Department of Economics Working Paper

Number 17-05| August 2017

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Key Points:

We use scientific information to develop a realistic hypothetical scenario for stormwater management on water quality improvements.

Detailed scientific information reduces the willingness to pay for runoff abatement programs.

Using a attribute non-attendance model we are able to control for scenario rejection and measure scale effects

Key Words:
stormwater management, stream water quality, scientific communication, stated preferences, willingness to pay, attribute non-attendance

Abstract: We integrated physical science data with a social science survey to better understand people's preferences for stormwater runoff abatement measures. Data from a long-term monitoring project on Boone Creek in North Carolina revealed that two key concerns from stormwater runoff are thermal pollution and high salinity. We used this data to develop text and images to include in a survey to assess public attitudes about and willingness to pay for stormwater runoff abatement measures in the Appalachian region. The survey provided information about various methods to reduce stormwater runoff including containment systems and permeable pavement. In addition, our survey asked follow-up questions to evaluate if the scenario presented was perceived as achievable. Lastly, to assess the impact of scientific information on individual preference for stormwater runoff abatement, we randomly assigned different levels of scientific information to survey respondents. Our results find that survey respondents who saw more detailed scientific information had a lower willingness to pay for runoff abatement programs. We also find scope effects for those respondents who think the stormwater management plan can be achieved.

Stormwater management continues to challenge communities throughout the United States as “stormwater pollution, flooding and other impacts impose serious impacts on water quality, public health and local economies” (USEPA 2016). Like all water-related concerns, managing stormwater runoff is complex and requires understanding not only the physical phenomena but social phenomena as well. While public attitudes about runoff related to agriculture have been fairly well assessed, there remains a dearth of information about attitudes in more residential settings. Further, the data that do exist about public knowledge and behavior relevant to stormwater are highly variable. Some studies find that people do not consider runoff to be a concern for their community (Bartlett 2005, Keeley et al. 2013, Turner et al. 2016) while others find a high level of concern (Baptiste et al. 2015). Studies find that there are not consistent or predictable connections between individuals’ knowledge about stormwater runoff and their actions to alleviate negative consequences of runoff (Prokopy et al 2008, Baumgart-Getz et al 2012, Persaud 2013). Therefore, research efforts focused on better understanding the links between the physical and social aspects of stormwater management are warranted. Our work offers some insight into using science-derived information about the physical effects of stormwater runoff to improve efforts to evaluate public attitudes about managing stormwater, and more specifically, to better assess attitudes about paying for such management.

In previous research using valuation methods, Whitehead and Groothuis (1992) found that respondents in North Carolina were willing to pay for management to reduce stormwater runoff from agricultural lands. More recently, Londono, Cadavid and Ando (2013) found that respondents value reduced basement flooding more than reductions in yard or street flooding. In addition, they found that citizens value improved water quality as well as improved hydrologic function and aquatic habitat from reducing runoff. Bin and Polasky (2004) analyzed how hurricane stormwaters influence property values and found that homes located within a floodplain were of lower market value than those located outside the floodplain. Brent et al. (forthcoming) found that Australian respondents were willing to pay for reduced flash flooding, improved local stream health and decreased peak urban temperatures.

Van Houtven et al. (2007) in a meta-analysis of 18 willingness to pay studies for water quality improvements concluded the following:

> Greater detail and consistency in the type of information reported in published water quality valuation studies would enhance the social utility of the empirical literature. In particular, more detailed characterizations of the studied water resources and affected populations would be beneficial. Ideally, these descriptions would include pre-change and post-change water quality, and information on the spatial and temporal variation in water quality, physical characteristics and typical uses (including designated uses) of the water resources.

Lund (2015) discusses the importance of integrating physical and social sciences to manage water resources. Following these suggestions, one goal when designing our survey was to provide respondents with greater detail about the impacts of stormwater runoff. We use science based scenarios to describe temporal variations in both water quality and aquatic health as stormwater runoff alters the temperature and salinity of streams.

To inform our science based scenarios, we used data from a long-term monitoring project on an urbanized stream in Boone, North Carolina, showing that key stream quality concerns are thermal pollution and salinity from salts used to melt ice on roads and sidewalks. In short, stormwater runoff drives hot, salty water into the stream with concomitant negative consequences (Cockerill and Anderson 2014; Cockerill et al. 2017). We used the information generated from this data to develop a realistic hypothetical scenario revealing the negative consequences of runoff on stream water quality and showing how stormwater management measures can improve stream water quality. Using the contingent valuation method (CVM), we attempt to analyze how our science based scenarios affect willingness to pay for stormwater abatement measures.

We have no a priori predictions on the influence of scientific information on individual's willingness to pay for stormwater management policies. Groothuis and Miller (1997) find that information from university sources are the most trusted of all sources and individuals use the information provided in the survey to update their knowledge of the problem. We suggest that by randomly assigning information in our survey we can analyze how respondents update their knowledge about water management when presented with detailed scientific information.

We also attempt to quantify the effect of scope on individuals' valuation by providing respondents with various combinations of water quality improvements and stormwater management levels. Following the method used by Carson and Czajkowski (2014), we developed a single bound referendum valuation question where respondents were asked a follow up question to determine if they believed the goal of the stormwater management plan could be met. This allows us to use attribute non-attendance (ANA) models to control for the effect of 'scenario rejection' for those who do not believe the plan is feasible (Hensher, Rose and Greene 2005, Alemu et al. 2013). We hypothesize that ANA may be one reason that some CVM studies fail to pass the scope test (Whitehead 2016). To date, we know of no contingent valuation study that has employed stated attribute non-attendance in the empirical models.

In the following sections, we summarize the stream monitoring study that provides the scientific background to the CVM scenario, describe the survey deployed, and provide the empirical results. We conclude with a discussion of the role scientific information may play in social science research and how both social and physical science provide insights into managing stormwater.

Scientific Background on Stormwater Influence on an Urbanized Creek.

Researchers have monitored stream temperatures and salinity levels along Boone Creek for more than a decade (Anderson et al. 2011, Cockerill et al. 2017). The monitoring network now includes five stream gauges, seven electrical conductivity sensors to measure salinity and more than 30 stream temperature sensors along the length of the 1.8 km study reach and adjacent small tributaries.

The data show two primary water quality concerns in Boone Creek: (1) elevated stream temperatures with many storm-induced temperature surges each year of greater than 1^{o} C within 15 minutes, and (2) salinity values that are not typical of freshwater high-gradient mountain streams. Stormwater runoff is the primary culprit for both of these phenomena, with temperature surges occurring on warm days due to runoff from heated pavement and buildings and salinity spikes occurring on cold snowy days when road salt has been applied to area infrastructure.

Thermal pollution in headwater streams is pervasive in urban areas (Nelson and Palmer 2007). Anderson et al. (2011) first described temperature surges in Boone Creek showing over four summers of monitoring, that the 72 temperature surge events displayed a mean rise of 2.63^{o} C and durations of 30.4 minutes. Cockerill et al. (2017) further noted an increase in the number of surge events over a ten-year monitoring period. Cockerill et al. (2017) showed, for example, 111 temperature surge events occurred in 2015 with 60% of them rising above 20^{o} C, which is a critical temperature for cold-water habitat fauna (Wang and Kanehl 2003; Wang et al. 2003).

Saline contamination of Boone Creek is a more complex problem because, unlike heat, salt does not leave the groundwater/stream system. Instead, runoff from storm events, even during summer months, acts to keep the salinity derived from snowmelt runoff in the riparian aquifers lining the stream. This is a growing issue in many cold-regions. Godwin et al. (2003)

show that chloride levels in the Mohawk River, New York, rose 243% between 1942 and 1998. Novotny et al. (2008) discuss similar trends in the lakes within the Twin Cities Metropolitan Area in Minnesota, where urban lakes show 10 and 25 times the sodium and chloride levels, respectively, of non-urban lakes, and levels have been rising since 1960. Road salt runoff negatively affects water quality, aquatic species, concrete infrastructure, and human health (Corsi et al., 2010; Wang et al., 2006). Cockerill et al. (2017) demonstrated with numerical experiments that the dynamics of urban mountain streams like Boone Creek, which show frequent flashy conditions (i.e. streamflow rises rapidly in response to rainfall events, but also recovers quickly following an event), can increase the residence time of salt in the hydrologic system. This occurs because rapid changes in stream stage during storm events raise stream levels above the adjacent water table, leading to reversed gradients and temporary losing stream conditions (i.e. stream water flows into the groundwater system). Thus, under salt or heat contamination, these reversed gradients transport the solutes and/or heat to the groundwater system, where it has to return to the stream as baseflow under much lower energy (gradient) conditions. In summer months, freshwater events create a damming effect, spreading the salt resident in the riparian aquifer and increasing the residence time of the solutes. In this way, stream dynamics play an important role in the residence time of contaminants. Cockerill et al. (2017) also demonstrated that employing stormwater management to reduce stream stage fluctuations by 50% can be nearly as effective at reducing salinity levels as cutting road salt usage in half. Again, this is due to the dynamics of the stream/groundwater interactions, which are reduced under lower flow conditions.

Survey Methods

We drafted a survey instrument to assess public attitudes about stormwater management and asked a convenience sample of people with diverse backgrounds to take the draft survey and provide feedback. In addition, we pre-tested our survey with internet platforms. We used the same internet platform to field the final survey online (SurveyMonkey and Survey Sampling International online respondent panels). Our target population included residents of the Appalachian region from North Carolina in the south to New York in the north. This region features mountainous terrain and receives snow. These physical traits allow us to generalize the Boone Creek data for the broader region.

We received 1472 total surveys completed between May 27 and June 6 2016. About 4% of respondents answered the survey in less than five minutes. We eliminated these respondents from our data set assuming they did not pay enough attention to the survey to provide meaningful responses. This left a total of 1367 responses with 37% from Pennsylvania, 14% from Tennessee, 11% from West Virginia, 9% from North Carolina, another 9% from Ohio, 8% from Kentucky, and about 4% each from New York, Virginia and Maryland.

To assess how detailed, science-based information would influence responses we conducted an experiment. Early in the survey question sequence, we provided half of our respondents with the following text based on data from the Boone Creek monitoring program:

> University researchers have been monitoring water quality in the Appalachian Region and find that many streams suffer from "thermal pollution." This means that water temperatures are frequently higher than normal.
>
> Additionally, salt content often exceeds recommended levels for a healthy stream system. The salt is from de-icing streets and sidewalks in the winter. Researchers have concluded that the source of the warm and/or salty water is runoff from roads and buildings when it rains or snows. This is called stormwater runoff.
>
> This research suggests that there is a connection between stormwater runoff, long term salt levels in rivers and streams and "compromised aquatic health." Compromised aquatic health means that fish and the insects they eat or the plants they need for shelter struggle to live in that water.
>
> Because there are complex relationships between streamflow and groundwater, salt remains in the stream's system all year. When it rains, water pushes the salt from the

> stream into the groundwater system. Following storm events, groundwater returns to the stream (this is called baseflow) carrying the salt with it. Over time this is increasing the total amount of salt in the system and this contributes to compromised aquatic health.

Additionally, we used the Boone Creek data to populate a model showing rising salinity levels over time. Cockerill and Anderson (2014) show that salinity levels in Boone Creek have been rising over time. As already noted, this finding is in line with research in other regions (Godwin et al. 2003, Novotny et al. 2008, Kaushal et al., 2005). This modeling output was used to create a non-site-specific diagram that accompanied the text above (Figure 1). The diagram shows increasing salinity levels and highlights that these levels do compromise aquatic health. The diagram also shows both summer and winter salinity peaks from stormwater runoff.

Specific location does present a challenge in linking what we understand about a physical system with social attitudes and perceptions about that system. Ideally, we would have robust monitoring data and modeled results for each watershed and would then target people in each watershed with a survey that featured the data from their watershed. The reality, however, is that getting such detailed data for even a single watershed is expensive and time intensive. It is also difficult to identify potential survey respondents based on watershed rather than on a more common political boundary, such as state or zip code. Therefore, given our understanding of cold, mountainous regions generally, we applied actual stream data to generate a scenario that is applicable to a broad population. Further, the survey did consistently refer to the respondent's County by name to focus their attention on thinking about the data presented as being relevant to them.

The survey provided all respondents with a realistic contingent valuation scenario explaining how stormwater can be managed:

Slowing down the water flow is important to reduce water temperatures and salt from

> stormwater runoff so that by the time the water reaches a stream the temperature is lower. There are numerous stormwater management practices that can slow water flow. These include installing permeable pavement in parking lots and sidewalks, installing rain gardens, cisterns, and other water collection systems.

Three photographs of stormwater management practices showing how rain gardens, rain barrels, and permeable pavement can be used in a local landscape accompanied the text (Figure 2).

Following the Van Houtven et al. (2007) recommendation that CVM descriptions "include pre-change and post-change water quality, and information on the spatial and temporal variation in water quality" we provided a realistic scenario based upon the scientific information. To provide a status quo baseline to our study, at the midpoint of the survey, all respondents viewed Figure 3 (a simplified version of Figure 1) and the following text:

> The graph illustrates the scientific evidence suggesting that if nothing is done to address stormwater runoff and long-term salt levels, rivers and streams in {respondent's County} will suffer from compromised aquatic health within the next few years. Compromised aquatic health means that fish and the insects they eat or the plants they need for shelter struggle to live in that water.

Figure 3 illustrated that the baseline of stream quality is just below the threshold of compromised aquatic quality and that this line will be crossed in the near future if no stormwater management is implemented. The horizontal axis showed the time horizon and how salt levels have risen over time.

The survey then stated:

> Completely eliminating salt use is usually not a realistic option in {respondent's County}. Another option is to install permeable pavement and water collection systems. These can slow down stormwater so that it enters a stream more gradually. This allows the salt level to become more dilute before it enters the stream.

Using the discrete choice experimental design, we chose different levels of stormwater management implementation to test the importance of the level of change from the status quo. We employed a split sample with respondents receiving one of two scenarios: a ten percent increase in management practices or a fifty percent increase in management practices. In the survey, we stated:

> Suppose that a stormwater management plan has been designed that would increase the use of stormwater management practices by 10% (50%) in {respondent's County}. A 10% (50%) increase means that the number of practices would increase by 10 (50) for every 100 units of current practices. For example, if there were 100 acres of permeable parking lots this number would increase to 110 (150). If the number of rain barrels were 1000 these would increase to 1100 (1500). Scientists believe that a 10% (50%) increase in stormwater management practices could decrease long-term salt levels by (25% 50% 75%).

To test for scope, the survey included a modified version of Figure 3 to illustrate how stormwater management practices can reduce salinity levels by twenty five percent, fifty percent, or seventy five percent over time. For illustrative purposes, Figure 4 shows the fifty percent reduction graph that one third of respondents saw. For all three levels of reduction the salinity trend line was below the dashed line representing compromised aquatic health. Larger values of reduction should increase the willingness to pay for the management program (Whitehead 2016).

To capture potential scenario rejection that might lead to attribute non-attendance of the scope variable we asked a follow up question: "Do you think that the stormwater management plan could achieve a reduction in long-term salt levels of (25%,50% 75%) in {respondent's County}? Possible answers included: Definitely Yes, Probably Yes, Probably No, Definitely No, and I Don't Know. We consider those who did not think the plan could achieve the goal as rejecting the scenario. We create a scenario rejection variable by coding both Definitely Yes and Probably Yes responses as one and all others as zero.

The survey included a CVM question using a tax payment vehicle. We randomly assigned either an annual payment mechanism or one-time payment mechanism with various levels of the tax payment. Leading up to the actual CVM voting question, the survey stated:

The stormwater management plan would require additional funding. Counties in the

> Appalachian Region raise revenue from different combinations of sales, income and property taxes. Additional revenue from these sources could be used to subsidize the increase in stormwater management practices in {respondent's County}.
>
> One estimate is that it would require a one-time [annual] increase of about $A per household in county sales, income or property taxes to fund the stormwater management plan. So, for example, if your combined county sales, income or property tax bill was $1000 last year it would be $1000 + A this year (and back to $1000 each year after that) [and $1000 + A each year after that]. (where each respondent saw one value for $A=28, 78, 128, 178, 228, 278 or 328).
>
> Imagine that you have the opportunity to vote on the proposed stormwater management plan in a countywide referendum. If more than one-half (50%) of the voters in {respondent's County} vote for the plan then it would be put into practice and your county tax bill would increase.
>
> Now we would like to know how you would vote in a {respondent's County} referendum.

We then asked: "If you could vote today in a {respondent's County} referendum, would you vote for or against the stormwater management plan?" Respondents could select from the following options:

> "I would vote for the stormwater management plan"
>
> "I would vote against the stormwater management plan"
>
> "I am undecided"
>
> "I would not vote."

In our analysis, we coded all undecided voters as no votes as suggested by Groothuis and Whitehead (2002) and Caudill and Groothuis (2005). We excluded individuals who stated they would not vote (n = 59) giving us a sample of 1308.

Data

In Table 1, we report the means of the variables used in our study. An average respondent was 46 years old, with 14 years of education and an income of $51,335. Forty-nine percent live in urban areas, twenty-one percent in suburban areas, and thirty percent in rural areas. Thus seventy percent of our respondents live in urban/suburban places where runoff issues are likely similar to those on Boone Creek, making our monitoring data applicable. Forty-eight percent of respondents were randomly assigned the more detailed scientific information, (labeled **Science** in Table 1). When asked toward the end of the survey, sixty-four percent of the respondents either agreed or strongly agreed with the statement: "I understand all the information presented to me on the proposed stormwater management plan" (labeled *Understand* in Table 1). Seventy percent of respondents believed that the stormwater management program could achieve the salinity reduction level they saw in the survey (labeled *Achieve* in Table 1). We suggest that these respondents are accepting the CVM scenario as realistic while those who do not believe the reduction is possible reject the scenario. Therefore, we used the variable, *Achieve*, in our ANA model to identify those who reject the scenario. Twenty-eight percent of the survey respondents, n=363, did not think the stormwater program could achieve the goals as measured by the scope variable. Following Carson and Groves (2007, page 185), we hypothesize that these respondents ignore the scope variable. In Table 2, we report referendum vote responses by tax level for both the annual and the one-time tax. Consistent with economic theory, the proportion of yes votes falls as the tax rate increases; however, the trend is relatively flat. Also, at the lowest tax level of $28 only slightly more than fifty percent are in favor of the proposal with a one-time payment and slightly less than fifty percent are in favor with an annual payment suggesting that many people may have a low, possibly zero, willingness to pay for stormwater runoff abatement management. Yet, at the highest tax level of $328 we find that more than a third of respondents who were asked if they would pay that amount would vote yes on the proposal. This suggests that for some respondents stormwater abatement management programs are highly valued.

Model

To theoretically model the referendum vote, consider a resident who receives utility from both a consumption good, z, and an improvement in water quality, q, where q represents benefits from implementing stormwater runoff abatement measures. 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 stormwater abatement is implicitly defined as the payment that equates indirect utility with different water security conditions, $v(q^{o}, y) = v(q', y - WTP)$, where q^{o} is the status quo level of stream salinity and q' is the improved level of water quality. In our case, the willingness to pay question for stormwater runoff abatement measures follows a dichotomous choice framework. The variable *Vote* is a qualitative variable equal to one if the respondents answered: “I would vote for the stormwater management plan.” We empirically estimate the referendum vote model with an ANA conditional logit estimation technique.

Hensher, Rose and Green (2005) introduced the concept of attribute non-attendance in choice experiments. As part of their survey, they directly asked respondents if they ignored various attributes and used these statements in their empirical model. Alemu et al. (2013) consider the reasons for ANA. These include attitudinal statements about whether the attribute is important to the respondent, whether ignoring the attribute made it easier to choose between the alternatives, whether the attribute levels were of an unrealistic magnitude and whether the respondent refused to make tradeoffs with an attribute. In the contingent valuation literature, these reasons have been considered protest responses and scenario rejection (Carson and Groves 2007, page 185).

Extending the results of Alemu et al. (2013), we propose an attitudinal variable, whether the respondent believes that the target scope level can be achieved, to serve as an ANA indicator for our scope variable. In particular, we propose that there are two types of respondents:

$$U = \alpha_1 Tax + \alpha_2 Scope|Achieve = 1 + \alpha_3 Input + \alpha_4 Annual + \alpha_5 Science + \alpha_6 Reminder$$

$$U = \alpha_1 Tax + \qquad\qquad\qquad\qquad + \alpha_3 Input + \alpha_4 Annual + \alpha_5 Science + \alpha_6 Reminder$$

Respondents who believe that the scope of the policy can be achieved include the scope level in their utility function when placing their referendum votes during the survey. The second type of respondent ignores the scope variable due to its unrealistic nature.

Following Siikamäki and Larson (2015) we estimate the probability that the respondent would vote for the policy with the multinomial logit model:

$$\pi(Vote = FOR) = \frac{\exp(\alpha' x_k)}{\sum_{j=1}^{2} \exp(\alpha' x_j)}$$

where k is the chosen alternative among j= 1, 2 alternatives (i.e., for, against). The results of the MNL models are presented in Table 3. The baseline model without ANA yields poor results. Only the coefficient on the tax amount is statistically different from zero ($p < 0.05$, one-tailed test).

When scope non-attendance is accounted for the in the MNL model all of the regression coefficients are statistically significant at the $p < 0.05$ level except for the coefficient on program inputs of a ten percent increase or fifty percent increase. By contrast, dropping the respondents who do not think the program goals can be achieved leads to a statistically significant scope coefficient but none of the other coefficients are statistically significant.

In Table 4, we report the willingness to pay estimates. The marginal willingness to pay on the scope variable is equal to \$7.95. Scaling this up to the magnitude of the policy change, willingness to pay is \$199 for a 25% improvement, \$398 for a 50% improvement and \$596 for a 75% improvement. Willingness to pay is \$99 lower with the annual payment schedule. The budget reminder lowers willingness to pay by \$97. The effect of the science information on willingness to pay is -\$113.

To further explore the influence of science information, we estimate three probit models reported in Table 5. The first estimates the factors that affect the likelihood that individuals believe the stormwater management will achieve the goals. This probit identifies the characteristics of respondents who are more likely to accept the scenario and consider the scope attribute in their referendum votes compared to those who reject the scenario and, we assert, ignore the scope attribute. We find a nonlinear effect for education; education increases the likelihood respondents will believe that the management goals will be met but at a decreasing rate. The coefficient on education is positive and the coefficient on education squared is negative. The concave relation peaks at 15 years of education. In addition, we find that age decreases the likelihood for the respondent that the management goals will be achieved.

To test the role of scientific information on scenario rejection we use both the science and understand dummies as well as their interaction in our probit analysis. We find that the coefficient on science is negative and significant while the coefficient on understanding is positive and significant. We also find that the interaction dummy between science and understanding is positive and significant.

To provide the interpretation on the influence of scientific information consider two subsets of respondents. The first subset includes individuals who received the detailed science information but report they do not understand all the information on the proposed stormwater management plan. For these individuals, the marginal effect is only the coefficient on the science dummy which is -.286. The second subset includes individuals who report they understand the information and also received the detailed scientific information. Their marginal effect is the coefficient on science plus the coefficient on the interaction term which is -.286 plus .386 or .100. Our results show that for the subset of individuals who state they do not understand all the information on the stormwater management plan and also received the detailed scientific information increases scenario rejection. However, respondents who state they understand all the information on the management plan and also received the detailed scientific information are more likely to believe the management goals can be achieved thus reducing scenario rejection.

We find that the level of scope has no influence on whether respondents believe the stormwater management goals will be met. The results suggest that the scenario rejection does not arise from the scope variable itself but from another reason such as respondents' understanding of the information provided. We also find no difference between city, suburban and rural residents.

Given that perceived understanding of the management plan influences scenario rejection in different manners, we estimate two additional probit models on the determinants of perceived understanding. One model uses the subsample of respondents who reject the scenario and the other uses the subsample of individuals who believed that the stormwater management plan could be achieved. We include the demographic variables education, age, age squared. We find that education has a positive effect on perceived understanding in both models. Age has a concave relationship with the perceived understanding in the subsample that does not reject the scenario. We find that the detailed scientific information has a positive and statistically significant effect in the subsample that does not reject the scenario while detailed scientific information has no influence on understanding in the subset that rejects the scenario. We find that the dummy variable indicating if the respondent resided either in an urban or suburban area has no influence on understanding. Overall, we find that detailed science information influences respondents differently depending upon if the report they understand all the information on the stormwater management plan given or do not understand this information.

Discussion

The results from the willingness to pay scenario align with economic theory in our attribute non-attendance model. We find that the attribute non-attendance model, as applied to a discrete choice experiment, controls for scenario rejection in the scope variable. Once we control for the scenario rejection, we find that higher tax amounts lowers the likelihood of voting for the proposal and respondents are more willing to pay a one-time tax rather than annual taxes. Our willingness to pay estimates range from $199 for a 25% reduction to $596 for a 75% reduction in saline levels. In addition, we find that detailed science information reduces respondent's willingness to pay by $113.

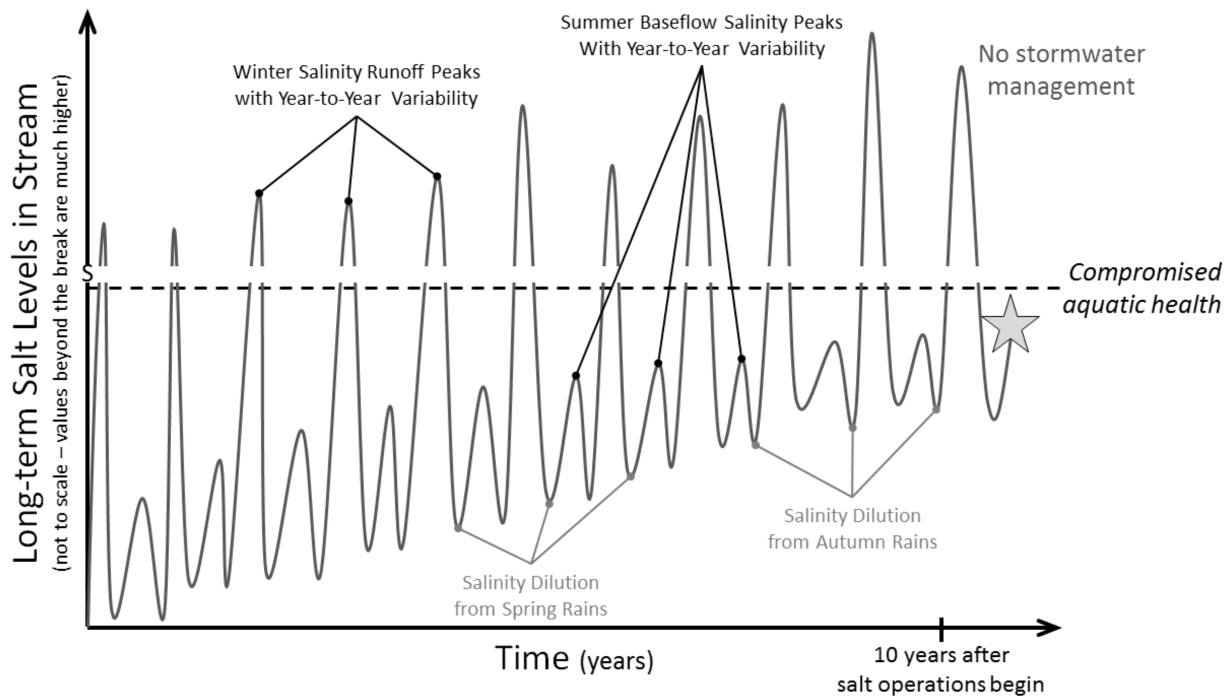
We also find that detail scientific information is viewed differently by subsets of respondents. First, for the respondents who believed that the management policy could be achieved, detailed scientific information increased their perceived understanding of the information provided about a potential management plan. These individuals who accept the management scenario as feasible may have internalized the science-based information provided and this subsequently influenced their perceived level of knowledge. Second, for respondents who rejected the management scenario, detailed scientific information had no influence on perceived understanding of the management plan presented. These individuals who reject the scenario might also be rejecting the information provided indicated by the result that detailed scientific information does not influence their perceived knowledge of the stormwater management program.

In addition, among respondents who felt the proposed management efforts could be achieved, the positive relationship between seeing the more detailed science-based information and reporting that they understood the information provided about the management plan may reflect a "blinded with science" phenomena whereby even a superficial appearance of scientific credibility can sometimes increase a message's persuasive power (Tal and Wansink 2016). On the other hand, this may reflect a reinforcement phenomenon, as those who saw the more detailed text and the graphic in Figure 1 also received the more simplified representation of the science-derived information in Figures 2 and 3. Seeing the information in two different forms at different places in the survey may have helped increase comprehension or at least perceived comprehension. If comprehension actually did increase, this would explain a willingness to pay to avoid the negative consequences of not implementing stormwater management, as portrayed in all of the science-derived text and figures.

Our specific focus on accessing the influence of detailed, science derived information revealed interesting results with several possible explanations. First, the detailed scientific information increased scenario rejection in respondents who received the scientific information but stated they did not fully understand the information. This scenario rejection could lead to protest nos where individuals opt for the status quo. Alternatively, the reduction in the willingness to pay may be survey specific, i.e., the information we provided respondents lowered all respondent's willingness to pay. Future research should focus on the these competing hypotheses.

Overall, our analysis reflects the challenges inherent in integrating data and information about the physical reality of stormwater runoff with a social science survey. The physical science data is site specific and it is a challenge to provide that same level of specificity across a large spatial scale relevant to gathering survey data. Our results do indicate, however, that providing the more detailed information does influence some responses. Therefore, further assessing what information respondents deem relevant, as well as how much information to provide and in what format are promising topics for further research on assessing public attitudes about stormwater management. Based on our experience with this project, we do believe that incorporating the best scientific information available into a contingent valuation scenario can help ensure more realistic answers to hypothetical questions.

Figure 1.



Long-term Salt Levels in Stream
(not to scale – values beyond the break are much higher)
Winter Salinity Runoff Peaks
with Year-to-Year Variability
Summer Baseflow Salinity Peaks
With Year-to-Year Variability
No stormwater
management
Compromised
aquatic health
Salinity Dilution
from Spring Rains
Salinity Dilution
from Autumn Rains
Time (years)
10 years after
salt operations begin

Figure 2.

Rain gardens or bioretention svstems hold water during storms and release it slowly.

Permeable pavement allows water to soak through it rather than running off of it.

Rain barrels or larger cisterns collect water during storms for later use in gardens, car washing etc.

Figure3

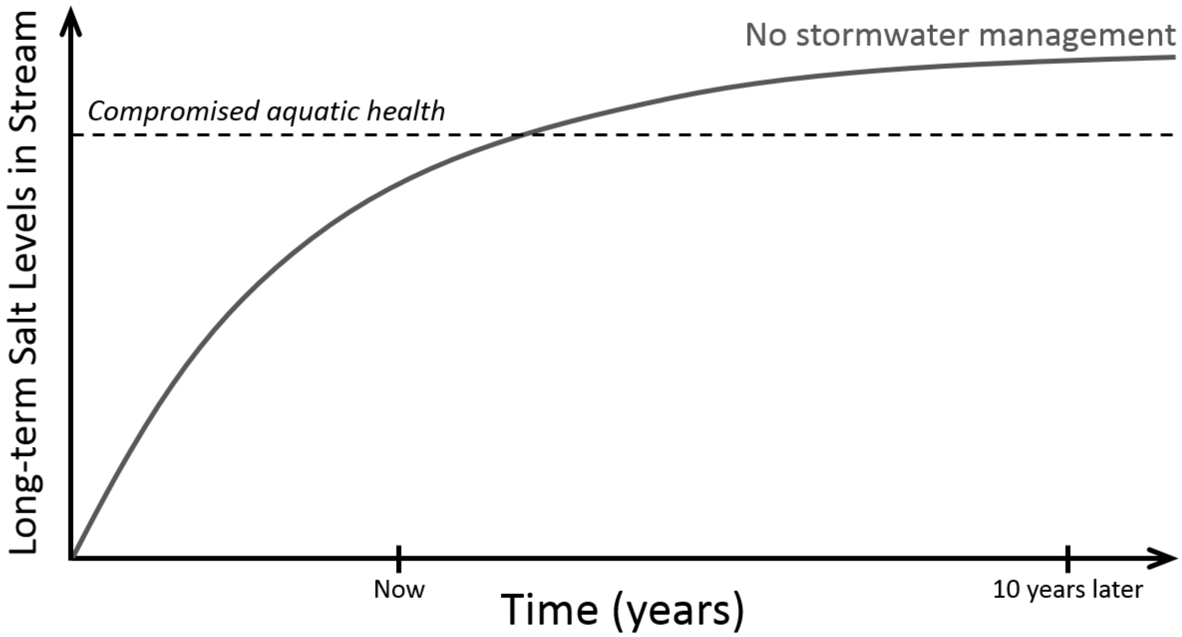

No stormwater management
Compromised aquatic health
Long-term Salt Levels in Stream
Now
10 years later
Time (years)

Figure 4

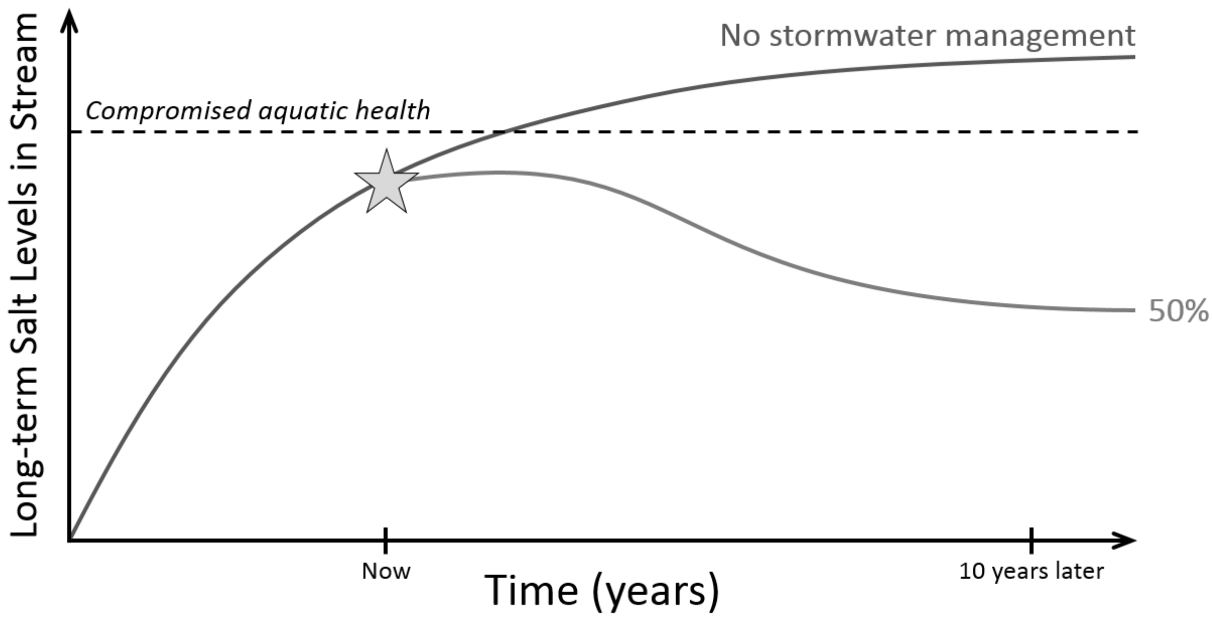

No stormwater management
Compromised aquatic health
50%
Long-term Salt Levels in Stream
Now
10 years later
Time (years)

Table 1. Data Summary

Variable	Mean (Standard Deviation)
Science	0.48
Understand	0.64
Achieve	0.70
Age	46 (15)
Education	14 (2.2)
Income	$51,335 ($39,113)
Suburban resident	0.21
Urban resident	0.49
Rural resident	0.30
SurveyMonkey Panel Respondent	0.69

Sample Size = 1308

Table 2. Referendum Votes

	One Time Payments		Annual Payments	
Tax	%For	Sample	%For	Sample
28	50	94	49	92
78	49	97	44	90
128	47	104	37	83
178	47	97	51	97
228	51	101	35	84
278	41	86	45	107
328	31	83	35	93
Total	48	662	43	646

Table 3. Multinomial Logit Models for the Probability of a For Vote

	Base Model			ANA Model		
	Coefficient	S.E.	t-stat	Coefficient	S.E.	t-stat
Tax	-.00089	0.00049	-1.80	-.00237	0.00049	-4.86
Scope	0.0018	0.00208	0.88	.0189	0.0019	9.54
Input	0.0162	0.107	0.15	-0.124	0.109	-1.14
Annual	-0.156	0.108	-1.44	-0.234	0.1109	-2.11
Science	-0.109	0.106	-1.03	-0.268	0.1076	-2.49
Reminder	-0.0556	0.108	-0.52	-0.231	0.1097	-2.11
LL Function	-896.00			-847.06		
AIC	1804.0			1706.1		
R^2	0.0051			0.059		
Sample	1308			1308		
Scope ANA				363		

Table 4: Willingness to Pay estimates

		WTP	S.E.	t-stat
Scope	$-\alpha_2/\alpha_1$	7.95	1.54	5.17
Annual	$-\alpha_4/\alpha_1$	-98.51	55.28	-1.78
Science	$-\alpha_5/\alpha_1$	-113.12	54.45	-2.08
Reminder	$-\alpha_6/\alpha_1$	-97.48	54.70	-1.78

Table 5: Determinants of Achieve and Understand (Probit)

	Achieve (standard error)	Understand (standard error)	Understand (standard error)
		Achieve = 0	Achieve=1
Reduction	-.001 (.002)	-.001 (.003)	.001 (.002)
Science	-.286** (.120)	-.138 (.129)	.255** (.089)
Understand	.611** (.107)		
Understand × Science	.386** (.157)		
Age	-.007** (.003)	-.021 (.025)	.064** (.017)
Age squared	--	-.0003 (.0003)	-.0007** (.0001)
Education	.515** (.184)	.053* (.016)	.049** (.021)
Education squared	-.017** (.006)		
Suburban resident	.100 (.113)	.031 (.197)	-.112 (.122)
Urban resident	-.103 (.089)	.204 (.151)	-.066 (.102)
SurveyMonkey Respondent	.041 (.082)	.118 (.140)	.184* (.094)
Constant	-3.10** (1.30)	-.813* (.714)	-1.558** (.482)
Log-likelihood	-704.53 **	-262.18*	-541.70**
Sample Size	1308	338	970

**significance at 5% level. *significance at 10% level.

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Acknowledgements: We would like to thank Appalachian State University for funding the Water Cluster: Integrating Geology, Economics and Policy Analysis through the CONducting ComplEx Research Together (CONCERT) Grants