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Moving beyond the exchange value in the nonmarket valuation of ecosystem services

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ABSTRACT

There has been much discussion across the ecosystem services literature as to the role of economic valuation in identifying ecosystem service values and shaping policy. This article demonstrates a non-typical use of a nonmarket valuation technique known as the stated choice experiment (CE) for understanding a range of public preferences for stream-related ecosystem services in Macon County, NC. The experiment was carried out as part of the National Science Foundation funded Coweeta Long Term Ecological Research initiative, and it reflects an interdisciplinary attempt to produce knowledge regarding ecosystem service values that is of relevance to policy makers. The CE uses a split-sample design to test for the impact of mechanism of program implementation on respondent preferences and demonstrate a range of public willingness to pay (WTP) for stream health improvements. Responses are analyzed with a latent class logit and the results show that altering the mechanism of program implementation changes the latent class composition. Results also demonstrate consistent preferences for certain attributes of stream health, but WTP for ecosystem service provisioning varies widely with proposed program implementation. The use of the CE in this research demonstrates the flexibility of the tool for combining with interdisciplinary knowledge, as well as the usefulness of information provided by nonmarket valuation techniques for informing policy design.

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1. Introduction

In land use planning and other decision contexts, there is growing consensus that characterizing the value of ecosystem services is essential for designing effective policy (Costanza et al., 1997; Pascual et al., 2010; Kareiva et al., 2011), but there is uncertainty as to how to identify and measure the multiple values of ecosystems and incorporate these values into policy (De Groot et al., 2010; Goulder and Kennedy, 2011). Nonmarket valuation methods, a variety of economic techniques that are typically used to estimate the (monetary) exchange values of goods and services that are not exchanged in a market setting, are integral to estimating ecosystem service values (Swinton et al., 2007). While traditionally developed to understand the marginal impact of specific policy changes, and to estimate willingness to pay (WTP) for marginal environmental improvements (Champ et al., 2003), there is increasing interest in using these techniques to evaluate a wide range of public preferences for ecosystem services absent specific policy or program proposals.

Nonmarket valuation, and other economic techniques that emphasize exchange values over cultural and ecological values, have been subject to criticism regarding the inability of exchange values to represent the total value of an ecosystem (Kosoy and Corbera, 2010; Chan et al., 2012). Critics have asserted that exchange value is an inadequate proxy for the multitude of values underlying ecosystem services (Martinez-Alier et al., 1998; Norton and Noonan, 2007), as well as the multitude of services produced by healthy functioning ecosystems (Ghilarov, 2000). This critique has generally led to two responses: (1) a complete rejection of economic valuation approaches and their usefulness in environmental management (McCauley, 2006), or (2) attempts to incorporate a multitude of methods and knowledge systems into ecosystem service valuation for the sake of informing policy (Brondízio et al., 2010). Increasingly, economists are engaging with interdisciplinary teams in an attempt to incorporate cross-disciplinary knowledge into experimental design. Such collaboration, including that which motivated the experiment described in this paper, demonstrates the flexibility of valuation methods and enhances their efficacy for informing policy.

Nonmarket valuation faces criticism of more technical nature as well. One frequent criticism of stated preference methods in particular (a nonmarket valuation technique that uses well-crafted

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hypothetical scenarios to elicit preferences), is the well-documented presence of hypothetical bias. Hypothetical bias is observed in studies that compare WTP estimates from hypothetical payment decisions in stated preference studies and WTP estimates from comparable actual payment decisions (see for example Champ et al. (1997), Champ and Bishop (2001) and Moore et al. (2010)). To some, this suggests that these methods are not reliable tools for understanding public preferences. Hypothetical bias is a clear concern when seeking precise WTP estimates for use in benefit cost analysis, and it is important to continue to develop techniques to reduce hypothetical bias. But, its presence does not render stated preference methods irrelevant. As our application illustrates, these methods can be used to characterize relative preferences for different aspects of ecosystem services, even if precise estimates of WTP are not feasible.

Nonmarket valuation can contribute to a broad interdisciplinary literature on ecosystem service values by explicitly incorporating flexibility into experimental design and analysis. This paper demonstrates how nonmarket valuation can be used as part of a complex research scenario in which there is a need to understand the potential benefit of improved ecological health and related ecosystem services without a specific mechanism, policy, or ecological change identified. We use a nonmarket valuation technique, a stated choice experiment (CE), that was designed in an interdisciplinary setting to provide a priori preferences related to possible programs to improve stream health and related stream ecosystem services in Macon County, NC. We analyze results with a latent class logit to understand preference heterogeneity for program design. WTP estimates provide information on both the range of public WTP for stream health improvements, and a means for comparing preferences across program design and latent classes. Through this approach, we demonstrate the utility of nonmarket valuation methods beyond the need for precise estimates of exchange values for use in benefit cost analyses.

1.1. Site description

Macon County, NC, is located in the Blue Ridge region of Southern Appalachia. There are several ecosystem services associated with healthy streams in Macon County that are of concern to academics and policy makers. Healthy streams provide for aquatic habitats, protecting biodiversity in a region that has high rates of aquatic endemism (Scott, 2006). Healthy streams provide clean water for recreational, agricultural, and consumptive purposes. Water quality provided by these streams is particularly important because this region is credited with supplying much of the freshwater for consumptive purposes to the southeastern United States (Viviroli et al., 2007; Webster et al., 2012). Livelihoods in Macon County also depend on recreational ecosystem services. For example, southern Appalachian streams provide trout habitat (Scott and Helfman, 2001), which contributes to tourism revenues from fishing. And finally, perhaps ironically, streams have an amenity value for housing construction (Chamblee et al., 2009).

Southern Appalachia has experienced demographic changes that are threatening stream health, and consequently, the ecosystem services produced by healthy streams. Southern Appalachia is a historically impoverished mountainous region that was primarily dedicated to agriculture until the later-half of the 20th century (Gragson and Bolstad, 2006). Over the last 50 years, Macon County has witnessed an influx of what are sometimes referred to as “exurban” migrants – middle and upper class urban residents who are attracted to the rural landscape for the purposes of retirement and vacation homes (Gustafson et al., 2014; Vercoe et al., 2014). The land uses in the region have subsequently shifted from agricultural use to housing development (Gragson and Bolstad, 2006). The urbanization of the landscape has been linked to degradation of local streams, including: riparian deforestation (Audrey et al., 2009), increased sedimentation (Clinton and Vose, 2006; Price and Leigh, 2006), increased fecal coliform pollution (Lohse and Merenlender, 2009), and increased stream nitrogen concentrations (Webster et al., 2012).

The influx of urban migrants to the region has caused social impacts in tandem with the ecological impacts. Social scientists researching Macon County have documented a division between long term residents who have relied on agriculture and extractive industries (such as logging and mining) for income (Isserman and Rephann, 1995), and more recent arrivals who are typically wealthier, and are often seasonal second home owners (Gustafson et al., 2014). These demographic groups sometimes have different visions for stream management (Evans, 2013). Therefore, if stream management policy in the region is to provide a just conservation solution to degraded streams, it must navigate the power dynamics between these two groups (Vercoe et al., 2014). Our research was designed to provide information on the aspects of stream health that are most important to stakeholders, while deepening understanding of the feasibility of different policy mechanisms for stream improvements in the region.

2. Methods

In order to link these economic valuation estimates to indicators of biological integrity and ecosystem service production (Johnston et al., 2011), our survey was designed in consultation with ecologists, anthropologists, and geographers working in the National Science Foundation funded Coweeta Long Term Ecological Research site (CWT LTER). To the extent possible, the attributes of the stated choice experiment (CE) are aligned with components of the Stream Visual Assessment Protocol (SVAP), a biological index of stream health that ecologists have shown to be directly applicable to the study area (Bjorkland et al., 2001). We chose to use a CE because this method can estimate the WTP for the individual indicators of stream health. We also needed to estimate preferences for stream health improvement without a specific policy or mechanism proposed that would generate this improvement, and a CE allows us to consider how factors beyond the ecological change might affect WTP estimates. Given that program design can affect preferences (Colombo et al., 2005), we were able to use a CE to understand how preferences depend upon implementation decisions.

2.1. Sample selection

We used parcel tax data and hydrologic data from http://gis2.maconnc.org/www2/gis/ to identify a sample of Macon County residents. The Macon County tax file includes 44,250 total parcels. After removing duplicate parcels, non-residential parcels, and parcels lacking address information, a total of 26,993 remained in the sample frame. At the time of our survey, another survey was being conducted targeting riparian landowners in Macon County. To avoid overburdening riparian landowners, 2500 of these riparian owners were sampled for the parallel survey and the remaining 772 were returned to our sample frame. We then randomly selected 3500 parcels for our sample. Because of this framework, riparian parcels were under-sampled for our survey. This is not a primary concern because our analysis is focused on the relative importance of stream health characteristics, and not on aggregating WTP across the population. Further, an indicator variable identifying riparian parcels was not significant in any of the models estimated, suggesting that there is not a significant difference in values between residents of riparian properties and other residents.

2.2. Experimental design

All survey materials were refined based on repeated consultation with researchers, local resource managers, and residents, as well as feedback from two focus groups held in Franklin, NC. 19 Focus group participants were recruited through advertisements in the Franklin Press newspaper and through fliers. A $40 incentive was provided for participation in each two-hour focus group. In addition to improving the overall readability of the survey, these focus groups identified specific issues that influenced the final design of our choice experiment. Of greatest impact, we learned that inclusion of mechanism of program implementation could cause protest responses among Macon County residents. As a result, we split the survey sample and tested for differences between voluntary and mandatory mechanisms of implementation.

The survey instrument provided information on stream health and stream-related ecosystem services, and solicited participation in the CE. Auxiliary questions asked participants about recreation experiences, environmental attitudes, and demographics. The CE component invited respondents to participate in a hypothetical referendum that would affect future stream health in Macon County, NC. The sample was split to test for variation in responses due to the mechanism of program implementation. Half of the surveys explained that stream health standards would be reached by establishing *mandatory* regulations regarding allowable land uses. The other half of the surveys explained that stream health standards would be reached by *voluntary* regulations that would provide monetary incentives for landowners to manage land in specific ways that contribute to program goals.

Each choice occasion presented two alternatives for stream characteristics and an "opt out" alternative (Fig. 1). The stream characteristics included six attributes to be tested: water quality, muddiness, livestock access, vegetation around streams, aquatic animals, and cost. Each attribute had 2, 4, or 8 possible values as described in Table 1. A separate insert included with the survey featured descriptions of the attributes and levels included in the choice questions (Fig. 2). The insert also included information about the current conditions of streams in Macon County. Using NGENE 1.1.1, we created a d-efficient experimental design with 20 choice scenarios blocked into 5 groups (i.e., four choice questions per respondent). This resulted in 10 versions of the survey, with each block of choice questions presented in the context of both mandatory and voluntary mechanisms of implementation.

The final choice experiment was conducted via mail survey between September 2012 and February 2013. The survey was sent to a sample of 3500 Macon County residents. We mailed the survey using a modified Dillman method (Dillman, 2007), in which

If you were voting in a referendum that would create a program to have 75% of streams in Macon County reach one of the following sets of standards through (mandatory regulation of land use decisions / voluntary incentive payments to landowners), how would you vote? (*Check one box below.*)

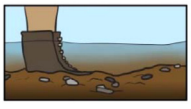
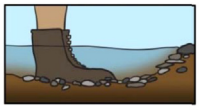
	Alternative A	**Alternative B**	
Water quality	Agriculture, fishing, swimming and drinking	Not safe for any use	
Muddiness	 Muddy	 Some Mud	
Livestock Access			
Vegetation around Streams	 Sparse Vegetation	 Thick Vegetation	
Aquatic Animals	 Snails	 Brook trout and Salamanders	
Cost to your household	$60/year	$40/year	$0/year
Check ONE box. →	**I vote for Alternative A** ☐	**I vote for Alternative B** ☐	**I would not vote for either alternative.** ☐

Fig. 1. Example choice experiment question.

Table 1
Attributes and levels of choice experiment.

Attributes	Definition	Levels
Water quality	The possible water uses according to minimum water quality requirements	Not safe for any uses; Agriculture, Fishing; Agriculture, Fishing, Swimming; Agriculture, Fishing, Swimming, Drinking
Muddiness	The amount of mud on stream bottom and suspended in streams	No Mud; Some Mud; Muddy; Thick Mud
Livestock access	Permission for livestock to directly enter streams	Access Permitted; Access Prohibited
Vegetation around streams	The minimum required thickness and density of the riparian buffer for streams	No Vegetation; Sparse; Medium; Thick
Aquatic animals	The aquatic animals potentially found in streams	Snails; Largemouth Bass, Red Breasted Sunfish; Rainbow Trout, Brown Trout; Brook Trout, Salamanders
Cost	Annual cost to household	$0, $10, $20, $40, $60, $80, $100, $200, and $400

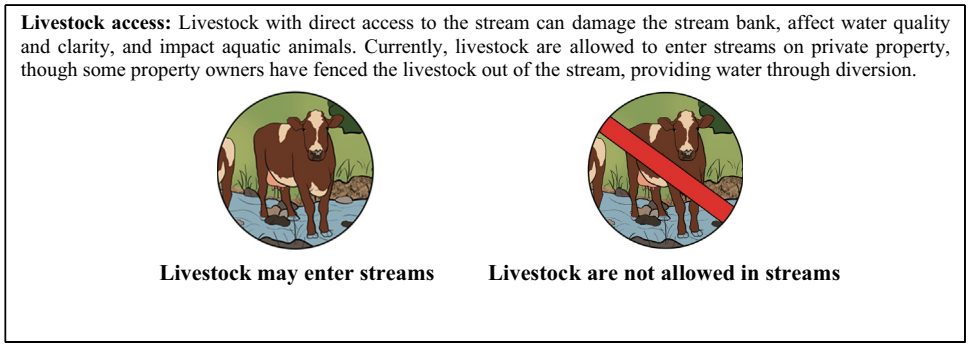


Fig. 2. Example of attribute/level description provided in the insert.

three contacts were made: (1) a cover letter and survey, (2) a follow-up postcard, and (3) an additional copy of the survey to non-respondents. As an incentive, a two-dollar bill was included with the initial mailing.

2.3. Latent class model and WTP estimates

We used a latent class logit model to estimate WTP for stream health indicators under both mandatory and voluntary programs. Standard logit models inherently assume homogenous preferences across the population (other than differences explicitly accounted for by inclusion of sociodemographic or other variables in the regression model). Latent class models and random parameter models are two approaches that allow for heterogeneous preferences. Both assume there is unobservable variation in preferences across the population that cannot be accounted for by including additional variables of observed differences. For a more complete discussion of these models, see for example (Greene and Hensher, 2013). A latent class model, such as the one used here, estimates unique preferences for distinct classes within the population. It is not possible to directly observe which class an individual should be assigned to, but the model estimates the probability of class membership based on the individual's response. In this way, the latent class model allows for preference heterogeneity based on unobservable characteristics, and provides some information that can help describe those unobservable characteristics (Boxall and Adamowicz, 2002; Birol et al., 2006).

Using NLOGIT 5, we estimated a latent class logit model in which class membership is conditioned on the individual characteristics described in Table 2, and the choice between stream health alternatives depends on the choice attributes described in Table 1. To be explicit, the indirect utility function driving the choice decision for member i of class s can be written as:

$$U_{ils} = \beta_{0s}\text{ASC} + \beta_{1s}\text{Water Quality}_i + \beta_{2s}\text{Muddiness}_i + \beta_{3s}\text{Livestock access}_i + \text{Vegetation}_i + \beta_{5s}\text{Aquatic Animals}_i + \beta_{6s}\text{Cost}_i + \epsilon_i$$

The probability that individual i is a member of class s is estimated by

Table 2
Variables describing latent class membership probability.

Variable name	Survey question	Proxy for
Voluntary efforts	Stream Improvements should be voluntary	Position on government mandates for environmental care
Slope	An ordinance should monitor slope developments	Position on zoning laws
Tax	Taxes should be increased on homes purchased on slopes	Position on taxes
First generation	Are you the first generation of your family to live in Macon County?	Tenure
Primary residence	Use of property	Time spent in region and investment in community
Income > 60 K	Annual income less than 60,000 USD per household	Income

$$W_{is} = \frac{\exp\ (\alpha_{0j} + \alpha_{1s}\mathrm{Vol}_i + \alpha_{2s}\mathrm{Slope}_i + \alpha_{3s}\mathrm{Tax}_i + \alpha_{4s}\mathrm{FirstGen}_i + \alpha_{5s}\mathrm{Prim\ Res}_i + \alpha_{6s}\mathrm{Income}_i)}{\sum_{s=1}^{S} \exp\ (\alpha_{0j} + \alpha_{1s}\mathrm{Vol}_i + \alpha_{2s}\mathrm{Slope}_i + \alpha_{3s}\mathrm{Tax}_i + \alpha_{4s}\mathrm{FirstGen}_i + \alpha_{5s}\mathrm{Prim\ Res}_i + \alpha_{6s}\mathrm{Income}_i)}$$

We chose a two-class model to explore population heterogeneity, and used WTP estimates to compare preferences across classes. We estimated several latent class models with varying numbers of classes for both the mandatory and voluntary subsamples. The literature suggests two methods for determining the optimum number of classes to estimate the model. One methods relies on Akaike's information criterion (AIC) (Andrews and Currim, 2003; Kikulwe et al., 2011), and the other considers class membership probabilities (Greene and Hensher, 2013). For each subsample, we began with a 2-class model. Increasing the number of classes led to increasingly low probability of membership, and no improvement in AIC. This is largely due to the fact that all of our class predictor variables are binary. As a result, we chose a two class model. Finally, we calculated willingness to pay (WTP) for proposed stream health improvements across the classes of the Mandatory and Voluntary groups. We calculated expected WTP for each attribute conditional on class membership. We estimated standard errors using the Delta Method of the Wald Procedure in NLOGIT 5.0.

3. Results

3.1. Descriptive statistics

The mandatory and voluntary subsamples have similar demographic characteristics (Table 3), and these appear to generally represent the home-owning population of Macon County, NC. The overall response rate (any response divided by the number of surveys delivered) was 40.8%, with similar response rates for the voluntary and mandatory subsamples (40% and 42% respectively). The survey population demographics are comparable to county demographics provided by the most recent 2014 American Community Survey, which reports a median age of 48.6 years and a mean household income of $53,124 USD (www.census.gov). Our respondents are slightly older and wealthier than the census population, likely an artifact of our survey targeting home owners as opposed to residents. Slightly over half of respondents stated that Macon County is their primary residence, reflecting a large population of second home owners. Though the US Census does not provide numbers of second home owners, some statistics offer insight into tenure patterns. For example, the 2010 US Census reports that only 57.8% of total housing units were occupied. Of vacant homes, which were by definition "for sale," 76.6% were designated for seasonal use.

Table 3
Descriptive statistics for sample populations. Percentages were calculated as a percent of total subsample, excluding observations with incomplete or missing information.

Variable	Mandatory	Voluntary
Gender (% male)	66%	69%
Education (% with university degree)	56%	57%
Tenure (% over 10 years)	65%	70%
Median Age (years)	65	65
First Generation (% first generation)	66%	64%
Primary Residence (% primary)	56%	55%
Income (over 60 K)	56%	52%
Voluntary efforts (% agree)	65%	61%
Slope (% agree)	90%	89%
Tax (% agree)	62%	64%

Survey responses reveal a division in the population regarding mountain slope development. The majority of respondents agreed with the statement that "efforts to improve stream water quality should be voluntary" as shown by "Voluntary Efforts" (Table 3). A similar percentage of respondents agreed that "taxes should be increased on homes purchased on hill slopes." A vast majority of respondents also agreed with the statement, "An ordinance should be put in place to monitor mountain slope development." These last two questions reflect different reactions toward steep slope development in Macon County. While it is apparent that the majority of respondents would like to see greater control over the construction that is occurring on steep slopes and in landslide hazard areas, fewer respondents would support a policy that uses taxes to help control this development.

3.2. Latent classes and preferences for stream health

The latent class logit demonstrated an improved fit over the multinomial logit, with an adjusted R^2 of .242 and .243 for the mandatory and voluntary models, respectively. This suggests significant heterogeneity of preferences and has important implications for the accurate estimation of coefficients and WTP measures. We estimated additional multinomial logit and latent class models using different specifications and explanatory variables. We found that the goodness of fit was superior in the latent class models in all cases, and that additional explanatory variables did not significantly improve goodness of fit measures.

The final models presented in Table 4 used the same set of variables to condition class membership for both the Mandatory and Voluntary groups. For each group, parameters on class determinants were normalized to zero for one class, and those of the other class were interpreted relative to the first (Boxall and Adamowicz, 2002). For both groups, the two latent classes reflected a roughly equal share of respondents. Results indicated that residents of Macon County generally had consistent preferences for certain attributes of stream health across the population regardless of program design (Table 4).

The exogenous variables defining class composition changed depending upon program implementation. The description of the hypothetical mandatory program specified that increased costs, paid by the respondent's household, would go toward a program that would implement mandatory regulations regarding allowable land uses. For the Mandatory group, the best predictor of class related to tenure in the region. We therefore labeled the Mandatory classes Long Term Residents and New Arrivals. Relative to the New Arrivals, Long Term Residents were more likely to permanently reside in Macon County, not be first generation residents, and have a lower household income (Table 4). This group also was more likely to oppose a tax increase for hillslope development. The Voluntary group was presented with a potential program that would rely on incentives to encourage voluntary adoption of particular land uses that support stream health. The class divisions for this group centered not on tenure in the community, but on ideological differences. We labeled the Voluntary classes as Land Rights Advocates and Zoning Supporters, to reflect differences in support for mandatory regulation. The Land Rights Advocates

Table 4
Estimates for mandatory and voluntary programs by class[a].

	Mandatory program implementation		*Voluntary program implementation*	
	Long term residents	New arrivals	Land rights advocates	Zoning supporters
Water quality	.238 (.076)***	.301 (.044)***	.224 (.087)***	.395 (.045)***
Muddiness	−.304 (.091)***	-.408 (.049)***	−.538 (.111)***	−.423 (.051)***
Livestock access	.108 (.191)	−.247 (.105)**	.121 (.221)	−.083 (.101)
Vegetation	.010 (.076)	.045 (.041)	.061 (.090)	.029 (.040)
Aquatic animals	.186 (.092)**	.121 (.044)***	.181 (.103)*	.123 (.046)***
Cost	-.010 (.002)***	−.004 (.001)***	−.005 (.001)***	−.004 (.001)***
Opt out	1.910 (.323)***	−.556 (.197)***	2.829 (.351)***	−.386 (.198)*
Class membership probability	.474	.526	.472	.524
Class characteristics				
Intercept	.000 (.190)	–	−.323 (.215)	–
Voluntary efforts	−.005 (.007)	–	.471 (.188)**	–
Slope	.006 (.012)	–	-.660 (.298)**	–
Tax	−.484 (.139)***	–	.188 (.243)	–
First generation	−.488 (.139)***	–	.006 (.013)	–
Primary Residence	.489 (.139)***	–	−.064 (.221)	–
Income > 60 K	−.001 (.000)***	–	−.001 (.000)***	–

Significance levels are indicated by: * ($p < 0.1$), ** ($p < 0.05$), *** ($p < 0.01$).

[a] Parameters estimated using NLOGIT 5. Standard error is presented in parentheses.

were relatively more likely to be opposed to mandatory environmental regulations and to oppose zoning restrictions related to hillslope development (Table 4). Income was the only class membership predictor that was significant for both the Mandatory and Voluntary groups.

Class composition varied across both groups according to the *opt out* variable. This was an alternative specific constant equal to 1 if the respondent selected the status quo alternative, and 0 if the respondent selected either Alternative A or B (see Fig. 1). The coefficient on *opt out* was positive for Long Term Residents (Mandatory Program) and Land Rights Advocates (Voluntary Program), indicating that members of these classes were more likely to choose the status quo option. Conversely, this coefficient was negative for both the New Arrivals (Mandatory) and Zoning Supporters (Voluntary), indicating that these classes were less likely to choose the status quo option.

3.3. Willingness to pay estimates

Some WTP measures were consistent in rank across the classes (Table 5). Across all groups, the *Muddiness* attribute garnered the highest WTP among the sample population, where respondents were willing to pay for decreases in stream sedimentation and mud accumulation. The second highest WTP within each class was to improve overall stream *Water Quality*. There was not an observable WTP for any class for vegetation around streams.

The other attributes varied in WTP significance and magnitude across latent classes. Within the Mandatory group, New Arrivals expressed a higher WTP for all attributes of stream health relative to Long Term Residents (Table 5); likely reflecting their higher reported income. The New Arrivals class was the only class in both groups with significant WTP for *Livestock Access*, and they were WTP to avoid banning cows from streams (the status quo). The Voluntary group also showed differences in WTP estimates between classes. Generally, the Zoning Supporters exhibited a higher WTP for most components of stream health when compared to the Land Rights Advocates (Table 5). This likely is due to their higher reported income. The exception is the WTP for *Muddiness* among Land Rights Advocates, which demonstrated a statistically equivalent WTP equal to Zoning Supporters.

4. Discussion

The results from our split-sample design indicate that WTP for stream health improvements depends on both program emphasis and implementation. Based upon interdisciplinary consultation prior to the design and administration of the CE, we expected that positions on taxes and zoning, as well as tenure characteristics, may particularly influence WTP for attributes of stream health. Long term residents of the region have been characterized as traditionally self-reliant and averse to both taxes and zoning laws (Cho and Newman, 2005; Gragson and Bolstad, 2006). We expected, therefore, that long term residents may be more averse than new arrivals to the hypothetical proposal of a government

Table 5
WTP estimates for attributes based on program implementation and class membership[a].

	Mandatory		*Voluntary*	
	Long term residents	New arrivals	Land rights advocates	Zoning supporters
Water quality	24.93 (10.14)**	80.53 (14.92)***	45.89 (23.80)*	99.41 (15.74)***
Muddiness	−31.80 (9.01)***	−109.10(12.66)***	−110.11(25.02)***	−106.57(10.93)***
Livestock access	n.s.	−65.96 (26.43)**	n.s.	n.s.
Vegetation	n.s.	n.s.	n.s.	n.s.
Aquatic Animals	19.42 (11.15)*	32.43 (13.65)**	n.s.	31.08 (13.49)**

Significance levels are indicated by: * ($p < 0.1$), ** ($p < 0.05$), *** ($p < 0.01$).

[a] Estimates derived using the delta method of the Wald procedure in NLOGIT 5.0. Standard Error is presented in parentheses.

program regulating stream health. However, our results suggest that the potential dividing line in a conflict over a proposed program may depend upon program design.

Our results show that program design influenced willingness to participate in the hypothetical program, as demonstrated by opt out responses. Though opt out responses revealed a preference for the status quo, consistent choice of the status quo can indicate a "protest response", or a response that objects to the terms of the hypothetical program and not the specific attributes of each alternative (Adamowicz et al., 1998). In the Mandatory group, the preference for the status quo among Long Term Residents likely reflected protests against the mandatory land use restrictions that would be implemented by the program, and the implication that increased household expenses would fund such restrictions. In the Voluntary group, the Land Rights Advocates likewise demonstrated a clear aversion to government restrictions on private property rights; however, it appears that a different group was protesting. The ideological division in the Voluntary group did not coincide with the demographic division based on land tenure seen in the classes of the Mandatory group. This suggests that the proposal of a program that would cost money to the respondent's household but would fund voluntary incentives for landowners was more appealing to the long term residents, and thus diminished the potential division between these demographic groups. Hence, the voluntary program design appeared to abate a demographic division observed by other researchers and present in the mandatory program design. These findings can translate directly to policy development by better targeting programs that meet local stakeholders concerns while abating cultural barriers to participation.

Regardless of program design, stream sedimentation and suspended sediment, or *Muddiness*, was the attribute that most influenced CE responses. The importance of this issue to the population surveyed was particularly salient in contrast to the second most important issue – water quality. We expected that water quality might be the most important attribute, since it was specifically described as the direct use to humans. While the population surveyed did have a WTP for overall water quality improvements, this concern was clearly secondary to the more pressing issue of stream muddiness. The fact that muddiness was important is not surprising, as it has been identified as a major challenge to stream health in the region (Webster et al., 2012).

Macon County has seen a surge of second home construction in the region, often on steep slopes where the potential exists for landslide hazards (Gustafson et al., 2014). Home and road construction has caused erosion and, consequently, increased stream sedimentation (Price and Leigh, 2006). Increased sediment load, and overall muddiness of streams, has been documented as a pressing issue for many residents of Macon County (Evans, 2013). This issue has caused considerable contention in the region, where an initial attempt to publish landslide hazard maps and instigate zoning ordinances was quickly buried in the local municipality (Vercoe et al., 2014). However, 86% of respondents expressed agreement with the statement, "An ordinance should be put in place to monitor mountain slope development." Anthropological research in the region revealed a lack of confidence in local governing authorities to support and enforce environmental regulations (Evans, 2013). Our results indicated that despite the lack of regulation surrounding current hillslope development, there was public support and WTP for such a policy that could mitigate stream sediment contamination.

Our CE results showed a few unexpected preferences for attributes of stream health that have direct policy implications. For example, the Long Term Residents class in the Mandatory group had a high WTP for aquatic animals relative to other attributes. This was especially notable given the lower overall ability to pay of this class. We believe this finding was due to the fact that fishing provided an important source of tourism revenue in the region, and long term residents were the group most likely to be employed by the tourism industry. Fishing also was an important recreational activity among long term residents; thus, it constituted a cultural value for this group (Evans, 2013). The combination of the direct income support and cultural value likely explains the high WTP to conserve aquatic animals among the Long Term Residents class.

We also learned general information about public preferences for livestock access. We knew from our focus groups and from collaboration with the LTER team of interdisciplinary researchers that livestock in streams historically has been a contentious issue, with several towns attempting, and failing, to regulate livestock access to streams. Because of this, we expected to observe a positive WTP for a policy that would prevent livestock from accessing streams. Instead, our results suggested a positive WTP to avoid banning livestock. We hypothesize that this can be explained by a shift in attitudes toward livestock agriculture in the region, as well as a general decrease in agricultural activity in Macon County. Whereas in the past, agriculture may have been blamed for stream degradation, at the time of survey completion the public appeared to perceive that construction and erosion were most influencing stream health. Given the consistent decline of agriculture in the region (Gustafson et al., 2014), this result may be due to a concern for conserving the rural pastoral aspect of the landscape that attracted some of the "new arrivals" to the region (Gragson and Bolstad, 2006). This would explain the negative WTP for livestock access by the New Arrivals class.

The lack of WTP for increased riparian buffer is interesting because this attribute impacts stream ecosystem services of value to the public. This phenomenon is likely explained by cultural perceptions of what constitutes a healthy stream. Anthropological research conducted in the region demonstrated that residents have a misconception of the role of a riparian buffer in moderating stream health. Evans (2013) found that many long term residents considered low amounts of vegetation to be good for the stream, while many new arrivals wanted less vegetation around the streams so as to maintain a clear view. Our results underscore the reality that some stream characteristics might be ecologically beneficial, but reduce the overall value of the stream to the local population. In our case, cultural and aesthetic values appeared to trump perceived ecological value. This suggests that there may be a role for environmental education in future policy to inform the public about how ecosystem services they value are produced by healthy streams.

Given that this CE was designed to understand public support for a hypothetical policy, we examined the range of WTP for different policy designs. We calculated the total individual WTP for a hypothetical program that would target improvements for multiple stream health attributes (Table 6). The hypothetical program would improve water quality in 75% of Macon County Streams from "suitable for agriculture" to "suitable for agriculture, fishing, and swimming." Muddiness would decrease from "over 3 in. of mud on stream bottom" to "1–3 in.," and aquatic animals such as largemouth bass and red breasted sunfish would be common in streams. As expected, the unconditional WTP for the Voluntary program ($198) was greater than for the Mandatory program ($153). This indicated an overall preference for voluntary, incentive based mechanisms for maintaining and improving stream health rather than mandatory restrictions on permissible land use. The difference in WTP conditioned on classes was significant for both the Mandatory and Voluntary groups. Members of the New Arrivals and Zoning Supporters classes reported higher incomes than members of the other class in each group. This supported the higher overall WTP by these classes. However, the difference in magnitude was much

greater for the Mandatory group than for the Voluntary group. Within the Mandatory group, the WTP by New Arrivals was three times larger than that of Long Term Residents. For the Voluntary group, the WTP by Zoning Supporters was only 1.5 times larger than that of Land Rights Advocates. Thus, the mandatory program design had a wider WTP range, underscoring that this mechanism of implementation was more divisive among respondents.

an attribute associated with stream sedimentation due to hillslope erosion, was the attribute of greatest importance across the sample population, suggesting that a proposed policy may want to first target this attribute. Water quality and aquatic animals had an intermediate level of importance to respondents, which indicates that an effective policy would also need to emphasize these elements.

Our results further demonstrate that effective policy requires

Table 6
Willingness to pay for program targeting improvements in the indicated components of stream health by one level.

Program components	Mandatory		Voluntary	
	Long term residents	*New arrivals*	*Land rights advocates*	*Zoning supporters*
Water quality=suitable for agriculture, fishing, and swimming **Muddiness**="muddy" **Aquatic animals**=largemouth bass, red breasted sunfish.	$76.15	$222.06	$156.00	$237.06

5. Conclusion

Our CE design demonstrates the importance of nonmarket valuation as part of a suite of interdisciplinary tools that can be used in conversation with one another to understand ecosystem service values. While it is common practice in the nonmarket valuation literature to consult with ecologists and hold focus groups with the target population prior to the implementation of a survey, it is less so to consult with teams of researchers working in the region as was facilitated within the LTER research context. Consultation with ecologists and anthropologists allowed us to key in on the aspects of stream health and related ecosystem services that were most relevant for Macon County as well as most pressing to the residents of the region. Interdisciplinary consultation also allowed us to better understand the subpopulations of our study region as revealed in the CE analysis and results.

The results of this study demonstrate an effective use of nonmarket valuation for informing ecosystem services policy design. Though there has been criticism of stated preference methods due to the potential unreliability of WTP estimates, we demonstrate that the CE is a useful tool in nonmarket valuation precisely *because* of the hypothetical context. The methodology and analysis shown here exemplifies how the CE can be used to understand a range of values and heterogeneity in the population for specific attributes of stream health. Our survey suggested a range in WTP of $76.15–$237.06 per household per year to improve stream health by one level of each attribute in the region of Macon County. The difference between these estimates depended upon program design and internal characteristics of the population, and our survey provided the bounds on WTP and possible program implementation.

Our CE results also revealed preferences for hypothetical program implementation that can inform policy development in Macon County, NC. First of all, a mandatory mechanism of program implementation was less preferred to a voluntary mechanism. Of the two hypothetical programs described in the CE, the program directing voluntary incentives to landowners for providing stream ecosystem services had an overall higher WTP for attributes of stream health. This suggests that the program implementation described within CE surveys is an important component of WTP. The voluntary program mechanism also appeared to mitigate a cultural division among the population. Though we cannot comment on how effective or costly a voluntary incentive program would be, the results of this survey indicate that there is a social benefit associated with such a program. The efficacy and solvency of a voluntary program is a potential area for future work.

The CE results also demonstrated consistent preferences for certain attributes of stream health across the population. Muddiness,

understanding both the ecological and the social context of the problem. As evidenced here, the population of Macon County did not have clear preferences for every attribute of stream health, even when these attributes are co-produced or depend upon one another. For example, none of the classes identified in our experiment showed a WTP for increasing the riparian buffer around streams in the zone. However, this attribute is widely recognized among ecologists as being critical for the production of ecosystem services that did have value to respondents, such as increased water quality and decreased sedimentation (Gregory et al., 1991; Sweeney et al., 2004). If these attributes are crucial to maintaining the ecosystem services that are valued by the population, ecologists and policy makers need to clearly articulate this connection. The ecosystem services framework, particularly the focus on connecting ecosystem function to ecosystem services, may be particularly helpful in achieving this goal.

The research presented here demonstrates the flexibility of nonmarket valuation in understanding a broad range of public values for ecosystem services and related indicators of ecosystem health, as well as policy preferences across the population. We suggest that future research in ecosystem services valuation should focus less on obtaining accurate measurements of WTP for evaluating a particular policy, and more on understanding general population preferences to then incorporate into policy design. The interdisciplinary approach we take to nonmarket valuation in this study is a step in this direction.

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