Water Does Not flow Up Hill: Determinants Of Willingness To Pay For Water Conservation Measures In The Mountains Of Western North Carolina

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Abstract

Even in historically water-rich areas, population growth and drought put pressure on water supplies. Understanding public attitudes about water management and, especially water conservation, may become increasingly salient as even humid regions attempt to shift to demand side management. Using the contingent valuation method we estimate the willingness to pay for water conservation measures. Our analysis finds that younger individuals, individuals with higher education and higher income are more likely to say they are willing to pay for these measures. We also find that valuations depend on how the water source is managed. People who are on municipal water or a shared well are willing to pay more for public water conservation measures than individuals who have their own well or access to a spring. In addition we find that older individuals and respondents who have ancestors in the area are less willing to pay for water conservation methods. Lastly, using bivariate probit analysis that focuses on averting behavior and our contingent valuation question, we find that there are some unmeasured characteristics of respondents that make them more likely to participate in private averting behavior and increase their willingness to pay for public water conservation measures.

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"We never know the worth of water till the well is dry" – Thomas Fuller, Gnomologia, 1732

1. Introduction

With an average of 50 inches of rain per year and several feet of snow, water quantity concerns may seem unfounded in the mountains of western North Carolina. Increasing population coupled with recent droughts, however, has put pressure on regional water supplies. Several counties throughout western North Carolina experienced double-digit growth rates between 2000 and 2010, and droughts in 2002–2003, 2007–2008, and 2010 temporarily reduced the available supply throughout the region. In 2007, towns in the region enforced drought measures. For example, in Blowing Rock (pop 1200) in Watauga County, restaurants were required to use disposable tableware to avoid running dishwashers. To effectively deal with these stresses on water supply new policies and practices have been initiated, prompted by both state mandates and local pressure. One response has been to seek new supply sources. Throughout the region several towns have either secured a new source since the 2007 drought or are in the process of obtaining a new source. Municipalities have also implemented conservation programs. For example, Boone (pop 17,000)[1], the largest town in the study area, began its "Every Drop Counts" program in 2005, which includes offering free water-conserving showerheads and water leak audits. In 2011, the town implemented a toilet rebate program to reimburse businesses and home-owners who replaced high water use toilets with models that use less water.

The growing demand for water in western North Carolina and potential for drought suggests it is important to understand the extent to which residents support water conservation efforts. A 2011 survey in the U.S. of state conservation measures revealed that all states have room for improvement, and North Carolina specifically was granted a 'C' for its conservation efforts (Christiansen et al., 2012). North Carolina is a humid state and conservation has not been a priority; however, there is growing recognition among

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[1] In addition to approximately 16,000 students attending university.

scholars that the past is not a prologue for the future (Milly et al., 2008). Even in humid regions that have historically had ample water supplies, demand side management (e.g. conserving and improving efficiency) offers a more cost-effective approach than seeking new water supplies (supply side management) and must be part of any water management portfolio (Hoffner, 2008; Butler and Memon, 2005).

In our project, we developed survey questions to ascertain self-reported conservation behaviors as well as a contingent valuation scenario to assess willingness to pay for household and public water conservation measures. The contingent valuation scenario was based on conservation measures that could be included in a holistic demand side management strategy; they also represent practices that have been promoted in this region and so are familiar to the general public. Our survey area covers Ashe and Watauga counties in northwestern North Carolina. These counties offer insights into a rural, but growing area[2] where a large proportion of the population relies on individual wells or springs as their water source. These counties also offer a comparative look at public attitudes conditional on water source as Watauga County has a greater proportion of its population served by a municipal supply than Ashe County. Furthermore, regional studies are highly relevant for assessing attitudes about water management and conservation because much water management, especially in humid regions that rely on riparian management systems, happens at the household and local government level rather than at the state or national level.

Our two primary objectives in this paper are (i) to use the contingent valuation (CV) method to estimate households' willingness to pay for publically funded conservation efforts that would be paid for via a one-time tax and (ii) to compare conservation behaviors of households who use different water sources (i.e., municipal, individual well, spring, or shared well). Section 2 discusses the related literature; Section 3 describes our survey and provides descriptive data from the sample; Section 4 discusses households' private conservation (or averting) behaviors; Sections 5 and 6 discuss the contingent valuation scenario and results, and Section 7 provides conclusions.

2. Related literature

Policy makers promoting residential demand side management can benefit from better understanding public attitudes and behavior regarding conservation and technological efficiency. This includes understanding household valuations of specific water supply management approaches. The CV method has long been used in assessing water-related concerns. Early CV research linked the requirements of the Clean Water Act with water recreation (Binkley and Hanemann, 1978; Carson and Mitchell, 1993). There is a subsequent body of work associating river health and drinking water quality (Desvousges, Smith, and Fisher, 1987; Bliem and Getzner, 2012). The Safe Drinking Water Act prompted use of CV studies to meet cost-benefit analysis requirements (Whitehead and Van Houten, 1997), and there has been some attention to protecting groundwater that serves drinking water supplies (Crocker, Forster, and Shogren, 1991). In high-income countries, however, there has been little assessment of willingness to pay (WTP) for water delivered to a household, likely because regulations ensure a high quality household water supply. The available research does show that individuals who perceive that they do have high quality drinking water have a lower WTP to improve the quality (Tanellari et al., 2015; Beaumais et al., 2014). There has been growing attention to linking risk perception about drinking water quality, especially related to specific contaminants, and WTP to address those perceived risks. As might be expected, higher perceived risk is tied to higher WTP for clean-up or improvements in the water supply infrastructure (Tanellari et al., 2015).

More relevant to our focus on water quantity, there is a growing body of literature on WTP and water security, including developing resilience during drought conditions. Hensher, Shore, and Train (2006) illustrate that households' willingness to pay for reliability may depend on the 'historical context and expectations of shortages'. Their survey employs stated choice experiments using households in Canberra, Australia at a time when the area was experiencing mandatory restrictions. They found that WTP to avoid moderate water restrictions was not very high because people perceived the restrictions to be a reasonable method to reduce wasteful water use. Respondents viewed restrictions that allowed for some daily (or every other day) watering or that were in place for short periods as statistically equivalent to no restrictions. Households were willing to pay to avoid more serious restrictions, however. The Canberra study found households would pay approximately 31% of their annual water bill to go from a high level of restriction (e.g. banning most outdoor water use) to no restrictions. Households were also willing to pay to reduce restrictions from once every 10 years to once every 20. A similar study of Aurora, Colorado households found a higher willingness to pay based on a CV survey to reduce restrictions from one in 10 years to one in 30 years (Howe and Smith, 1994).

In putting the CV/WTP literature into context with general attitudinal research about water quantity (i.e., supply security or reliability) as opposed to quality, we find that in the US, studies are more prevalent in western states (e.g., Griffin and Mjelde, 2000; Howe and Smith, 1994; Salvaggio et al., 2014) than in the southeast. In general, there is a dearth of information relevant to public attitudes about water quantity concerns and conservation behavior in humid climates. In separate studies, Florida and Georgia residents were found to be more concerned with water quality than water quantity (Lamm, 2013; Responsive Management, 2003). Furthermore, Georgia residents perceived conservation to be salient only when it is directly tied to localized, community issues (Responsive Management, 2003). Even following the 2007 drought, Evans et al. (2011) found that the Georgia public was divided on whether they felt water quantity was a problem for their community.

In other regions, studies have shown that behavior related to conservation is complex and a variety of factors motivate people to conserve (e.g., attempting to stem a perceived environmental threat, participating in socially desirable behavior, and responding to price changes) or not conserve (e.g. exercising a perceived right to use as much water as desired) (Gilg and Barr, 2006). Renwick and Archibald (1998) looked at the distributional effects of price and non-price demand side management policies in Santa Barbara County, California during drought conditions and showed that demand reduction associated with management policies depends on household attributes including income and lot size (i.e., landscaping). Pricing policies impacted low income households more than high income households, while quantity targets had a larger impact in lower density areas where more landscaped area was maintained. Renwick and Archibald (1998) note the importance of understanding the composition (socioeconomic and structural/technological) of households to predict the quantitative and distributional impacts of demand side management policies.

Our research demonstrates the additional importance of understanding the effect of water source on households' attitudes and willingness to support demand side management as a conservation method. Our CV scenario differs from previous literature related to water quantity in that it is directly related to demand side conservation as opposed to improving reliability (which typically involves supply side measures) or avoiding water restrictions.

[2] Using Census data, NC's population grew approximately 18% between 2000 and 2010. Ashe County grew at a more modest 12%, but Watauga's population grew almost 20%.

Table 1
Survey data with relevant Watauga and Ashe population data.

	Sample mean or %	Standard deviation	Watauga county	Ashe county
Income	61,890	40,670	53,048	47,902
Age	61.19	14.68	43[a]	52[a]
White	97	–	95	97
Female	43	–	50	51
Years of education	15.11	3.18	14.06	12.72
Home owner	92	–	55	78
Missing income dummy	9	–	.	.
Ashe resident	49	–	.	.
Ancestor	50	–	.	.
City water	17	–	36	19
Shared well	19	–	64	81
Spring	12	–		
Individual well	52	–		

Watauga and Ashe population data are from the 2010 and 2013 Census.
[a] Authors' calculation of the group mean of all ages greater than 20 using 2010 Census data.

Table 2A
Private averting behaviors.

Question	%Yes	%No	%Don't know
Do you have low-flow toilets in your home? ($n = 699$)	59	31	10
Do you have water saving showerheads in your home? ($n = 700$)	63	27	10
Do you have low-flow faucet aerators in your home? ($n = 701$)	41	41	18
Do you have a front-loading Energy Star washing machine? ($n = 696$)*	30	65	5
Does your household use an efficient Energy Star dishwasher? ($n = 616$)**	50	40	10
Do you only use your washing machine for full loads? ($n = 692$)	78	20	2
Do you only use your dishwasher for full loads? ($n = 598$)	84	13	3
Do you have a rainwater collection system such as a cistern or rain barrel? ($n = 699$)	9	86	5

* 6 report they do not have a washing machine.
** 85 report they do not have a dishwasher.

3. Survey methodology and sample representativeness

The survey of 51 questions, including demographic questions, was mailed in May 2013 to a random sample of 3000 Watauga and Ashe County residents.[3] The random sample of households was purchased from Survey Sampling International.[4] Our survey method consisted of a primary mailing, a post card reminder and a second mailing to all non-respondents of the first mailing.[5] In the end, 2413 useable addresses and 714 responses were obtained for a response rate of 34%. Due to the response rate our sample could suffer from sample selection or non-response bias (Whitehead, Groothuis, and Blomquist, 1993). To address non-response bias we use sample weights to correct for both oversampling of older respondents and undersampling of young respondents.[6]

Table 1 contains a summary of our non-weighted survey variables. The average age of respondents was 61 years, average income was $62,000, and the average years of education was 15.1. Comparing our sample to US Census data from the counties, we find that about 19% of Watauga County residents and 29% of Ashe County residents are 60 or older;[7] the average years of education is 14.1 in Watauga County and 13.5 in Ashe County; the average household income is about $53,000 in Watauga County and about $48,000 in Ashe County. Therefore, our respondents tend to be older, slightly more educated, and have higher income than the general population in this area.

Half of the respondents report having ancestors who live or lived in this region. Almost all (97%) of respondents report their race as white and 92% own their homes. As shown in Table 1, the racial composition of our sample is consistent with the population, but the sample over-represents homeowners. Regarding water source, 52% report having their own well, 12% their own spring, 19% a shared well and 17% are on a municipal water supply. In Watauga and Ashe Counties, 36% and 19%, respectively, of the population is actually served by a municipal supply with the rest having access to a private source of some kind (Kenney et al., 2009; HCCOG, 2010). The available data do not further delineate private sources into springs and individual or shared wells.

4. Self-reported conservation behavior

To understand individuals' private conservation (i.e., averting behavior) we asked respondents about the water fixtures in their home. Since 1992 U.S. federal regulations have required that toilets use no more than 1.6 gal (6.1 l) per flush,[8] showerheads 2.2 gal (8.3 l) per minute, and faucets 2.5 gal (9.5 l) per minute. These are generically referred to as "low-flow" fixtures. Unless homeowners have intentionally replaced them, older residences have much higher water use fixtures. For example, toilets manufactured prior to 1980 use 5–7 gal (19–26 l) per single flush. The survey, therefore asked respondents if they have low flow toilets, shower heads, and faucet aerators in their homes. In addition we asked whether respondents have Energy Star dishwashers and front-loading washing machines and if they use these appliances only for full loads. Energy Star is a voluntary labeling program that tells consumers a particular appliance is more energy/water efficient than a traditional model. For example, a clothes washing machine with the Energy Star label means that the machine uses 13 gal (49 l) of water per load (or less) compared to the 23 gal (87 l) per load a standard washing machine uses. Using appliances only when full is advice given throughout the U.S. to promote water conservation. Table 2A shows that most respondents say they do have water saving devices and practice conservation behavior. Importantly, 92% of our respondents own their homes, lowering the risk that ignorance about fixtures/appliances is reflected in the responses. While self-reported behavior and actual behavior may differ, these results still reflect awareness that individual conservation measures are important and/or desirable.

Table 2B further divides these results by water source. We find that individuals on municipal water are slightly less likely to have low flow toilets, water saving shower heads or low flow faucet aerators compared to individuals with other sources of water. Individuals with shared wells are the most likely to have Energy Star appliances and are also the most likely to say they use their dishwashers for full loads. More than 75% of respondents on any water source report they use their washing machines for full loads.[9]

[3] A test survey was developed in 2012 and administered in the Town of Boone, the largest town in the broader study area, and this generated 129 responses that were used to revise several of the survey questions and survey structure. Additionally, a group of 12 students at Appalachian State University served as a focus group that took the survey and provided feedback.

[4] http://www.surveysampling.com.

[5] To the extent possible we attempted to follow the tailored designed method (Dillman, Smyth, and Christian, 2009).

[6] Our sample weights are calculated as the percent of population as measured by Census data divided by the percent of our sample in each age group.

[7] Restricting the population to age 20 and older, 23% of Watauga County residents and 35% of Ashe County residents are 60 and older.

[8] In U.S. households toilets are almost universally 'single-flush' style.

[9] Based on the 2009 Residential Energy Consumption Survey published by the US Energy Information Agency, approximately 69% of homeowners in North Carolina and South Carolina (the survey aggregates these two states) have Energy Star dishwashers.

Table 2B
Private averting behaviors by water source.

	Municipal water	Shared well	Private spring	Private well
% Low flow toilet	53	60	62	54
% Water saving shower head	51	62	64	64
% Low-flow faucet aerators	34	42	40	41
% Rainwater collection system	07	07	08	09
% Energy Star dishwasher	47	51	33	42
% Energy Star washing machine (front loading)	30	32	22	31
% Full load dishwasher	74	82	57	70
% Full load washing machine	78	78	79	76
How important to use less water	2.58	2.48	2.42	2.40

When asked "How important is it to you that households in North Carolina use less water in their homes?" on average respondents on all water sources agree that saving water is important. On a 1 to 3 scale with 1 being not important and 3 being very important, average scores ranged from 2.58 for individuals on municipal water to 2.40 for individuals on private wells. Over all, individuals report that saving water is important and that they do use water conservation measures. There is some limited support that actual behavior is in line with reported behavior, as despite population growth, average annual water use in the Town of Boone has decreased from 2.1 million gal for the period 2004–2008 to 1.9 million gal for 2009-2013. There is no data collected on actual use for individuals with springs or wells in this region, so it is not possible to assess reported behavior against actual behavior. In the next section, we analyze if individuals are willing to pay higher taxes to provide county-wide conservation measures.

5. Contingent valuation model

Consider the utility function of a resident who receives utility from consumption good, z, and a more secure water supply, q, where q represents benefits from implementing water conservation measures. Then a resident maximizes her utility, $u(q, z)$, subject to a budget constraint $y = pz$ where the price of z is normalized to one. Solving for the indirect utility function yields $v(q, y)$. The willingness-to-pay, *WTP*, for water conservation amenity is implicitly defined at the payment that equates indirect utility with different water security conditions, $v(q^o, y) = v(q', y\ \text{-}WTP)$, where q^o is the current level of security and q' is the improved security. In our case, the willingness to pay question for water conservation measures follows a dichotomous choice framework. The variable *For* is a qualitative variable equal to one if the respondents answered FOR to the question:

> *"Suppose that to implement water conservation measures county residents would pay a one-time payment of $A per household in higher county taxes. The money would be used to provide rebates to residents for the purchase of low flow toilets or rain barrels to help save water at home. The money would also be used to re-vegetate creek banks and install permeable pavement where feasible. These measures reduce runoff from storms and help with recharging the groundwater supply. The goal of the program is to provide more water security in the county and to ensure a more stable water supply that can ease stress during droughts. Suppose that this proposal to approve the tax and provide conservation measures will be on the next election ballot. Remember, if the proposal passes you would make a one-time payment of $A in higher taxes and you would have $A less to spend on other things. Also remember that if the referendum passes the conservation measures would be implemented and more water would be available in your county during times of drought."*

Approximately 15% have front loading washing machines. Our sample is below the average for dishwashers and above for front loading washers.

Table 3
Frequency of responses to the CVM question.

Amount	%For	%Against	%Don't know
$5	60	23	17
$20	49	34	17
$40	44	39	17
$80	39	43	18
$150	30	51	19

$N = 664$

Mitchell and Carson (1989) state a "CV scenario must be informative; clearly understood; realistic by relying upon established patterns of behavior and legal institutions; have uniform application to all respondents; and hopefully, leave the respondent with a feeling that the situation and his response are not only credible but important." To this end, we developed our CV scenario using specific activities that reflect actual conservation measures that have been used in these counties. There are frequent well-publicized rain barrel sales and giveaways in the region. The largest town in the study area implemented a toilet rebate program in 2011. In the past decade there have been numerous well-publicized stream re-vegetation projects implemented on both public and private land throughout this region. There have also been several pilot projects testing permeable pavement in parking lots and sidewalks implemented in these counties. Therefore, these activities are familiar to area residents and enable a realistic CV scenario. The $A took on the values of $5, $20, $40, $80 or $150 and these values were randomly distributed among the mailed surveys. We asked respondents how they would vote on this proposal with three choices FOR, AGAINST or DON'T KNOW. In addition we used a county tax referendum format because it has been used in the past to fund county projects.

In Table 3 we show the frequency of answers by the $A values. We find that the frequency of respondents who would be willing to pay falls with the value of $A as 60% were willing to pay $5 but only 30% were willing to pay $150.[10] About 18% of respondents answered "don't know" for all levels of $A. One problem that arises when coding dichotomous choice CV questions is what should be done with "don't know" and "no" responses. We follow the conservative approach and code all "don't know" and "no" responses as "against" responses (Carson and Hanemann, 2005; Groothuis and Whitehead, 2002; Caudill and Groothuis, 2005).[11] An approach that explores the reasons behind "no" responses can be found in, for example, Ramajo-Hernández and Saz-Salazar (2012).

Another potential problem that arises with CV surveys is hypothetical bias (Whitehead and Cherry, 2004). Hypothetical bias exists if respondents are more likely to say they would pay a hypothetical sum of money than they would actually pay if placed in the real

[10] We believe that $5 is the lowest bid that would be credible in a referendum election. It is plausible that 40% of the respondents who answered no to the $5 payment could either have a true zero WTP or protest zero (as noted by Carson, 1991). Our high bid of $150 dollars might not have been able to identify individuals with higher WTP, but given our CV scenario, we believe it captured the plausible costs of the conservation measures provided.

[11] To further explore the "don't know" response, we estimated the ordered logit model and the multinomial logit models. Using the ordered logit model we find some evidence that "don't know" is a middle response. Using the multinomial logit model, we find that the don't know response is much like a no response. We report only the conservative approach. The other results are available from the authors upon request. Carson and Hanemann (2005) state, "A conservative approach, that will always tend to underestimate WTP, is to treat all don't know responses as "not favor" responses. A "protest zero" can be seen as a variant of a "don't know" response, in the sense that the respondent effectively said "no" but has given some type of response which suggests that it might not be a true zero."

Table 4
Determinants of public conservation measures (*For1* and *For2*).

Variable	*For1* Coefficient estimates	*For1* Marginal effects	*For2* Coefficient estimates	*For2* Marginal effects
Constant	1.012 (.236)	.253	.833 (.337)	.204
Log WTP Bid	−.442 (< .001)	−.110	−.376 (< .001)	−.092
Age	−.024 (< .001)	−.006	−.025 (< .001)	−.006
White	.674 (.205)	165	723 (.201)	.163
Female	.260 (.152)	065	.268(.134)	.066
Years of education	.103 (.003)	.026	.083 (.016)	.020
Income	.005 (.107)	.001	.007 (.019)	.002
Missing income dummy	−.569 (.173)	−.140	−.157 (.709)	−.038
Own	−.507 (.094)	−.124	−.596 (.045)	−.148
Ashe	.012 (.949)	.003	−.030 (.873)	−.008
Ancestor	−.904 (< .001)	−.222	−.855 (< .001)	−.206
City water	.416 (.089)	.102	.232 (.331)	.057
Shared well	.422 (.076)	.102	−.048 (.836)	−.011
Spring	−.290 (.351)	−.072	−.594 (.072)	−.138
Chi squared	156.06 (< .001)		139.46 (< .001)	
Pseudo R^2	.17		.15	
McFadden R^2	.15		.12	
Log likelihood	−381.87		−386.39	

Sample weighted by age. $N = 664$ (*p*-value in parentheses).

situation. Because economic values are based on actual behavior, hypothetical bias may lead to economic estimates that are too high. One method used to mitigate potential hypothetical bias is the certainty rating. For the subset of respondents who say they are willing to pay the bid amount, we ask: "On a scale of 1 to 10 where 1 is 'not sure at all' and 10 is 'definitely sure', how sure are you that you would make the one-time donation of the tax amount?" Following Poe et al. (2002); Vossler et al. (2003), and Champ, Moore, and Bishop (2009) only respondents who answer 8, 9 or 10 are coded as a *for* response to provide a lower bound estimate. We identify this variable as *For2*; the variable *For1* does not take respondents' certainty into account. Champ, Moore, and Bishop (2009), for example, find that in a CV study with three treatments: (i) a real payment, (ii) a hypothetical payment with a reminder of a budget constraint and (iii) a hypothetical payment with a certainty scale, the certainty scale treatment with respondents who answer 8, 9 or 10 followed the same distribution as the individuals who were in a real payment treatment. They suggest that the certainty scale can help eliminate hypothetical bias.

We estimate a logit model for each variable *For1* and *For2* where

$$P(Y = 1) = \frac{e^{\beta' x}}{1 + e^{\beta' x}}.$$

Y is equal to one if the individual is for the water conservation tax increase, and *X* is a vector of explanatory variables that include demographic characteristics, source of respondent's water supply, the natural log of the bid amount and a county dummy.

As shown in Table 4, our results indicate that as the tax payment increases respondents are less likely to vote for the proposal. In the *For1* specification, individuals who share a well or are on city water are more likely to vote for than individuals with a private well (the excluded category). Individuals who have springs are no more likely to vote for than those with private wells. Additionally, increases in education and income raise the likelihood of voting for the proposal, while increases in age decrease the likelihood of voting for the proposal.[12] Neither gender, race, nor county of residence influence the likelihood of supporting the proposal. Home ownership and having ancestors in the region, however, both lower the likelihood of voting

Table 5
Willingness to pay estimates.

	WTP *For1*	WTP *For 2*
Means	$19.43 (< .001)	$6.83 (.017)
City water	$38.25 (.042)	$14.07 (.097)
Shared well	$38.74 (.034)	$6.67 (.113)
Private spring	$7.28 (.152)	$1.56 (.325)
Private well	$14.90 (.002)	$7.59 (.027)
Ancestor	$6.96 (.015)	$2.19 (.129)
No ancestor	$53.90 (.002)	$21.19 (.007)
Age 30	$102.74 (.019)	$52.48 (.022)
Age 65	$15.86 (< .001)	$5.33 (.037)
High school 12 years	$9.40 (.013)	$3.74 (.100)
Graduate degree 20 years	$60.76 (.023)	$20.00 (.054)

Sample weighted by age $N = 664$ (*p*-value in parentheses).

for the proposal. This supports previous research showing newcomers to an area and residents who are native to an area have different views about and preferences for managing environmental resources (Groothuis, Groothuis, and Whitehead, 2008; Groothuis, 2010; Cockerill and Groothuis, 2014).

To better understand the WTP and the hypothetical bias corrected WTP we use the Cameron (1988) technique to calculate point estimates of the median value of the WTP for various subsets of respondents (Table 5). As an example, the WTP for water conservation measures is $19 when evaluated at the means of all variables but falls to $7 when corrected for hypothetical bias. For individuals on municipal water the WTP is higher at $38 and remains positive at $14 when corrected for hypothetical bias. The WTP for respondents with shared wells is $39 or $7 dollars when corrected for hypothetical bias. Individuals with private wells have a $15 willingness to pay that falls to $8 when corrected for hypothetical bias. For individuals with springs, WTP is never significantly different from zero. We also find that the WTP for respondents who have ancestors in the mountains of North Carolina is $7, but this also falls to zero with the hypothetical bias correction. In addition, we find that age matters, as respondents who are 30 have a WTP of $103 that falls to $52 when corrected for hypothetical bias but 65-year olds only have a WTP of $16 falling to $5 when corrected for hypothetical bias. Lastly, we find that individuals who have a high school education are willing to pay $9 that falls to $4 when corrected for hypothetical bias while individuals with graduate degrees are willing to pay $61 dollars that falls to $20 when corrected for hypothetical bias.

[12] As with many contingent valuation studies the income question suffers from non-response. To keep the information of the income non-respondents we code income as zero and then include a dummy variable equal to one for income non-respondents. We find that individuals who fail to respond to the income question are also less likely to vote yes.

Table 6
Bivariate probit models.

Variable	For1	Low flow Toilet yes = 1	For1	Energy Star Dishwasher yes = 1	For1	Aerator Faucet yes = 1	For1	Full Load Wash yes = 1
Constant	.665 (.233)	−1.38 (.004)	.622 (.25)	−1.00 (.062)	.589 (.264)	.540 (.227)	.581 (.290)	.430 (.290)
WTP bid	–.272 (<.001)	–	–.268 (<.001)	–	-.260 (<.001)	–	–.253 (<.001)	–
Age	–.014 (<.001)	.006 (.044)	–.014 (<.001)	–.009 (.004)	–.014 (<.001)	–.003 (.296)	–.014 (<.001)	–.015 (.001)
White	.389 (.259)	.145 (.652)	.370 (.281)	–.017 (.967)	.404 (.221)	–.168 (.572)	.412 (.239)	.236 (.494)
Female	.158 (.154)	–.155 (.134)	.158 (.157)	–.007 (.946)	.157 (.161)	–.422 (<.001)	.156 (.166)	.053 (.667)
Years of education	.061 (<.001)	–.002 (.917)	.062 (.003)	.033 (.104)	.062 (.004)	–.027 (.197)	.060 (<.001)	.073 (.002)
Income	.003 (.095)	.005 (.002)	.003 (.098)	.008 (<.001)	.003 (.103)	–.000 (.804)	.003 (.098)	–.002 (.197)
Missing Income Dummy	–.351 (.162)	.300 (.187)	–.357 (.178)	.931 (<.001)	–.350 (.169)	.071 (.755)	–.358 (.150)	–.160 (.529)
Home owner	–.333 (.078)	.627 (.001)	–.335 (.081)	.208 (.245)	–.318 (.097)	.008 (.961)	–.320 (.092)	.260 (.269)
Ashe resident	.018 (.880)	.190 (.095)	.014 (.909)	.331 (.00)	.014 (.909)	–.051 (.647)	.015 (.903)	–.005 (.967)
Ancestor	–.545 (<.001)	.034 (.763)	–.540 (<.001)	.022 (.842)	–.539 (<.001)	–.249 (.028)	–.542 (<.001)	–345 (.014)
City water	.277 (.086)	.067 (.647)	.270 (.089)	–.009 (.950)	.271 (.092)	–.312 (.031)	.275 (.088)	–.113 (.494)
Shared well	.254 (.070)	.099 (.481)	.253 (.070)	.045 (.731)	.250 (.075)	–.079 (.553)	.257 (.069)	–.065 (.693)
Spring	–.147 (.414)	.302 (.087)	–.144 (.424)	–.003 (.988)	–.147 (.421)	–.201 (.281)	–.154 (.398)	.283 (.194)
Rho (ρ)	**.120 (.084)**		**.135 (.050)**		**.121 (.089)**		**.212 (.004)**	
Log-likelihood	–805.3		–801.2		–805.5		–681.6	

Sample weighted by age $N = 664$ (p-value in parentheses).

6. Combining stated preferences and revealed preference models

Our analysis focuses on two types of water conservation preferences: revealed and stated. Private averting behaviors such as purchasing low flow toilets and Energy Star appliances provide revealed preference data about water conservation. The contingent valuation scenario provides stated preference data of public water conservation measures. Whitehead et al. (2008) suggest that combining revealed and stated preference techniques can provide insights to behavior that may not be identified by looking at each separately. They further suggest that combing each method might improve econometric efficiency. One method to combine the data is by using a bivariate probit model. Consider the following model:

$$\pi\,(\text{For} = 1) = \Phi(x_1\beta_1 + \varepsilon_1)$$

$$\pi\,(\text{Avert} = 1) = \Phi(\text{x}_2\beta_2 + \varepsilon_2)$$

$$\rho = \text{corr}(\varepsilon_1\varepsilon_2),$$

where π is the probability of either voting for the CV scenario or participating in the averting behavior, Φ is the probit function, Xβ are the vector of explanatory variables, ε_1 and ε_2 are the respective error terms, and ρ captures the potential correlated error structure between the stated preference and the revealed preference methods. If the sign of ρ is positive then there exists some unobservable characteristic the makes a respondent more likely to participate in an averting behavior and more likely to vote for on the CV proposal. Thus a positive ρ suggests that private conservation and public conservation measures are complementary. If the sign of ρ is negative then there exists some unobservable characteristic the makes a respondent more likely to participate in an averting behavior and less likely to vote for on the CV proposal suggesting that private conservation and public conservation measures are substitutes.

A priori, it is not clear if the two measures are complements or substitutes. If the two techniques complement each other we would expect to find that individuals who use private averting measures are also more likely to vote for the public conservation scenario because both reflect a desire for water conservation. Alternatively, if people perceive the two as substitutes we would expect respondents who spend their conservation budget on private measures to be less likely to vote for the public conservation scenario.

To test the two possibilities, we estimated eight bivariate probits- one for each of our averting behaviors reported in Table 2A: These averting behaviors include ownership of a low flow toilet, water saving shower head, aerator faucet, Energy Star front load washing machine, Energy Star dishwasher, or water collection rain barrel. These averting behaviors also include using dishwashers or washing machines only for full loads. We report the results of only four of the eight bivariate probit analyses between our stated and revealed preference water conservation measures because these were the only bivariate probits where the ρ was found to be statistically significant. When the ρ is insignificant combining the two provides no additional information and are uncorrelated choices.

The four we report are the bivariate probits using the revealed preference for the purchase of low flow toilets, the one for purchasing an Energy Star dishwasher, the one for using a washing machine for only full loads, and the one for using aerator faucets. In all bivariate probit models we find that the ρ statistic is positive and significant at the 90% or higher level (Table 6). The four positive ρs suggest that respondents have some unmeasured characteristic that increases both the likelihood of voting for the conservation referendum and participating in private averting measures. Our results therefore provide some evidence that public water conservation measures and private conservation behaviors are complementary.

In addition, we find that increases in income increase the likelihood of purchasing capital items such as low flow toilets and Energy Star dishwashers. Home ownership also increases the likelihood of the purchase of low flow toilets. We also find that residents of Ashe County are more likely to invest in low flow toilets and Energy Star dishwashers than Watauga County residents. Regarding education, we find that as years of education increase the likelihood of purchasing an Energy Star dishwasher also increases. Similarly, higher education raises the likelihood of using washing machines with full loads. We find mixed results regarding age for private conservation measures; older individuals are more likely to have low flow toilets but are less likely to have Energy Star dishwashers, aerator faucets or only use washing machines for full loads. Individuals with ancestors in the area are less likely to use private conservation measures of having aerator faucets or doing laundry with only full loads.

7. Conclusion

Our results suggest that while general concern about water issues is only moderate among respondents, private averting behaviors are common, with a majority reporting employing a variety of water conservation behaviors. Less than half of respondents, however, are willing to pay for public conservation measures when the tax amount is above twenty dollars. The general lack of concern about the water supply suggests that the perceived risk is low and therefore no significant actions need to be taken. Our results fit with previous research on perceptions of existing water conditions and perceived risk (Tapsuwan et al., 2014; Zhang et al., 2013).

The mean WTP for public conservation measures is $19 per household. In Watauga County there are 20,403 households, so the aggregate WTP is about $388,000. In Ashe County there are 11,755 households making the aggregate WTP about $223,000. Therefore, from an efficiency perspective, if the cost of the public conservation program is less than $388,000 in Watauga County and less than $223,000 in Ashe County the public conservation measure should be undertaken. These benefits, however, are most likely lower than the cost of providing the services our CV proposal suggests. For example, rain barrels cost about $90 each wholesale, low flow toilets cost $170 each wholesale, permeable pavers cost about $2–$10 per square foot installed (lowimpactdevelopment.org), and the cost of vegetation for a creek project in this region is about $670/acre (Watauga River Partners, 2012).

Our analysis further suggests that there are key differences in who supports public measures and these differences are important to decision-makers pursuing demand-side management. For instance, individuals who share a water source, either a well or through a municipality, are much more likely to vote for a public water conservation proposal than those using an individual water source. Therefore, decision-makers within a municipality may have an easier time moving toward demand-side management. The majority of the population in this region, however, is not served by a centralized, public supply. Population growth and/or drought will put increasing pressure on the total water supply, independent of whether that water is provided to residents through a centralized, community system or through individual wells. Our study suggests that convincing people with an individualized supply to support public conservation measures may be challenging. Because these households do report practicing averting behavior, decision-makers may find traction in trying to link individual water management decisions to the broader water supply system to show that all of the water in the region is connected.

Our survey data is confined to a small area. Under current policy, however, water management in rural areas *is* local. Therefore understanding the preferences in a specific area may be prudent because, although our research suggests that support for public water conservation actions funded with taxes may be low in this region, both individual and public conservation measures are likely to be necessary in future management portfolios. Our results provide important insights on the understudied topic of perceptions about water quantity in humid states, and households' willingness to pay to support public conservation efforts. Moreover, our study illustrates the challenges facing counties that want to encourage conservation behaviors when a large portion of residents use individually managed water sources.

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