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Abstract: A computerized survey instrument was developed to estimate the economic value of riparian restoration along the Little Tennessee River in western North Carolina. Restoration benefits were described in terms of five indicators of ecosystem services: abundance of game fish, water clarity, wildlife habitat, allowable water uses, and ecosystem naturalness. An iterative sequence of dichotomous choice contingent valuation questions were presented to local residents to assess household willingness to pay increased county sales taxes for differing amounts of riparian restoration. Our results showed that the benefits of ecosystem restoration were "super-additive". That is, the total value of conducting many restoration projects exceeded the sum of the value of projects evaluated independently or at too small of a spatial scale. We also estimated the costs of riparian restoration activities by collecting and analyzing data from riparian restoration projects in the study area. After adjusting our estimated valuation function for socio-economic characteristics of the population, the benefit/ cost ratio for riparian restoration throughout the entire watershed was about 2.2 to 1.

Keywords: riparian restoration, contingent valuation, super-additivity, complements in valuation

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1. The need for economic analysis of ecosystem restoration

Ecological systems provide benefits to humans that are generally not accounted for in market transactions. Consequently, economic activities can cause degradation of ecological systems and ecosystem services may be underprovided or entirely lost. If ecosystems are resilient to changes caused by degradation, it may be possible to restore ecosystem services. However, ecosystem restoration is still highly experimental and can be very costly to implement.

During the past decade, the federal government has become increasingly concerned with protecting ecosystem integrity. As a consequence, federal funds have been provided for restoration activities in order to improve the condition of degraded ecosystems. Efficient investment of public funds targeted to restoration can be evaluated by conducting cost-benefit analyses of restoration programs. Although this approach is based on marginal analysis (as contrasted with the macro analysis reported by Costanza et al. 1998), we think that information gathered in a careful cost-benefit analysis can be used to inform policy-makers about the level of ecosystem restoration that is consistent with social values.

The objectives of this study were to develop and test a general methodology for valuing the provision of ecosystem services at different spatial scales and to compare the economic benefits of riparian ecosystem restoration with their costs. This was accomplished via a process that involved detailed conversations with stream ecologists and focus groups with local citizens. This allowed us to develop an iterated contingent valuation survey method for estimating the economic value of watershed restoration activities based on computerized interviews with members of the local population. Data were also collected on the cost of restoration projects in the LTR watershed. This allowed us to compare the costs and benefits of watershed restoration at different spatial scales.

2. History of the Little Tennessee River ecosystem

In this paper, we conduct a cost-benefit analysis of restoration activities along the Little Tennessee River (hereafter LTR) and which is located in the southern Appalachian Mountains. The Little Tennessee River (LTR) originates in Rabun County Georgia; it flows north into North Carolina before terminating at Fontana Dam, just south of the Great Smoky Mountains. The LTR basin contains about 100,000 hectares of mountainous terrain of which 49% is part of the Nantahala National Forest, 37% is in privately held forest, and the remainder (14%) is developed.

Historically, the Little Tennessee River watershed was part of the homeland of the Cherokee Nation. After European settlement, the region supported logging, agriculture and mining industries. Initial crops in the LTR valley were corn, wheat, rye and other grains. During the late 1940's the Tennessee Valley Authority began to address the sediment loads in the LTR. Grasses were planted on vertical sections of productive land reducing soil erosion. However, land use shifted as farmers began increasing livestock production. Over the years, many farmers have cleared their land toward the riverbank to maximize output.

In more recent times, tourism, recreation and the draw of living in an aesthetically pleasing environment has led to rapid population growth and an increase in the number of people who visit the area. In the last twenty years the population in Macon County, North Carolina (our study area) has doubled, leading to concerns about the future health of the watershed and the ecosystem services the watershed provides.

The majority of land within the watershed is privately owned and private land use decisions have had a major impact on ecosystem structure and function (Wear and Bolstad 1998). Non-point pollution from agricultural activities (such as watering cattle in streams) and development (housing and commercial development along streams and creeks) threaten the ecological integrity of the watershed. These economic activities have generated increased sediment, nutrients, fecal coliform bacteria, toxic chemicals, oil, grease, and road salt into the river system.

3. Prior riparian restoration activities and costs in the LTR watershed

A restoration program for the LTR watershed was initiated in 1995 and 59 projects had been completed by 2001. A total of 54 projects have set aside 45,118 feet, or 8.5 miles, of riparian buffer. This activity consists of planting trees and grasses to stabilize the riverbank. On 14 projects, fences were installed to prohibit livestock from entering the river. And on 5 projects, alternative water systems were developed for watering livestock.

Only 35 of the riparian buffer projects had sufficient cost data available to estimate project costs. We estimated that riparian buffers without fencing cost, on average, \$0.98 per foot (based on data from 29 projects). With fencing, average costs were \$3.13 per foot (based on data from 6 projects).

A second riparian restoration activity in the LTR watershed involved rebuilding eroding stream banks with revetments. Revetments consist of large tree branches or logs that are anchored to the stream bank with cables. Of the 54 projects, 45 landowners restored 15,321 feet (or 2.90 miles) of stream bank using revetments. 34 landowners used trees from their own property and the other projects brought in trees from off-site.

Revetments are typically quite costly to construct. The average cost of revetments where on-site trees were available for construction was $15.50 per foot. If on-site trees were not available, the average cost of revetments was $20.33 per foot.

Cost sharing is provided through the Natural Resources Conservation Service to landowners desiring to create riparian buffers or install revetments on their land. The NRCS program funds 75% of the cost while the landowners must provide the other 25%. If landowners contribute their own trees to a revetment project, then their cost share falls to 10% of that project. Thus, the private benefit to landowners who decide to enter into a project with the NRCS can be estimated to equal or exceed the dollar amount of their cost share agreement.

The upper LTR watershed is approximately 20 miles in length. Although approximately 8.5 miles along the river have received restoration treatments, many segments along the river still need to be restored. In our valuation experiments, we estimate the value of restoring up to 6 more miles of river. This would constitute complete restoration (not all stretches of the river require restoration).

4. Economic methods for estimating the value of riparian ecosystem services

While estimates of the costs of ecosystem restoration are relatively easy to compute, estimation of economic benefits is more difficult. Economic valuation of non-market goods and services is based on a utilitarian perspective. That is, the source of value in economic analysis is attributed to individuals who are the best judges of the trade-offs that they are willing to make. The amount of money that people are willing to pay (WTP) for an increase in some environmental service is a widely used neo-classical economic concept of value (e.g., see Freeman 1993).

Using the Total Economic Value approach (Turner 1999), ecosystem benefits can be broadly categorized into two classes: use values and non-use values (Krutilla 1967). For example, use values associated with riparian ecosystems can include benefits arising from in-stream uses (such as fishing, swimming or boating), withdrawal for drinking water or irrigation, enhanced aesthetics for nearby uses such as picnicking, consumptive activities such as hunting, and non-consumptive activities such as bird-watching. Riparian ecosystems can also enhance non-use values such as providing benefits for future generations (bequest values) and providing intrinsic values such as simply knowing that a healthy ecosystem exists.

In a number of previous studies, non-market valuation techniques have been applied to the problem of estimating the economic value of freshwater ecosystem services. Wilson and Carpenter (1999) reviewed 30 articles using non-market valuation techniques published in the scientific literature from 1971 to 1997. Each study was classified according to one of the three primary valuation methods: hedonic pricing, travel cost method, or contingent valuation. Among their conclusions, they state “Resource managers and ecologists should be aware that nonuse values have been shown to comprise a sizable portion of total economic value associated with freshwater ecosystems. One important conclusion that follows is that if such values are left out of policy analysis, resulting policy will tend to overestimate the role of use values, and underestimate the role of nonuse values. Without efforts to quantify the nonuse benefits associated with freshwater ecosystem goods and services, policy and managerial decisions could potentially be skewed in favor of environmentally degrading practices by neglecting the diffuse social interests that benefit from the many nonuse oriented characteristics of such systems." (p. 789).

Stated preference techniques such as the contingent valuation method (CVM) are the only economic methods available that are able to include non-use values in estimates of Total Economic Value. The CVM involves construction of a hypothetical market or referendum scenario in a survey. A proposed increase in the quantity or quality of a specific resource is communicated to the respondent in words and/ or visual aids. Faced with a hypothetical market characterized by a description of particular ecosystem services that would be provided at a given price, respondents state whether they would vote YES or NO for the program. From the responses, estimates of WTP can be obtained.

Recently, Loomis et al. (2000) used the CVM to estimate the value of restoring ecosystem services along a 45-mile stretch of the South Platte River in Northern Colorado. A dichotomous choice willingness to pay question regarding purchasing increased ecosystem services such as dilution of wastewater, natural purification of water, erosion control, habitat for fish and wildlife, and recreation was administered to 100 participants. A mean annual household willingness to pay of $252 was estimated for the increase in ecosystem services. Using estimated water leasing costs and farmland easement costs necessary to implement the program, benefit cost ratios varied between 1.4:1 and 5.22:1 depending on whether those refusing to be interviewed had a zero value or not.

Our study differs from Loomis et al. (2000) by considering how the scale of ecosystem restoration is related to the provision of benefits. It may be that the benefits from riparian restoration projects in the same watershed are linked, so that investments in one or a few projects may be of limited value while marginal (and average) benefits increase as projects are added (Noss and Cooperrider 1994). Thus, we propose to test the hypothesis that riparian restoration benefits are "super-additive" or complements in valuation. This follows from Madden's (1991) definition of substitutes (complements) for rationed goods: "…good *i* is a substitute (resp. complement) for good j if the *willingness to buy* good *i* goes up (resp. down) as good *j becomes less available*…" (p. 1498). Positing that riparian restoration programs are complements suggests that, *ceteris paribus*, the sum of independent valuations of restoration projects will be less than the value of the restoration projects taken together.

5. Ecosystem valuation survey design

In order to design a meaningful survey that can be used to estimate the economic value of ecosystem services, it is imperative that economists work closely with ecologists to define the set of services that are impacted by prevailing ecosystem conditions and that could be restored through management activities. Failure to develop an understanding of the complete set of ecosystem services that could be influenced by restoration activities can lead to a number of problems. First, economists may estimate values for an incomplete set of ecosystem services, leading to an underestimate of the value of ecosystem protection. Second, if economists estimate the value of each ecosystem service in isolation, and then add up the values for each of the services, then estimates of total ecosystem value may be too high or too low, depending on whether ecosystem services are substitutes, complements or are truly independent in value (Hoehn 1991). Third, ecosystem values may vary depending on the scale of ecosystem restoration. That is, the economic benefits provided by a single restoration project may be very low if the project is not effective in enhancing the overall level of ecosystem services. The value of multiple projects that do in fact enhance the overall provision of ecosystem services may then be "super-additive", or greater than the sum of the benefits provided by individual projects valued in isolation.

For our study, a team of economists conferred with at team of ecologists from the U.S.D.A. Forest Service Coweeta Hydrologic Laboratory to discuss the set of ecosystem services that have been impacted by land uses in the LTR watershed and the particular restoration activities that were being undertaken to address degradation of the riparian ecosystem. In these sessions, concern was expressed about the impact of residential and commercial development along streams that served as tributaries to the LTR. Review and input on the relationships between ecosystem services and restoration activities in the LTR watershed were also obtained in focus group sessions with ecologists in the Institute of Ecology at the University of Georgia, Athens.

Based on these conversations and input, several ecosystem services (and indicator variables for each service) were identified: (1) habitat for fish (abundance of game fish),

(2) habitat for wildlife (wildlife habitat in buffer zones), (3) erosion control and water purification (water clarity), (4) recreational uses (allowable water uses), and (5) ecosystem integrity (index of ecosystem naturalness). Generalized categories representing the level of provision of each indicator were assigned to represent low, moderate or high levels of provision of ecosystem services. This technique was used to obviate problems associated with characterizing an exact change in ecosystem services that could be expected to obtain from the implementation of specific riparian restoration activities.

In order to obtain information about the effect of program scale on the valuation of economic benefits, respondents were asked to vote on four different programs. For this watershed, it was decided that complete restoration could be accomplished by installing riparian restoration projects along an additional 6 miles of the riverbank. Therefore, we decided to include three levels of river restoration in the experiment: 2 miles of new restoration, 4 miles of new restoration and 6 miles of new restoration.

In order to estimate the value of protecting the tributaries of the LTR, we included a base program that would require best management practices to be implemented at construction sites and along private roads in order to prevent sediment from entering tributaries to the LTR. BMP's include activities such as the construction of drop structures (e.g., weirs) to minimize the amount of soil movement down slopes. BMP activities would be paid for by the private sector.

For each program, general levels of provision for each of the indicators of ecosystem services were constructed (Table 1). Indicator levels were also provided for the status quo scenario so that respondents could discern changes in ecosystem services from the status quo.

6. A computerized survey instrument

A computerized survey instrument was developed using Ci3 software. This format was developed to facilitate communication of information about the sources of riparian ecosystem degradation in the LTR watershed, the various riparian restoration and protection activities that could be implemented to address the problem, and the ecosystem services that would be enhanced by the watershed programs. This format allowed us to make extensive use of photographs and diagrams depicting restoration activities. Land use maps were included to depict land use change in the study area, and showed the proximity of economic development to the LTR and its tributaries. The use of a computerized instrument may eliminate the potential for bias that is sometimes induced by in-person surveys.

The computerized instrument provided us with the opportunity to customize the bidding structure in the iterative referendum voting scenarios. Bid amounts for the 4-mile and 6-mile restoration programs were conditional on the response to the prior referendum question. A YES response to the 2-mile or 4-mile restoration referendum questions led to a higher bid amount for the subsequent program, whereas a NO response led to the same bid amount for the subsequent program. The initial bid amounts were randomly selected from the amounts \$1, \$5, \$10, \$50 or \$75. Final bid amounts ranged from 1 to \$500.

The valuation questions asked the respondent to consider a vote to approve or reject specific management programs for the Little Tennessee River watershed. The management program would be one of the alternative riparian ecosystem programs described above. The scenarios stated that if the respondent agreed to support the program, payment would be collected through an increase in the local (county) sales tax. It was also stated that a restoration program would be implemented only if a majority of county residents voted in favor of it. Finally, respondents were asked to consider their current expenses before answering the referendum questions.

7. Citizen valuation panel

Four focus group sessions were conducted in the study area to evaluate how well the computerized survey instrument worked. Focus group participants were provided with a $25 incentive for their time. A major concern expressed in the focus groups was the construct of our payment vehicle. Initially, we included State income tax as the payment vehicle. After discussion with focus group participants, we altered our payment vehicle to an increase in the local sales tax. In the southern U.S. where the study area is located, local sales taxes that must be approved in a public referendum are a common and familiar means of financing local public goods and services. It was noted that the county had recently passed an increase in the sales tax and that some people were reluctant to vote for further tax increases.

The citizen valuation panel was a non-probability sample made up of recruits from local civic organizations. Although we did not use a formal “quota” sample, where quotas are defined over specific socio-economic variables, an attempt was made to recruit a diverse set of citizens to make up the panel. Harrison and Lesley (1996) state "If the goal of the sampling exercise is indeed to generate a good valuation function for the purpose of predicting population responses, then it does not follow that probability sampling is the best thing to do. Instead, one should try to ensure sample variation in all of the explanatory variables that will be used to predict the population mean, even if this means generating a greater number of responses for certain stratification categories than is found in the population" (p. 83). Then, once a valuation function is estimated, population values for stratification categories such age, gender, and income can be inserted in the valuation function to predict WTP for the population.

Each individual who participated in the final survey received a $40 incentive payment. Ninety-six people completed the computerized interviews (this represents about 0.7% of the households in the County). A comparison of socio-economic characteristics of the sample and for the County (based on the 2000 Census) showed that the income and education of the sample were higher than the values for the population (Table 2). This result is not uncommon for probability samples. We also found that the age and gender characteristics of our sample were quite close to the population values. However, our sample included a much larger proportion of people who owned property along the LTR than was found in the general population. Over sampling people living along the LTR allowed us to test for differences in WTP between the two population groups that may be attributable to differences in non-use value. The survey panels were held in the study area using computer labs at Franklin High School and Southwestern College.

8. Statistical Analysis

The binary responses to the referendum questions were analyzed using a random utility model. For each of the different programs shown in Table 1, respondents were asked if they would vote to support the LTR watershed program at the stated bid amount. The probability of voting YES can be expressed as

$$\Pr[v(z^j, y - t_{ij}) + \varepsilon_{ij} \geq v(z^0, y) + \varepsilon_{i0}] \qquad [1]$$

where ν is indirect utility, z^j is a vector of ecosystem services for program j, z^0 is a vector of ecosystem services for the status quo, y is income, t_{ij} is the tax payment for program j and ε is a random error term. Equation [1] can be re-written as:

$$\Pr[\Delta v \geq \varepsilon_{i0} - \varepsilon_{ij}] = \Pr[\Delta v \geq \eta]. \qquad [2]$$

If it is assumed that η is normally distributed, equation [2] can be estimated using a probit model.

It is popular in the valuation literature to specify the WTP function as lognormally distributed. Similar to Bishop and Heberlein (1979), we used a logarithmic transformation of the bid amount in our statistical model. This model, which constrains WTP to be non-negative, can be shown to provide a utility-theoretic estimate of WTP (Hanemann and Kanninen 1999). If the random component of utility ε is randomly distributed, and if η and WTP are lognormal, then the probability of a YES vote is

$$\Pr[vote'yes'] = \Phi(\alpha - \mu \ln(bid)) \qquad [3]$$

where Φ is the normal cumulative distribution function, μ is the parameter estimate on the log-bid amount, and α is either the estimated constant (if no other explanatory variables are included in the equation) or the "grand" constant, which is computed as the sum of the estimated constant plus the product of the other explanatory variables times their mean values.

Hanemann (1984) advocated the use of median WTP as a measure of economic welfare. While the mean WTP has been shown to be very sensitive to small changes in the right tail of the WTP distribution, the median is much more robust to these effects. In addition, median WTP indicates the amount at which 50% of the sample would vote for a particular referendum. This is in keeping with our survey structure, where we reminded people that the conditions of a referendum would only take effect if at least one-half of the population voted in favor of it. Consequently, we use the median as a conservative estimate of WTP. As shown by Hanemann and Kanninen (1999) median WTP can be computed from the parameter estimates in equation [3]:

$$WTP^{median} = \exp\left(\frac{\alpha}{\mu}\right) \quad . \qquad [4]$$

By including independent variables in the model specification that represent socio-economic characteristics, WTP values for the sample can be estimated by using sample means to compute the grand constant α in equation [4]. Alternatively, WTP values for the population can be estimated by computing the grand mean using population values.

For the purposes of estimation in our study, we let the number of miles of restoration (MILES) represent proxies for vectors of ecosystem services. This is because we were not interested in valuing the individual ecosystem services. Rather, we were interested in holistically valuing the bundle of services represented by the specific programs. In fact, we expect that it would be problematic to estimate individual values for ecosystem services because they are likely to be highly collinear. That is, restoration activities that improve one ecosystem service are likely to simultaneously improve other ecosystem services.

We anticipate that the value of ecosystem services may be a non-linear function of the scale of restoration activities. Thus, we used a quadratic form to represent restoration scale. WTP for varying degrees of restoration can then be compared with WTP for the maximum amount of restoration. This is accomplished by adjusting the term representing the product of the parameter estimates on MILES and $MILES^2$ and the number of miles restored in the computation of the grand constant.

Because of the iterative sequencing of valuation questions used in our survey design, it was necessary to estimate panel models for the analysis. In particular, we used an error-components model to control for individual effects that might persist across iterations of the experiment. In an error-components model, the error term is comprised of a permanent component α_i that captures idiosyncratic behavior of the individual, and a transitory random shock υ_{it} (Hsiao 1986):

$$\varepsilon_{it} = \alpha_i + \upsilon_{it} \quad . \qquad [5]$$

The idea behind equation [5] is that two identical individual may systematically differ in their propensity to choose identical policy options due to idiosyncratic preferences. If the parameter α_i is treated as randomly distributed across the population, a random effects model results.

If we assume that individual effects follow a normal distribution in the population, then a random effects model can be estimated (Greene 2000). In this model, an idiosyncratic component in the error term introduces autocorrelation in the responses.

The correlation coefficient ρ is equal to the ratio of the variance of the permanent component to overall variance:

$$\rho = \frac{\sigma_\alpha^2}{\sigma_\upsilon^2 + \sigma_\alpha^2} \qquad [6]$$

where, in dichotomous choice models it is typically assumed that σ^2_v=1. Thus, the value of ρ increases as the variance of the idiosyncratic component increases relative to the variance of the random component.

9. Statistical results

Standard and random effects versions of the statistical model were estimated (Table 3). A likelihood ratio test showed that the random effects model was statistically superior to the standard probit model ($\chi 2$ statistic = 58.41, significant at > 0.01 level). The sales tax amount was significant at the 0.01 level or higher in both of our models. The results indicate that, as the sales tax amount was increased, the probability of voting YES on a referendum for riparian restoration decreased.

In the standard probit model, whether or not the respondent had a COLLEGE degree was positive and significant at the 0.02 level, AGE of the respondent was positive and significant at the 0.07 level several, and log(INCOME) was positive and significant at the 0.15 level in explaining variation in the referenda votes. The statistical significance of these variables decreased in the random effects model. However, the correlation coefficient in the random effects model was significantly different than zero at greater than the 0.01 level. Due to the statistical superiority of the random effects model, it appears that the correlation coefficient is an omitted variable in the standard probit model, and failure to include this parameter would lead to biased parameter estimates using our data. The relatively large value estimated for the correlation coefficient indicates that the variance in individual effects was large relative to the overall variance in the model.

Significant parameter estimates, at greater than the 0.01 level, were obtained in the standard and random effects probit models for the linear and quadratic terms describing programs that varied the number of MILES of riparian restoration. This indicates that the scale of restoration was important to citizens in the valuation experiment. Also, the parameter estimate on whether or not respondents owned PROPERTY along the LTR was significant at greater than the 0.01 level in both model specifications. (PROPERTY was estimated by a count of houses within 200 meters of the LTR using aerial photos). Our results indicate that people who lived along the LTR had a lower WTP than other people in the County. This may reflect high non-use values by people who don't live along the river but value the knowledge that the riparian ecosystem is being restored to a healthy condition. Alternatively, it may reflect actual or anticipated expenditures for riparian restoration by people living along the river, or opportunity costs associated with land use restrictions in riparian buffers. Because some restoration costs accrue to people participating in restoration programs, their WTP for new programs via higher sales taxes may be less than WTP by people not facing those expenditures.

10. Economic benefits and costs of riparian ecosystem restoration

Using the results in Table 3 and the formula in equation [4], median WTP values were calculated (Table 4). WTP values were estimated using the values for the socio-economic variables computed from our sample and using the values for Macon County as reported in the 2000 Census. In both statistical models, WTP values estimated using Census data were less than WTP values estimated using sample means. We used the population adjusted valuation functions in our comparison of ecosystem restoration costs and benefits.

Marginal WTP values for different levels of riparian ecosystem restoration were found to be "super-additive". This means that WTP increased at an increasing rate with the scale of restoration activities. This is an important result. Super-additive benefits suggest that low levels of ecosystem restoration may generate low levels of public benefits per unit of restoration. Conducting a benefit-cost analysis at the project level, for example, may indicate that public investments are not economically feasible. However, if analyses were conducted at a watershed level, as was done in our study, the benefit-cost analysis may show that public investment would be desirable.

Annual WTP estimates were compared with costs based on the historical cost data we collected. To make the comparisons tractable, we needed to make some assumptions about "typical" restoration activities. Using the cost data we collected, we assumed that, for every mile of riparian buffer that is established, 0.34 miles of revetment would be installed (2.9 miles of revetment/ 8.5 miles of buffer). Using a weighted average cost estimate (on-site trees and without on-site trees) of $16.37/ foot for constructing revetments, this translates into $5.56 per "typical" foot of restoration ($16.37*0.34).

Assuming that fencing is installed for ½ of the length of riparian buffers (46% of the total length of riparian buffers was fenced in our project data), the average cost of fencing per "typical" foot of restoration would be \$2.06/ foot. Thus, the average cost per foot of typical restoration would be \$7.62. Recall that, under the cost-share program, landowners must pay 25% of the cost, or \$1.91/ foot in our example. Thus, the public benefits must equal or exceed 75% of the cost, or \$5.72/ foot, for public investment in riparian restoration to be economically feasible.

Using the estimates reported in Table 4 for median WTP, the public benefits of restoring the remainder of the riparian ecosystem in the LTR watershed exceed the public share of the costs. For example, consider the benefits estimated using the (statistically superior) random effects valuation function adjusted for the socio-economic characteristics reported by the 2000 Census. The county wide benefits of a total riparian restoration program that enforces BMP's at new construction sites and adds 6 new miles of river restoration is \$395,526. This is equivalent to benefits of \$12.49 per foot of restoration, or a benefit/ cost ratio of 2.18. This ratio is within the range of benefit/ cost estimates reported by Loomis et al. (2000) for restoring a 45-mile section of the Platte River (1.4 to 5.22). However, it is important to note that the county-wide benefits of enforcing BMP's and restoring 3 miles of river is only \$36,856, (estimated using population data and the random effects valuation function). This is equivalent to benefits of \$2.33 per foot of restoration, or a benefit/ cost ratio of 0.41. Thus, the scale of restoration is clearly an important factor in conducting benefit/ cost analysis of ecosystem restoration projects. In our study, respondents were willing to pay a "premium" for total restoration of the LTR ecosystem relative to more modest restoration levels.

11. Summary and Conclusions

This study makes several important contributions to the literature concerning the economic valuation of ecosystem benefits. First, the local economic benefits of ecosystem restoration can be successfully assessed using a computerized valuation instrument. Based on the analysis reported in this paper, we contend that a computer-assisted valuation panel is a promising approach for valuing complex ecological systems.

Second, when using a non-probability sample to estimate a valuation function, it is essential to adjust the valuation function using socio-economic parameters from the population of interest. Although socio-economic data are often collected in CV surveys, they are often not included in the reported model specifications. Failure to adjust the valuation function for population parameters may lead to biased estimates of WTP and incorrect policy choices may be made.

Third, it is essential to consider the scale of ecosystem restoration when conducting a valuation experiment. Our results showed that ecosystem restoration values were super-additive with respect to the number of miles of restoration, suggesting that riparian restoration projects are complements in valuation. This result is consistent with the study by Hailu et al. (2000) who found that multiple programs for protecting old-growth forests, prairie grasslands and mountain streams were perceived as complements by respondents. Thus, it is important to recognize that, while the benefits of restoration projects considered independently might not exceed the costs of restoration, the aggregate benefit of many restoration projects taken together might exceed restoration costs because the combined programs are more effective in improving the quality of riparian ecosystems.

Finally, it is important to consider the "extent of the market" when conducting local valuation studies. In our study, we found that people who did not live along the Little Tennessee River were willing to pay more for river restoration than people who lived along the river. Although we conducted our analysis at the county level, some people living in neighboring counties probably hold positive values for ecosystem restoration in the LTR watershed. Moreover, because we were able to link our sales tax payment vehicle to county policy, our valuation methodology provides a means for county nonresidents to help pay for the county restoration programs. For example, nonresident visitors to the LTR watershed who purchase retail goods and services in the watershed would also pay the sales tax. If we had applied our valuation function to a broader geographic area, then the benefits of riparian restoration would have increased.

We warn that the ecosystem values we obtained in this study may or may not apply to other watersheds due to differences in population characteristics and the super-additivity of restoration scale. However, we are encouraged to find that, viewed at a local scale, the economic benefits of restoring an entire watershed exceeded the costs. Certainly, human populations living in many different and diverse watersheds may benefit from riparian restoration activities. Future research should be conducted to discern within which watersheds restoration activities could be justified using a cost/benefit criterion and what scale of restoration provides the greatest net social benefits.

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Table 1. Overview of hypothetical Little Tennessee River riparian restoration programs used in the iterative contingent valuation experiment

	Current Situation	Program 1	Program 2	Program 3	Program 4
Indicator of Ecosystem Service	No small streams protected by BMP's + no new river restoration	All small streams protected by BMP's + no new river restoration	All small streams protected by BMP's + 2 miles of new river restoration	All small streams protected by BMP's + 4 miles of new river restoration	All small streams protected by BMP's + 6 miles of new river restoration
Game Fish	Low	Low	Low	Low	High
Water Clarity	Low	Low	Moderate	Moderate	High
Wildlife habitat in buffer zones	Low	Moderate	Moderate	High	High
Allowable Water uses	Low	Moderate	Moderate	Moderate	High
Index of ecosystem "naturalness"	Low	Low	Moderate	High	High

Table 2. Descriptive statistics for Macon County, North Carolina

Data source	Median Income ($)	Median Age (years)	Males per 100 females	Bachelor's degree or higher (%)	Property along LTR (%)
Sample	45,000	47	82	72	52
2000 Census	28,696	45.2	92.1	13.2	5*

* Based on the estimated number of households within 200 meters of the Little Tennessee River using aerial photographs available at "terraserver.homeadvisor.msn.com".

Table 3. Parameter estimates from simple and random effects probit models of willingness to pay an increase in sales tax for local riparian restoration.

Variables	Standard probit	Random effects probit
Constant	-1.982	-3.222***
	(1.444)	(3.717)
ln(Bid)	-0.199***	-0.540***
	(0.054)	(0.147)
Miles	-0.283***	-0.450***
	(0.107)	(0.168)
$Miles^2$	0.060***	0.097***
	(0.017)	(0.026)
ln(Income)	0.178	0.315
	(0.124)	(0.316)
Female	0.077	0.021
	(0.149)	(0.390)
Age	0.011*	0.023
	(0.006)	(0.016)
College	0.402**	0.638
	(0.174)	(0.481)
Property	-0.591***	-1.0223***
	(0.145)	(0.372)
ρ	--	0.623***
		(0.087)
log-Likelihood	-229.396	-200.192
McFadden R^2	0.11	0.22
Observations	384	384

Note: Standard errors in parentheses. *** denotes significance at the 0.01 level. ** denotes significance at the 0.05 level. * denotes significance at the 0.10 level.

Table 4. Annual economic benefits, calculated at sample and population means, for riparian restoration in the Little Tennessee River watershed

Model used for calculation/ benefit category	Partial program (3 miles)	Full program (6 miles)
Probit		
Per household benefits, sample means	$1.17	$53.76
Per household benefits, population means	$0.75	$34.34
County benefits, sample means	$15,044	$689,652
County benefits, population means	$9,608	$440,486
Random effects probit		
Per household benefits, sample means	$3.73	$40.03
Per household benefits, population means	$2.87	$30.83
County benefits, sample means	$47,845	$513,449
County benefits, population means	$36,856	$395,526