Preferences for environmental quality across the rural-urban divide

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Abstract

Policies and management efforts can improve local water quality, fish populations, and contribute to regional environmental goals such as reducing hypoxia in the Gulf of Mexico. However, an environmental policy or program that affects both rural and urban populations might be inequitable if the policy benefits one group more than the other. We advance research on water quality valuation and integrated assessment in three ways. (1) We estimate people's willingness to pay for local changes that would increase the likelihood of reducing hypoxia far downstream in the Gulf of Mexico. (2) We test for differences between rural and urban residents in the values they place on water quality improvements in freshwater rivers and streams. (3) We demonstrate how these valuation estimates can be used to evaluate the size and spatial distribution of total benefits of water quality improvements in a watershed. We find strong evidence that both urban and rural people are willing to pay for local improvements to water quality in a watershed. We also find both populations are willing to pay for local contributions towards reducing hypoxia in the Gulf of Mexico, with rural residents placing a higher value on this improvement than urban residents in the same watershed. We simulate four improvement scenarios and estimate that the rural areas of the watershed can benefit as much as 3 to 4 times the more urban clusters. While aggregate benefits still accrue where population is most dense, we find this is not due to a lower demand for water quality, and instead find strong evidence that rural residents value environmental improvements more than the urban and sub-urban areas of the Midwest watershed.

Keywords: choice experiment, water quality, valuation, hypoxia, rural urban divide[1]

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1 Introduction

Integrated assessment of water quality policies require information about the total values of changes in water quality, and the distribution of those values among different groups of people. Previous research on water quality valuation has shed light on the average values people place on some dimensions of pollution reduction in some surface waters (Bergstrom and Loomis 2017) and have been used in meta-analyses to be distributed via benefit transfer methods (Johnston, Besedin and Stapler 2017). Use values for water quality have also been estimated at a national scale using policies such as the Clean Water Act to identify changes in average housing prices (Keiser and Shapiro 2018). However, we know little about how people value local contributions to non-local improvements such as the value they place on achieving national targets aimed at reducing the transmission of nutrients to the Gulf of Mexico (Phaneuf 2002, Babcock and Kling 2015). As a further matter, we know little about how willingness to pay for any water quality improvements are distributed among sub-groups of people. An environmental policy or program that affects both rural and urban populations might be inequitable if the policy benefits one group more than the other. This paper advances research on water quality valuation and integrated assessment by estimating new dimensions of public value for water quality improvements, testing whether values vary between urban and rural residents of a watershed, and illustrating how to use those values in a spatially disaggregate integrated assessment of a land-use change policy or management plan.

One narrative of environmental policy is that policies like fracking bans are foisted upon rural residents by people in urban areas (Gibbs (2016) and Farber (2018). The American Farm Bureau advocated strongly to roll back the expansion of the waters covered by the Clean Water Act (USEPA 2017) that would have resulted from the so-called “Waters of the U.S.” rule published by EPA in 2015, and some academic research shows that urban residents give more support for environmental policies than people in rural areas of the U.S. (Salka 2001). However, the environmental sociology literature has generally found little difference between rural and urban residents in their interests for environmental quality. Arcury and Christianson (1993) estimate urban residents tend to be more knowledgeable about environmental problems and have stronger environmental world views. However, they find no differences between groups in environmental concern or action, and join Salka (2001) in finding that much of the variation between rural and urban was being driven by differences in education, income, age, and gender. Similarly, Mobley (2016) explores factors of environmentalism as measured by concern for water quality pollution and its impact, and find sociodemographic traits to be strong predictors of environmentalism, but no traceable differences between rural and urban respondents. Symons and Karlsson (2018) suggest that those who hold traditional laissez-faire beliefs (liberal freedoms) might be changing in the face of climate change. They argue that state-directed policies driving environmental conservation and quality are becoming more accepted, or have the potential to be, across populations that previously would be opposed to such innovations.

Nonmarket valuation studies primarily treat rural and urban geography as characteristics that are either controlled for in estimates of willingness to pay (WTP), or included as covariates when modeling heterogeneity across space (Campbell, Hutchinson and Scarpa 2009, Czajkowski, et al. 2017, Johnston, Besedin and Holland 2019). Racevski and Lupi (2006) find rural residents in Michigan are less likely to support forest management efforts involving conservation, but conclude this is likely due to rural communities being more timber-dependent, relying on forests products for production or exports. Moreover, Moon and Griffith (2011) find that agriculture producing regions of the United States increase their WTP for environmental quality if nonmarket and market goods are provisioned jointly as compliments rather than substitutes. Melstrom et al. (2015) estimate urban rivers and streams are less valued than rural for recreational fishing, but do not distinguish between rural and urban recreationists and their underlying values. More work is needed in environmental economics to test whether a rural-urban divide exists in WTP for environmental improvements.

In order to address a growing concern about the deteriorating condition of the waters in the gulf, the U.S. Environmental Protection Agency's 2008 Gulf Hypoxia Action Plan (GHP) has tasked the 12 upstream states with the responsibility of reducing their state's transmission of nutrients such as nitrate-nitrogen and phosphorus by 45% by the year 2040. For the state of Illinois, this has resulted in the creation of the Illinois Nutrient Loss Reduction Strategy (INLRS). To better understand how implementation of a geographically broad policy will affect residents of these states, it is important to examine the value residents place on changes to water quality in their local watersheds. It is also important to identify the extent to which these individuals value their local watershed's contribution to nonlocal improvements such as reducing the scale of the hypoxic dead zone in the Gulf.

We use a choice experiment (CE) to estimate WTP for benefits of water quality improvements such as increased numbers of different fish species, fish populations, reductions in local algal blooms, and increased likelihood of reaching national nutrient loss reduction targets. We test for differences in preferences between rural and urban respondents. We design our CE survey to be tightly coupled to biophysical models of watershed improvements, linking attribute levels to ranges of improvements predicted by those models and using individualized maps to convey information about how improvements vary across spatial sub-regions of the watershed in a manner that varies experimentally across alternatives in choice sets.

We estimate that people place positive and significant values on local water quality improvement and on helping to achieve basin-wide success in reducing hypoxia in the Gulf of Mexico. We also find that rural residents place higher values on some of the environmental benefits of watershed improvement. Finally, we demonstrate how these estimates can be used in spatially disaggregated integrated assessments.

2 Application

Freshwater systems throughout the American Midwest have been severely altered due to decades of intensive agriculture production (Manifold and Swamp 1998, Alexander, et al. 2008). Tributaries located within the upper Mississippi River Basin (MRB) carry excess nutrients, byproducts of intensive agriculture production, to the Mississippi River where they are eventually released into the northern Gulf of Mexico. An overabundance of these nutrients is known to contribute to the large seasonal hypoxic dead zone off the cost of Louisiana and Texas (Rabotyagov, et al. 2014, Rabalais, et al. 2010, Diaz and Rosenberg 2008).

The area examined in our study is the Upper Sangamon River Watershed (USRW) in central Illinois, USA (Figure 1). This watershed is listed as a priority watershed due to its high levels of nitrate-nitrogen and phosphorus transmission within the MRB (USEPA 2008, USEPA 2013). The population in the study area is diverse and includes large swaths of rural landscape with several urban clusters.[2] The characteristics of the USRW are representative of many watersheds in the MRB and provides an excellent setting for examining value differentials and policy-induced distributional effects across rural and urban populations.

[2] Residents of the USRW span a wide range of socioeconomic and geographic characteristics. Preferences are known to be heterogeneous across these populations (Hanley 2003, Jacobsen and Hanley 2009).

In stated preference studies, preferences have been shown to be heterogeneous in a respondent's distance to the improvement (Hanley, Schläpfer and Spurgeon 2003), across geological (Brouwer, Martin-Ortega and Berbel 2010) and geopolitical (Johnston and Duke 2007) boundaries. Emerging from this literature is the recognition that the presentation of space can greatly affect respondent choice, introducing an unwanted source of measurement error (Schaafsma, et al. 2013, Johnston, Holland and Yao 2016). Following recommendations highlighted in Johnston et al. (2016) we incorporate individualized maps for each alternative in the choice set. These maps include both the location of the proposed improvements by highlighting specific sections of the river, and the marked location of the respondent to reduce the mental cognition required to process each alternative, and minimize the spatial error of the resulting estimates. We discuss this in more detail in the following section.

Proposed environmental changes were stated in our survey as being attributable to changes in local agriculture practices. The exact mechanism used to deliver these improvements was not explicitly specified, but simply stated as being the most efficient as determined by agricultural extension and policy experts. In the background portion of the survey we do provide examples of current practices throughout the region such as: cover crops, reduced tillage, riparian buffers, and other measures intended to reduced sediment and nutrient runoff from the surrounding area. This was done to help mitigate confounding factors such as preferences for regulation or land-management mechanisms, which could affect the estimation of preferences for endpoints. The changes in agriculture practices stated as possible mechanisms for watershed change are currently well-accepted and widely used throughout the region. As such, changes in agricultural practices should be interpreted as the ramping up of current policies and perceived as non-hypothetical.

Each respondent was presented a series of six choice cards containing a no-change (status-quo) scenario and two alternative (improved) scenarios. Each scenario contained a bundle of attributes and attribute levels determined by the experiment design, outlined in section 4. Table 1 provides a summary of the included attributes and their corresponding levels, they are also discussed in detail in section 4. The survey was distributed to a randomly selected group of respondents living within the watershed through Qualtrics, and independent firm specializing in internet survey research.

3 Choice experiment methodology

Choice experiments are widely used to elicit preference for nonmarket environmental amenities such as water quality in rivers and streams. Using this platform allows us to model preferences in the random utility framework (McFadden 1973). Preferences can be characterized by estimating the probability a respondent chooses a scenario from a choice set of alternatives varying in the level of their common environmental attributes (Hanley, Wright and Adamowicz 1998). Explicitly, the utility a person i derives from their chosen alternative j in choice card t can be summarized linearly by $U_{ijt} = \beta' X_{ijt} + \epsilon_{ijt}$. Where β' represents a vector of marginal utilities corresponding to attributes X, and ϵ is the stochastic portion in the choice model. If preferences were uniform between rural and urban residents, then the vector β' would be an appropriate representation of marginal utilities for both groups.

Our hypothesis that preferences are not uniform between rural and urban respondents means that estimating such a model would be inappropriate to capture the full distribution of marginal utilities. In the following sections we will outline our approach in modeling this heterogeneity, and the implications it has for values used in integrated assessment techniques.

3.1 Survey design

We designed the survey instrument to test for potential preference heterogeneity between residents who identify as rural, and those who identify as urban. This was examined in two dimensions: 1) geographical affiliation; and 2) stated type. The first, geographical affiliation, is simply determined using the U.S. Census Bureau's classification of rural — a census block group area with less than 1,000 residents per square mile (Ratcliffe, et al. 2016). Respondents who fit this designation are classified as rural, all others are classified as urban. The second, cultural affiliation, was determined by the respondent's stated affiliation in the post-survey questionnaire. The question is phrased as: "*Do you consider where you live to be rural?*" Our design allows us to test the following hypotheses:

Rural and urban preferences

H_0^1: Geographical: preferences for water quality vary between those who live in a geographically rural region and those who live in a geographically urban region.

H_0^2: Cultural: preferences for water quality vary between those who identify as rural and those who identify as urban.

Seven experimentally varied attributes were included in each scenario. Four relate to biophysical characteristics of water quality, two capture spatial heterogeneity, and one is the payment necessary to implement the proposed improvements. Table 1 summarizes each attribute, specifying what level is status-quo and what levels were offered that were improved. The values for biophysical attributes were informed by the work of hydrological and ecological modelers. Botero et al. (2018) modeled predicted changes in nutrient levels throughout the USRW resulting from hypothetical changes in local agricultural practices. Andres et al. (2019) use these predicted changes in nutrient levels, climate, and data from 110 monitoring sites across the USRW, to model changes in aquatic biodiversity.

Of the four biophysical attributes related to water quality, three were local and one non-local. Number of fish species and population of fish, two independent attributes, are local quantitative measures summarizing the current average number of distinct species of fish (diversity) and populations of individual fish per 100 linear yards of river (density). Dissanayake and Ando (2014) find that citizens have positive value for both species diversity and faunal density in grassland birds; we test whether people value two such attributes of fish in inland streams. Local water quality improvement is captured as percent reductions in the frequency of occurrence of algal blooms in the local watershed including streams and ponds; that ranged from 0% to 75% reduction. The fourth nutrient-pollution attribute pertains to region-wide nutrient reduction goals to reduce hypoxia in the Gulf of Mexico. In the background information of the survey, people were told about the national goal for nutrient loss reduction to reduce the size of the hypoxic zone, and they were told the nutrient pollution reduction target for Upper Sangamon River watershed's contribution to that goal. This attribute describes the likelihood that this watershed succeeds in meeting its targets for reductions in the level of nutrient transmission to the Gulf are met, and ranged from 0% (definitely will not succeed) to 100% (certain to succeed).

Local water quality-related changes from a nutrient-loss reduction strategy are not uniform throughout a watershed, but rather depend on local details such as depth, flow rate, and shad. Sophisticated IAM will be able to estimate the benefits an individual gains from non-homogeneous improvements in parts of a watershed that vary in distance from the individual. Thus, we partitioned the watershed into four equally sized sections, and given choice scenario specified the section of the watershed in which water quality attributes improved. The *location* attribute was varied as part of the experiment design; as a result, *distance* (measured as the distance from each respondent to the improved section of the watershed) also varied experimentally.

The final attribute included in the design is the payment necessary to achieve the proposed improvements, *cost*. We used an increase in annual county fees as the payment vehicle, verifying with focus groups that this was a salient and credibly binding mechanism for payment. The survey stated that the fee would be passed on to renters through an annual increase in rent charged by the landlord. A sample choice question is shown in Figure 2, and the survey text is in Appendix 1.

Hypothetical bias in choice experiments has been found to be problematic for eliciting unbiased estimates of willingness to pay (Cummings and Taylor 1999). We address this by including a modified cheap talk script in the information section of the survey, coupled with an opt-out reminder on each choice card (Ladenburg and Olsen 2014). Following each choice card, we also include certainty questions asking how sure the respondent was of the selection they just made (Ready, Champ and Lawton 2010).[3] A series of focus groups were held throughout the watershed with attendees from the general population. They were asked to take the survey, and participate in a 30 minute follow-up discussion. In response to focus group feedback, adjustments were made to incorporate their suggestions regarding ambiguities in management mechanisms and wording of the attribute changes. We deployed the survey in a pre-test with 79 completed surveys (237 observations) and adjusted the cost levels to ensure that the lowest non-

[3] The question asked: *How confident are you in your answer?* With the range: "0 - not at all confident"; "1 - somewhat confident"; and "2 - very confident." We use these responses to re-code any uncertain responses to the status-quo alternative as a robustness check and find no qualitative differences in our results.

zero level was not too high and the highest level was not too low. Figure A1 in the Appendix shows that all attribute levels were chosen with reasonable frequency by respondents.

3.2 Experimental design

Prior to administering the survey, we developed an orthogonal choice matrix to minimize the prediction error (D-error) of the model. We generated a fractional factorial using the *dcreate* package implemented in Stata (Hole 2015). To maximize the information recovered from the survey, we specify 18 unique choice cards to be selected. Each card contains two alternatives and a no change (status-quo) option. We then block the resulting design into 3 blocks. The final stage in the experiment design involves randomly selecting respondents into one of the 3 question blocks, leaving each respondent with six choice cards.

The preliminary experiment design was generated without including prior estimates for the β's. After an initial roll-out period of the survey, we updated this matrix of priors with the results of a mixed logit (MIXL) estimation using the data from the pretrial. Throughout the development of the D-efficient design, we impose several conditions. Non-ambiguous strictly dominated strategies are removed by imposing a no-free-lunch condition (improvement in any attribute will come at a non-zero cost) and a welfare improving restriction (no improvement across all attributes cannot come at a cost). Additionally, any design resulting in 1 or more of the 18 choice cards having one improved scenario alternative that was strictly dominated by another improved scenario alternative (e.g. higher level of improvements at a lower cost) we re-ran the design. Convergence was achieved after seven complete iterations of the design.

With the exception of *location* and *distance*, we allow the status-quo level of each attribute to be randomly included in the improved (non-status-quo) scenarios. This allows us to identify the marginal effect of moving from an attribute's status-quo level to the next higher, improved, level. For example, we are able to identify both the parametric marginal effects of a change in the probability of hitting the state's nutrient target (a single β coefficient normally distributed), as well as a non-marginal change from 0 to 50% (a β for each level of the attribute). We also include an alternative specific constant (ASC) for the status-quo alternative to capture any unobservable characteristics in the baseline levels of the watershed.[4]

3.3 Individualized maps and choice card generation

Each choice card contained a set of three alternatives, one status-quo and two improved scenarios. Each alternative on the card also included an individually geocoded map highlighting the section of river that would experience the improvements, and a marker locating the respondent within the watershed relative to the proposed improvements. Each map was individually created and geocoded using ArcPy integration in ArcGIS. Eleven towns and city centers distributed throughout the watershed were geolocated to provide a "you are here" marker in each map. The total number of combinations of choice cards, alternatives, and geolocations results in 594 different individualized maps. This also resulted in 594 different levels for the *distance* attribute listed as an attribute on the choice card.

In order to accommodate the individualization of alternatives and choice cards, images of the choice cards were created by integrating the mail merge capabilities of Microsoft Publisher, referencing an underlying matrix of all individualized combinations of the experiment design. The resulting pages of the document were then extracted using Python to create an image for each page representing a choice card in the experiment. The 594 choice cards images were then

[4] ASC's were also considered for each of the four river locations. The parameter *distance* does a sufficient job of capturing these preferences, and comparisons between models showed no meaningful differences in fit. Therefore we retain only the ASC for the status-quo alternative.

stored online using Amazon Web Services, and were referenced in real time while the respondent was taking the survey.

3.4 Survey administration

The survey was administered online using the Qualtrics system interface, paired with additional JavaScript and HTML to incorporate the individualized choice cards. Respondents were recruited from the 42 zip codes contained within the watershed. Once a respondent received an invitation to take the survey, they would arrive at the online interface where they were asked to enter their zip code. If the zip code was not one of the 42 qualifying, they would be screened and exited from the survey. The next step individualizing the CE was to ask respondents which of the eleven locations (towns or city centers) they lived closest to. Their response would then que the system to load a randomly ordered set of choice cards. Each alternative on the card includes a set of individually geocoded maps providing the location of the watershed that would receive the improvements and a marker locating the respondent within the watershed. Appendix 2 includes maps of the watershed and the zip codes sampled. Our final sample has complete responses from 187 individuals. Characteristics of the sample are discussed in section 5.

4 Econometric framework

4.1 General RUM model

Building on our earlier discussion regarding choice experiment framework, we assume that a respondent derives utility based on the observable characteristics contained within the choice card, and some characteristics unobservable to the researcher. Specifically, U is the utility respondent i derives by choosing alternative j on choice card t. Equation (1) can be estimated within the RUM framework as:

$$U_{ijt} = \lambda_i p_{ij} + \beta'_i X_{ij} + \epsilon_{ijt}. \quad (1)$$

Where X is a vector of attributes is, p is the price (*cost*) of the scenario, and ϵ is the stochastic component (taste-shock) capturing unobservable characteristics influencing the respondent's choice. Included in X is an alternative specific constant (ASC) that is equal to 1 for the status-quo alternative in each choice set, and 0 otherwise. Parameter β' is the vector of preference coefficients, and λ represents the coefficient on *cost*. Both β' and λ are indexed to be respondent specific when estimated using any of the random parameter logit models. We estimate equation (1) using a traditional attribute-correlated mixed multinomial logit (MIXL) (Train 1998).

Our first two hypotheses explore preference heterogeneity between rural and urban respondents. To estimate this relationship we start by simply introducing an interaction term D_i with and the attribute vector X, where $D = 1$ indicates that the respondent is categorized by the census as living in a rural block group (fewer than 1,000 people per square mile), and urban when $D = 0$. We have no reason to believe, a priori, that the marginal utility of income systematically varies between rural and urban groups, so this interaction does not include p. These assumptions build on equation (1) such that:

$$U_{ijt} = \lambda_i P_{ij} + \beta'_i X_{ij} \cdot D_i + \epsilon_{ijt}. \quad (2)$$

Equation (2) is estimated separately for H_0^1 (geographical preference heterogeneity) and H_0^2 (cultural preference heterogeneity). We do not find any meaningful differences between geographical and cultural affiliation in this specification, suggesting that respondent's stated affiliation aligns with the census definitions of rural and urban. The remainder of the analysis will simply employ the respondent's stated affiliation. By incorporating quantitative indicators of water quality, we can model preferences continuously for these attributes.[5]

4.2 Scale heterogeneity

An alternative way to model preference heterogeneity is to estimate a model that allows for differences in scale using the generalized multinomial logit model (GMNL) (Fiebig, et al. 2010, Hess and Rose 2012). To illustrate scale in our setting, we can build on the β's above such that they are now characterized by $\beta_i = \sigma_i(\beta + \eta_i)$ where $\sigma_i = \exp(\bar{\sigma} + \tau\xi_{0i})$ and $\xi_{oi} \sim N(0,1)$. Feibig et al. (2010) further disaggregate the parameter such that $\beta_i = \sigma_i\beta + \eta_i[\gamma + \sigma_i(1-\gamma)]$. The parameter τ identifies the degree to which scale heterogeneity exists, and γ identifies the degree of scaling. When γ is close to one, η_i is independent of the scaling, whereas when it is closer to zero the distribution of η_i is proportional to the scaling, and increasing as γ falls below zero. In the MIXL model specified in equation (2), both the scale parameter σ_i and γ are simply assumed to be equal to 1, in which case we recover $\beta_i = \beta + \eta_i$.

Differences in scale resulting from characteristics such as rural and urban geographies can be incorporated directly into σ_i as a covariate of scale (Sarrias and Daziano 2017). In our case, we specify $\sigma_i = \exp(\bar{\sigma} + \delta D_i + \tau\xi_{0i})$ where $D_i = 1$ indicates that a respondent is rural. The resulting parameter δ captures any variability in the error term due to a respondent being classified as rural or urban. Hess and Train (2017) disentangle the differences in scale and correlation in these models, suggesting scale is a more restrictive form of preference heterogeneity. We estimate preferences in both settings, allowing for full correlation across

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[5] We also model discrete changes in attribute levels and other nonlinear specifications such a log and quadratic functional forms. No interesting deviations emerge from these models, so as to provide clear interpretation of our results we prefer continuous specifications for all water quality attributes. Latent-class and random parameter latent-class models were also estimated with no meaningful differences in interpretation or fit.

parameters (our main specification) and the more restrictive form of scale heterogeneity.[6] Following Fiebig et al. (2010), we fix the ASC and do not allow it to be scaled by σ_i.

4.3 Welfare estimates and willingness to pay

Using the models estimated by equation (2) we estimate the policy relevant marginal willingness to pay (MWTP) for each attribute, and in the aggregate estimations the total willingness to pay (WTP) for each scenario. For all specifications we allow the coefficient on *cost* to be distributed log-normally. This is consistent with a priori assumptions surrounding the marginal utility of income. Moreover, as an alternative becomes more costly, the probability of that alternative being chosen should decline, all else constant. Much discussion has been made surrounding this assumption, and its implications in calculating MWTP. Following Carson and Czajkowski (2019) we estimate each model in two sequential stages to address these concerns. The first stage estimates the fully correlated model with the log-normal restriction on *cost* to derive a theoretically consistent estimator of the marginal utility of income. The second stage then uses the estimated coefficients as priors in a model where the parameter on cost is again assumed log-normal, but we place a constraint on the standard deviation of the coefficient such that it is equal to zero. This allows for fully identifiable moments in the calculation of MWTP (a ratio of two randomly distributed coefficients).[7] The resulting estimates can be described as: $MWTP_i = \beta_i/\lambda$, where λ is distributed log-normal with a standard deviation equal to 0. All β_i are distributed normal.

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[6] We estimate MIXL models using both *mixlogit* in Stata (Hole 2007a) and the *gmnl* package in R (Sarrias and Daziano 2017). We find no meaningful differences between the two approaches, and results from *mixlogit* are used for our analysis. We estimate the GMNL model using only the *gmnl* package in R.

[7] WTP estimates are produced using the post-estimation command *wtp* in Stata (Hole 2007b) and *wtp.gmnl* in R (Sarrias and Daziano 2017). Because of the restrictions imposed on the *cost* coefficient (Carson and Czajkowski 2019), we estimate WTP following initial model estimation in preference space.

5 Results

Table 2 presents summary statistics of the sample, showing it to be evenly divided between people in rural (52%) and urban (48%) areas, and half the sample own homes instead of renting. Respondents are predominantly white (74%) and female (76%); the former is consistent with the actual demographics of the area while the latter is just a function of gender differences in willingness to answer surveys. Our sample has broad representation of age, income, and education categories, and the distributions in our sample are similar to the census demographics for this area. This is an area with little in-migration; fully half the people in our sample have lived in the area for more than 30 years, and only 10% have lived there for 10 years or fewer. Figure A4 maps data from the 2011-2016 American Community Survey for the watershed. These plots show a relatively white, and rural watershed with several urban clusters. We also include a plot indicating the rural and urban areas of the watershed.

Figures 3 and 4 show the distributions of answers to qualitative questions about local recreation and water quality awareness. Less than 20% of respondents report having fished in the USRW at all. However, nearly 50% reported having visited the river or walked trails near the river, 80% of the sample reported having some familiarity with the water quality issues discussed in the survey, and about the same number of respondents reported past experience with algal blooms in the rivers or connected bodies of water.

The main regression results are in Table 4, which presents estimates of the basic MNL model, the MIXL model that accounts for individual heterogeneity in preferences, and the MIXL model with interactions between attributes and whether the respondent was from a rural area. The AIC and log-likelihood criterion suggest a strong improvement in fit over that of the MNL specification, so we focus discussion on the estimates that account for individual heterogeneity.

The standard deviations of the parameters have been suppressed, but summaries containing the full variance-covariance matrices are available in an online appendix. The MWTP estimates that correspond to those models are in Table 5; confidence intervals around mean estimates of MWTP are obtained using the Krinsky-Robb method (Hole 2007c).

The coefficient on the ASC for the “no program” option is always negative and significant, and suggests respondents prefer some change to none. The coefficients on cost and distance are negative and statistically significant. People have a positive marginal utility of money and prefer improvements that are close to where they live. The negative annual MWTP associated with *distance* from water quality improvements is -$0.002 per mile. The coefficient on the percent reduction of local algal blooms is robust and significantly positive. People would gain positive utility from reducing the frequency of these local problems in their watershed, with an average annual MWTP of $0.23 for just a one percent reduction in the frequency of algal blooms. Survey respondents seem to have even stronger preferences for contributing to reduction of the Gulf hypoxia problem. The coefficient on that attribute is also significant and positive in all regressions, with an implied average annual MWTP of $0.30 per percentage-point increase in the likelihood of achieving this watershed’s nutrient reduction contribution. In contrast to these other results, however, the coefficients on fish diversity and density are very small and not statistically different from zero.

We do find evidence of differences between rural and urban respondents. The MIXL model with rural interaction terms (third column of Table 4) finds positive coefficients on the rural interaction terms for algal bloom reduction and nutrient target accomplishment, and the latter is statistically significant. Rural residents in the USRW appear to place higher values on the water quality indicators presented in the choice experiment than do urban residents. While urban respondents have an average estimated annual MWTP of $0.24 for a percentage point increase in the likelihood of reaching nutrient reduction targets, the average estimated annual MWTP for rural respondents is $.39.

Evidence for heterogeneity is also found in a GMNL specification where difference between rural and urban respondents is modeled as a covariate of scale. Table 6 summarizes the GMNL model and its corresponding MWTP estimates. Full correlation between parameters could not be modeled in the GMNL specification. The parameter τ is large and significant, and suggests that the true data generating process is different for rural respondents than urban. A model that can flexibly allow for variation between the two groups of people is better suited to reflect their true, unknown, underlying preferences. A GMNL model allowing for scale heterogeneity only provides information about qualitative differences between the two groups of people, and differences in the values rural respondents have for water quality are better represented by the point estimates from the MIXL model in Table 4 that include interaction terms between living in a rural portion of the watershed and the attributes.

6 Integrated assessment application

To illustrate how preferences for water quality vary between rural and urban respondents we provide an example of how these values are distributed throughout the watershed. As mentioned, spatially targeted policies can result in varying magnitudes of improvements at different locations throughout the watershed. Botero-Acosta et al. (2018) have provided four discrete sections of the river that are separable in the level of improvements seen in each. We identify these locations as A, B, C, and D. Figure 1 provides a map of each of the four river sections within the USRW.

We first recovered the conditional means of the preference and MWTP parameters for each individual i (Sarrias and Daziano 2017). We do this with both the MIXL and GMNL models for comparison; however, we model the IAM exercise using the recovered means of the MIXL. Figure A3 summarizes the conditional means of the MWTP for each attribute, for the MIXL and GMNL models. The magnitude and distribution of the modeled preference heterogeneity is represented in this figure, and the resulting variation gives insight into the spatial and cultural heterogeneity throughout the watershed.

Each zip code is allocated a proportion of rural land area, determined at the census block group level (Ratcliffe, et al. 2016). This gives us variation within each zip code to model welfare separately for rural and urban respondents. In addition to recovering the distance to each section of river, this also allows us to estimate the quantity-within-distance measure as outline by Holland and Johnston (2017). We calculate the total linear stretch of river (in yards) for each zip code, which allows is to simulate improvements directly proportional to the quantities in attributes modeled in the biophysical models, and the level included in the choice experiment.

We simulate improvements for all sections of the watershed as modeled by Botero-Acosta et al. (2018). Table 7 provides a summary of the four sample scenarios we simulate. The first scenario models a 50% reduction in only the frequency of algal blooms in river section A. Scenario 2 models this same improvement except for river section C. Holding all else constant allows us to see how benefits might accrue differently depending on where the improvement takes place. Scenario 3 models only a single 75% likelihood that the watershed reaches it nutrient loss targets of 45% by the year 2040. Scenario 4 introduces a more complete improvement scenario where river section A sees a 75% reduction in the frequency of algal blooms, sections A and B receive an additional 50 fish (population) per 100 yards of river, section A receives an additional 2 species of game fish per 100 yards of river, and the watershed is 100% in reaching its nutrient targets.

Using the recovered conditional means of MWTP for each respondent in each zip code, we estimate aggregate measures of WTP at the zip code and watershed levels resulting from each of the four proposed scenarios. Table 7 summarizes the total WTP within the watershed for each scenario, and the spatial distribution of these benefits throughout the watershed. Table 8 provide a summary of the same scenarios, but presented with total WTP per capita, and again how these values are distributed throughout the watershed. The improved sections of river in each scenario are highlighted in red. Refinements could be made when modeling WTP throughout the watershed, or for use in transfer to similar watersheds, using spatial regression methods such as those discussed in Johnston et al. (2019) or De Valk and Rolfe (2018). However, the focus of this paper is to provide a proof of concept for estimating the distributional effects of policies related to water quality that span culturally and geographically diverse groups of people.

One interesting finding is that while total values still largely accrue in urban clusters due to the density of the population living there, the net benefits are found to be larger for more rural areas of the watershed. When we examine these benefits from an improvement on a per capita basis (Table 8), we see the distribution is more uniform, and in some cases higher in rural areas than in the urban clusters within the watershed.

7 Discussion

We have carried out a CE survey to estimate the values people in a sub-watershed of the Mississippi River Basin place on local improvements in water quality, local increases in fish diversity and populations, and contributing to regional success in reducing hypoxia in the Gulf of Mexico. We then applied those value estimates in a proof-of-concept assessment of the total values of hypothetical watershed improvements that shows how values accrue to rural and urban residents, and how values vary across space within the watershed.

We find that people place significant value on reducing the frequency of local algal blooms. We also find that people have even higher MWTP for increasing the likelihood that their watershed reaches the target set for it under the Illinois Nutrient Loss Reduction Strategy. The latter result fills a gap in the valuation literature, and provides further compelling rationale for the work on nutrient loss in which government agencies, NGOs, and industry groups are all currently engaged.

We did not find statistically significant estimates of MWTP for improving local fish diversity and populations. People in this particular watershed may be genuinely disinterested in these attributes of their watershed; that seems possible given the small fraction of respondents that report engaging in local fishing. These results may also be driven by the small absolute numbers of increases that were predicted by the biophysical models and included as attribute levels; more dramatic improvements might elicit significant MWTP. Finally, this finding may be driven by the small spatial scale over which fish population improvements were described Johnston et al. (2017).)

Is there an urban/rural divide in the values people place on environmental improvements? In this case, we find strong evidence that rural people actually have higher MWTP for reducing local algal blooms than do urban residents, and rural people may also even gain more value from contributing to hypoxia abatement. This finding can play an important role in helping to address, or reduce, the estimated differences in costs and benefits of water quality policy (Keiser, Kling and Shapiro 2019). Moreover, the results from our simulations suggest that these values are not trivial. For the USRW alone, the total WTP for reaching a 75% likelihood of reaching reduction targets (scenario 1) is estimated at approximately $1.3 million dollars annually. And when modeled with improvements that will likely come as compliments for any policy targeting reductions in nutrient loss and transmission to the Gulf (scenario 4), total annual benefits within the watershed are estimated to exceed $6 million dollars.

As debate over nutrient loss reduction strategies continues, it will be important to more accurately, and appropriately, consider the full range of costs and benefits into those discussions. In doing so, it is equally important to consider the distribution of these costs and benefits, and which groups of people these strategies might favor. Our findings play an important role in this effort, and more work needs to be done in order to further refine, and uncover, the hidden benefits reductions in nutrient loss and transmission. We suggest implementing strategies, such as the one carried out in this paper, throughout the Mississippi River Basin in order to further disaggregate the costs, and benefits, of economically sound and feasible water quality policy.

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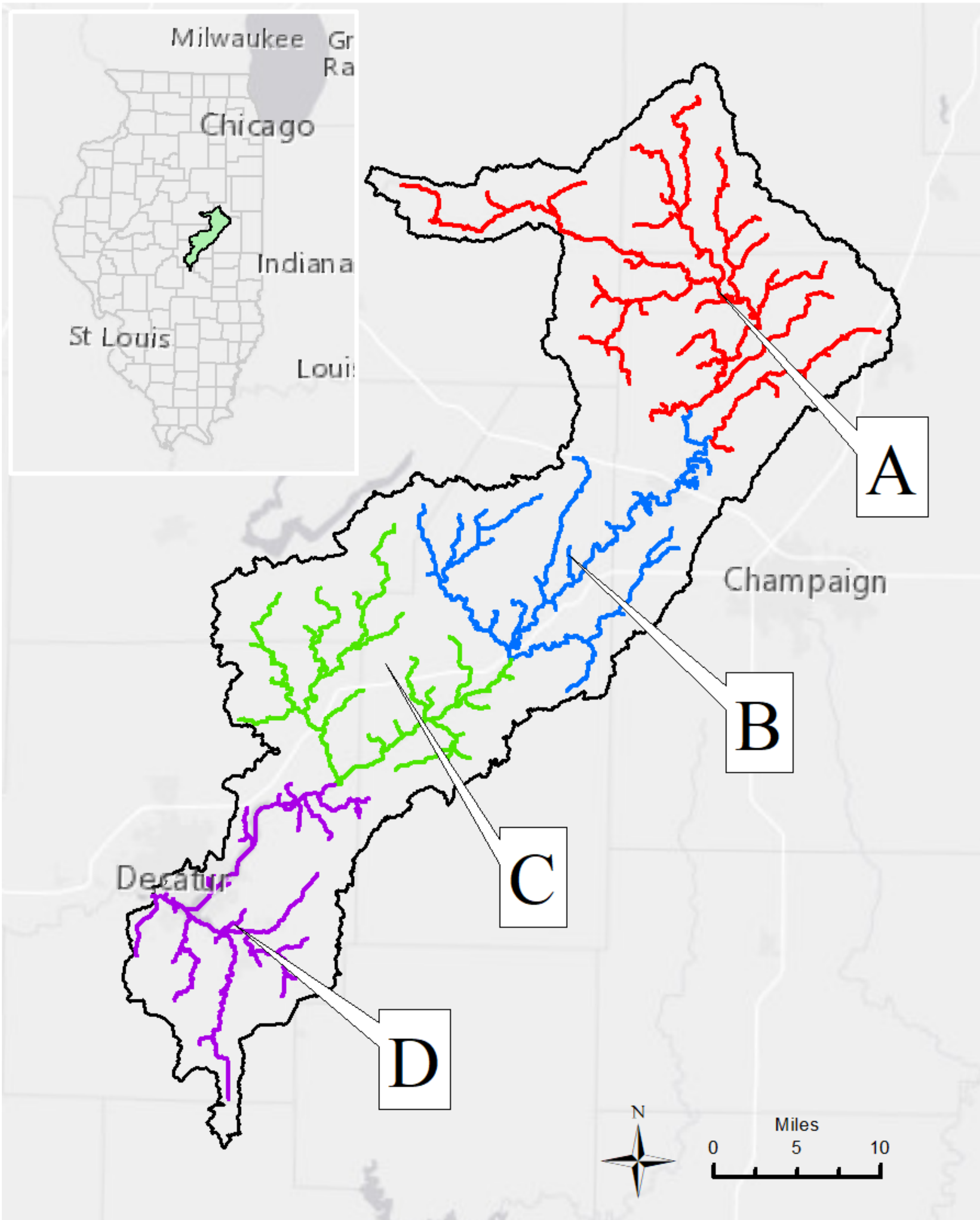
Figure 1: Study Area, the Upper Sangamon River Watershed



Note: The Upper Sangamon River Watershed is located in central Illinois. It is listed as one of the EPA's prioritized watershed for high transmission of nutrients to the Gulf of Mexico. The four sections of river (A, B, C, D) are highlighted, and included as attributes in the choice set.

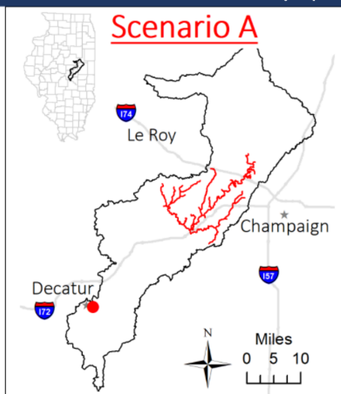
Figure 2: Sample Choice Question

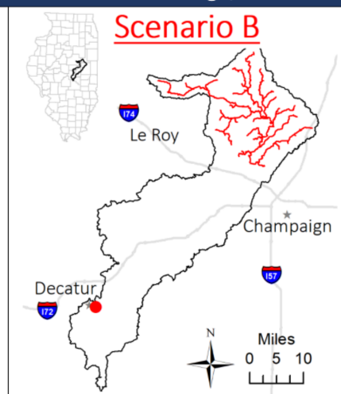
Experience from previous similar surveys is that people often say they would be willing to pay more money for something than they actually would. For example, in one study, 80% of people said they would buy a product, but when a store actually stocked the product, only 43% of people actually bought the new product. It is important that you make each of your upcoming selections like you would if you were **actually** facing these exact choices in reality. Note that paying for environmental improvement means you would have less money available for other purchases.

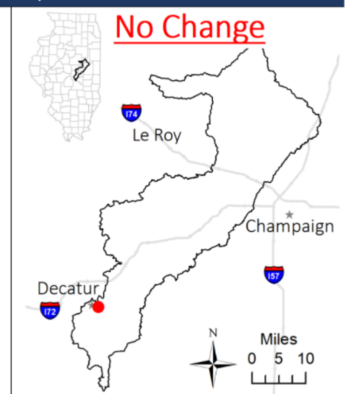
Ready, set, choose.

Remember, each of the six questions is separate and independent from the previous questions. For every question, Scenarios A and B are the ONLY options besides the "No Change." Which would you choose?

If scenarios A and B were the only options besides No Change, which would you choose?







	Scenario A	Scenario B	No Change
Game Fish Species	2	5	1
Fish Population	75	50	30
Algal Blooms Reduced	25%	0%	0%
Nutrient Target Met	75%	50%	0%
Distance from Home	23 miles	39 miles	-
Annual Cost	$5	$15	$0

If you are unsure about scenarios A or B, or would not actually spend the money, please choose No Change.

Table 1: Survey Attributes and Levels

Attribute	Levels (SQ)	Description
Game fish diversity	(1), 2, 3, 5	Number of different recreational game fish species per 100 yards of river
All fish density	(15), 30, 45	Number of all fish per 100 yards of river
Reduction in local algal blooms (%)	(0), 25, 75	Percent reduction in the frequency of local algal blooms
Likelihood of reaching nutrient target (%)	(0), 50, 75, 100	Likelihood that nutrient run-off from this watershed is reduced by the target of “45 percent by 2040”
Location	(A), B, C, D	The section of river where the improvements will be received
Distance	(varies)	The distance in miles from the respondent to the nearest point on the location attribute. This depends on where the respondent lives and which location is represented in the scenario.
Annual cost	(0), 5, 15, 30, 60	Payment vehicle: annual county fee (e.g. property tax)

Figure 3: Responses to Questions about Recreation

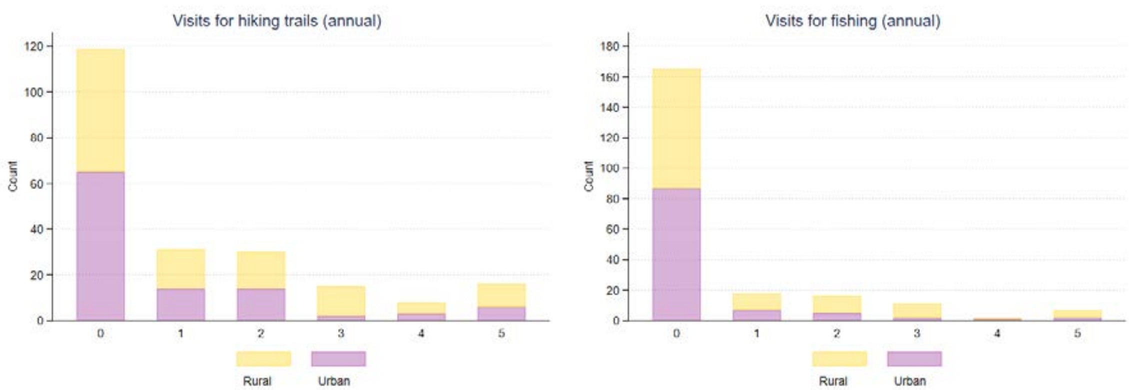


Figure 4: Responses to Questions about Water Quality Awareness

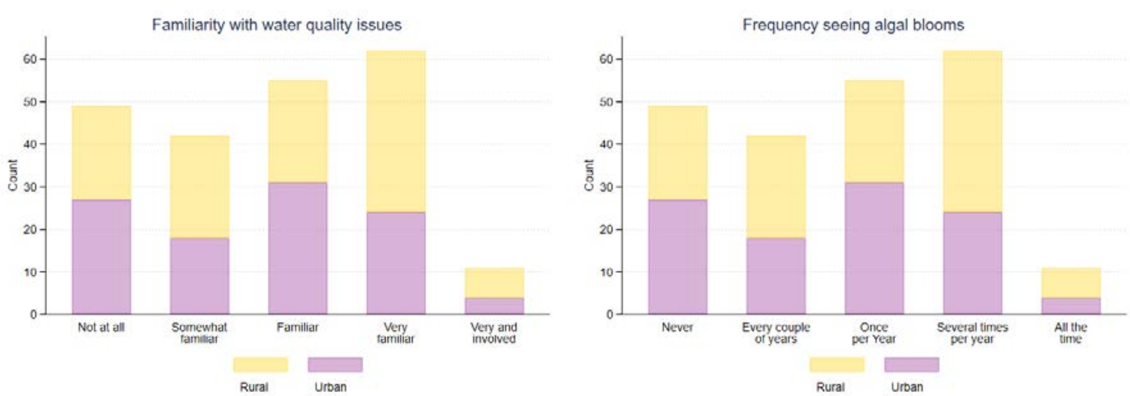


Table 2: Summary Statistics

	(1) N	(2) mean	(3) min	(4) max
Rural (self-reported)	219	0.53	0	1
Works in Agriculture	219	0.16	0	1
Male	219	0.33	0	1
White	219	0.74	0	1
Homeowner	219	0.55	0	1
Age				
18 – 29 years old	217	0.26	0	1
30 – 44 years old	217	0.30	0	1
45 – 64 years old	217	0.31	0	1
> 65 years old	217	0.12	0	1
Annual income ($k)				
< $25,000	217	0.26	0	1
$25,000 - $34,999	217	0.18	0	1
$35,000 - $49,999	217	0.13	0	1
$50,000 - $74,999	217	0.17	0	1
$75,000 - $99,999	217	0.12	0	1
$100,000 - $149,999	217	0.09	0	1
$150,000 - $199,999	217	0.03	0	1
> $200,000	217	0.02	0	1
Education				
Four-year degree	217	0.20	0	1
Graduate degree	217	0.12	0	1
High school / GED	217	0.27	0	1
Less than high school	217	0.05	0	1
Some college	217	0.25	0	1
Two-year degree	217	0.11	0	1
Years of Residency				
0 to 5 years	217	0.06	0	1
5 to 10 years	217	0.05	0	1
10 to 20 years	217	0.19	0	1
20 to 30 years	217	0.19	0	1
More than 30 years	217	0.51	0	1
Minutes to Complete	217	9.04	1.80	67.35

Note: Experience categories range from 0 (never go) to 5 (more than 5 times per year). *Water Quality Issues* relates to their current understanding of the water quality concerns in the watershed, and ranges from 0 (not aware of any) to 4 (very aware and involved). *Algal Blooms* refers to the respondent's current experience with algal blooms, and ranges from 0 (never see them) to 4 (very often, all the time).

Table 3: Differences between Respondents in Rural and Urban Areas

	(1) Rural		(2) Urban		(3) Difference	
Works in Agriculture	0.16	(0.32)	0.15	(0.40)	-0.01	(0.05)
Male	0.34	(0.47)	0.33	(0.47)	-0.01	(0.06)
White	0.70	(0.46)	0.78	(0.41)	0.08	(0.06)
Homeowner	0.49	(0.50)	0.60	(0.49)	0.11	(0.07)
Age						
18 – 29 years old	0.24	(0.43)	0.28	(0.45)	0.04	(0.06)
30 – 44 years old	0.28	(0.45)	0.32	(0.47)	0.04	(0.06)
45 – 64 years old	0.35	(0.48)	0.28	(0.45)	-0.07	(0.06)
> 65 years old	0.13	(0.34)	0.12	(0.33)	-0.01	(0.05)
Annual income ($k)						
< $25,000	0.30	(0.46)	0.22	(0.41)	-0.09	(0.06)
$25,000 - $34,999	0.14	(0.35)	0.22	(0.41)	0.08	(0.05)
$35,000 - $49,999	0.14	(0.35)	0.13	(0.34)	-0.01	(0.05)
$50,000 - $74,999	0.18	(0.38)	0.17	(0.37)	-0.01	(0.05)
$75,000 - $99,999	0.11	(0.31)	0.13	(0.34)	0.02	(0.04)
$100,000 - $149,999	0.07	(0.25)	0.10	(0.31)	0.04	(0.04)
$150,000 - $199,999	0.05	(0.22)	0.02	(0.13)	-0.03	(0.02)
> $200,000	0.02	(0.14)	0.02	(0.13)	-0.00	(0.02)
Education						
Four-year degree	0.17	(0.37)	0.23	(0.43)	0.07	(0.05)
Graduate degree	0.17	(0.37)	0.08	(0.27)	-0.09**	(0.04)
High school / GED	0.23	(0.42)	0.30	(0.46)	0.08	(0.06)
Less than high school	0.07	(0.25)	0.03	(0.18)	-0.03	(0.03)
Some college	0.23	(0.42)	0.27	(0.45)	0.04	(0.06)
Two-year degree	0.15	(0.36)	0.08	(0.27)	-0.07	(0.04)
Years of Residency						
0 to 5 years	0.08	(0.27)	0.04	(0.20)	-0.03	(0.03)
5 to 10 years	0.04	(0.20)	0.06	(0.24)	0.02	(0.03)
10 to 20 years	0.25	(0.43)	0.15	(0.36)	-0.10*	(0.05)
20 to 30 years	0.10	(0.30)	0.27	(0.45)	0.17***	(0.05)
More than 30 years	0.54	(0.50)	0.48	(0.50)	-0.06	(0.07)
Experience						
Recreational Fishing	0.36	(0.97)	0.77	(1.35)	0.42***	(0.16)
Hiking/Biking Trails	0.87	(1.42)	1.37	(1.65)	0.51**	(0.21)
Water Quality Issues	1.62	(1.21)	1.86	(1.24)	0.25	(0.17)
Algal Blooms	1.62	(1.21)	1.86	(1.24)	0.25	(0.17)
Minutes to Complete	8.94	(6.84)	9.14	(8.50)	0.21	(1.05)
Observations	104		113		217	

Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4: Main Results

	(1) MNL	(2) MIXL	(3) MIXL x Rural
ASC	-0.682***	-0.681**	-0.651**
	(0.159)	(0.249)	(0.247)
Cost	-0.013***	-4.972***	-5.028***
	(0.002)	(0.362)	(0.398)
Fish Species	-0.053	0.010	0.001
	(0.028)	(0.036)	(0.053)
Fish Population	0.001	0.002	0.002
	(0.001)	(0.001)	(0.002)
Algal Blooms	1.037***	1.209***	1.341***
(reduction)	(0.147)	(0.215)	(0.301)
Nutrient Target	1.006***	1.478***	1.231***
(likelihood of reaching)	(0.118)	(0.207)	(0.265)
Distance	-0.011***	-0.016***	-0.017***
	(0.003)	(0.004)	(0.004)
Rural x Species			0.005
			(0.074)
Rural x Population			-0.002
			(0.003)
Rural x Algal			0.239
			(0.452)
Rural x Nutrient			0.762*
			(0.380)
Full correlation	N	Y	Y
Observations	3906	3906	3906
McFadden R^2	0.102	0.072	0.083
AIC	4497.654	2368.343	2419.946
Log likelihood	-2240.827	-1150.172	-1133.973
CPU Time (minutes)	0.011	24.555	228.255

Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Column (1) gives results of multinomial logit (MNL) not taking into account individual preference heterogeneity. The constant for the MNL model was suppressed. Column (2) provides estimates of preference parameters for the sample without taking into account differences between rural and urban respondents. Column (3) incorporates heterogeneity between rural and urban respondents. Both MIXL models allow for full correlation across parameters. The full variance-covariance matrices can be found in the online appendix.

Table 5: Willingness to Pay (from columns (2) and (3) in Table 4)

	(1) MIXL	(2) MIXL x Rural
Fish Species	0.002	0.0003
	(-0.01, 0.02)	(-0.0001, 0.002)
Fish Population	0.0004	0.004
	(-0.0001, 0.001)	(-0.0003, 0.001)
Algal Blooms	0.24***	0.27***
(% reduction)	(0.15, 0.32)	(0.14, 0.39)
Nutrient Target	0.30***	0.24***
(likelihood of reaching)	(0.20, 0.4)	(0.13, 0.36)
Distance (miles)	-0.003***	-0.003***
	(-0.005, -0.002)	(-0.005, -0.002)
Rural x Species		0.001
		(-0.03, 0.03)
Rural x Population		0.0003
		(-0.001, 0.001)
Rural x Algal		0.05
		(-0.13, 0.22)
Rural x Nutrient		0.15*
		(0.01, 0.30)

95% Krinsky-Robb C.I. in parentheses

Note: Marginal willingness to pay (MWTP) values are estimated in Stata using the post-estimation command "*wtp*" (Hole 2007b). Confidence intervals are derived using the Krinsky-Robb method. Stars reflect significance of parameters estimated in preference space. Models correspond to the MIXL models from Table 4 (columns 2 and 3). Values are annual MWTP for a one-unit increase in the attribute, and are additive in the interaction terms. For example, the MWTP for a one percentage point increase in the likelihood of reaching the EPA's nitrogen reduction target for a non-rural resident is $0.24 per year. For a rural resident, they are willing to pay the sum of $0.24 and $0.15, or $0.39 per year for each percentage point increase.

Table 6: Scale Heterogeneity

	(1) GMNL	(2) WTP (GMNL)
ASC	-0.749**	
	(0.24)	
Cost	-5.08***	
	(0.67)	
Fish Species	0.003	0.0001
	(0.3)	(-0.02, 0.02)
Fish Population	0.001	0.0003
	(0.001)	(-0.000, 0.006)
Algal Blooms	1.07***	0.21***
(reduction)	(0.19)	(0.11, 0.29)
Nutrient Target	1.16***	0.25***
(likelihood of reaching)	(0.18)	(0.12, 0.33)
Distance (miles)	-0.015***	-0.002***
	(0.003)	(-0.003, -0.001)
Scale		
δ (*rural*)	0.25**	
	0.10	
τ	0.34**	
	(0.12)	
γ	-0.52*	
	(0.30)	
Full correlation	N	
Observations	3906	
McFadden R^2	0.123	
AIC	2349.31	
Log likelihood	-1157.7	

Standard errors in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Column (1) summarizes the GMNL specification where *rural* is modeled as a covariate of scale and characterized by δ. The parameter τ estimates the degree to which scale heterogeneity exists between the two groups. Column (2) is the resulting estimates of MWTP for attribute using the results from the GMNL model. Confidence intervals on MWTP are derived using the Krinsky-Robb method. Stars reflect significance of parameters estimated in preference space.

Table 7: Sample Integrated Assessment Value Estimates (total WTP)

	(1)	(2)	(3)	(4)
Algal Blooms	50% reduced Area A only	50% reduced Area C only	-	75% reduced Area A only
Nutrient Target	-	-	75% likelihood	100% likelihood
Fish Species	-	-	-	+ 2 species Area A only
Fish Population	-	-	-	+ 50 population Area A and B
Annual Benefits				
Rural People	$1,182,419	$1,184,493	$969,420	$4,809,813
Urban People	$506,075	$507,906	$343,794	$1,347,952
Total	$1,688,495	$1,692,399	$1,313,214	$6,157,765

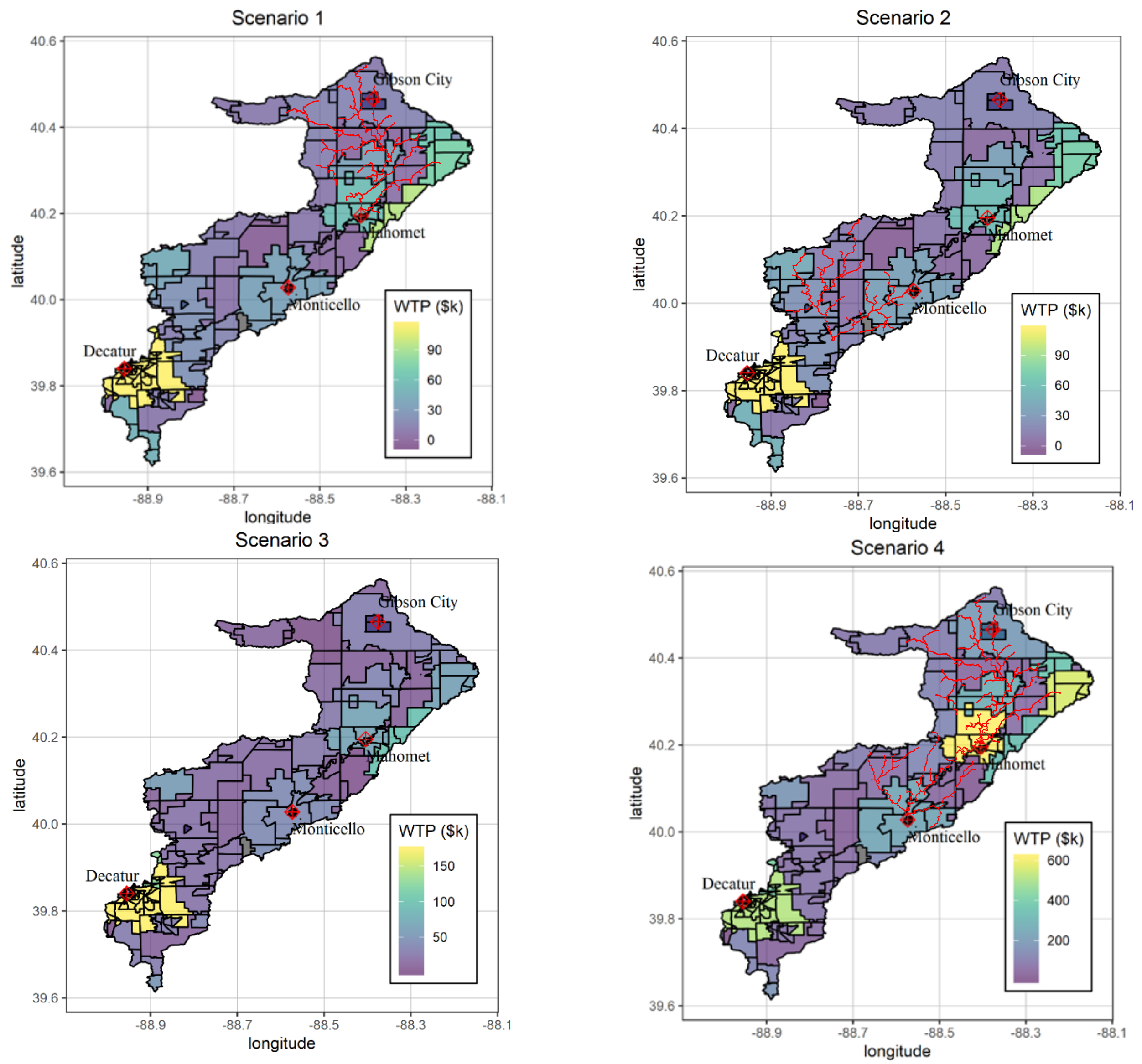
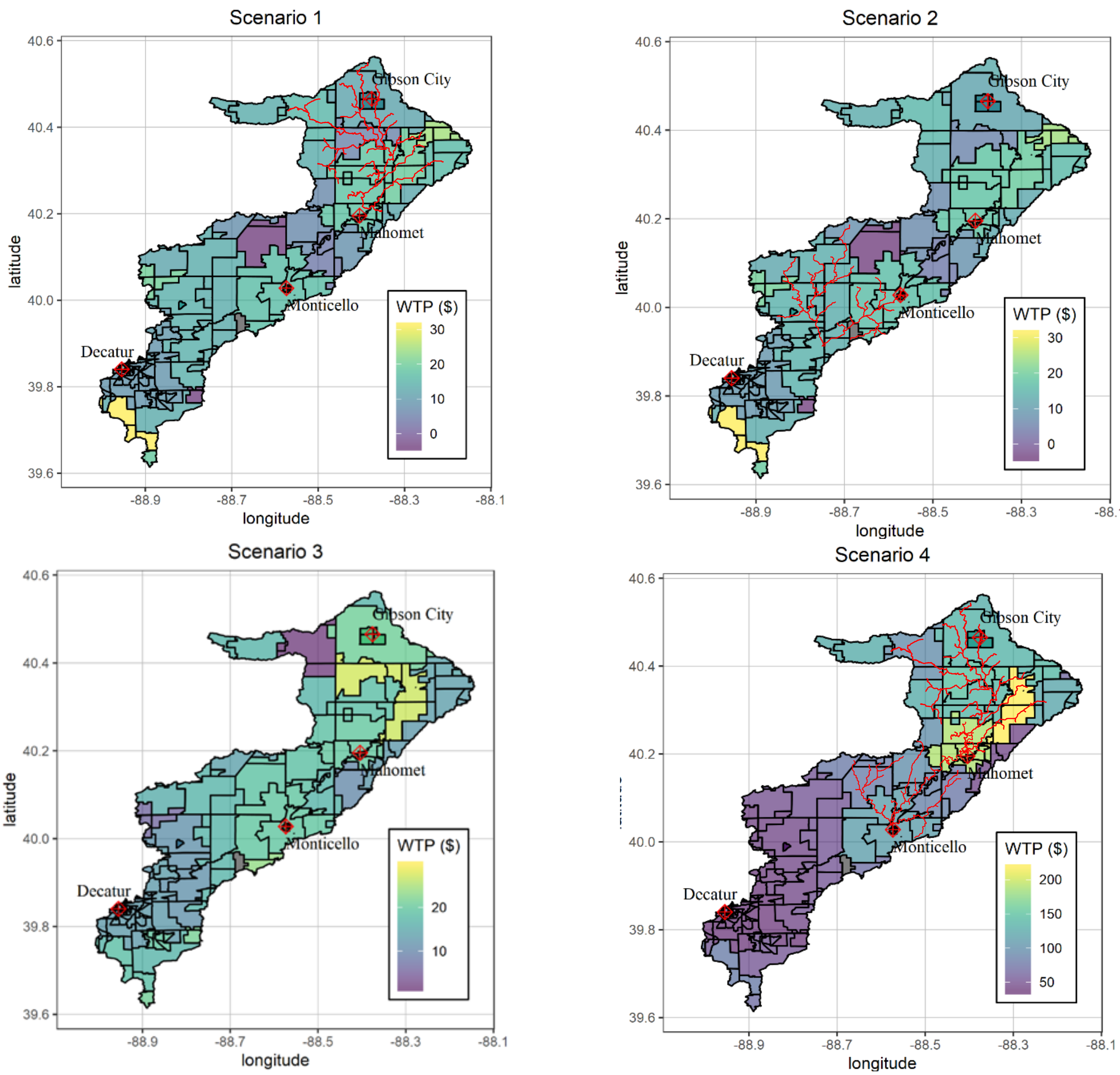


Table 8: Sample Integrated Assessment Value Estimates (total WTP per person)

	(1)	(2)	(3)	(4)
Algal Blooms	75% reduced Area A only	75% reduced Area C only	-	75% reduced Area A only
Nutrient Target	-	-	75% likelihood	100% likelihood
Fish Species	-	-	-	+ 2 species Area A only
Fish Population	-	-	-	+ 50 population Area A and B
Annual Benefits				
Rural People	$8.79	$8.16	$10.84	$53.79
Urban People	$3.76	$3.78	$3.85	$15.07
Mean	$6.28	$5.97	$7.35	$34.43



Appendix 1: Survey

Water Quality in the Upper Sangamon River Survey

This survey will collect information for research being conducted at the University of Illinois. The research will study how people value changes to water quality in a nearby watershed resulting from changes in agriculture practices. You will not be asked to provide your name or address and your participation and answers to this survey will be completely anonymous.

Participation is voluntary and will take approximately 10 minutes

You should only complete this survey if you are over 18 years old. Please complete the survey to the best of your ability. You may choose not to answer specific questions or discontinue the survey at any time.

Your participation in this survey is very important. You might not benefit directly from participation, but the information from this survey will help policy makers, economists, and watershed managers choose how and how much to improve water quality in your area. We will be happy to provide you with a copy of the final report at your request.

Please keep this information for your records

You should keep this information for your future reference. If you have any questions about this survey research or its results please contact: watersurvey@illinois.edu

If you have any questions about your rights as a research subject, including questions, concerns, complaints, or to offer input, you may call the Office for the Protection of Research Subjects (OPRS) at 217-333-2670 or e-mail OPRS at irb@illinois.edu.

Instructions

This survey measures what people think about changes in local water quality due to local changes in agriculture practices. We are interested in how much you care about features such as: fish species and populations, local problems from water pollution like algal blooms, and the likelihood of reaching targets that have been set to reduce serious water quality problems in the Gulf of Mexico.

The survey has two sections:

1. **In section one** of the survey, you will be asked six questions. In each of those questions, we will ask you to choose between two possible future scenarios and the current situation (“No Change”).

2. **In section two** of the survey, there will be some short questions about you so that we can understand what factors affect the way people feel about local water quality.

Remember that all your answers will be completely anonymous.

Background Information

Rivers, streams, and lakes in the U.S. Midwest have been changed by things like farming. The soil and climate in the region provide a great environment for growing crops. However, rain runs off fields and carries bits of soil (sediment) and chemicals from fertilizer and plants (nutrients) into local waters. Runoff of nutrients and sediment causes local problems, reduced fish numbers and sudden growths of green algae that smell bad and can be toxic. Nutrient pollution also creates a big area that is starved of oxygen (the hypoxic zone) in the Gulf of Mexico.

Upper Sangamon River Basin

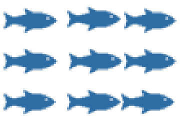
Locally, proposed changes that reduce nutrient runoff can improve rivers and lakes by providing clearer water and better habitat for fish. Improved water conditions can increase both the number of different **kinds** of fish (species) and **how many** fish there are (population). Some of these fish are game fish that are often fished for by recreational anglers, including bass, creel, and trout. Other types of fish are not directly interesting to people fishing, but they help support healthy homes in rivers and lakes for birds and other wild animals.

Hypoxia in the Gulf of Mexico

The nutrients and sediment that run off lands throughout the U.S. Midwest drain into the Gulf of Mexico. Once in the Gulf, these nutrients create a "dead zone" stretching thousands of square miles around the mouth of the Mississippi River. There are 12 states, including the state of Illinois, who have pledged to reduce the dead zone in the Gulf. Those states have agreed with the U.S. EPA to reduce nutrient flows from their lands by 45% by the year 2040.

Features of Water Quality Improvements

Depending on how it is done, changes in water quality can have different results. The features described below are of interest in this survey. Please read this carefully in order to answer the questions in the survey.

Species of Game Fish 	The number of different game fish species found in a typical 100 yards of river in the highlighted section of the river (100 yards is the length of a football field). A high number means you can expect to see many different kinds of game fish.
Population of All Fish 	The number of individual fish (from all species, game and non-game) found in a typical 100 yards of river in the highlighted section of the river. A high number means you can expect to see many individual fish. They may be all the same type, or they may be several different types.
Algal Blooms  Reduced	The percent reduction in the frequency of algal blooms in the highlighted section of the river. These are typically seen in the ponds and lakes connected to the river. A higher number means you will see fewer algal blooms. For example: 100 means 100 percent reduction so there are no algal blooms, 0 means the number of algal blooms stays exactly the same as it is now.
Nutrient Targets 	The likelihood that the Upper Sangamon River area succeeds in reaching its goal of reducing nearly half of the nutrients running down to the Gulf of Mexico by 2040. A higher number means the target is more likely to be reached. For example: 100 means the target is definitely reached; 0 means the target is definitely not reached.
Distance 	The distance in miles from you to the cleaned up section of the river. This feature depends on which section of river is cleaned up and where you live.
Annual Cost 	The amount of money that your household will have to pay every year to improve the water quality in the Upper Sangamon River. The money will be paid through an increase in annual county fees. If you are a renter, this will be passed on through rent charged by the landlord.

Current Experience

Before you answer the next questions, help us understand your current experience.

How often have you seen algal blooms in the rivers near you?

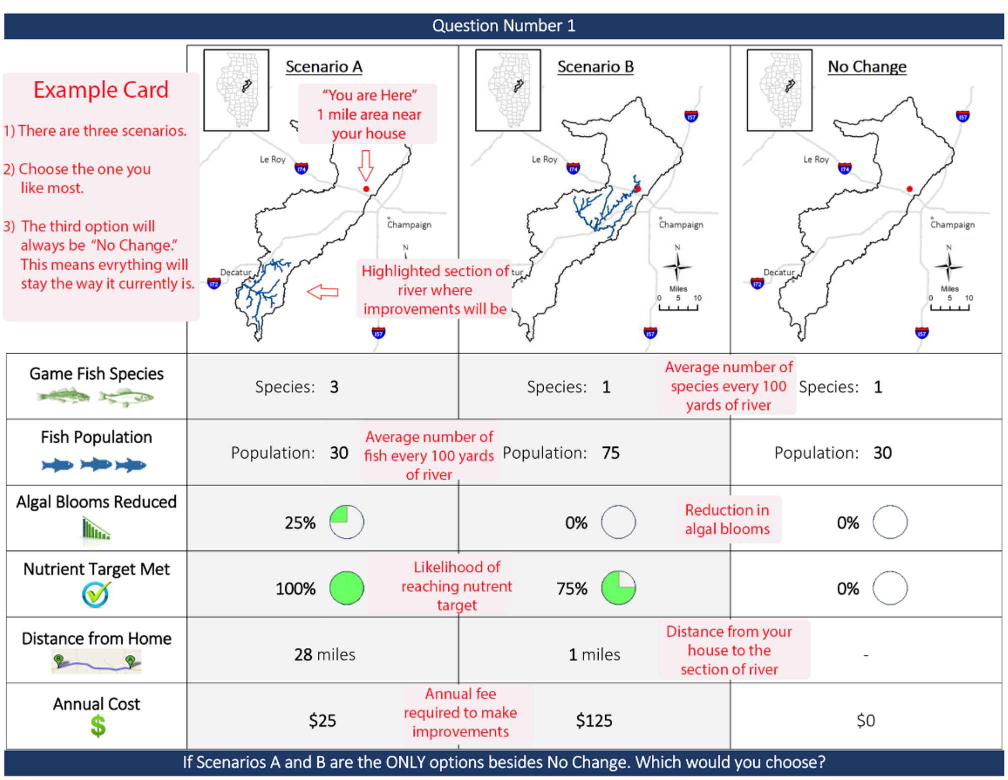
a) Never
b) Rarely, once every couple of years
c) Not often, once per year
d) Sometimes, several times a year
e) Very often

How many times in the last year have you gone fishing in the Upper Sangamon River?

a) 0
b) 1
c) 2
d) 3
e) 4
f) 5
g) more than 5

How many times in the last year have you participated in other recreation activities in the Upper Sangamon River Basin? (Boat, swim, bike, walk the trails, etc.)

a) 0
b) 1
c) 2
d) 3
e) 4
f) 5
g) more than 5



Things to Remember

For the purposes of this survey you should assume that every possible future scenario:

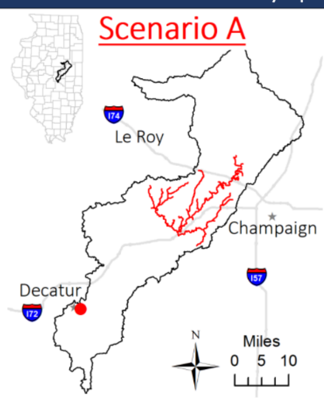
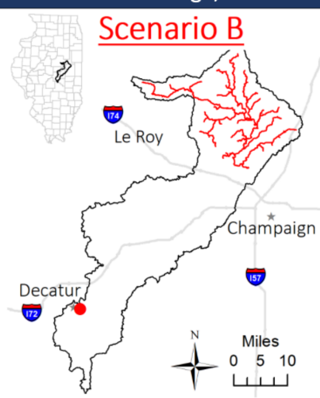
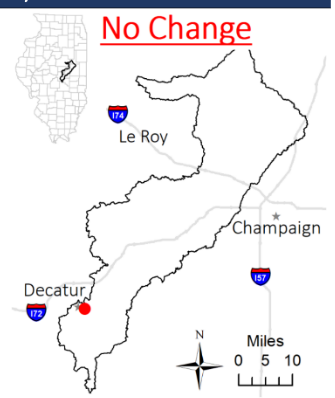
- will ONLY affect the highlighted area of the river
- will NOT result in additional changes such as fishing or visiting regulations
- will NOT result in a change in agricultural acreage or profits
- WILL be paid for by an annual increase in county fees

Experience from previous similar surveys is that people often say they would be willing to pay more money for something than they actually would. For example, in one study, 80% of people said they would buy a product, but when a store actually stocked the product, only 43% of people actually bought the new product. It is important that you make each of your upcoming selections like you would if you were **actually** facing these exact choices in reality. Note that paying for environmental improvement means you would have less money available for other purchases.

Ready, set, choose.

Remember, each of the six questions is separate and independent from the previous questions. For every question, Scenarios A and B are the ONLY options besides the “No Change.” Which would you choose?

If scenarios A and B were the only options besides No Change, which would you choose?

	Scenario A	Scenario B	No Change
			
Game Fish Species	2	5	1
Fish Population	75	50	30
Algal Blooms Reduced	25%	0%	0%
Nutrient Target Met	75%	50%	0%
Distance from Home	23 miles	39 miles	-
Annual Cost	$5	$15	$0

If you are unsure about scenarios A or B, or would not actually spend the money, please choose No Change.

Almost Finished

Now we are going to ask a few quick questions about you, and then you will be finished.

1. Do you consider where you live to be rural?
   a. Yes
   b. No

2. Think about your household's total income each year. What category does it fall into?
   a. Less than $25,000 per year
   b. $25,000 - $34,999 per year
   c. $35,000 - $49,999 per year
   d. $50,000 - $74,999 per year
   e. $75,000 - $99,999 per year
   f. $100,000 - $149,999 per year
   g. $150,000 - $199,999 per year
   h. More than $200,000 per year

3. Do you own your home?
   a. Yes
   b. No

4. Do you or your family farm or do work related to agriculture?
   a. Yes
   b. No

5. What is your age group?
   a. 18-29 years old
   b. 30-44 years old
   c. 45-64 years old
   d. Over 65 years old

6. What is your gender?
   a. Female
   b. Male
   c. Other

7. What is your race?
   a. White
   b. African American
   c. Hispanic or Latino
   d. American Indian, or Alaska Native
   e. Other

8. What is your highest level of education?
   a. Less than high school
   b. High school / GED
   c. Some college
   d. Two-year college degree
   e. Four-year college degree
   f. Graduate degree

9. How many years have you lived in central Illinois?
   a. 0 to 5 years
   b. 5 to 10 years
   c. 10 to 20 years
   d. 20 to 30 years
   e. More than 30 years

10. How familiar are you with the water quality issues discussed in this survey?
    a. 0 – not familiar at all
    b. 1 – somewhat familiar
    c. 2 – familiar
    d. 3 – very familiar
    e. 4 – very familiar and involved

11. Do you ever go fishing in the Sangamon River?
    a. 0 - No, never
    b. 1 - Sometimes, once per year
    c. 2 - Yes, several times per year

12. Do you ever go hiking or recreating near the Sangamon River?
    a. 0 - No, never
    b. 1 - Sometimes, once per year
    c. 2 - Yes, several times per year

13. Please add any comments, questions, or concerns that you would like us to know about.

Appendix 2: Additional Tables and Figures

Table A1: Rural, Urban, and Pooled Samples

	(1) Rural	(2) Urban	(3) Pooled
ASC	-0.786*	-0.562	-0.651**
	(0.323)	(0.385)	(0.247)
Cost	-5.233***	-4.622***	-5.028***
	(0.559)	(0.402)	(0.398)
Fish Species	-0.021	0.016	0.001
	(0.056)	(0.054)	(0.053)
Fish Population	0.000	0.002	0.002
	(0.002)	(0.002)	(0.002)
Algal Blooms	1.428***	1.339***	1.341***
(reduction)	(0.360)	(0.305)	(0.301)
Nutrient Target	1.781***	1.294***	1.231***
(likelihood of reaching)	(0.328)	(0.282)	(0.265)
Distance	-0.017**	-0.018**	-0.017***
	(0.006)	(0.006)	(0.004)
Rural x Species			0.005
			(0.074)
Rural x Population			-0.002
			(0.003)
Rural x Algal			0.239
			(0.452)
Rural x Nutrient			0.762*
			(0.380)
Full correlation	Y	Y	Y
Observations	2070	1836	3906
McFadden R^2	0.095	0.068	0.083
AIC	1241.941	1165.298	2419.946
Log likelihood	-585.970	-547.649	-1133.973
CPU Time (minutes)	42.432	35.488	228.255

Standard errors in parentheses $^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$

Note: Column (1) gives results of a MIXL model with only rural respondents. Column (2) gives results of a MIXL model with only urban respondents. Column (3) is the pooled model with interaction terms, the primary specification from our main results, Table 4. All models allow for full correlation across parameters.

Figure A1: Frequency of Chosen Attribute Levels

Note: Plots show substantial variation in the levels of each attribute as indicated in the chosen alternative from each choice set. Status-quo levels of each attribute (except *cost*) are represented in the far left column of each plot. From these plots we can see that fish *diversity* and fish *density* are more represented by the status-quo level than the other four attributes.

Figure A3: Conditional MWTP estimates from MIXL (left) and GMNL (right)

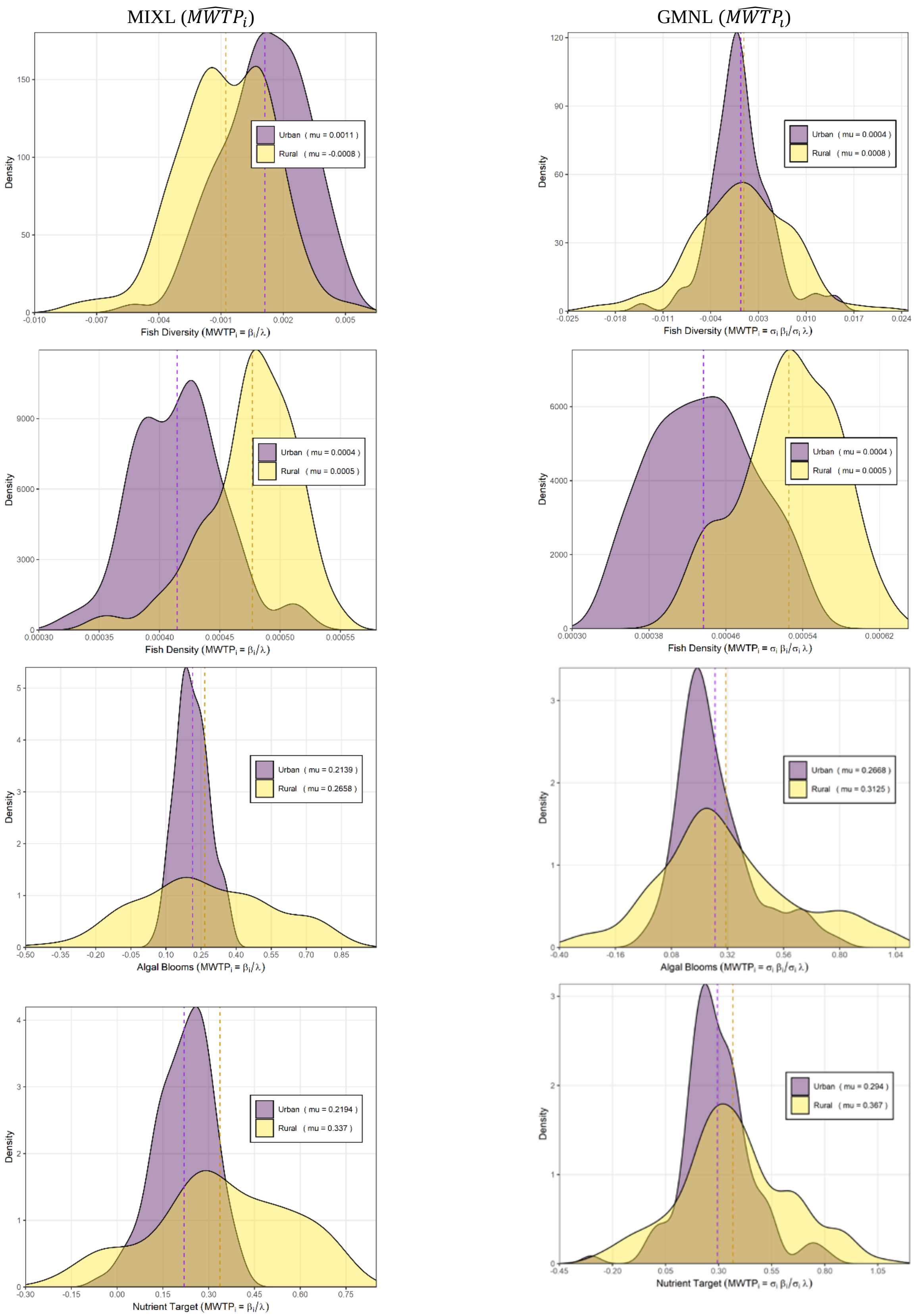


Figure A4: Demographics and characteristics plots of the USRB