The economic value of ecosystem services from delisting impairments: A case study of Lake St. Joseph, Louisiana.

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Abstract

Runoff from agricultural fields in Lake St. Joseph watershed caused sediment inflow into the lake resulting in the lake not meeting one of its designated uses, propagation of fish and wildlife. As a result, the lake was added to the state's year-2002 list of impaired waters for turbidity. Conservation agencies worked with local farmers to promote the implementation of Best Management Practices (BMPs) to decrease sediment runoff from crop fields within the watershed. In 2016, it was proposed that Lake St. Joseph be removed from the list of impaired waters. Such delisting is believed to provide a variety of benefits to people, often referred as ecosystem services. We measured the value of the ecosystem services provided by recreational activities, mainly fishing, using a meta-analysis based function transfer approach. The preliminary results show significant benefit in terms of fishing as a result of an increase in fish populations. Although ecosystem services are not exactly bought and sold in the market, their contribution to the local economy is significant, especially in Louisiana.

Keywords: Watershed, Best Management Practices, Turbidity, Valuation, Benefits Transfer

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Introduction

Louisiana is considered a sportsman's paradise for its rich history in outdoor activities. Rivers, lakes, and bayous support recreational fishing and a number of other water-related activities. In addition, Louisiana also harbors the largest row crop district in the country. Crop production related activities have the potential to contribute nutrients, chemicals, and other pollutants to these bodies of water, if proper land management measures, often referred as Best Management Practices (BMPs), are not put in place, ultimately resulting in declining of water quality in the surrounding bodies of water and not supporting primary and secondary contact recreation. Due to the connectivity of the lakes and bayous to the big river systems in the state, such as the Mississippi River, declining water quality in lakes and rivers can contribute to quality issues in the Gulf Coast.

One such case of declining water quality and not supporting recreational activities is the case of Lake St. Joseph, a 1,197-acre naturally separated oxbow of the Mississippi River. It is located in the Ouachita River Basin in Tensas Parish, Louisiana. This historic river channel supports recreational fishing, which is open to the public, and hunting activities (Louisiana Dept. of Wildlife and Fisheries 2014). Agricultural activity in close proximity to the lake greatly accelerated sedimentation in the lake affecting the recreational activities as well as impairment of fish and wildlife propagation designated use (U.S. EPA 2016). As a result, the lake was classified impaired for turbidity and dissolved oxygen levels and was placed on the 303(d) list, list of impaired waters, in 2004.

A watershed implementation plan, consisting of efforts to monitor pollution pathways, collect water quality data, and mitigate nutrients and sediments deposition in the lake through the use of BMPs, was developed by Louisiana Dept. of Environmental Quality with partnership from Louisiana Master Farmer Program and Louisiana Dept. of Agriculture and Forestry. Natural Resources Conservation Service provided cost-share helping landowners to implement voluntary practices to mitigate nutrient and sediment runoff from their fields. Conservation practices were implemented on approximately 5,100 acres of the 14,000-acre watershed (U.S. EPA 2016). Regular water sampling data showed that by year 2015 turbidity concentrations declined in the lake along with meeting the fish and wildlife propagation designated use (Fultz and Hendrix 2016).

The economic activities provided by such habitats often have value, usually both economic benefits and costs. Although, the costs of protecting such habitats is simple to estimate, estimating the benefits can be a challenge, mostly because the activities are neither bought or sold in markets (Loomis and White 1996).

Since the activities supported by these habitats have public good characteristics, measuring benefits using willingness-to-pay (WTP) is the conceptually correct measure of benefits (Just et al. 1982). Against this background, we estimate the benefits of water quality improvement in Lake St. Joseph, using the meta-analysis based benefit function transfer approach.

Meta-analysis benefit function transfer

In this approach, a statistical model of benefit estimates gathered from several studies and characteristics of individual studies (e.g., region, survey method, the body of water assessed) that were developed and analyzed is used for benefit transfer to predict WTP. It is generally accepted that function transfers perform better in predicting WTP than direct value transfers (Smith and Huang 1995) because function transfer allows explanatory variables to be adjusted to represent the policy site (Bateman and Jones 2003). Benefit transfer using meta-analysis has advantages over benefit estimate transfer and benefits function transfer such as controlling for differences in methodology among studies (Smith and Kaoru 1990) and controlling for differences between study site and policy site (Shrestha and Loomis 2001). Meta-analysis based function transfer functions have the added advantage of including information from a large number of studies and sites. Although, the accuracy of economic valuations of non-market goods using benefits function transfer remain a point of debate, relying on available valuations and predicting benefit values to advise policy makers is still a useful approach. There is substantial policy interest as it offers a means to estimate monetary values for environmental goods and services without performing an expensive primary valuation study.

Several studies have conducted meta-analysis of the benefit estimates, meta-analysis of travel costs benefit estimates (Smith and Kaoru 1990), meta-analysis of air quality benefit estimates (Smith and Huang 1995), meta-analysis of benefit estimates of rare and endangered species (Loomis and White 1996), and meta-analysis of water quality benefits (Van Houtven et al. 2007; Alvarez et al. 2016), among others. These studies have shown that benefit estimates are influenced by study characteristics and hence, meta-analysis can be used as a complement to other benefit transfer methods (Loomis and White 1996). Engel (2002) and Brander et al. (2007) produced an encouraging view of the meta-analysis based function transfers compared to the performance of a benefit function transfer. Moreover, when primary data collection is not feasible and there are no current alternatives to benefit transfer, several studies have shown that meta-analysis is a promising technique for befits transfer (Rosenberg and Loomis 2000; Adusumilli 2015).

Data and Method

To illustrate the meta-analysis results for benefit transfer method of valuation, we apply the estimates of the benefits of water quality improvements and consequent recreational fishing improvements in inland bodies of water from Van Houtven et al. (2007). Van Houtven et al. (2007) identified 90 studies published between 1968 and 2002 and created a database of water quality value estimates. After reviewing the estimates that could be expressed in comparable forms, 131 value estimates from 21 publications were included in their meta-regression. Their results showed that three functional forms, linear, semi-log, and log-linear all provided a reasonably good fit of the data. The statistical significance of the explanatory variable was relatively consistent across the three specifications. The most important result is that WTP estimates were significantly higher when water quality changes were characterized using recreational use descriptions. Variables, their description, mean values, and regression results of the linear model from Van Houtven et al. (2007) are presented in Table 1. In general, coefficients were of the theoretically expected signs. The model results are used to predict WTP for the policy site of interest, Lake St. Joseph in this case.

Table 1. Description of variables, their mean, and regression coefficients of the meta-analysis benefit function used to predict willingness-to-pay estimates[a]

Variable	Description	Mean	Coefficient
WTP2000	Annual WTP for water quality change (in 2000 dollars)	82.77	
WQI10CHANGE	Water quality change (10-point WQI)	3.39	7.21
WQ_REC_USE	=1 if the water quality change described in the study includes a reference to recreational use support (e.g., suitable for recreational fishing)	0.68	6.84
WQI10BASE	Baseline level of water quality from which water quality improves	2.8	2.49
ESTUARY	=1 if the water quality change occurs in an estuary	0.27	20.09
LOCAL_FWATER	=1 if the water quality change is restricted to freshwater in the local area (i.e., within a single body of water, county, or metro area)	0.43	-12.70
MIDWEST	=1 if the affected waterbodies are in the Midwest region of the U.S.	0.32	27.33
SOUTH	=1 if the affected waterbodies are in the Southern region of the U.S.	0.12	7.97
INCOME2000	Average household income (in thousands of 2000 dollars)	50.26	1.30**
INCOME_APPROX	=1 if average household income was not reported in study (approximated based on local Census data)	0.26	-0.44
PERCENT_USER	Percent of the sample population that are users of the affected water resource	62.74	0.51**
PUBLISHED	=1 if value is published in a peer-reviewed book or journal	0.51	61.75**
OPEN_ENDED	=1 if the value was estimated from an OE valuation question	0.6	-4.39
RESPONSE_RATE	Response rate for the survey used in the study (%)	58.02	-1.03
IN_PERSON	=1 if the survey used in the study was administered with an in-person interview	0.31	36.15
STUDY_YR73	=Year SP survey was fielded (minus 1973)	11.63	-2.96**
NUM_PERSON	Number of respondents in WTP estimation sample	266.56	
Constant			11.16

[a] Adopted from Van Houtven et al. (2007).

**Significant at 5-percent level.

When estimating benefit values, it is highly likely that some of the variables of the meta-regression model may not be available for the policy site. In such cases, benefit estimates prediction can be based on setting only relevant variables equal to one and other variables equal to their mean values, because that would allow predicting WTP for policy site consistent with the mix of valuation methods used in the literature (Shrestha and Loomis 2001).

As a first step, before actually performing a value transfer, we used Mean Absolute Percentage Error (MAPE), as reported in Brander et al. (2006), defined as $(Y_{obs}-Y_{est})/Y_{obs,}$ to forecast performance of the meta-regression model. Value or function transfer may result in a substantial error due to several reasons such as the difference in characteristics of the policy site to which values are transferred (Brouwer 2000) and/or not accounting for the differences in quality and quantity of services (Brander et al. 2007) or combining non-identical services. As a result, it is important to compare the scale of the errors in order to inform policy makers regarding the level of potential error involved. We chose the linear specification of the meta-regression model and compared the values of the WTP observations reported in Van Houtven et al. (2007) to those estimated using the meta-regression model, the average MAPE equaled 15%,[1] which is comparable to transfer errors associated with other value transfer exercises. Transfer errors in studies testing the validity of value transfer were in the range of 5-15% for sports fishing (Loomis 1992), 4-34% for water quality improvement that would support different types of lake recreation (Parsons and Kealy 1994) and 27-36% for biodiversity on agricultural lands (Brouwer and Spaninks 1999). A prescribed acceptable level of error is not meaningful as this level will be context specific and related to other policy criteria (Jiang et al. 2004); however, we assumed that the level of error is acceptable for this case study.

We chose the linear specification of the meta-analysis based benefit function and used it to predict WTP for Lake St. Joseph. Income, water quality change, region, type of water body, and assuming recreational use specification equals 1 in each case is used to predict WTP. Fish and wildlife propagation designated use was met because of decreased turbidity in the waters; however, there exists uncertainty with regard to the exact level of water quality change achieved because of decreased turbidity levels. As a result, we used a 2-unit, 3-unit, and a 4-unit change in water quality to predict WTP estimates. For all predictions, income was set at average annual household income in Louisiana in the year 2000. All other variables were set at their sample means. The predicted WTP estimates are converted to current dollars (2015 dollars) using the consumer price index.

Results

With the linear function, the predicted mean WTP estimates for a 2-unit change in water quality was $64 per household (2015 dollars). These values for 3-unit and a 4-unit change in water quality were $73 and $84 per household, respectively. Tensas parish has approximately 2,000 households, whereas, Louisiana has approximately 2 million households. Extrapolating the value per household to all household, the total value of water quality improvement resulting in improved recreational fishing is $128,000 to Tensas parish households and $128,000,000 to all Louisiana households. Since, there was no primary study conducted for the policy site, statistical equality of the site-specific and benefit function transfer estimates of the WTP could not be conducted. Confidence intervals are calculated assuming a stochastic distribution of the income variable. The Monte Carlo Simulation method is used to generate WTP estimates and the process is repeated 1000 times. The Simulations are carried in MS Excel. The WTP estimates and 95% confidence intervals are presented in Table 2.

Table 2. Predicted annual average willingness to pay estimates per household for water quality improvement in Lake St. Joseph, LA.

Water quality change	WTP per household	95% CI, LL	95% CI, UL
2.0	$64.2	$63.5	$64.9
3.0	$73.1	$72.4	$73.8
4.0	$84.3	$83.5	$85.1

[1] We were able to compare 56 WTP observations due to limitations with regards to availability of the information within the studies used in Van Houtven et al. (2007).

Conclusion

Louisiana is a sportsman paradise. Rivers, lakes, and bayous support recreational fishing and hunting to the recreational enthusiasts in the state and from the neighboring states. The impact to water quality can significantly affect recreational activities in these waters.

By focusing on meta-analysis based function transfer, we predict the economic benefits of water quality improvement. The common motivation of this valuation is to determine the WTP of households for protecting the quality of the waters supporting recreational activities.

Where policy analysis if often constrained by data availability, time, and money, benefit transfer methods provide ways to develop benefit estimates to assist policy makers in decision making. The paper uses a meta-analysis regression function to estimate the value of water quality improvements for the Lake St. Joseph in Ouachita River Basin, Louisiana. The meta-regression benefit function transfer computes the WTP value of the recreation site, adjusting for the site characteristics. The results show the WTP values, i.e., annual value per household to protect water quality in the range of \$64-\$84. We examined the robustness of using the meta-regression for out-of-sample value transfer. The resulting average transfer error is 15%.

Several researchers have mixed feeling regarding these valuation methods. For example, Dumas et al. (2005) indicate that benefit transfer is an acceptable approach when the results are advisory in nature rather than decision process; however, when primary data collection is not feasible, benefit transfer is sure to provide some valuable information regarding policy analysis. The use of benefits transfer in this study is to provide an understanding of the benefits of water quality improvements rather than to decide whether to implement practices that improve water quality. Although such benefit function transfer may be acceptable in some contexts, there is still a need for primary valuation studies.

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