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Peter A. Groothuis
Appalachian State University

Kristan Cockerill
Appalachian State University

Tanga M. Mohr
Appalachian State University

Department of Economics
Appalachian State University
Boone, NC 28608
Phone: (828) 262-2148
Fax: (828) 262-6105
www.business.appstate.edu/economics

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Determinants of Willingness to Pay for Water Conservation Measures in the Mountains of Western North Carolina

by

Peter A. Groothuis
Professor
Department of Economics
Appalachian State University

Kristan Cockerill
Assistant Professor
Interdisciplinary Studies
Appalachian State University

and

Tanga M. Mohr
Associate Professor
Department of Economics
Appalachian State University

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 these regions attempt to address water supply issues. 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 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 expenditures 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 water conservation measures.

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

Section 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. This region is growing rapidly and several counties throughout western North Carolina experienced double-digit growth rates between 2000 and 2010. Droughts in 2002-2003, 2007-2008, and 2010, temporarily reduced the available supply throughout the region. In 2007 many private wells went dry and towns throughout the region enforced drought measures. For example in the town of 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. Many municipalities have also implemented conservation programs. For example, Boone (pop 17,000), the largest town in the study area, began its "Every Drop Counts" program in 2005, which includes offering free low-flow showerheads and water leak audits. In 2011, the town implemented a toilet rebate program to reimburse businesses and home-owners who replaced high flow toilets with low flow models.

The growing demand in Western North Carolina and potential for drought suggests that understanding if and in what ways residents support water conservation efforts is important. A 2011 survey of state conservation measures revealed that all states have room for improving their conservation measures 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 scholars that the past is not prologue for the future. Even in regions that have historically had ample water supplies, conserving and improving efficiency offers a more cost-effective approach than seeking new water supplies and must be part of any water management portfolio (Hoffner 2008; Butler and Memon 2006). Of course, conservation is not a panacea for water managers, and although examining it is beyond the scope of this paper, the authors recognize the concerns with rebound effects relevant to improved water efficiency (Polimeni et al. 2008).

There is a dearth of information relevant to public attitudes about water quantity concerns and conservation behavior in humid climates. This lack of information is perhaps especially acute in the US southeast. In separate studies, Florida and Georgia residents were found to be more concerned with water quality than water quantity (Lamm 2013; Responsive Management 2003). Additionally, Georgia residents perceive conservation to be salient only when it is directly tied to localized, community issues (Responsive Management 2003). In other regions, studies have shown that the behavior related to conservation is complex and a variety of factors motivated people to conserve (e.g., attempting to stem a perceived environmental threat, participating in socially desirable behavior, and prices) or not conserve (e.g. exercising a perceived right to use as much water as desired) (Gilg and Barr 2006).

There have been willingness to pay studies focused on water quality (e.g., Boyle et al. 1993; Carson and Mitchell 1993; Desvousges et al. 1987; Birol et al.), but none focused on the perceived benefits of conservation for the sake of maintaining water supplies. In this project we developed a survey to ascertain self-reported conservation behaviors as well as a contingent valuation scenario to assess willingness to pay for public conservation measures in both Ashe and Watauga Counties in rural, northwestern North Carolina.

Section 2: 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. It consisted of a primary mailing, a post card reminder and a second mailing to all non-respondents of the first mailing. In the end, 2415 useable addresses and 714 responses were obtained for a response rate of 30 percent. Table 1 contains a summary of the demographic variables. The average age of respondents was 61 years and average income was $62,000. In the two counties of our sample, 24 percent of respondents have a high school degree or less, 18 percent have some college but no degree, 10 percent have an Associate's Degree, 24 percent have a Bachelor's Degree, and 24 percent have a graduate or professional degree. Comparing our sample to US Census data from the counties, we find that our respondents tend to be older, slightly more educated, and have higher income than the general population.

In addition, we find that 50 percent report having ancestors who lived in this region, 97 percent report their race as white, and 92 percent own their homes. Regarding water source, 52 percent report having their own well, 12 percent their own spring, 19 percent a shared well and 17 percent are on a municipal water supply. In Watauga and Ashe Counties, 36 percent and 19 percent, respectively, of the population is actually served by a public 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 private or shared wells.

Section 3: Self-Reported Conservation Behavior

To understand individual water private conservation or averting behavior we asked respondents how many have low flow toilets, water saving shower heads, low flow faucet aerators and rain water collection systems. In addition we asked how many respondents have Energy Star dishwashers and washing machines and if they use their dishwashers and washing machines only for full loads. In table 2 we report the results to these questions by water source. We find that individuals on city water are less likely to have low flow toilets, water saving shower heads or low flow faucet aerators compared to individuals with other sources of water. We find that individuals with shared wells are the most likely to have Energy Star appliances and are also the most likely to use their dishwashers for full loads. We find that few respondents have rainwater collection systems regardless of water source but over seventy five percent of respondents use their washing machines for full loads (also regardless of water source). When asked "How important is it to you that households in North Carolina use less water in their homes?" we find that all respondents 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 city water to 2.40 for individuals on private wells. Over all, we find that individuals report that saving water is important and that they do use water conservation measures. In the next section, we analyze if individuals are willing to increase taxes to provide communitywide conservation measures.

Section 4: Model

Consider a resident's utility function who receives utility from both a 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, $v(q^o, y) = v(q', y - WTP)$, 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 *Yes* 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."*

where $A took on the values of $5, $20, $40, $80 or $150. We asked respondents how they would vote on this proposal with three choices FOR, AGAINST or DON"T KNOW. Table 3 shows 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 for sixty percent willing to pay $5 to only thirty percent willing to pay $150. About eighteen percent of respondents answered 'don't know' for all levels of $A. One problem that arises when coding dichotomous choice CVM questions is what should be done with "don't know" responses. We follow the conservative approach and code all "don't know" responses as "no" responses (Groothuis and Whitehead 2002 and Caudill and Groothuis 2005). This is our *Yes1* variable.

Another problem that arises with CVM surveys is hypothetical bias (Whitehead and Cherry, 2004). Hypothetical bias exists if respondents are more likely to say that they would pay a hypothetical sum of money than they would actually pay if placed in the real situation. Since economic values are based on actual behavior, hypothetical bias leads to economic values that are too high. One method that is used to mitigate hypothetical bias is the certainty rating. For those respondents who say that they are willing to pay 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 Champ et al (2009) only respondents who answer greater than 7 are coded as a yes response. We identify this variable as *Yes2*. Table 3, reports the proportions of *Yes1* and *Yes2* at each cost level. The yes responses follow the expected pattern; as the payment goes up the proportion of yes responses fall.

We estimate logit model specifications for each of our "yes" variables:

1) $P(Yes) = X\beta + \varepsilon$,

where X is a vector of explanatory variables that include both demographic characteristics, source of respondent's water supply, the natural log of the bid amount and a county dummy.

Our results show that as the tax payment increases respondents are less likely to vote yes. When it comes to water source we find that individuals who share a well or are on city water are more likely to vote yes than an individual with a private well, which is our excluded category. We find that individuals who have springs are no more likely to vote yes that those with private wells. These results suggest that individuals who are on a shared supply, either a municipal supply or a shared well, view water conservation as a community effort.

Regarding demographics we find both increases in education and income raise the likelihood of voting yes, while increases in age decrease the likelihood of voting yes.[1] In addition, we find that females are more likely to vote yes than males but the race of the respondent does not influence the likelihood of voting yes. We find that neither home ownership nor county of residence influence the likelihood of voting yes. We do, however, find that individuals who have ancestors in the area are less willing to vote yes on the proposal. Previous research has show that newcomers to an area and residents who are native to an area have different views and preferences for environmental resources and policy measures (Groothuis et al. 2008 and Groothuis et al 2010).

To get an understanding of the magnitudes of the effects of both 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. The WTP, however, rises to $41 for individuals who have city water and remains positive at $15 when corrected for hypothetical bias. The WTP for respondents with shared wells is $44 or $12 dollars when corrected for hypothetical bias. Individuals with private wells have a $12 willingness to pay that falls to zero 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 $8 that 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 $50 that falls to $30

[1] As with many contingent valuation studies the income question suffers from many non-responses 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.

when corrected for hypothetical bias but 65-year olds only have a WTP of $17 falling to $5 when corrected for hypothetical bias.

Lastly we find that women are willing to pay $34 while men only $12. Using the hypothetical bias correction women's WTP falls to $14 and men's to $4. This result is at least partially in line with Brown and Taylor (2000) who found that men in their study demonstrated significantly higher hypothetical bias than women.[2] While, our regression analysis shows that women were actually more likely than men to contribute, both genders display hypothetical bias according to table 5.

These results show a divergence of preferences for using public funds for water conservation measures, and differ from the results found with private averting behavior where all sources of water had essentially the same level of participation. In the next section, we combine both the stated preference data with the averting behavior data to provide insights into water conservation measures.

Section 5: Combining stated preferences and revealed preference models

Our analysis focuses on two types of water conservation measures: private averting behavior such as purchasing low flow toilets and Energy Star appliances that reveal preferences about water conservation, and a contingent valuation scenario that provides stated preferences of water conservation measures. In our case it is not clear if the two measures complement each other or are substitutes for each other. In the first case where the two techniques complement each other we would expect to find that individuals who use private conservation measures are

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[2] Brown and Taylor (2000) compared contributions to the Nature Conservancy in a controlled setting using both 'real' and 'hypothetical' treatments. Subjects were placed in only one of the treatments and results were compared within and across treatments with a focus on gender differences. They do not find differences in the proportion of men and women choosing to contribute, but do find gender differences in the rate of hypothetical bias across treatments.

also more likely to vote yes on the public conservation scenario because both reflect a desire for water conservation. If the second case is correct, people perceive the two as substitutes and we would expect respondents who spend their conservation budget on private measures to be less likely to vote yes on the public protection scenario.[3]

To test the two possibilities, we report the results of two bivariate probit analyses between our stated and revealed preference water conservation measure: one using the revealed preference of low flow shower and one using the reveled preference of using a washing machine for a full load. We only report these two bivariate probits because all others did not find the rho coefficient statistically significant, suggesting that combing the two provides no additional information and are uncorrelated choices. In both bivariate probits we find that the rho statistic is positive and significant at the ninety percent level (Table 6). The positive rhos suggest that respondents have some unmeasured characteristic that both increases the likelihood of voting yes on the conservation referendum and participation in private conservation measures. Our results provide weak evidence that public water conservation measures and private conservation measures are complementary. This result is weak because it is only found on two of the eight bivariate probits and it is only found at the ninety percent confidence level.

Section 6: Conclusion

Our results suggest that water conservation measures are of moderate importance to residence of the mountains of western North Carolina. On private conservation measures we find that more than fifty percent of respondents report that they have low flow toilets and water saving shower heads and over seventy percent say that they use their washing machines for full

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[3] Whitehead et al. (2008) discuss the benefits of combining stated and revealed preference data including improved econometric efficiency (Whitehead et al. 2008).

loads. Of course, self-reported behavior and actual behavior may differ, but these results still reflect awareness that individual conservation measures are important and/or desirable.

For public conservation measures, our results suggest that the median WTP is $30 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. There are key differences, however, in who supports public measures. Individuals who share a water source, either a well or through a municipality, are much more likely to vote yes on a public water conservation proposal then individuals on private source of water. This has significant implications for water supplies and water management, as the majority of the population in this region 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 it is part of a public or private source. Although our research suggests that encouraging public water conservation measures may be a challenge in this region, both individual and public conservation measures are likely to be necessary in future management portfolios.

Table 1: Means

Variable	Mean	Standard deviation	Maximum	Minimum
Yes1	.45	.50	1	0
Yes2	.38	.49	1	0
WTP bid	57.25	50.79	150	5
Age	61.19	14.68	99	18
White	.97	.16	1	0
Female	.43	.50	1	0
Education Some College	.18	.38	1	0
Education Associates	.10	.29	1	0
Education Bachelors	.24	.43	1	0
Education Graduate	.24	.43	1	0
Income	61.89	40.67	20	150
Missing Income Dummy	.09	.28	0	1
Own	.92	.28	1	0
Ashe	.49	.50	1	0
Ancestor	.50	.50	1	0
City Water	.17	.37	1	0
Shared Well	.19	.39	1	0
Spring	.12	.32	1	0

N=664

Table 2

	City water	Shared Well	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	.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

N=664

Table 3:

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

N=664

Table 4: Determinants of WTP=Yes1 and Yes2

Variable	Yes1 Coefficient (p-value)	Yes2 Coefficient (p-value)
Constant	1.215 (.12)	.685 (.40)
Log WTP Bid	-.439 (.00)	-.360 (.01)
Age	-.014 (.03)	-.017 (.01)
White	.459 (.42)	.504 (.40)
Female	.437 (.02)	.473 (.01)
Education Some College	.459 (.03)	.462 (.12)
Education Associates	.827 (.02)	.617 (.07)
Education Bachelors	.870 (.00)	.537 (.07)
Education Graduate	.869 (.00)	.707 (.02)
Income	.006 (.03)	.008 (.00)
Missing Income Dum	-.699 (.06)	-.404 (.30)
Own	-.411 (.22)	-.165 (.64)
Ashe	-.040 (.83)	-.007 (.97)
Ancestor	-.716 (.00)	-.648 (.00)
City Water	.504 (.04)	.401 (.10)
Shared Well	.539 (.02)	.321 (.17)
Spring	-.152 (.61)	-.261 (.40)
Chi squared	143.84 (.00)	117.90 (.00)

N=664

Table 5: Willingness to Pay estimates

	WTP	WTP –hypothetical bias corrected
Means	$19.05 (.00)	$6.57 (.02)
City Water	$40.76 (.04)	$15.20 (.10)
Shared Well	$44.16 (.02)	$12.17 (.08)
Spring	$9.11 (.13)	$2.42 (.29)
Private Well	$12.91 (.00)	$4.99 (.05)
Ancestor	$8.40 (.01)	$2.66 (.12)
No Ancestor	$43.00 (.01)	$16.10 (.01)
Age 30	$50.35 (.05)	$29.46 (.08)
Age 65	$16.92 (.00)	$5.47 (.02)
Female	$33.67 (.00)	$13.90 (.01)
Male	$12.41 (.00)	$3.74 (.07)

N=664 (p-value in parenthesis)

Table 6: Bivarite probit

Variable	Yes1	Low flow Shower yes=1	Yes 1	Full Load Washing yes=1
One	.714 (.14)	.792 (.07)	.710 (.15)	1.070 (.00)
WTP bid	-.267 (.00)	---	-.216 (.00)	---
Age	-.008 (.04)	-.005 (.17)	-.008 (.04)	-.014 (.00)
White	.276 (.43)	054 (.87)	.288 (.44)	.22 (.55)
Female	.269 (.02)	-.091 (.38)	.264 (.03)	.124 (.29)
Education Some College	.381 (.02)	-.193 (.23)	.374 (.02)	-.382 (.03)
Education Associates	.507 (.01)	-.182 (.36)	.507 (.01)	.013 (.95)
Education Bachelors	.530 (.00)	-.261 (.12)	.524 (.00)	-.122 (.52)
Education Graduate	.528 (.03)	-.170 (.34)	.521 (.01)	.190 (.33)
Income	.004 (.03)	.001 (.58)	.004 (.03)	-.000 (.92)
Missing Income Dummy	-.433 (.08)	.250 (.21)	-.432 (.08)	-.028 (.90)
Own	-.261 (.22)	.049 (.80)	-.264 (.21)	-.100 (.69)
Ashe	-.020 (.86)	-.028 (.80)	-.017 (.88)	-.159 (.18)
Ancestor	-.434 (.00)	-.148 (.18)	-.434 (.00)	-.225 (.08)
City Water	.320 (.04)	-.333 (.02)	.323 (.04)	-.036 (.82)
Shared Well	.328 (.01)	-.068 (.62)	.327 (.02)	.029 (.86)
Spring	-.065 (.71)	-.040 (.80)	-.073 (.68)	.225 (.23)
Rho	.118 (.09)		.144 (.06)	
Log-likelihood	-818.42 (.00)		-733.67 (.00)	

N=664

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