N = 632$)

Recycle light bulbs?	Yes = 2%
Have ferronic device?	Yes = 5%
Use yard products with Selgar-D?	Yes = 2%
Have energy saving TV?	Yes = 14%
Heard about fur ban proposal?	Yes = 18%
Heard about Christmas tree ban proposal?	Yes = 10%
Heard about car ban proposal	Yes = 14%

[13] The item for pool draining was not analyzed in this fashion because there was so little variance.

[14] The t-values ranged roughly between 1.0 and 2.0. While most of these t-values failed to make the conventional 0.05 level, their combined probability certainly did.

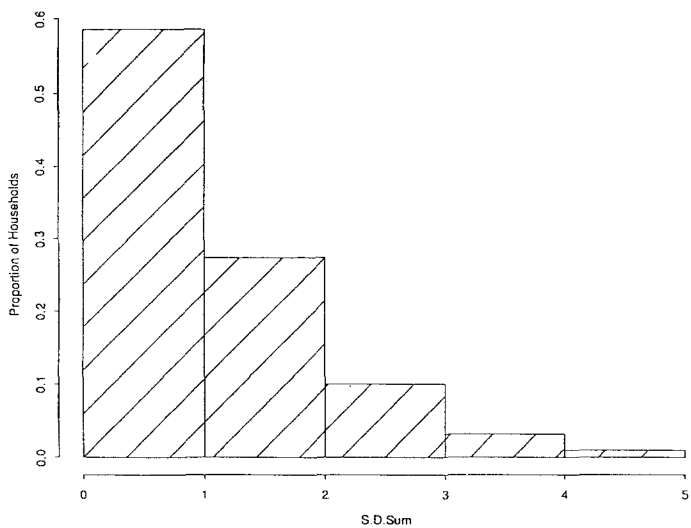

Fig. 1. Number of social desirability items endorsed.

saving action of not flushing the toilet after each use socially *un*desirable. The other exception was watering the lawn or garden in the afternoon. Respondents who scored higher on the social desirability index were *more* likely to water their lawn or garden in the heat of the day. Even post hoc, we had no sensible explanation for the sign reversal, and conjecture that we were victimized by Type II error.

Given the general pattern of the relationships between the social desirability and water conservation reports, we then decided to sum the water conservation items as a means of data reduction. We felt that the sum would allow us better to explore variation in water conservation practices rather than considering each of the water conservation items individually. We included in the sum the two items showing negative relationships with the social desirability index. Dropping them from the index after our earlier exploratory work, risked capitalizing on chance. Readers who disagree with this strategy should keep in mind that by including the 'rogue' items, we are taking the conservative path; if anything, we are attenuating the relationship between reported water conservation practices and the social desirability index.

The histogram of the sum of water conservation practices is shown in Figure 2. The sum ranges from zero to 11 (out of a possible 17) with the mode at 3. About half of the sample initiated 4 or more water conservation activities, with about 10% initiating more than 8.

Much of the earlier work on social desirability (cited above) suggests that the tendency of respondents to answer in social desirable ways is related to education. The insecurities and confusions of less well educated respondents would make them especially vulnerable. As a next step, therefore, we explored the relationship between the water conservation index, on the one hand, and the social desirability

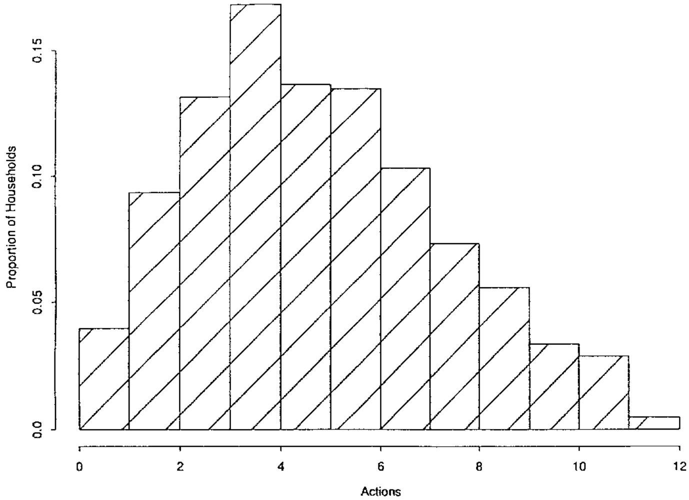

Fig. 2. Number of water conservation actions.

index and the respondent's years of education on the other. Since we had little idea what the response surface would be, we used a smoother based on robust locally-weighted regression estimates (Cleveland, 1979). Figure 3 shows the results of the 'lowess' smooth.

The response surface in Figure 3 collapses because of sparse data for social desirability scores greater than 3 and years of education below 8. Nevertheless, the story is reasonably clear. First, respondents with more education report a larger

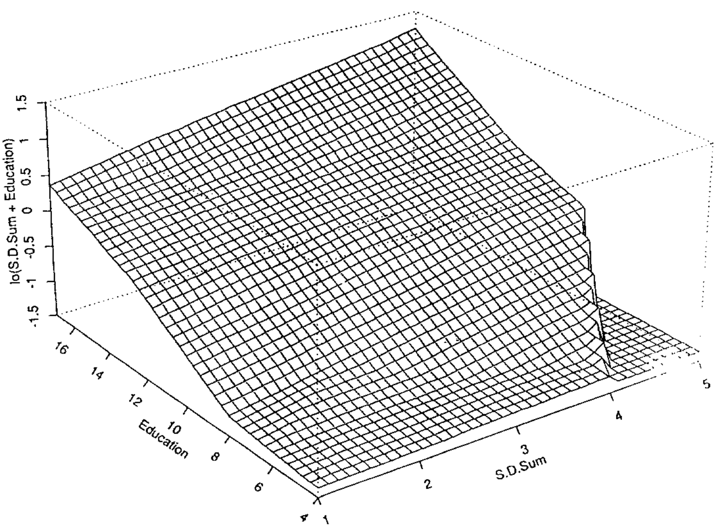

Fig. 3. Lowess smooth of water conservation data.

number of water conservation practices across the full range of social desirability scores. This suggests that the anticipated education effect is not a social desirability artifact; the effect is 'real'. Second, regardless of years of education, respondents who endorse a greater number of the social desirability items report larger numbers of water conservation practices.[15] The social desirability items 'catch' respondents over all educational levels.

Convinced that the relationship between the social desirability index and the sum of the water conservation practices was not explained by the respondents' years of education, we turned to a more 'parametric' form of analysis that would allow us to consider a larger number of explanatory variables consistent with the literature on conservation behavior. We conceptualized the sum of water conservation practices as a count of events that were not likely to be independent. This implies that the conventional Poisson formulation would be inappropriate; we needed to estimate a dispersion parameter (anticipated to be less than 1.0), rather than constrain the dispersion parameter to 1.0. That, in turn, led to a Poisson regression model, estimated with quasi-MLE, in which the dispersion parameter was unconstrained (McCullagh and Nelder, 1991, Chapter 9).[16] Explanatory variables included:

1. the social desirability index;
2. metropolitan area (Los Angeles or San Francisco);
3. years of education;
4. income;
5. occupation;
6. whether there were children living at home;
7. whether the dwelling was owned or rented;
8. whether the dwelling had a pool; and
9. whether the dwelling had a lawn or garden.

The rationale for most of these explanatory variables was provided earlier. In addition, metropolitan area was included to address the widely held belief that Bay Area residents are more 'conservation minded' than Los Angeles Area residents. Such assertions have figured significantly in political battles over water distribution in California. The presence of children was included because of a conjecture that parents with daily reminders of their 'investment' in the future would be more likely to conserve water. There is also anecdotal evidence that children are likely to be especially conservation conscious and foster conservation at home. And whether the dwelling had a lawn or garden or whether the dwelling had a pool were included because having a lawn or garden allowed for a greater variety of conservation practices.

[15] One must keep in mind that the response surface in Figure 3 makes no allowance for sampling error. Some of the smaller hills and valleys are no doubt easily attributed to sample-to-sample variation.
[16] We used the conventional log link because of the lower boundary of zero and because of the shape of the response surface in Figure 3.

Table III shows the results.[17] To begin, the social desirability index is strongly related to the number of water conservation practices reported. The multiplier of 1.07 means that for every index item endorsed, the number of reported water conservation practices increase by a multiplicative factor of 1.07, or 7%. This implies that if one compared respondents who endorsed none of the index items with respondents who endorsed 4 of the index items (the maximum number in our data), the number of reported water conservation practices would be larger for the latter by a factor of 1.31, or 31% (1.07^4). Insofar as the index is capturing inflated reports because of the social desirability of being 'green', the biases are clearly non-trivial; for the respondents who score 4 on the index, all of the percentages reported in Table I should be reduced by about a third.

For all of the other variables in the table, the signs of the relationships with water conservation practices are consistent with expectations. Home owners are more likely to undertake water conservation, and people with lawns, gardens or pools are as well. There is also a bit of evidence that households with children are more likely to engage in a larger number of water conservation practices, but the multiplier is very small and *t*-value well under 1.0. Likewise, Los Angeles Area residents report fewer water conservation practices, but here too, the multiplier is very small and

TABLE III: Quasi-MLE Poisson regression results for water conservation practices ($N = 632$)[18]

Variable	Multiplier	*t*-value
Social Desirability Index	1.07	3.28
Los Angeles resident	0.96	1.00
Years of education	1.01	1.06
Income more than $60,000	1.11	2.38
Professional occupation	1.11	2.00
Managerial occupation	1.06	0.91
White collar occupation	1.10	1.67
Children at home	1.03	0.83
Own dwelling	1.19	3.76
Have pool	1.06	1.00
Have lawn or garden	1.88	13.85

[17] Consistent with our expectations, the dispersion parameter estimate was less than 1.0 (0.88). This means that had we used conventional Poisson regression with the dispersion parameter constrained to 1.0, our standard errors would have been too large by a factor of 1/0.88.

[18] The omitted category for occupation is blue collar. All *t*-values larger than 1.64 are statistically significant at the 0.05 level for each of the variables except income, where a *t*-value of 1.96 is required. With the exception of income, all of the null hypotheses were one-tailed. We do not like significance tests much nor frequentist statistical inference more generally, but we know of no way to do proper Bayesian inference with a quasi-likelihood function. The product of a prior density and a quasi-likelihood function does not produce a proper posterior density.

the *t*-value well under 1.0 (in absolute value). There seems to be no substantial truth to the claim that San Francisco residents are 'more water conservation minded' than Los Angeles residents.[19]

It is perhaps not surprising to find in Table III that respondents with greater income, more education and higher status jobs are more likely to engage in water conservation practices. But there is also some reason to believe that income, education and occupation may all have distinct effects. Income has a strong positive effect, implying that as practiced, water conservation has costs that higher income households are more able to afford. Education also has a positive effect. The multiplier of 1.01 implies that if one compares respondents with an advanced degree to respondents with only a high school degree, the better educated respondents report 108% of the water conservation practices reported by less well educated respondents.[20] This may mean that for the water conservation activities undertaken by our respondents, information and information processing skills are an asset. Finally, the positive relationship between higher status occupations and water conservation may indirectly tap pro-environmental life styles.

In an effort to better understand how social position affected water conservation practices, we divided the conservation practices into two separate scales: water conservation practices depending on behavioral changes (e.g., turning off the shower when soaping up) and water conservation practices depending on technological change (e.g., installing drip irrigation). We then estimated the parameters for two separate models, otherwise identical to the model underlying Table III.

It was apparent that while the pattern of multipliers was very similar in the two equations, the strength of the relationships differed for some key variables. For the technological change, the multipliers for education, income, home ownership and having a yard or garden were far larger than for behavioral change. For example, the education multiplier for technological change was 1.03 (t-value = 2.26), while for behavioral change the multiplier was 0.99 (t-value = −0.72). Likewise, the income multiplier for technological change was 1.16 (t-value = 2.07), while the income multiplier for behavioral change was 1.06 (t-value = 1.09).

In retrospect, the increased impact of education is not surprising since some of the technology is new and not necessarily widely available. The income effect is reasonable since technological change may require a significant financial investment. The increased impact of home ownership is also sensible since renters may not be able to make physical changes in their dwellings and may also have no long term incentive to do so. The greater impact of having a lawn or garden simply reflects an increase in the number of technical options relative to the number of behavioral options.

[19] The absence of important differences was also apparent when the water conservation variable was regressed on area of residence alone.
[20] The *t*-value, however, is only a little greater than 1.0.

5. Conclusions

It is clear that households in the Los Angeles and Bay areas reduced their water consumption through a variety of mechanisms. Some involved water use inside the home and some involved water use outside the home. Some required changes in behavior and some depended on the purchase of new technology. However, households differed a bit in the mix of strategies employed. In particular, while households with higher socio-economic status were more inclined to adopt a greater number of different water conservation practices, they were especially inclined to take the technological route. But more was involved than just the ability to afford new water saving technology. Education and occupation also weighed in. Education we interpreted as a means to acquire and process the information necessary, while occupation was taken to be a proxy for life style.

We stress, however, that both are only interpretations. We have no direct measures of the information. The problem with life style is conceptual. In particular, one risks the tautology of defining a pro-environmental life style as one in which individuals practice conservation and recycling and then concluding that individuals with pro-environmental life styles are more likely to conserve and recycle. The alternative of defining life style in terms of attitudes would seem to open the door to still worse social desirability artifacts, even assuming that some conceptual clarity could be achieved.

We found little evidence either in bivariate or multivariate analyses for the commonly held belief that compared to Bay Area residents, Los Angeles residents care little about water conservation. What small differences we did find were attributed to a slightly greater tendency in the Bay Area to invest in technological solutions.

Finally, there is a strong empirical relationship between our nonsense social desirability items and reports of water conservation practices. Adjustments based on these items reduced the self-reports by as much as 30%. There is, of course, the deeper question of whether such adjustments are really justified; is the empirical relationship solely a function of social desirability or is at least some of the relationship due to variability in actual water conservation practices? The answer can only be found in data that would allow one to validate the self-reports directly.[21] Nevertheless, our findings are fully consistent with strong social desirability biases, and the implied adjustments are within sensible bounds. At the very least, the findings make clear that taking self-reports of water conservation activity on face value risks serious errors.

What, then, are the next methodological steps? It is important to stress that we have no commitment to the particular nonsense items used. Indeed, we are developing new and better ones for our ongoing research program. Moreover, in other

[21] This would not be easy to do since different kinds of water use would have to be monitored. However, the obstacles are certainly not technical. For example, many drip irrigation systems in use in California control the amount and timing of watering.

research contexts, rather different kinds of nonsense items would be required. Yet, we think a *prima facie* case has been made that material elicited in a telephone interview might be used to adjust potentially inflated self-reports of water conservation practices. We now require that nonsense items such as ours be validated with external data. If one can show that nonsense items permit accurate adjustments for inflated self-reports, the nonsense items may be routinely included in survey instruments and then used to undertake adjustments of self-reports of conservation practices.

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