2012

Water conservation behavior in Australia

Sara Dolnicar
University of Wollongong, s.dolnicar@uq.edu.au

Anna Hurlimann
University of Melbourne

Bettina Grun
Johannes Kepler Universitat Linz, Austria, bettina@uow.edu.au

Publication Details

Dolnicar, S., Hurlimann, A. & Grun, B. (2012). Water Conservation Behavior in Australia. Journal of Environmental Management, 105, 44-52.

Water conservation behavior in Australia

Abstract

Ensuring a nation's long term water supply requires the use of both supply-sided approaches such as water augmentation through water recycling, and demand-sided approaches such as water conservation. Conservation behavior can only be increased if the key drivers of such behavior are understood. The aim of this study is to reveal the main drivers from a comprehensive pool of hypothesized factors. An empirical study was conducted with 3094 Australians. Data was analyzed using multivariate linear regression analysis and decision trees to determine which factors best predict self-reported water conservation behavior. Two key factors emerge: high level of pro-environmental behavior; and pro-actively seeking out information about water. A number of less influential factors are also revealed. Public communication strategy implications are derived.

Keywords

water conservation behavior, regression analysis, decision tree, pro-environmental behavior, information seeking, Australia

Disciplines

Business | Social and Behavioral Sciences

Publication Details

Dolnicar, S., Hurlimann, A. & Grun, B. (2012). Water Conservation Behavior in Australia. Journal of Environmental Management, 105, 44-52.

WATER CONSERVATION BEHAVIOR IN AUSTRALIA

Sara Dolnicar[a*], Anna Hurlimann[b] and Bettina Grün[c]

* Corresponding author

[a] Institute for Innovation in Business and Social Research,
School of Management & Marketing
University of Wollongong, Wollongong, NSW 2522, Australia
Phone: +61 2 4221 3862
Fax: +61 2 4221 4210
sara_dolnicar@uow.edu.au

[b] Faculty of Architecture Building and Planning
The University of Melbourne, Melbourne 3010, Australia
Phone: +61 3 8344 6976
Fax: +61 3 8344 5532
anna.hurlimann@unimelb.edu.au

[c] Institute for Innovation in Business and Social Research and
Department of Applied Statistics
Johannes Kepler Universität Linz, Altenbergerstraße 69, 4040 Linz, Austria
Phone: +43-732 2468-6829
Fax: +43-732 2468-6800
Bettina.Gruen@jku.at

WATER CONSERVATION BEHAVIOR IN AUSTRALIA

Abstract

Ensuring a nation's long term water supply requires the use of both supply-sided approaches such as water augmentation through water recycling, and demand-sided approaches such as water conservation. Conservation behavior can only be increased if the key drivers of such behavior are understood. The aim of this study is to reveal the main drivers from a comprehensive pool of hypothesized factors. An empirical study was conducted with 3094 Australians. Data was analyzed using multivariate linear regression analysis and decision trees to determine which factors best predict self-reported water conservation behavior. Two key factors emerge: high level of pro-environmental behavior; and pro-actively seeking out information about water. A number of less influential factors are also revealed. Public communication strategy implications are derived.

Keywords: water conservation behavior, regression analysis, decision tree, pro-environmental behavior, information seeking, Australia

1. Introduction

The conservation of water resources is a critical component of the effective and environmentally sustainable management of municipal water supplies. It is anticipated that climate change will decrease the reliability of water supplies, due to reductions in rainfall, and the increasing variability of rainfall events (Intergovernmental Panel on Climate Change, 2007). The conservation of water resources will therefore become increasingly imperative.

In Australia many locations felt the impact of changed climatic conditions on water resources: a 12 year drought affected many areas of the State of Victoria in South Eastern Australia. The drought was in line with worst case scenario models for climate change impacts on water resources (Government of Victoria, 2006), leading to mandated restrictions on the use of water for non-essential purposes (such as watering lawns and washing cars). Water restrictions are seen as a short term solution to balance supply and demand. The government has a policy position which seeks to limit restrictions to no more than 5% of the time (Government of Victoria, 2006, p.18). To achieve this aim, and secure the state's supply of water, the Victorian government is currently constructing the largest desalination plant in the southern hemisphere. Concurrently, the government is also encouraging the use of other water sources such as recycled wastewater for non-potable purposes. However, alternative water sources often come at high economic costs and significant greenhouse gas emissions (for a discussion see: Hurlimann, 2007; Schiffler, 2004).

Given the imperative of water conservation for environmental sustainability, efficient municipal water management, and climate change mitigation, it is critical to understand what factors contribute to water conservation behavior. Being aware of these factors will inform water managers, governments and public policy officers of how best to encourage water conserving behaviors, and thus reduce the need to augment existing water supplies. Despite the importance of increasing water conserving behaviors, relatively limited research has been conducted to date (Hurlimann, Dolnicar & Meyer 2009).

This paper seeks to address the gap by testing a comprehensive model of water conservation behavior. Specifically, it responds to calls by authors of previous studies (e.g. Corral-Verdugo & Frias-Armanta, 2006) for studies conducted with larger sample sizes of respondents from geographically diverse regions in order to increase the generalizability of findings. Furthermore, our study contributes by including a comparatively large set of hypothesized explanatory variables.

1.1 Attitudes towards water conservation and water conservation behavior

A significant body of work on factors contributing to positive attitudes towards water conservation exists. Factors include environmental awareness (Dickinson, 2001), information (Bruvold and Smith, 1988; Sah and Heinen, 2001; UNESCAP et al., 2006), being female (Lipchin et al., 2005), having experienced drought (Burton et al., 2007; Kideghesho et al., 2007) and perceived cost benefits (Institute for Sustainable Futures, 2003).

However, it is known that attitudes do not necessarily translate into actual behavior (including: Bagozzi, 1978). A number of studies find the association between positive attitude towards water conservation and actual water conservation behavior to be weak: Miller and Buys' (2008) residential study in Australia's South East Queensland finds that most participants report feeling responsible for water conservation, but this attitude is not reflected in their day-to-day water use behaviors. Similar conclusions are drawn by Aitken, McMahon, Wearing & Finlayson (1994), Watson, Murphy, Kilfoyle & Moore (1999), De Oliver (1999), and Gregory & Di Leo (2003).

Using actual water conservation behavior as a dependent variable is not trivial. Only a limited number of studies have used actual or reported behaviors as the dependent variables.

A review of these studies (see Table 1) indicates that: beliefs regarding human-environment interactions; attitudes about water in general; attitudes about water conservation; information sources; knowledge about water-related issues; social norms relating to water; habits; perception of water crisis and knowledge about climate change, have all been identified as being associated with water conservation. In addition, a number of socio-demographic variables also associated with water conservation have been identified, namely: age; income; education; dwelling type; property value; number of residents in the household; and not owning a garden.

Insert Table 1 here

Other studies have hypothesized, but not empirically tested, other factors which may reduce water consumption. For example, Troy, Holloway and Nissen (2006) find that domestic water consumption in the Australian Capital Territory fell 19% between 2001 and 2004. Reasons hypothesized to have contributed include education programs, a lengthy drought, water restrictions and demand management initiatives.

The main limitation of previous work is that the number of explanatory variables included in the studies tend to be low. Also, many studies rely on small sample sizes, or samples from a limited geographical region; Corral-Verdugo and Frias-Armenta (2006) explicitly state that replication studies with larger and geographically more representative samples are required. We address these limitations in our research described below.

2. Materials and methods

2.1 Fieldwork administration

Data was collected in January 2009 using an Australian permission-based research-only internet panel. In total, 13,884 invitations were sent out, leading to a final sample size of 3094 respondents (22% response rate) of which 1,495 respondents were representative of the Australian population with quotas set for gender, age, state and education level. The remaining 1599 respondents were not representative; instead they were collected from specific locations because of their unique water situations (see Figure 1):

(1) Adelaide – where drinking water is sourced predominantly from the River Murray and water restrictions are common;
(2) Sydney – which has experienced periodic droughts over time;
(3) Brisbane – where a significant drought period in the 2000's provided impetus for a potable recycled water scheme to deliver recycled water to dams if the water storage levels deplete below 40% of capacity;
(4) Melbourne – where after a significant drought period in the 2000's, a large scale desalination plant is being constructed with significant public opposition;
(5) Perth – where significant decreases to inflows into water storages are being experienced and where various water infrastructure projects have been constructed or are currently under construction;
(6) Darwin – a tropical location where no water shortages have been experienced;
(7) The Mallee – a regional area in the State of Victoria which has a very low average rainfall, which experienced a significant drought period in the 2000's; and
(8) Toowoomba – a regional urban centre in the State of Queensland which experienced a significant drought in the 2000's and where the public voted against a potable recycled water system in a referendum.

Insert Figure 1 here

The present study does not require a representative sample because the aim is to identify factors which affect water conservation. Rather, it is critical that there is sufficient discrimination in variables hypothesized to play a role. This is ensured by the way the sample was drawn.

The online data collection allowed controlling for non-response: respondents could not proceed without having completed all questions on a page. As a consequence, missing values due to oversight or unwillingness to answer did not occur.

Respondents have the following socio-demographic characteristics: the mean age is 44 years (standard deviation 16). The youngest respondent is 14 years and the oldest 87 years. About half of the respondents are female (53 percent) and 37 percent have a university degree. Ten percent do not provide their annual income; eight percent state they have an income of less than $20,000. Between 14 and 18 percent of respondents fall into the following income groups: $21,000 to $40,000, $41,000 to $60,000, $60,000-$80,000, $81,000-$100,000 and over $100,000.

2.2 Questionnaire

The behavior of interest (dependent variable) in this study is self-reported past water conservation behavior, which was measured using the 17 items provided in Table 2. The final water conservation variable is a summated score over all 17 binary items. A value of 17 thus indicated the maximum, a value of 0 minimum water conservation behavior. The average is

12.5 (standard deviation 2.8). The survey was accompanied by a preamble advising that "It is very important that you answer all questions honestly, even if you feel that a different answer would appear to be more socially desirable. This is the only way that we can learn how Australians really feel about environmental issues." The aim of this preamble was to facilitate accurate reporting of behavior. Internet surveys have been found to increase honest responses, given that respondents feel more anonymous (Babbie, 2008).

Insert Table 2 here

A number of variables were included as being potentially explanatory of people's stated water conservation behavior. These include variables which have previously been found to influence conservation behavior, and additional factors which the authors hypothesized could potentially contribute:

Environmental attitudes were measured using the 15 item New Ecological Paradigm (NEP) scale (Dunlap, Van Liere, Mertig & Jones, 2000), which, according to Bragg (1996), is the most widely used instrument for measuring environmental attitudes. Response options were Strongly agree (2), Mildly agree (1), Unsure (0), Mildly disagree (-1), and Strongly disagree (-2). Item-level responses were added to the total NEP score.

Environmental concern was measured using six items developed by Berenguer, Corraliza & Martin (2005) for general environmental concern. Five response options were provided. Responses were added to give the overall value for environmental concern.

Altruism was measured using Clarke, Kotchen and Moore's (2003) nine item altruism scale, which is based on Schwartz's (1970; 1977) norm-activation model. Five response options were provided. The total altruism value is the sum over all nine altruism items.

Pro-environmental behavior was a summated value across respondents' answers to the following question: "You will now see a list of behaviors. Please indicate how frequently you carried out each of these behaviors at home in the last year?" Response options were Always (coded as 4), Often (coded as 3), Rarely (coded as 1), Never, and Not applicable (both coded as 0). This list was first used by Dolnicar and Leisch (2008) who compiled it from a number of prior publications on pro-environmental behavior.

A *moral obligation* to behave in an environmentally friendly way has been shown to be a good predictor of pro-environmental behavior. For example, Berenguer et al. (2005) find moral obligation to be the best predictor of pro-environmental behavior, and Dolnicar and Leisch (2008) find moral obligation to be a useful segmentation base to identify subgroups of the population with distinct levels of pro-environmental behavior. We used the following wording for the single item measure: "Do you consider yourself morally obliged to carry out environmentally friendly behaviors?" Respondents answered with Yes (1) or No (0).

Knowledge and perception of (or attitudes to) recycled and desalinated water were measured with 30 items developed by Dolnicar and Schäfer (2006) and subsequently used also in Dolnicar and Schäfer (2009). Respondents answered with Yes (1) or No (0). The final measure was derived by summing across all items.

Active involvement in searching for information about water was measured using a single item asking respondents: "How much effort have you made this year to look for information on water-related issues (water recycling, desalination, water conservation, rain water etc.)?" Respondents had four response options: Absolutely no effort (coded as 0), A small effort (1), A big effort (2), and A huge effort (3). Trumbo and O'Keefe (2005) found information to be a significant factor with regard to explaining conservation behavior. They measured 'information' as a three component variable, two components included 'seeking' and 'attention'.

Previous use of recycled / desalinated water was measured using a single item worded as follows: "Have you ever used recycled water / desalinated water?" Answer options included Yes (1) and No (0).

Experience with water restrictions was measured by asking respondents "Have you ever experienced water restrictions?" Answer options were Yes (1) and No (0).

Perception of being limited by water restrictions was measured by asking "To which extent do you feel limited by water restrictions?" Answer options were: Not at all (0), Slightly (1), and Strongly (2). For analysis, slightly and strongly were collapsed.

People who influence was computed as the sum over 14 items which listed different social sources of influence, e.g. friends, partner, scientist etc. Answer options were Yes (1) and No (0).

Finally, a number of socio-demographic questions were asked covering age, gender, education, size of city, cultural background, feeling of belonging to the region, importance of religion, their relocation intention if water supply could not be assured, whether or not water restrictions in the past have led them to change their behavior, media use in general (to measure 'exposure' to information about water issues – the third component of information measured by Krumbo and O'Keefe 2005), and whether or not they have read, heard, or seen any specific information about water recently.

2.3 Analyses

We conducted two analyses to gain an understanding of the factors that affect water conservation behavior. First we conducted a regression analysis. All of the proposed independent variables were assumed to affect conservation behavior. A multivariate linear regression model was fitted using water conservation behavior as the metric dependent variable. Variables were selected by omitting the variable with the largest *p*-value and then comparing the two nested models – the one including this variable with the one without this variable – using an F-test (backward selection). The selection process was stopped when all *p*-values were larger than a pre-specified significance level of five percent. The final model only contains variables which, if omitted, would significantly reduce the variance explained by the fitted model.

The final model was analyzed with respect to (1) the variables included, (2) the relative importance of each variable selected, and (3) the estimated coefficients for each of the variables. To assess the relative importance of the variables, the "dominance" statistic, C, is used to take into account the direct and indirect effects of the variable on the dependent variable (see Budescu, 1993). The comparison of the dominance values of two variables indicates that the variable with the higher dominance value is more useful in all subset regressions and therefore has a higher relative importance. The linear regression analysis assumes that no interaction effects between the explanatory variables occur and that they influence the dependent variablein the same way regardless of the values of the other explanatory variables.

Decision trees are an alternative model especially designed to detect interaction effects and find groups of respondents with similar levels of conservation behavior (Breiman, Friedman, Olshen & Stone, 1984). This analysis reflects the need to view people as a heterogeneous group, rather than assuming that they all behave in the same way, which was recently highlighted by the findings of Dolnicar and Grün (2008), that environmentally friendly behavior differs both across different groups of people as well as within people across context. Decision trees have the advantage that they (1) account for complicated interactions between variables, (2) are easily interpretable, and (3) inherently perform variable selection. This model is fitted to the data to gain complementary insights into those gained by the regression model, and to verify if neglecting potential interaction effects influences the results and conclusions drawn. Unbiased recursive partitioning (Hothorn, Hornik & Zeileis, 2006) is used as the fitting method for this study's decision tree. The fitting method recursively partitions the data into two subsets using binary splits. Each split is made on the basis of one independent variable and leads to subgroups with similar conservation behaviors. The method is therefore regarded as an a priori (Mazanec, 2000) or commonsense segmentation (Dolnicar, 2004) of the respondents.

Recursive partitioning is an iterative method consisting of the following steps: (1) determining whether or not a splitting variable exists which can improve the model fit and, if so, (2) splitting respondents into sub-groups using this variable. Different recursive partitioning procedures vary in the way they measure the dependency between each explanatory variable and the dependent variable, as well as how the split is made. Unbiased recursive partitioning applies conditional inference procedures for selecting the splitting variable which gives unbiased variable selection results. Alternative procedures have the drawback that variables with many possible splits, or variables with many missing values, are systematically favored (Breiman et al., 1984). In addition, in unbiased recursive partitioning, a natural stopping criterion for the procedure exists: the iterative process stops if the null hypothesis that all explanatory variables are independent of the dependent variable cannot be rejected at the pre-specified significance level of five percent. The considered splits are binary, meaning that each step leads to the division of one sub-group into two new sub-groups.

3. Results and discussion

The regression analysis explains 33 percent of the variance in the dependent variable, conservation behavior. Results are provided in Table 3 including the regression coefficient estimate, the standard error, and the p-value of the t-test if the regression coefficient is significantly different from 0. The variables are ordered by importance. In addition the generalized variance-inflation factors (GVIFs, Fox and Monette, 1992) are provided for each variable. The GVIFs range from 1.0 to 2.0 for all variables included in the final regression model indicating that multi-collinearity is not a problem. The metric variables were standardized before regression analysis and their regression coefficients can be interpreted as change in water conservation behavior if the explanatory variable changes by one standard deviation. For binary variables, the coefficient indicates the change in water conservation behavior if the answer is Yes instead of No. For categorical variables, the baseline category included in the intercept is indicated in parentheses and the estimated coefficients for change in water conservation behavior for the other categories when compared to the base category are given in the table. For example, the water conservation behavior of respondents who state that they watch non-commercial TV channels is 0.36 lower than for respondents who do not watch TV.

Figure 2 contains standardized regression coefficients. All factors that positively affect water conservation behavior plot to the right of the vertical axis and all factors that affect behavior negatively plot to the left. The length of each bar indicates the extent of the effect, which can be interpreted as how much the water conservation behavior changes in standard deviations if the explanatory variable is increased by one standard deviation.

The dominance statistic indicates that general pro-environmental behavior is the best predictor of water conservation behavior, followed by people's active involvement in searching for information about water. Information seeking behavior was included in

Trumbo and O'Keefe's (2005) study which measured 'information' as a three component variable: seeking, exposure and attention. They also found information to be a significant factor with regard to explaining conservation behavior.

Furthermore, water conservation behavior is positively associated with: behavioral change due to water restrictions experienced in the past; previous use of recycled water; considering relocation if there was insufficient water in their area; feeling morally obliged to behave in an environmentally friendly manner; susceptibility to influence from others; not having a university degree; no previous use of desalinated water and not watching TV and/or reading quality newspapers, which were defined as broadsheets distributed nationally.

Insert Table 3 and Figure 2 here

Figure 3 contains results of the recursive partitioning analysis. Recursive partitioning aims to identify which variables best discriminate between segments of the population with different levels of conservation behavior. These variables are shown as ellipses at the top part of the chart. The final segments are shown at the bottom of Figure 3. As can be seen, respondents have been split into 15 segments. Each of the segment plots at the bottom of Figure 3 shows the distribution of water conservation behavior among members of this segment. For example, Segment 1 on the far left, has a very low average level of water conservation (6.4 on a scale of 17), as opposed to Segment 15 on the far right (14.6). The recursive partition model explains 33 percent of the variance. The numbers of respondents in each segment are, from left to right, 44, 23, 101, 262, 112, 165, 100, 473, 505, 263, 194, 316, 127, 43, and 366.

The top section of Figure 3 provides insight into which variables best discriminate between those segments. As can be seen, pro-environmental behavior again emerges as the most crucial explanatory variable. The top three splits all use this variable and separate out those people with high (to the very right) and low (to the very left) water conservation behavior scores.

Insert Figure 3 here

Among those respondents who demonstrate a very low level of pro-environmental behavior (segments along the left branch), having made little effort in seeking out information best describes the group with the lowest level of water conservation behavior. The group with the highest level of conservation behavior is defined only by the variable of pro-environmental behavior; no additional variables contribute to a further splitting of this group. Other variables identified as discriminating between high and low conservation behavior levels in the intermediate segments include: effort undertaken to search for water information, extent of behavioral change due to water restrictions, and previous experience with recycled water use. In addition, previous experience with water restrictions, as well as the feeling of being limited by water restrictions, both emerge as good discriminating variables in this model. Several variables included in the regression model, but with a rather small influence, are not present in the decision tree. Of those variables not included in the decision tree, only moral obligation emerges as an important factor in the regression model. However, the proportion of respondents feeling morally obliged differs significantly over the segments, as indicated by a χ^2-test (Deviance difference = 439, df = 14, p-value < 0.001).

Respondents assigned to segments in the right part of the tree are more likely to feel morally obliged whereas the respondents in Segment 1 in the far left of the tree feel the least morally obliged to behave in an environmentally friendly way.

Because recursive partitioning accounts for interaction effects between explanatory variables the decision tree allows checking (1) if the additivity assumption of the main effects of the explanatory variables in the regression is justified and (2) if some variables have a different effect depending on other variables. The repeated inclusion of the variable pro-environmental behavior indicates that the decision tree aims at approximating the linear relationship between this variable and the dependent variable using a step function. This means that the decision tree confirms the linear relationship between these two variables. In addition the decision tree also indicates that for respondents who already have a very high level of pro-environmental behavior no other variable is able to increase the water conservation behavior. This indicates that the additivity assumption of the different explanatory variables does only hold for respondents who do not have an extremely positive pro-environmental behavior.

4. Conclusions

The aim of this research was to conduct a comprehensive empirical study that would contribute to our understanding of the relative impact of different factors on people's (self-reported past) water conservation behavior. We tested some explanatory variables which had been shown in previous research to positively influence water conservation behavior. These variable included: information (Dziegielewski, 1991; Watson et al., 1999; Hills et al., 2002; Trumbo and O'Keefe, 2005); environmental attitudes measured using the New Ecological Paradigm (Corral-Verdugo et al., 2003, 2006); and a range of demographic variables including age (Clark and Finley, 2007; Miller and Buys, 2008); and education (Clark and

Finley, 2007). Additionally, we went beyond existing empirical research regarding water conservation behaviors to include possible explanatory variables which had not yet been tested.

A number of factors are strongly related to water conservation behavior, with the strongest predictors of (self-reported) water conservation behavior being:

(1) General pro-environmental behavior. Water conservation is strongly related to pro-environmental behavior; people are likely to engage in water conservation behavior because they are interested in protecting the environment in general or conserving limited natural resources. People who conserve water not only behave in an environmentally friendly way, they also tend to feel morally obliged to behave in this way.

(2) Efforts made to find information about water related matters. The fact that those who conserve water also make a significantly greater effort to find information about water indicates that they are proactively interested in water-related matters. They seek out information and are likely to base their behavior on the information obtained.

While these two findings are very robust, they are not of particular practical use since people who are already conscious about environmental issues and actively seek out water related information do not need to be convinced in public information campaigns that they should conserve more water. The only public policy implication that can be derived from the above findings is that efforts should be made to increase the general level of environmental awareness among the population.

Nonetheless, a number of other factors have emerged from this study as being significantly associated with water conservation behavior. Some of these are very suitable for informing the development of public information campaigns to increase water conservation, specifically: previous experience of water restrictions; being limited by water restrictions;

and past changes in behavior due to water restrictions. These factors all lead to increased water conservation behavior. A clear communication strategy can be derived from these findings. Namely, messages should make the population aware of the negative personal consequences they will experience in the case of insufficient water supplies, and should also show people how, through communal efforts, they can avoid such consequences.

The significant association between media usage and water conservation behavior which was revealed by the regression analysis also leads to practical recommendations about which communication channels should and should not be used to communicate messages. Since people who already engage in water conservation behaviors tend to watch less TV and read more newspapers, TV would be a good communication channel for reaching those whose water conservation behaviors could be improved. Newspapers are not a good choice except if they are local newspapers, which tend to be read more by people with low levels of water conservation behavior.

The main contribution of the present study was to simultaneously test for a wide range of factors which may explain stated water conservation behavior. This has led to novel insights, including the identification of factors which have only low potential to be useful in public information campaigns which aim to increase water conservation behavior. Conversely, insights have also been made in regards to identifying communication messages and strategies most likely to attract the attention of the Australian population to encourage water conservation behaviors. These may also be applicable to other developed nations. As demonstrated in the introduction to this paper, achieving increased water conservation is critical to ensuring the sustainable management of water resources and is particularly paramount in light of changing climatic conditions.

The present study uses the predominant measure applied in the past in water conservation studies, namely self-reported water conservation behavior (see Table 1). Future work replicating this and other water conservation behavior studies with an actual behavior measure as dependent variable, as opposed to the self-reported past behavior measure which has been shown by Hamilton (1985) to be somewhat biased, is recommended.

Acknowledgements

This study was funded through Australian Research Council (ARC) Discovery Grant DP0878338 and Austrian Science Fund (FWF) Elise-Richter Grant V170-N18. We thank Hannah Kelly and Angelique Kelly for research assistance provided, and Rob Hood for his assistance with producing Figure 1.

References

Aitken, C., McMahon, T.A., Wearing, A.J., Finlayson, B.L., 1994. Residential water use: Predicting and reducing consumption. Journal of Applied Social Psychology, 24, 136-158.

Ajzen, I., 1985. From intentions to actions: A theory of planned behaviour. In J. Kuhl and J. Beckman, (Eds.), Action-Control: From Cognition to Behaviour. Heidelberg: Springer, pp. 11-39.

Babbie, E., 2008. The basics of social research. Belmont, California: Wadsworth Publishing.

Bagozzi, R.P., 1978. The construct validity of the affective, behavioral and cognitive components of attitude by analysis of covariance structures. Multivariate Behavioral Research, 13, 9-31.

Berenguer, J., Corraliza, J.A., Martin, R., 2005. Rural-urban differences in environmental concern, attitudes, and actions. European Journal of Psychological Assessment, 21, 128-138.

Bragg, E.A., 1996. Towards ecological self: deep ecology meets constructionist self-theory. Journal of Environmental Psychology, 16, 93-108.

Breiman, L., Friedman, J., Olshen, R.A., Stone, C.J., 1984. Classification and regression trees. Monterey, California: Wadsworth & Brooks/Cole Advanced Books & Software.

Bruvold, W.H., Smith, B.R., 1988. Developing and assessing a model of residential water conservation. Water Resources Bulletin, 24, 661-669.

Budescu, D.V., 1993. Dominance analysis: A new approach to the problem of relative importance of predictors in multiple regression. Psychological Bulletin, 114, 542-551.

Burton, M., Marsh, S., Patterson, J., 2007. Community attitudes towards water management in the Moore Catchment, Western Australia. Agricultural Systems, 92, 157-178.

Clarke, C. F., Kotchen, M. J., Moore, M. R., 2003. Internal and external influences on pro-environmental behavior: Participation in a green electricity program. Journal of Environmental Psychology, 23, 237-246.

Corral-Verdugo, V., Bechtel, R. B., Fraijo-Sing, B., 2003. Environmental beliefs and water conservation: An empirical study. Journal of Environmental Psychology, 23, 247-257.

Corral-Verdugo, V., Frias-Armenta, M., 2006. Personal normative beliefs, antisocial behavior, and residential water conservation. Environment and Behavior, 38, 406-421.

De Oliver, M., 1999. Attitudes and inaction: A case study of the manifest demographics of urban water conservation. Environment and Behavior, 31, 372-394.

Dickinson, K., 2001. Urban water conservation: Consumer attitude, environmental policy tools and the implications for sustainable development. Melbourne, Australia: University of Melbourne.

Dolnicar, S., 2004. Beyond 'commonsense segmentation' – a systematics of segmentation approaches in tourism. Journal of Travel Research, 42, 244-250.

Dolnicar S., Grün, B., 2008. Environmentally friendly behavior – can heterogeneity among individuals and contexts / environments be harvested for improved sustainable management? Environment and Behavior, 41, 693-714.

Dolnicar, S., Schäfer, A. I., 2006. Public perception of desalinated versus recycled water in Australia. In Proceedings of the 1st Annual Desalination Symposium, Honolulu Hawaii, 7-9th May 2006. Denver: American Water Works Association.

Dolnicar, S., Schäfer, A. I., 2009. Desalinated versus recycled water: Public perceptions and profiles of the accepters. Journal of Environmental Management, 90, 888-900.

Dolnicar, S., Leisch, F., 2008. An investigation of tourists' patterns of obligation to protect the environment. Journal of Travel Research, 46, 381-391.

Dunlap, R. E., Van Liere, K. D., Mertig, A. G., Jones, R. E., 2000. Measuring endorsement of the New Ecological Paradigm: A revised NEP scale. Journal of Social Issues, 56, 425-442.

Dziegielewski, B., 1991. “The drought is real”: Designing a successful water conservation campaign. In Proceedings of the International Seminar on Efficient Use of Water, Mexico City, October 1991. Mexico: International Water Research Association.

Fox, J., Monette, G., 1992. Generalized Collinearity Diagnostics. Journal of the American Statistical Association, 87, 178-183.

Government of Victoria, 2006. Sustainable water strategy: Central Region action to 2055. Melbourne, Australia: Department of Sustainability and Environment.

Gregory, G. D., Di Leo, M., 2003. Repeated behavior and environmental psychology: The role of personal involvement and habit formation in explaining water consumption. Journal of Applied Social Psychology, 33, 1261-1296.

Hamilton, L. C., 1985. Self-reported and actual savings in a water conservation campaign. Environment and Behavior, 17, 315-326.

Hothorn, T., Hornik, K., Zeileis, A., 2006. Unbiased recursive partitioning: A conditional inference framework. Journal of Computational and Graphical Statistics, 15, 651-674.

Hurlimann, A., 2007. Time for a water re-'vision'. Australasian Journal of Environmental Management, 14, 11-18.

Hurlimann, A., and Dolnicar, S., 2011. Voluntary relocation - an exploration of Australian attitudes in the context of drought, recycled and desalinated water. Global Environmental Change, 21, 1084-1094.

Hurlimann, A., Dolnicar, S., Meyer, P., 2009. Understanding behaviour to inform water supply management in developed nations - A review of Literature, conceptual model and research agenda. Journal of Environmental Management, 91, 47-56.

Institute for Sustainable Futures, 2003. Urban water demand forecasting and demand management: research needs review and recommendations. Melbourne, Australia: Institute for Sustainable Futures, and University of Technology, Sydney.

Intergovernmental Panel on Climate Change, 2007. Climate change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Intergovernmental Panel on Climate Change.

Kideghesho, J. R., Roskaft, E., Kaltenborn, B. P., 2007. Factors influencing conservation attitudes of local people in Western Serengeti, Tanzania. Biodiversity and Conservation, 16, 2213-2230.

Lipchin, C. D., Antonius, R., Roishmawi, K., Afanah, A., Orthofer, R., Trottier, J., 2005. Public perceptions and attitudes towards the declining water level of the Dead Sea Basin: A multi-cultural analysis. In S. Schoenfeld (Ed.), Palestinian and Israeli environmental narratives. Toronto: Centre for International and Security Studies, York University.

Mazanec, J. A., 2000. Market segmentation. In J. Jafari (Ed.), Encyclopedia of Tourism (pp. 125-126). London: Routledge.

Miller, E., Buys, L., 2008. The impact of social capital on residential-affecting behaviours in a drought-prone Australian community. Society & Natural Resources, 21, 244-257.

Russell, S., Fielding, K., 2010. “Water demand management research: a psychological perspective” Water Resources Research, 46, WO5302.

Sah, J. P., Heinen, J. T., 2001. Wetland resource use and conservation attitudes among indigenous and migrant peoples in Ghodaghodi Lake area, Nepal. Environmental Conservation, 28, 345-365.

Schiffler, M., 2004. Perspectives and challenges for desalination in the 21st century. Desalination, 165, 1-9.

Schwartz, S. H., 1970. Elicitation of moral obligation and self-sacrificing behavior. Journal of Personality and Social Psychology, 15, 283-293.

Schwartz, S. H., 1979. Normative influences on altruism. In L. Berkowitz (Ed.), Advances in experimental social psychology (Vol. 10, pp. 221-279). New York: Academic Press.

Troy, P., Holloway, D., Nissen, K., 2006. Domestic water consumption in the ACT. Canberra: Australian National University College of Science.

Trumbo, C. W., & O'Keefe, G. J., 2005. Intention to conserve water: Environmental values, reasoned action, and information effects across time. Society & Natural Resources, 18, 573-585.

UNESCAP, UNESCO, and Tehran Province and Tehran City Water and Wastewater Companies, 2006. Tehran water conservation demonstration project at the Nasim residential complex. Retrieved June 15, 2010 from http://www.unescap.org/esd/water/conservation/2005/Brochure.pdf.

Watson, R., Murphy, M., Kilfoyle, F., Moore, S., 1999. An opportunistic field experiment in community water conservation. Population and Environment, 20, 545-560.

Table 1: Factors found to influence water conservation behaviors in select past research

Factor which positively influences water conservation	Study	Behavior measurement A= actual; S = self-reported; E = estimated; I = stated intention	Format tested S = single variable; M = multiple variable
Involvement in water consumption decisions	Gregory & Di Leo (2003)	A	M
Information	Trumbo & O'Keefe (2005)	S	M
	Dziegielewski (1991)	S	S
	Watson et al. (1999)	S	M
	Hills et al. (2002)	A	S
Positive attitude to water conservation	Syme et al. (2004)	E	M
	Murphy et al. (1991)	S	M
	Moore et al. (1994)	S	M
	Cameron and Wright (1990)	S	M
Ecological beliefs about water (e.g. is a limited resource – using the New Ecological Paradigm Scale)	Corral-Verdugo et al. (2003)	S	M
	Corral-Verdugo et al. (2006)	S	M
Media interventions	Moore et al. (1994)	S	M
Behavioral intention	Murphy et al. (1991)	S	M
	Watson et al. (1999)	S	M
	Moore et al. (1994)	S	M
Knowledge of water conservation related issues	Murphy et al. (1991)	S	M
	Gregory & Di Leo (2003)	A	M
	Moore et al. (1994)	S	M
	Hamilton (1985)	A	S
Social norms regarding water conservation	Trumbo & O'Keefe (2005)	S	M
	Corral-Verdugo et al. (2003)	S	M
	Corral-Verdugo et al. (2006)	S	M
	Lam (1999)	I	M
	Clark and Finley (2007)	I	M
Beliefs regarding human-environment interactions	Corral-Verdugo et al. (2008)	S	M
Perception / concern of / about water crisis / drought	Bruvold (1979)	S	M
	Lam (2006)	S	M
	Clark and Finley (2007)	I	M
Awareness about climate change	Clark and Finley (2007)	I	M
Habits: fostering low water use	Gregory & Di Leo (2003)	A	M
DEMOGRAPHIC FACTORS			
Age: older respondents	Miller & Buys (2008)	S	M
	Clark and Finley (2007)		
Income: lower income respondents	Miller & Buys (2008)	S	M
	Gregory & Di Leo (2003)	A	M
	Corral-Verdugo et al. (2003)	S	M
Education: lower	Clark and Finley (2007)	I	M
Not owning a garden	Clark and Finley (2007)	I	M

Living in a detached dwelling	Miller & Buys (2008)	S	M
	Clark and Finley (2007)	I	M
Net annual property value (negative)	Aitken et al. (1991)	A	M
	Aitken et al. (1994)	A	M
Number of residents per household (negative)	Aitken et al. (1991)	A	M
	Aitken et al. (1994)	A	M

Note: references included in the table are not in the reference list. They are included in the supplementary material available online.

Table 2: Water conservation items used to construct the dependent variable (water conservation behavior)

I collect water from shower/sink/bath for use elsewhere
I take shorter showers
I make sure that taps do not drip
I strictly adhere to water restrictions
I collect water when it rains (not in a rainwater tank)
I have a dual flush toilet
I rarely water the garden
I recycle grey water from the washing machine for garden / outdoor use
I recycle grey water from the shower for garden / outdoor use
I minimize toilet flushing where possible
I use water efficient showerheads
I use water efficient taps
I only use the washing machine when it is full
I only use the dishwasher when it is full
I do not wash my car with water
I use minimal water for cleaning
I do not hose my driveway

Table 3: Summary of the final linear regression model including information on the dominance C and the generalized VIF (GVIF) for each variable and the regression coefficient estimates (Estimate) with corresponding standard errors (Std.Error) and *p*-values of *t*-tests.

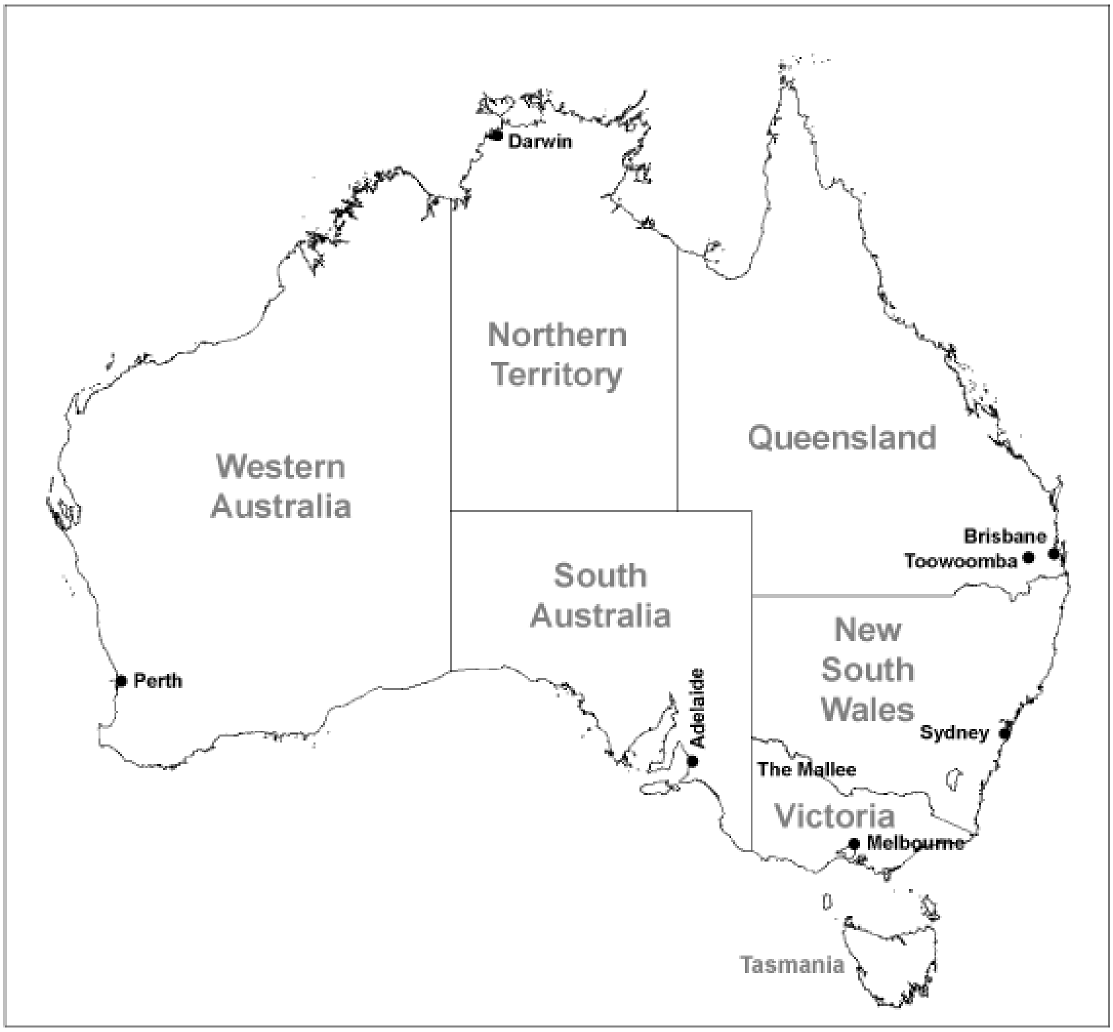
	Dominance C (%)	GVIF	Estimate	Std. Error	*p*-value
Intercept	–	-	12.14	0.43	< 0.001
Pro-environmental behavior (Stronger)	58.2	1.5	1.19	0.05	< 0.001
Active involvement in searching for information about water (Higher)	19.2	1.3	0.39	0.05	< 0.001
Moral obligation	7.3	1.2			
– Yes			0.34	0.13	0.007
Behavioral change due to water restrictions	6.3	1.0			
– Yes			0.79	0.12	< 0.001
Previous use of recycled water	3.5	1.1			
– Yes			0.38	0.09	< 0.001
Extent of influence of others (Stronger)	1.8	1.1	0.08	0.04	0.046
Likelihood of relocation (Higher)	1.3	1.0	0.12	0.04	0.003
Education level	0.9	1.1			
– University degree			-0.35	0.09	< 0.001
Previous use of desalinated water	0.8	1.1			
– Yes			-0.53	0.12	< 0.001
Watch TV (Don't watch)	0.4	1.1			
– Private / commercial			-0.36	0.41	0.370
– State / non-commercial			-0.65	0.41	0.117
Read Newspaper (Quality)	0.4	1.1			
– Local			-0.21	0.09	0.015
– None			-0.05	0.18	0.773

Explained variance: $R^2 = 0.33$

Watch TV: Respondents indicated if (1) they don't watch TV or their favorite TV channel is (2) a private / commercial channel or (3) a state / non-commercial channel.

Read Newspaper: Respondents indicated if their favorite newspaper is (1) a quality newspaper or (2) a local newspaper or (3) if they do not read newspapers.

Figure 1: Map of Australia indicating the locations of study



Source: Hurlimann and Dolnicar (2011). Reproduced by permission of Global Environmental Change, Elsevier

Figure 2: Standardized regression coefficients for the water conservation behavior model

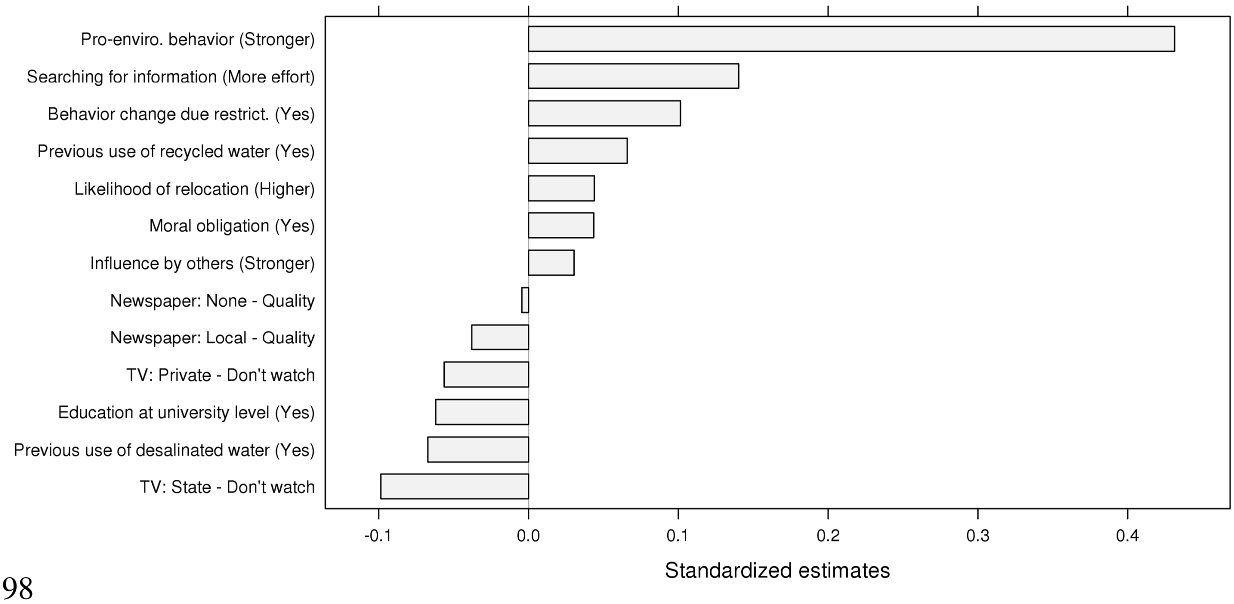
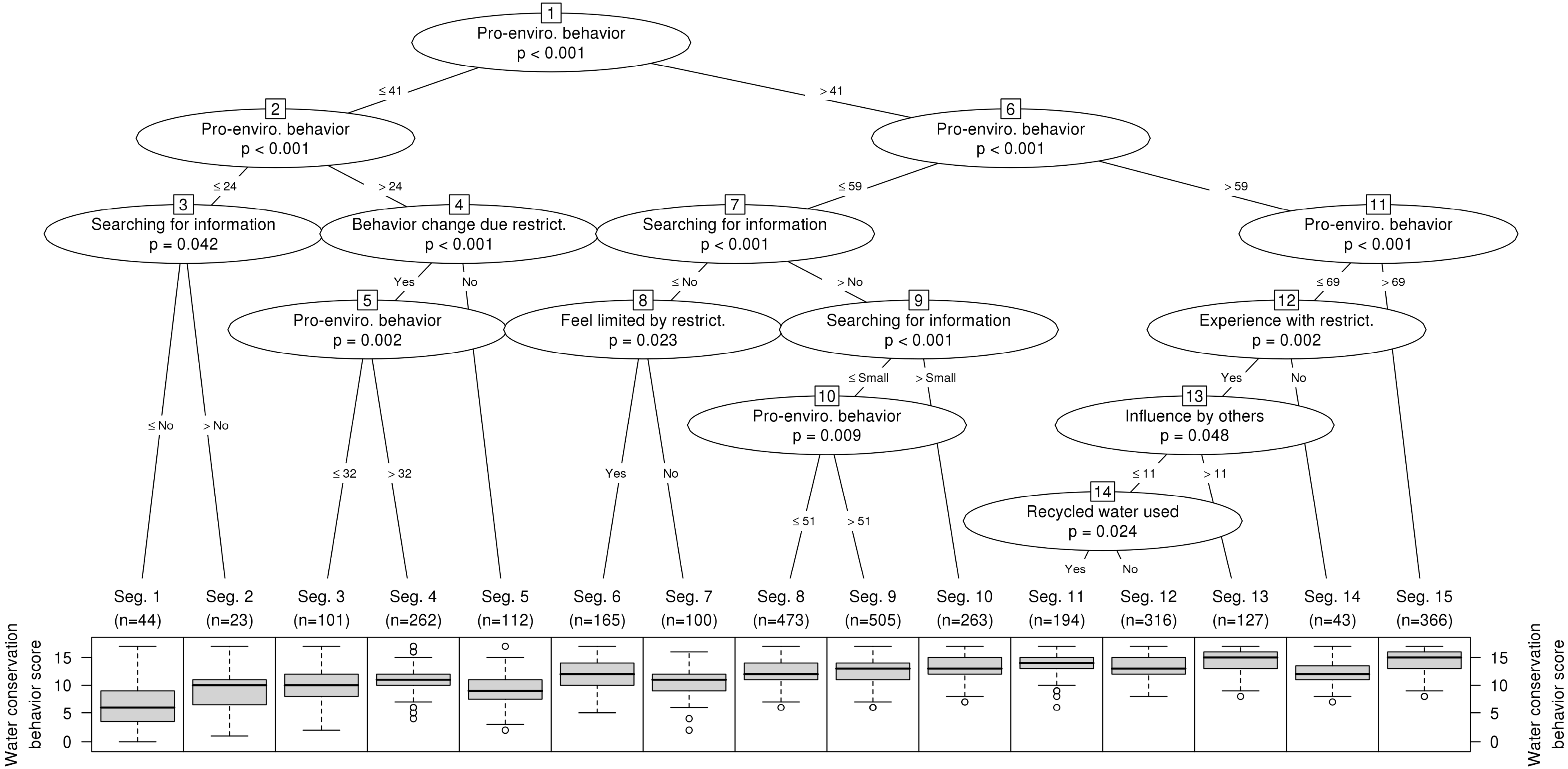


Figure 3: Recursive partitioning results for water conservation behavior



Low water conservation High water conservation

Explained variance: 0.33