Calibrating Benefit Function Transfer to Assess the Conservation Reserve Program

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to Assess the Conservation Reserve Program

INTRODUCTION

Benefit transfer promises inexpensive measures of economic value in situations of deficient data. In particular, benefit transfer allows for the generalization of a narrowly focused study to a larger region, thereby avoiding potentially costly replications of the original study. In response to legislative requirements that non-market benefits be counted, and public sector budget constraints, the use of benefit transfer by government agencies has intensified.

For example, the Damage Assessment Center at the National Oceanographic and Atmospheric Administration (NOAA) assesses the damages resulting from small "Type-A" spills or accidents using the National Resource Damage Assessment Model for Coastal and Marine Environments (French et al., 1995).[1] This model uses benefit estimates from various sources to produce damage assessments based on limited physical information from the spill site. Another application of benefit transfer is the U.S. Forest Service's development of Resources Planning Act values for national forests to use in long range planning processes to meet the requirements of the National Forest Management Act.

[1] For example, the Comprehensive Environmental Responses, Compensation and Liability Act (CERCLA), the Oil Pollution Act, and the National Forest Management Act all involve the use of non-market benefit measurement in some manner.

A crucial distinction in benefit transfer involves whether to transfer point estimates (such as user day values) or the benefit function itself (such as the demand function from which day use values are computed). Transferring point estimates from the “study area” to the unstudied “policy area” is a common practice, especially in federal government planning and procedures[2]. Benefit function transfer, in contrast, involves use of the benefit function itself, in conjunction with demographic and physical/biological data from the affected policy area. Since function transfer recognizes the unique physical and demographic characteristics of the policy area, it is argued (Loomis 1992) that estimates derived using function transfer are superior to simpler, but undifferentiated, point transfer estimates.

The accuracy of benefit function transfer will depend on the degree of similarity between the study area and the policy area. Large differences in the non-market commodities, population demographics and social institutions will tend to create large bias. The strength of benefit function transfer, as opposed to point estimate transfer, is that we account for some of these differences. In practice, since all studies are imperfect, and since exactly appropriate data may often be difficult to obtain, a potential for bias exists. In consequence, methods of reducing such biases should be considered..

[2]Both NOAA and the Forest Service transfer point estimates in their benefit estimation procedures. Two popular U.S. government sources of these numbers can be found in Hay (1988a, 1988b) and Waddington et al. (1994).

The objective of this study is to develop national estimates of the non-market water-based recreational benefits of reductions in soil erosion through the use of benefit function transfer. The focus is on the water quality impacts of the Conservation Reserve Program[3] and other agricultural policies such as the adoption of BMPs (better management practices). The first step involves estimating a recreational demand model based on individual observations for four states from the 1992 National Survey of Recreation and the Environment. Next, the functional form of the model is transferred to the nation using county level U.S. Census data. This procedure incurs a risk of bias due to the transfer of a function to a policy area for which only aggregate information is available (e.g., Desvouges et al. 1992). Thus, a key element of the transfer procedure is an explicit correction for possible aggregation bias.

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CONDUCTING BENEFIT FUNCTION TRANSFER

[3]The Conservation Reserve Program, established in title XII of the Food Security Act of 1985 (P.L. 99-198), is a 35 million acre voluntary long term crop-land retirement program administered by the USDA. The volunteer operator receives 50 percent of the cost of establishing permanent cover on the land and an annual rental payment.

Transferring a benefit function involves selecting a proper function to transfer, gathering data to estimate benefits at the policy area, and calculating welfare changes at the policy area using the transferred function. [4] The welfare function [W(P,D,Q)], estimated at study area “s,” is a function of the prices (P), demographic characteristics (D) and environmental quality (Q) of the inhabitants of the study area. In a given study area s (say, a single county), total welfare (W1) might be estimated as the average individual welfare of the i=1..N_s survey respondents times the county population (POP_s), which equals:

(1) $W1_s = POP_s*\{\Sigma_i W(P_i,D_i,Q)/N_s\}$. $i = 1,...,N_s$

Another estimator of welfare uses aggregate information, such as county averages obtained from the U.S Census. Using such information, an aggregated measure of total welfare in the county might be estimated as the welfare of the county specific representative individual times the county population (POP_s):

(2) $W2_s = POP_s*W(E(P_s),E(D_s),Q_s)$,

where $E(P_s)$ and $E(D_s)$ are the expected price and demographics of the representative individual of county s.

[4] Desvouges et. al (1992) provide five criteria for accomplishing this task.

Given that one's sample is randomly drawn and therefore representative, $W1_s$ will provide a consistent estimate of the population's welfare. In contrast, for typically non-linear welfare functions, $W2_s$ will not equal $W1_s$, and furthermore $W2_s$ will be a biased measure of the population welfare (Hellerstein, 1995).[5] Therefore, when transferring one's results to policy area "t", the use of $W2_t$ ($W2_t$=POP_t*W(E(P_t),E(D_t),Q_t)), is subject to bias. However, since individual data is not likely to be available for area, W2 may be the only available option for measuring welfare.

Examining the magnitude of this bias in the study area may provide information that would be useful in calibrating $W2_t$ in the policy area. One possibility is to compute $W2_s$ (in the study area) using aggregated data. Given a measure of $W1_s$, estimates of $W2_t$ in the policy area could be calibrated by the ratio $W1_s/W2_s$ (from the study area). A more ambitious approach, and the one used in this paper, involves computing a location (county) specific "calibration function" (C) to be transferred along with the benefit function.

The calibration function is computed using the original survey data, along with a set of aggregate measures of distinct locations (say, counties) within the survey area.[6] The following procedure is then used:

i) Compute $W1_s$ and $W2_s$ for each of the s=1..S distinct regions.

ii) Estimate γ in $c_s=C(Z_s,\gamma)$, where $c_s=W1_s/W2_s$ and Z_s is a set of aggregate

[5] Jensen's inequality (see Mood et al.) states that if X is a random variable and f(•) is a concave function, then $E[f(X)] \leq f(E[X])$.

[6] It is assumed that a location (say, county) identifier is available for each observation in the

variables that may include $E(P_s)$, $E(D_s)$ and $Q_{s.}$

iii) Compute $c_t=C(Z_t,\gamma)$.

iv) Compute a calibrated welfare measure for the policy area as the product $W2_t$ x c_t.

The choice of the Z variables will depend on data availability. Since the deviation of W_2 from W_1 will worsen as intra-location variation increases, inclusion of measues of the variance of the explanatory variables, as well as their averages, is advisable. Examples of this would include the standard deviation of income, along with per capita income.

THE DATA

Sources of Data

sample.

Recreational trip taking information comes from the 1992 National Survey of Recreation and the Environment (NSRE), a large survey aimed at providing national data for several recreational activities. One component of the NSRE is a survey of water based recreational activities in four "area study" regions in the U.S.[7] This study is based on these results.[8] Respondents were asked to recall the number of trips taken to up three wetlands, three lakes and three rivers that were less than 100 miles from their residence within the last 12 months where the presence of water was an important reason for taking the trip. The name of each destination as well as its distance and direction (e.g., north, north east, east, etc.) from the respondent's residence were obtained. When possible, destination names were matched to area maps to recover the location (latitude and longitude) of each destination. If the map location could not be determined, then the self reported distance and direction was used to determine the location of the trip destination.

[7] These four "area study regions" are located in Indiana, Nebraska, Pennsylvania and Washington.

[8] At the time this analysis was undertaken, results from the national survey were unavailable.

The resulting data contains information about the water based recreation of about 1500 persons evenly divided among the four area study regions. About 50% of the respondents participated in any water based activity with an average annual participation rate of approximately 16 trips over the year. To capture the intrinsic differences between lake and river based recreation, lake and river trips are modelled separately[9].

[9] Due to infrequent wetland recreation, trips to wetlands were treated as lake trips for estimation purposes.

The physical conditions at the destinations themselves are described by data from the 1992 National Resources Inventory (NRI). The 1992 NRI is the most recent of a series of inventories conducted every five years by the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS)[10]. It contains information on the status, condition, and trends of land, soil, water and related resources on non-Federal land in the U.S.[11] The survey is scientifically designed and based on recognized statistical sampling methods. Data are collected for the 1992 NRI for more than 800,000 locations (points) by NRCS personnel. Each datum, or point, represents a homogenous area of land of varying size. Although the geographic location of each point is known, it is not available to preserve the anonymity of the land owner. To use the data in a geographic analysis, White et. al. (1989) has suggested the formation of "NRI polygons" based on the NRI sample point identifier. Each sample point carries an identifier placing it in one of 3,041 counties, 209 Major Land Resource Areas and 2,111 hydrological units. Intersecting these boundaries results in 14,414 NRI polygons for the 48 conterminous states in the U.S. that contain at least one NRI point. The average polygon size is 102,518 acres, ranging from a minimum of 1,290 acres to a maximum of 677,647 acres. The point specific information in each polygon can be aggregated to a polygon level observation using an area weighted average. The average attribute for the j-th polygon (A_j) is represented by:

(3) $A_j = (\Sigma_{i \in j} A_i * Area_i)(\Sigma_{i \in j} Area_i)$,

[10] Formerly known as the Soil Conservation Service.

[11] The NRI covers the 48 conterminous states, Hawaii, Puerto Rico and the U.S. Virgin Islands.

where i indexes NRI points in polygon j, $Area_i$ is the area of the i-th NRI point and A_i is the attribute of the i-th NRI point.

Since confidentiality restrictions preclude the use of of point specific information, these aggregate polygon are used to define trip sites. Instead of specifying individual lake and river locations as destinations, the locations were mapped into NRI polygons. Five variables describe each destination (NRI polygon)[12]. Trip cost is the travel cost from the centroid of the respondent's zip code zone to the centroid of the NRI polygon[13]. Two variables indicating land characteristics in the polygon are the percentage forested area and percentage privately owned area. A priori, the expectation is that large amounts of privately owned land represent a lack of recreational opportunities while large amounts of forested land augment recreational quality. Average erosion in each polygon is the average sheet and rill soil erosion in tons/acre calculated using the universal soil loss equation (USLE)[14]. This variable is used as an indicator of water quality at each destination. Changes in erosion are assumed to produce changes in water quality, which then impacts the enjoyment of recreational activities.

Is There a Relationship Between Erosion and Water Quality?

[12] To be consistent with the survey questions, any polygons further than 100 miles of the respondent's residence were not assumed to be in the choice set of trip destinations.

[13] Trip cost is the round trip travel cost (distance*$0.35) plus the round trip time cost ((personal income)*0.333*distance/50).

[14] The USLE is a deterministic formula that uses soil type, land use, land coverage and land slope information to predict potential erosion occurring at the NRI point.

The early stages of this analysis included the collection of biological water quality data from the EPA Storet system for the years 1990-1994 in the four area study states. The goal was to construct a physical model capable of predicting changes in water quality resulting from changes in erosion. The resulting data are too limited to produce a reliable physical model, but do provide some evidence of a relationship between water quality measures (total nitrates, total phosphorous and dissolved oxygen) and erosion levels. To investigate this relationship, average water quality variables[15] for lakes and rivers were regressed on a constant term and the natural logarithm of the polygon erosion rate. All of the regression parameters (Table 1) are of the anticipated positive sign except for the dissolved oxygen model for rivers. The low R^2 statistics associated with all six models may be the result of removing variation from the water quality data by averaging it over sampling points and polygons. It is also a likely indication that water quality is affected by many factors other than erosion. Despite the low R^2 statistics, the sign and significance of most of the erosion parameters lend some support to a relationship between water quality and ambient erosion.

THE MODEL

The benefit function is estimated using a two stage discrete-count demand model similar to that proposed by Feather et al. (1995). The first stage is a random utility model (RUM) describing the choice of destination on a recreational outing. The

[15] Each variable was averaged over unique sampling (latitude, longitude) points, separated into lake and river sampling points and averaged over polygons.

strength of the RUM is that it captures substitution among competing sites when quality changes occur. The drawback of the RUM is its inability to account for changes in the total quantity of trips when changes in site quality occur. Both of these questions are important because quality changes presumably create two effects: substitution amongst sites and changes in participation. To better address the participation component of the problem, a secondary participation model is often estimated. These models allow for changes in participation to occur when changes in site quality occur. Both components of this model are described below along with estimation results.

The RUM is commonly used to estimate situations referred to as "corner solutions" where one, or a few goods are chosen from a larger set of substitutable goods. This large choice set is composed of all relevant "elemental alternatives" [Ben-Akiva and Lerman (1985)]. For example, all lakes within a few hours drive from an individual's home may form the set of elemental alternatives for a certain type of water based recreation. The random utility of elemental alternative l to individual k [U_{lk}] is written as:

(4) $U_{lk} = V_{lk} + \varepsilon_{lk}$, $l = 1,...,L$ $k = 1,...,N$

where V_{lk} is the deterministic portion of the utility function and ε_{lk} is an independently and identically distributed extreme value random variable with mode 0 and scale parameter μ. Typically, V_{lk} is written as a linear function of income (Y_k), the cost incurred in visiting the site (C_{lk}), and a vector of characteristics describing the site ($\mathbf{b}_l=[b_{l1},...,b_{lm}]$):

(5) $V_{lk} = \beta(Y_k-C_{lk}) + \mathbf{\Theta b}_l$,

where β and $\mathbf{\Theta} = [\Theta_1,...,\Theta_m]$ are parameters to be estimated. It is well known that the parameters of V_{lk} can be estimated using a multinomial logit model:

(6) $P_k(l) = \exp(\mu V_{lk})/\Sigma_j \exp(\mu V_{jk})$ $j = 1,...,L$

where $P_k(l)$ is the probability of individual k choosing elemental alternative l.

The use of aggregated alternatives (i.e., NRI polygons) adds bias to the RUM which can be partially removed by including a measure of size in the indirect utility function. Denote the i-th aggregated alternative (polygon) as L_i where L_i is a mutually exclusive set of elemental alternatives. The random utility of the k-th individual choosing an elemental alternative contained in the set L_i [U_{ik}] is:

(7) $U_{ik} = Max(V_{lk} + \varepsilon_{lk}) \quad \forall\, l \in L_i$

It has been shown [see Parsons and Needelman (1992)] that (7) can be decomposed into:

(8) $U_{ik} = V^*_{ik} + (1/\mu)\ln(M_i) + (1/\mu)\ln(B_i) + \varepsilon_{ik}$,

where V^*_{ik} is the average utility of the i-th aggregate alternative, M_i is the number of elemental alternatives in the i-th aggregate alternative, and B_i is a measure of the variability of the utilities of the elemental alternatives in the i-th aggregate alternative:

(9) $B_i = \Sigma_l \exp[\mu(V_{lk} - V^*_{ik})]/M_i, \qquad \forall\, l \in L_i$.

Since B_i depends on V_{lk}, it cannot be recovered. Operationally, the aggregate model is estimated as:

(10) $P_k(i) = \exp\{V^*_{ik}+(1/\mu)\ln(M_i)\}/\Sigma_j \exp\{V^*_{jk}+(1/\mu)\ln(M_j)\}$,

Estimation results of this portion of the model appear in Table 2. Although the signs of the parameters in each model are identical, parameter magnitudes and levels of significance vary. In each model, trip cost is significant and negative indicating that respondents prefer closer locations to further ones. The parameters associated with percentage of forested area, which is assumed to be a positive attribute, are unexpectedly negative. This may indicate that heavily forested areas are less accessible to recreationalists. The parameters associated with the percentage of privately owned land, which is assumed to represent a lack of recreational opportunities, are negative as anticipated. Average erosion has an anticipated negative sign in both models suggesting that more water based recreation occurs in areas with low erosion rates. The final variable, Log(Size), is the correction factor for aggregation bias (M_i)[16].

The RUM addresses the decision of where to go, but ignores the decision of "how much to go". Changes in destination qualities cause visitation probabilities to change allowing for substitution amongst destinations. Changes in total participation and decisions of whether or not to participate at all cannot be accounted for using this first stage of the model. Several options exist for linking the RUM model to a continuous model that incorporates participation decisions (see for example Bockstael et al., 1987; Morey et al., 1993; Parsons and Kealy, 1995; Feather et al. 1995). Most advocate using information from the RUM, and socio-economic variables in a "participation equation". This study uses a method proposed by Feather et al. (1995). The approach consists of estimating total participation, (T_k), as a function of expected trip costs, $E(C_k)$, expected destination qualities, $E(\mathbf{b}_k)$, Income, Y_k, and socio economic variables, $\mathbf{S}$:

(11) $T_k = f_k(E(C_k),E(\mathbf{b}_k),Y_k,\mathbf{S})$.

Expected costs and qualities are calculated from the first stage RUM:

[16] The correction factor is acres of lake area (meters of river length) for the lake (river) model. These variables were collected from a geographic information system mapping coverage of lakes and rivers in the U.S. on a 1:200,000 scale.

(12) $E(C_k)=\Sigma_i P_k(i)C_{ik}$,

(13) $E(\mathbf{b}_k)=\Sigma_i P_k(i)b_i$,

where k indexes individuals and i indexes aggregate alternatives. Participation is assumed to be directly related to expected quality and inversely related to expected costs. Changes in destination quality will change destination probabilities in (10) which will change expected costs and qualities in (12) and (13). Treating (11) as a demand equation allows for conventional welfare measures resulting from quality changes to be computed. Changes in expected costs cause movements along the demand function while changes in expected qualities cause shifts in the demand function. The resulting change in welfare (ΔW) is the difference in consumer surplus between the final cost and quality state (C_{k1},$\mathbf{b}_{k1}$) and the initial cost and quality state (C_{k0},$\mathbf{b}_{k0}$):

(14) $$\Delta W = \int_{C_{k1}}^{\infty} f_{k1}(E(C_{k1}),E(\mathbf{b}_{k1}),Y_k,\mathbf{S})dC_k \;-\; \int_{C_{k0}}^{\infty} f_{k0}(E(C_{k0}),E(\mathbf{b}_{k0}),Y_k,\mathbf{S})dC_k.$$

To accommodate decisions of zero and nonzero participation, (11) is estimated using a double hurdle count model (see Yen, 1993; Blisard and Blaylock, 1993; Shonkwiler, 1994). Essentially, this model assumes that two "hurdles", or different sets of variables, determine consumption. The first (Z_k) depends on mainly demographic variables (age, gender, education, etc.) while the second (X_k) depends mainly on economic variables (price, quality, etc.). Let D_k denote the latent decision to participate where participation (T_k) equals zero if $D_k \leq 0$:

(15) $E(D_k) = \Gamma_k = \exp(Z_k'\tau)$.

When observed participation is positive ($T_k > 0$), then observed participation equals desired participation (T_k^*) where:

(16) $E(T_k^*) = \lambda_k = \exp(P_k\delta+X_k'\alpha)$,

where P is the price (travel cost), X is a vector of (expected) quality variables and δ, α

are parameters to be estimated. In the double hurdle poisson model, the probability of observing zero participation is:

(17) $\Pr(T_k = 0) = \Pr(T_k^* \leq 0) + \Pr(T_k^* > 0)\Pr(D_k \leq 0)$

$= \exp(-\lambda_k)+(1-\exp(-\lambda_k))\exp(-\Gamma_k).$

The probability of observing positive participation is:

(18) $\Pr(T_k > 0) = \Pr(T_k^* > 0)\Pr(T_k^*|T_k^* > 0)\Pr(D_k > 0)$

$= (1-\exp(\Gamma_k))\exp(-\lambda_k)\lambda^{Tk}/T_k!.$

Expected trip cost and quality, along with income, describe the intensity of participation (X_k) variables in the double hurdle model. The variables affecting the decision to participate (Z_k) are income, age, gender and education. The estimation results in Table 3 show that both sets of variables are generally significant and consistent in sign across the lake and river recreation models. Higher incomes and levels of education are positively associated with participation while age is negatively associated with participation. A gender dummy variable suggests that males tend to be participants more often than females. The second stage variables represent the decision of how much to participate and are anticipated to have the same sign as those in the RUM. This is generally true with the exception of % Forest and % Private Own in the river model and the expected size variable in both models. Income, which is assumed to effect both the intensity and the participation, is negative indicating that avid participants tend to have lower income levels.

In the double hurdle poisson model, expected consumer surplus for the k-th individual is ($E(CS_k)$):

(19) $E(CS_k) = -(1-\exp(\Gamma_k))*(\lambda_k/\delta).$

Welfare changes (ΔW) are the difference in expected consumer surplus from the final state, $E(CS_k'')$, to the initial state, $E(CS_k')$,:

(20) $\Delta W = E(CS_k'') - E(CS_k')$.

TRANSFER AND WELFARE RESULTS

Transferring the model to the nation requires a national data set of environmental quality and demographic information. National environmental quality information is provided by the NRI. National demographic information is provided by the U.S. Census. A "representative individual" was constructed in each of the 3,071 counties in the 48 conterminous states using the 1990 U.S. Census. By assumption, this individual resides in the geographic centroid of the county, has the average income, age, gender and education found in the county, and faces a recreational choice set of NRI polygons within 100 miles of the county centroid.

Three hypothetical changes in erosion are considered based on 1982 NRI erosion levels[17]. 1982 levels are used because they reflect erosion rates that prevailed before the effect of the Conservation Reserve Program (CRP), initiated i 1985, was observed. All three scenarios represent an increase in the current average erosion rate of 1.283 tons per acre:

<u>Scenario #1:</u> Change erosion rates to the 1982 level for all agricultural and non-agricultural land. This is the national erosion level in 1982 which was 1.681 tons per acre on average.

<u>Scenario #2:</u> Change erosion to the 1982 level for land that were either cropland in 1992, or cropland in 1982. Leave all other land at the 1992 level.

[17] 1982 NRI erosion rate is taken from the revised estimates found in the 1992 NRI.

This is the change in erosion that occurred on agricultural land over the past decade. The average erosion rate under this scenario is 1.654 tons per acre.

Scenario #3: Change erosion to 1982 level on all land that is currently enrolled in the CRP, leave all other areas at the 1992 level. This is the change in erosion attributable to the CRP. The average erosion rate under this scenario is 1.289 tons per acre.

Before transferring the benefit function to the nation as a whole, welfare measures were computed in the study area using the NSRE data and the Census data. Table 4 shows changes in welfare and total consumer surplus computed using three aggregation approaches. The first column contains the average welfare measures computed using the individual NSRE data. This is the approximate "true" measure in (1) before being multiplied by population. The third column contains averages using representative individual data from the U.S. Census. This is the measure in (2) that will be computed in the policy area before being multiplied by population. The large differences between column one and three suggest that significant bias may occur when the function is transferred. The bias comes both from nonlinearity in the benefit function and disparities between the NSRE data and the Census data. The second column in Table 4 helps to separate the effects. This column contains average welfare measures computed by creating representative county individuals from the NSRE data. Since the welfare measures in columns one and two are based on the same data, differences between these columns result from the nonlinearity of the benefit function. Differences between columns two and three result from disparities between the U.S. Census data and the NSRE data. The results in Table

4 suggest that nonlinearity in the benefit function causes a large portion of the bias that occurs in the transfer.

To account for the transfer bias, a "calibration function" is estimated using these welfare estimates. This involves regressing the ratio of county average individual consumer surplus (column one in Table 4) to county representative consumer surplus (column three in Table 4) on county Census information[18]. Estimation results appear in Table 5. Demographic variables appearing in the benefit function, as well as proxies of their variances are used to predict the ratio described above. Measures of age (AGE), proportion of elderly in the county (AGEGE65) and low income households in the county (INC20) explain most of the variation in the welfare ratio.

The welfare experiments consist of first calculating a hypothetical erosion rate for each NRI polygon. Next, expected costs and qualities are calculated under both the observed (1992) erosion rate and the hypothetical erosion rate using (12) and (13). These expected variables, along with the demographic county specific information, are used in (20) to compute a welfare measure for each representative individual. The individual's welfare measure is then aggregated to the county level by multiplying it by the county population and the predicted calibration ratio. The individual county measures are then summed to arrive at a national estimate of the change in welfare due to the hypothetical change in erosion.

Both calibrated and uncalibrated welfare estimates appear in Table 6. The uncalibrated measure is biased due to nonlinearity in the benefit function. Calibrated

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[18] Price and quality information is not included in the estimation because these data do not change when the benefit function is transferred.

benefit estimates are less than half of the uncalibrated estimates for lake recreation and two thirds of the uncalibrated estimates for river recreation. The following discussion relies on the calibrated welfare measures since they are an estimate of the "true" welfare in (1).

The welfare estimates show that lake users are impacted by each of the scenarios much more than river users. The likely reason for this is the more intensive use of lakes as opposed to rivers for water quality sensitive contact types of activities. The estimates also show that most of the benefits of erosion reduction occurring from 1982 to 1992 are attributable to better management of agricultural lands. Comparing scenario #1 to scenario #2 shows the portion of benefits attributed to changes in erosion on agricultural lands. Approximately 78% ($611.04 million) of the $787.94 million in annual benefits and 98% of the total erosion reductions over the previous 10 years can be attributed to erosion control on agricultural lands. The third scenario measuring the effect of the CRP shows that the water based recreational benefits associated with this program are relatively small. Less than 1%, or $5.1 million, of the benefits attributed to agricultural erosion control are a result of the CRP. This is because the reduction in erosion attributable to the CRP is small[19]. Approximately 60% of the 35.4 million acres of CRP land has high wind erosion rates, and negligible sheet and rill (soil) erosion (Osborn, et. al (1992)). Changes is erosion on this land does not contribute toward any recreational benefits because the analysis assumes that wind erosion has no impact on

[19] According to NRI data, the CRP is responsible for reducing average nation-wide erosion from 1.289 tons/acre to 1.283 tons/acre.

water quality.

Few studies exist to compare these results to. Clark et. al (1981) estimated cropland's annual contribution to erosion based damage to all water based recreational damages to be $1.24 billion (adjusted to 1994 dollars). This number reflects the benefits that would occur if the detrimental effects of erosion on water quality from agricultural lands were eliminated. A more recent study by Ribaudo (1989) places the annual benefits of the CRP to freshwater fishing at $69.7 million (adjusted to 1994 dollars). Ribaudo estimated a physical model relating sediment discharges, stream flow and water storage to pollutant concentrations in aggregated sub-areas of the U.S. He then predicted the CRP's effect on pollutant concentrations (via sediment discharges) and used this information in a trip day intensity prediction model. Changes in days of participation were multiplied by an independent per fishing day value ($25.00) to arrive at the welfare estimate. Although Ribaudo's work benefits from using a physical model relating erosion with pollutant levels, it has the drawback of using much more aggregated destinations than were used in this study and relying on transferring a point estimate instead of a benefit function to determine welfare measures.

SUMMARY AND CONCLUSIONS

Refining methods of benefit transfer techniques is essential due to its increasing use in policy analysis. Benefit transfer offers a reliable short cut to an expensive and time consuming original analysis only if it is carefully applied. Although benefit function transfer is recognized to be superior to simply transferring a point estimate, the approach is still susceptible to biases. One refinement considered in this paper is recognizing and dealing with the bias resulting from deriving benefits for representative individuals from benefit functions estimated using individual observations. Due to nonlinearities in the benefit function, the transferred function may provide a poor estimate of the welfare change at the policy site.

In this study, a model used to evaluate the recreational benefits of soil erosion reductions that occurred over the past decade on agricultural lands is estimated in four study areas and transferred nationwide. Comparing welfare measures computed using individual observations versus representative data in the study area indicated that large biases will result when the transfer is performed due to nonlinearities in the benefit function. To adjust for this, information from the study area in the form of a calibration function was transferred along with the benefit function. This allowed the national benefit estimates to be adjusted for the effect of using representative data to estimate national welfare measures.

The national benefit measures themselves indicate that erosion reductions on agricultural lands over the past decade have generated large recreational benefits. National reductions in erosion are estimated to be $787.94 million with $611.04 million being attributed to agricultural erosion reductions. The benefits attributed to the CRP are less than 1% ($5.1 million) of the agricultural benefits. This relatively small share of CRP benefits occurs because over half of the CRP is on lands with high levels of wind erosion, not sheet and rill (soil) erosion. The analysis assumes that wind erosion has no effect on water quality. The remaining CRP acreage is small compared to the total amount of agricultural land in the nation. Thus, changes in erosion on this land has a small impact on aggregate erosion levels.

This, as with most national studies, is not without faults. The analysis is based on four regional samples of water based recreation that are assumed to be representative of the nation as a whole. Erosion rates, instead of actual water quality variables, are assumed to influence behavior. Additionally, "sites" are defined as aggregate NRI polygons instead of individual lakes and streams. As discussed in the data section, there is some evidence that water quality measures are statistically influenced by erosion. Whether these measures influence recreational behavior is unknown. The bias associated with using aggregated sites is somewhat, but not completely, removed by including a size measure in the RUM specification. While the issue of the four regional samples being representative of the behavior of individuals nation-wide cannot be addressed, more data would increase the accuracy of the national estimates.

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Table 1 - Linear Regression of Water Quality Measures on 1992 Soil Erosion[a]

Dependent Variable[b]	Water-Body Type	Constant	ln(Erosion)	R^2	# Obs
Nitrates	Lake	2.205*	0.551*	0.05	107
Nitrates	River	1.901*	0.305*	0.11	334
Phosphates	Lake	0.843*	0.388*	0.06	112
Phosphates	River	0.566*	0.123*	0.09	306
Dissolved Oxygen	Lake	9.979*	1.000*	0.13	98
Dissolved Oxygen	River	10.042*	-1.123*	0.17	370

[a]Water quality data (Dependent Variable) from EPA STORET system is averaged over a unique location then over the NRI polygon by type of water body. Average water quality is then regressed on average weighted NRI polygon erosion (tons/acre) calculated using the USLE.
[b]Nitrates are total dissolved nitrates in mg/l; Phosphates are total phosphates in mg/l; Dissolved Oxygen is total dissolved oxygen in mg/l
* denotes significance at the 5% level

Table 2 -- Random Utility Models of Lake and River Recreation[a]

Parameters[d]	Lake Recreation Model[b]	River Recreation Model[c]
Trip Cost	-0.0834 (-108.1)	-0.0992 (-90.0)
% Forest	-1.4271 (-18.4)	-0.4545 (-5.0)
% Privately Owned	-1.0778 (-19.3)	-0.3101 (-4.5)
Erosion	-0.1511 (-18.1)	-0.1308 (-2.1)
Log(Size)	0.0141 (5.5)	0.1150 (16.4)

[a]Random utility models based on water oriented recreational activities at lakes and rivers. t-statistics for the null hypothesis that the parameter equals zero appear in parenthesis.
[b]Estimated using a sample of 706 individuals averaging 9.78 lake based trips per person. Most participants visited more than one location over the year; the number of unique respondent/location pairs is 1323.
[c]Estimated using a sample of 447 individuals averaging 10.81 river based trips per person. Most participants visited more than one location over the year; the number of unique respondent/location pairs is 772.
[d]Trip cost is the round trip travel cost (distance*$0.35) plus the round trip time cost ((personal income)*0.333*distance/50). % Forest is the percentage of the polygon in forest cover. % Privately Owned is the percentage of the polygon that is privately owned. Erosion is the 1992 NRI sheet and rill erosion rate in tons per acre estimated using the USLE. Log(Size) is the natural logarithm of acres of lake area (meters of river length) for the lake (river) model.

Table 3 -- Double Hurdle Poisson Models of Lake and River Based Recreation[a]

	Lake Recreation Model[b]	River Recreation Model[c]
Participation Parameters[d]		
Constant	-0.2183	-0.7567
	(-1.59)	(-4.36)
Family Income	0.0067	0.0035
	(3.59)	(1.49)
Age	-0.0178	-0.0186
	(-7.30)	(-6.05)
Gender	0.3679	0.6567
	(4.71)	(6.79)
College	0.2191	0.0827
	(2.51)	(0.76)
Intensity Parameters[e]		
Constant	3.6353	6.2761
	(37.28)	(37.09)
E(Cost)	-0.0214	-0.1044
	(-5.30)	(-20.65)
E(% Forest)	-0.3466	0.8621
	(-4.59)	(12.98)
E(% Private Own)	-0.3784	1.1479
	(-2.53)	(8.29)
E(Erosion)	-0.0462	-0.0309
	(-2.47)	(-2.99)
E(Size)	-0.0413	-0.1927
	(-4.21)	(-16.1)
Family Income	-0.0021	-0.0057
	(-3.70)	(-9.85)

[a] Double Hurdle Poisson models of lake and river based recreation participation and intensity.
[b] Estimated using a sample of 1510 survey respondents consisting of 706 participants and 804 nonparticipants.
[c] Estimated using a sample of 1510 survey respondents consisting of 447 participants and 1063 nonparticipants.
[d] Constant is a constant term. Family Income is the respondent's family income in dollars. Age is the respondent's age in years. Gender equals one if the respondent is male, zero otherwise. College equals one if the respondent has completed a college education.
[e] Constant is a constant term. E(Cost) is expected trip cost. E(% Forest) is expected percentage of land in forest cover. E(% Private Own) is expected percentage of land privately owned. E(Erosion) is expected erosion. E(Size) is expected lake area (river length) for lake (river) trips. Family Income is the respondent's family income in dollars.

Table 4 -- Comparison of Individual Welfare Levels in the Study Area

Lake Recreation

Scenario[d]	Individual[a]	Rep NSRE Individual[b]	Rep Census Individual[c]
1[e]	3.776	14.635	14.782
2[f]	3.463	13.795	13.913
3[g]	0.001	0.015	0.018
CS[h]	232.46	663.22	684.37

River Recreation

Scenario[d]	Individual[a]	Rep NSRE Individual[b]	Rep Census Individual[c]
1[e]	0.995	1.730	1.860
2[f]	0.866	1.546	1.660
3[g]	0.001	0.002	0.002
CS[h]	51.58	86.31	93.21

[a]Change in welfare in $1.00 units is computed for each NSRE respondent then averaged over respondents. Results of averaging individuals within a county and then over counties made little difference.
[b]Change in welfare is computed by creating a representative county resident from the NSRE data. This individual is assumed to reside in the county centroid. The resulting per county estimates were then averaged over all counties in the survey.
[c]Change in welfare computed using representative individual data from the U.S. Census. The counties included are the same as those in the NSRE sample.
[d]Change in welfare is initial consumer surplus (evaluated at 1992 erosion rate) minus final (scenario level) erosion rate. Scenario #1 changes erosion to 1982 level for all NRI points. Scenario #2 is change erosion to 1982 level for all NRI points except those that were not
cropland in 1982 and 1992 (these are left at the 1992 level).
[g]Change erosion to 1982 level on all NRI points that are currently enrolled in the CRP, leave all other NRI points at the 1992 level.
[h]CS is total consumer surplus observed at the initial (1992) erosion rate.

Table 5 -- Calibration Function Estimates[a]

Variable[b]	River Recreation[c]	Lake Recreation[d]
CONSTANT	1.2144	0.4970
	(1.376)	(1.633)
PERMALE	0.9956	0.3104
	(0.625)	(0.565)
AGE	-0.0361	-0.0081
	(-2.849)	(-1.863)
HIGHSC	0.3041	0.0588
	(1.084)	(0.607)
INC20	-2.1149	-0.5982
	(-2.766)	(-2.268)
INCOME	-0.0050	-0.0007
	(-0.592)	(-0.235)
AGEGE65	3.2893	0.5452
	(2.935)	(1.410)
R^2	0.229	0.232
R^2-Adjusted	0.189	0.193

[a]Least squares regression of observed county calibration factors on county data from the U.S. Census. Calibration factor is the average consumer surplus in each county from individual NSRE data divided by the consumer surplus of the representative individual from the U.S. census. Sample size is 126.
[b]Constant is the constant term; PERMALE is the proportion of the county that is male; AGE is the average age of persons in the county in years; HIGHSC is the proportion of persons in the county who have graduated from high school; INC1020 in the proportion of households in the county who have incomes less than $20,000 per year; INCOME is the median annual household income in the county in $1000.00 dollar units; AGEGE65 is the proportion of persons in the county who are 65 years old or older. R^2 (R_2-Adjusted) is the (adjusted) coefficient of determination. t-statistics for the null hypothesis that the parameter equals zero are in parenthesis. Sample size is 126.
[c]For the river recreation model.
[d]For the lake recreation model.

Table 6 -- National Welfare Calculations[a]

	Uncalibrated[b]	Calibrated[c]
Scenario #1[d]		
Lake Recreation	1777.73	648.75
River Recreation	226.42	139.19
Scenario #2[e]		
Lake Recreation	1387.08	501.73
River Recreation	178.91	109.31
Scenario #3[f]		
Lake Recreation	13.60	4.70
River Recreation	0.64	0.40

[a]Sum of change in expected consumer surplus (initial minus final) in million dollar units times county population for three scenarios of erosion changes. Initial quality state is 1992 USLE erosion rate in tons/acre.
[b]Difference ($ million) in expected consumer surplus for representative county individual times county population.
[c]Difference ($ million) in calibrated expected consumer surplus for representative county individual times county population.
[d]Change erosion to 1982 level for all NRI points.
[e]Change erosion to 1982 level for all NRI points except those that were not cropland in 1982 and 1992 (these are left at the 1992 level).
[f]Change erosion to 1982 level on all NRI points that are currently enrolled in the CRP, leave all other NRI points at the 1992 level.