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Evaluating the accuracy of the benefit transfer method: A rural water supply application in the USA

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Due to declining federal, state, and local government budgets, there is an increasing need to analyze the benefits of government funded programs to determine where increasingly limited funds would best be spent. The benefit transfer technique is analyzed for the development of a rural water supply system and guidelines for successful benefits transfer are presented. Benefit transfer appears to provide reasonably accurate estimates of natural resource benefits if a broad based benefit model is used. The benefits-transfer-based estimates are accurate as long as a model based on data from a wide variety of conditions is used or the model is based on data from a very similar region. The wide-based data modeling approach has the greatest practical application. These findings are based upon contingent valuation data obtained from four sites in the western USA.

Keywords: benefits transfer, willingness to pay, Tobit models, pooled data analysis.

Introduction

The need for benefit analyses is increasing in the United States and other countries due to regulatory requirements and the desire to maximize the benefits from limited public expenditures. However, the funds available for completing these analyses have been decreasing. As a result, there is a need for benefit estimation methods that are relatively quick and inexpensive to complete compared to detailed site-specific studies, but rigorous enough to make informed resource management decisions. One estimation method that may meet these criteria is benefits transfer.

Benefits transfer involves the application of existing benefit estimates or models to a policy site where resource value estimates are needed. Benefits transfer has been used by government agencies for many years. Despite improvements in benefits transfer procedures, use of this method is still viewed by some as a poor substitute for detailed site specific analyses due to the unknown variability and potential bias associated with the estimates. However, relatively few studies have evaluated the accuracy of benefits transfer and most of those studies have focused on recreation benefits.

The primary purpose of this paper is to evaluate the potential for using pooled primary data from existing studies to estimate a general benefit model, which can then be used in a benefits transfer context. The use of a pooled model may be the most promising application of benefits transfer (Desvousges *et al*., 1998). The model estimated in this analysis is the willingness to pay

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for rural-domestic water system improvements. Contingent valuation data obtained from four sites in the western United States are the basis of the willingness to pay model. The appropriateness of applying a general willingness to pay model to a specific site is tested by estimating a model using pooled data from three sites, applying the model to a fourth site, and comparing the model estimate to actual survey results at the fourth site.

The results of this analysis indicate the use of a pooled model in a benefits transfer framework can produce reasonably accurate estimates of rural water supply improvement benefits. The results from this analysis are combined with findings from previous studies to propose general guidelines for applying the benefits transfer technique.

Literature review

Benefits transfer is not a new approach to estimating resource values. The unit day value method of estimating recreational use values is a benefits transfer procedure that has been used to analyze the potential benefit of recreational facility development since the 1960s. Application of the benefits transfer method assumes that a general natural resource valuation relationship exists that can be estimated and applied to other geographical areas. If a model can be estimated that includes the important factors that influence natural resource values, then benefits transfer can in theory produce reliable results through the application of the general model to the policy site.

Previous benefits transfer studies have established sound reasons for the use of the methodology, such as the expense associated with collecting primary data and a lack of time and funds available to complete a benefit analysis (Boyle and Bergstrom, 1992; Brookshire and Neill, 1992). In addition, if precise benefit estimates are not needed in order to make a policy decision, then an expensive data gathering effort may not be justified and benefits transfer may be an acceptable method for estimating resource values.

The use of benefit function transfers has improved the methodology (Loomis, 1992; Loomis *et al.*, 1993; Parsons and Kealy, 1994; Carlson and Palmer, 1997). Benefit function transfer allows a better accounting for variability between the site from which the model is derived (study site) and the site where the model is applied (policy site) (Berrens, 1993). Applying demand curves to a policy site is likely to be less biased than applying mean value estimates to a policy site because the magnitude of benefits depend on a complex set of characteristics which are better represented by a demand equation than a point estimate. A recent study by Rosenberger and Loomis (2000) indicated that the use of a national meta-analysis model of outdoor recreation fits the data fairly well and that a national meta-analysis model would be a good tool for evaluating broad policies influencing a large number of sites.

Despite recent improvements in the benefits transfer methodology, the accuracy of the method remains in doubt. A recent article by Bergstrom and DeCivita (1999) summarized the results of several benefits transfer studies and, based on those studies, evaluated the reliability of the method. The results of their review indicated that using benefits transfer to estimate resource values at a policy site based on a previous analysis at another study site has the potential for a large error. One study included in the review was a study by Kirchhoff *et al*. (1997), which evaluated the performance of benefits transfer using bird watching data from two sites in southern Arizona and white water rafting data from two sites in northern New Mexico. The results of the bird watching and rafting analysis indicated that the use of benefit function transfer can potentially produce better estimates than simply transferring a mean benefit estimate, but the overall performance of benefit transfer was not very good. Even small differences in the resource can have a large impact on the type of use and, therefore, the value of the resource. Another study using data from the US Fish and Wildlife Services' 1996 National Survey of Fishing, Hunting, and Wildlife Associated Recreation indicated an inter-regional benefits transfer for hunting trips was not reliable (Intarapapong *et al*., 2000).

Despite concerns about benefits transfer from one specific site to another, Bergstrom and DeCivita also indicated benefits transfer based on value estimator models may be a promising technique. The analysis presented in this paper is essentially a value estimator model because the transferred model is based on a variety of data sources representing a variety of conditions. In addition, reliable and good quality water supplies may be easier to value than other natural resources. Therefore, this analysis may be a better test of the benefit transfer method itself rather than a test of the importance of resource similarity in completing benefit transfers.

The use of benefits transfer for rural water system improvements

This section presents a comparison of rural water supply benefits estimated through the use of a general rural water supply willingness to pay models and the willingness to pay estimated from a site-specific survey. Through this comparison the accuracy of the benefits transfer method is evaluated.

Sources of data

This analysis is based on contingent valuation data from four regions of the western United States. These regions are: the Lewis and Clark Rural Water System in southeast South Dakota and portions of western Iowa and Minnesota, the Fort Peck County Rural Water District in north central Montana, the northwest region of Oklahoma, and the New Mexico portion of the Navajo Indian Reservation (Piper and Martin, 1997). Groundwater is the current primary source of domestic water in each of these areas except Fort Peck, where water for domestic use is hauled from a nearby treatment plant. Each of the four areas is considering the development of surface water supplies for meeting future water demand.

The population of the Lewis and Clark area has been growing rapidly, causing concern that current groundwater supplies will not be able to meet future demand. Sioux Falls has implemented watering restrictions during summer months in the past and some rural areas have experienced water quality and reliability problems. The Lewis and Clark area was divided into 'urban' and 'rural' areas. The northwest Oklahoma region is not experiencing rapid population growth, but the primary source of water (the Ogallala Aquifer) has been drawn down significantly over the last several years. As a result, supplemental water supplies may be needed in the future for the northwest Oklahoma region. Residents of the Fort Peck Rural County Water District must haul water for domestic use from a water treatment plant in nearby Fort Peck. Groundwater in the District is not suitable for domestic use. Groundwater quality is a concern in many areas of the Navajo Reservation. In addition, many households on the Reservation must haul water for domestic use.

The willingness to pay for domestic water supply improvements was obtained from the four study areas using contingent valuation surveys. The actual wording used in each survey is presented in the appendix. The estimated willingness to pay for each area is presented in Table 1. The range is based on the survey averages and a variety of estimated models. A detailed discussion of the survey methodologies used and empirical results obtained from the surveys are presented in Piper and Martin (1997).

Method of analysis

Four models are used to evaluate the benefits transfer procedure. Two of the models are pooled general models. The first model includes data from all of the sites except Fort Peck and the second model includes data from all of the sites except northwest Oklahoma. These two models are used in a benefits transfer framework to estimate willingness to pay for water supply improvements in Fort Peck and northwest Oklahoma, respectively. The benefits transfer based estimates are compared with the actual survey results to evaluate the performance of benefits transfer using a pooled general model.

The third model is the rural Lewis and Clark model from Piper and Martin (1997) and the fourth model is the Fort Peck model, also from Piper and Martin (1997). These models are included to evaluate the performance of benefits transfer based on data from a single site and compare those results with the pooled models. Both the rural Lewis and Clark and Fort Peck models are applied to the northwest Oklahoma study area. The transferred model estimates are then compared to the actual survey results.

The Oklahoma study area is similar to the rural Lewis and Clark area but is very different from the Fort Peck area. Therefore, the benefit estimate from the transferred Lewis and Clark model is expected to be closer to the actual survey results than transferring the Fort Peck model. However, if a general pooled model is a more desirable method of benefits transfer, then the estimates generated by the two general models should be more accurate than the site-specific models.

Table 1. Willingness to pay results

Region	Range of willingness to pay (US$, per household per month)
Fort Peck	6·63–8·93
Urban Lewis and Clark	4·92–11·96
Rural Lewis and Clark	4·43–9·97
Navajo	11·63–17·29
Oklahoma	3·89–11·37

Application of these four models provide information to evaluate the use of pooled models under different policy site conditions, the use of single site models where the study and policy sites have similar characteristics, and the use of single site models where the study and policy sites are not similar. The reason for including the fourth model is to make sure that the benefits transfer procedure for rural water supplies is not simply estimating the same magnitude of value regardless of the site characteristics.

The survey questions asked at each of the study sites included several different types of close-ended willingness to pay questions as well as a follow-up open-ended payment question. Due to the difference in the type of close-ended question asked in each survey and the difficulty in trying to determine if the close-ended data area compatible, the open-ended data were used to estimate the willingness to pay model.

The model

The general willingness to pay model used in this analysis is based on a water supply improvement and, therefore, is a measure of the benefit from the new supply. The same explanatory variables are used for all of the models estimated in this analysis. The variables included in the general model are limited to those that are consistent across all of the data sets. However, the variables included in the model are the factors that are most likely to affect willingness to pay. The general willingness to pay model is hypothesized to be:

$$WTP=f(HHSize, Cost, Age, Income, Haul, Ceremony),$$

where:

HHsize=number of people in the household,

Cost=the monthly cost of water to the household,

Age=the age of the respondent,

Income=gross household income,

Haul=the household hauls water for domestic supplies (1 = yes and 0 = no),

Ceremony=the household participates in ceremonies that require water (1 = yes and 0 = no).

It is expected that household size, income, the need to haul water, and ceremonial water use would all have a positive influence on willingness to pay. Household size is included as a proxy variable for use, where HHsize indicates a greater dependency on water supplies and a greater willingness to pay to keep that use. Higher income allows a person the opportunity to pay more for water if necessary, resulting in a higher willingness to pay. Hauling water is an inconvenience, therefore, it would be expected that households which haul water would be willing to pay more for a good quality water connection to their home than a household which does not currently haul water. Ceremonial water use in the context of this analysis represents water used in Native American ceremonies. Ceremonial water use represents a water need for which there are no substitutes. Therefore, a household that hosts ceremonies would be expected to have a higher willingness to pay for reliable water supplies.

Current water cost is likely to have a negative impact on willingness to pay because higher water costs reduce the income available to spend on water and the new system is not likely to result in reduced water rates. However, water cost can also be an indication of use, which would have a positive effect on willingness to pay. Water cost in the Navajo area is also a measure of inconvenience because a large percentage of water costs are associated with hauling water. Therefore, the expected sign for the water cost variable is uncertain.

Previous willingness to pay studies have shown a negative relationship between age and willingness to pay. However, older residents may have a better understanding of water quality changes that have occurred over several years and may recognize problems that would not be apparent to younger residents. Therefore, the expected sign for the age variable is also uncertain.

Regression results

The models were initially estimated using ordinary least squares. The results were tested for heteroskedasticity using the Park/Glejser test, where the absolute value of the residuals were regressed on the water cost variable and the income variable in separate regressions (Park, 1966; Glejser, 1969). The square root of the residuals was also used. This test indicated that the unexplained portion of the variance in willingness to pay increased as the cost of water increased. This is likely due to the increasing importance of water cost to the household budget as the cost of water increases or the increasing importance of water supplies to household members as the cost of water increases.

To improve the efficiency of the model, weighted least squares regressions were used to estimate the models. The square root of the cost of water was used as a weight for the dependent variable and all of the independent variables for each observation. The weighted least squares regression results excluding data for Fort Peck and northwest Oklahoma are presented in Table 2.

All of the estimated coefficients that were statistically different from zero at the 10 percent level of confidence or better (as indicated by the *t* statistics) were of the expected sign. The only variable that was not consistently different from zero was age, which has an uncertain effect on willingness to pay. The coefficient of determination (R^2) adjusted for degrees of freedom ranged from 0·126 to 0·144 and the *F*-statistics indicate all of the overall equations are significant at the 5% level or better.

The weighted least squares models are relatively easy to estimate and apply in a benefits transfer context. However, the open-ended data are censored at a willingness to pay of $0 and least squares estimation can result in biased and inconsistent estimates (Maddala, 1983). Maximum likelihood based Tobit models provide unbiased and consistent estimates because the censored nature of the data is taken into account (Maddala, 1983). Therefore, willingness to pay equations were re-estimated using Tobit models. The Tobit models were tested for heteroskedasticity using a moment based Lagrange Multiplier test, where the hypothesis that the variance of the estimates do not change according to income or the cost of water is tested. The Chi-square based test indicated the cost of water variable was causing heteroskedasticity problems. Therefore, weighted tobit models were estimated. The Tobit results excluding Fort Peck and northwest Oklahoma, respectively, are presented in Table 3.

The signs for the significant variables in the tobit regressions are the same as for the least squares regressions. Generally, the results of the tobit regressions appeared to be similar to the least squares regressions. The major difference between the least squares and tobit results is the significance of the cost of water and age variables. Given the potential for biased and inconsistent estimates, the tobit based estimates are likely to be the most accurate. However, the Tobit model results are more difficult to apply in a benefits transfer framework. In some cases the ease of using the least squares models along with the similarity of the results may justify using the ordinary least squares estimates.

Table 2. Pooled data sets weighted least squares results

Variable	Estimated coefficient	*t*-statistic	Expected sign
Data excluding Fort Peck			
Household size	0·47392	1·89**	Yes
Water cost	0·024725	2·35*	–
Age	0·0056662	0·19	–
Income	0·000044824	2·35*	Yes
Haul water	8·6253	5·85*	Yes
Ceremonial use	4·7984	3·41*	Yes
Constant	1·3945	–	–
Adj. R^2=0·144			
F=83·82*			
Model observations=932			
Data excluding Oklahoma			
Household size	0·52550	1·77**	Yes
Water cost	0·049110	3·53*	–
Age	0·022039	0·60	–
Income	0·000016744	0·67	Yes
Haul water	5·2961	3·85*	Yes
Ceremonial use	5·5126	3·55*	Yes
Constant	0·23787	–	–
Adj. R^2=0·126			
F=62·14*			
Model observations=697			

*Significant at the 5% level.
**Significant at the 10% level.

Table 3. Pooled data sets Tobit results

Variable	Regression coefficient	Asymptotic t-ratio	Expected sign
Weighted Tobit, excl. Ft Peck			
Household size	0·70589	1·83**	Yes
Water cost	0·012089	0·73	–
Age	−0·081070	−1·75**	–
Income	0·00011335	3·83*	Yes
Haul water	14·050	6·21*	Yes
Ceremonial use	4·7747	2·23*	Yes
Constant	−3·4273	–	–
Log-likelihood			
Ratio=180·3*			
Model observations=932			
Weighted Tobit, excl. Oklahoma			
Household size	0·83293	1·82**	Yes
Water cost	0·051166	2·40*	-
Age	−0·042611	−0·73	–
Income	0·000064124	1·64**	Yes
Haul water	8·8717	4·14*	Yes
Ceremonial use	6·2793	2·63*	Yes
Constant	−6·8598	–	–
Log-likelihood			
Ratio=63·6*			
Model observations=697			

*Significant at the 5% level.
**Significant at the 10% level.

The benefits transfer application

Benefits transfer using the least squares models is accomplished by simply substituting the mean values from the specific sites to the transfer models and calculating willingness to pay. Using the Tobit models to estimate benefits for another site is not as straight forward as for the least squares estimates. The estimated coefficients from the Tobit models cannot be applied to an outside site using the mean values for the explanatory variables because the Tobit model estimates are based on probabilities of a dependent variable exceeding a threshold. Using the Tobit coefficients along with the estimates for the density function and predicted probability, the expected value of willingness to pay can be estimated (Maddala, 1983). The equation that can be applied to the estimated Tobit model is shown in the equation below.

$$E(y)=[\{(\beta_1^* X_1)+(\beta_2^* X_2)+\ldots+(\beta_n^* X_n)\}^*(Prob\ y>limit)] + [(\text{Estimated density function})^* (\text{standard error of the estimate})]$$

The values X_1, X_2, to X_n represent the mean values of the equation variables obtained for the policy site. The β coefficients are the estimated regression coefficients from the Tobit model. Prob $y>$limit is the predicted probability that the willingness to pay is greater than zero, given the mean values from which the equation is estimated. The estimated density function and standard error of the estimate were obtained from the Tobit model output. Applying the Tobit regressions to outside policy sites assumes that the structure of the probabilities and standard errors are the same for both sites.

The estimates of willingness to pay based on benefit transfer of the pooled models are presented in Table 4. The average estimates from actual

Table 4. Benefits transfer estimates of willingness to pay for Fort Peck and Oklahoma

Model used for estimation	Estimate (US$)	Percent from actual
Pooled model, excluding Fort Peck		
Estimates for Fort Peck		
Weighted least squares	11·01	+23·3%
Weighted Tobit	10·64	+16·3%
Actual estimate from survey	8·93	–
Pooled model, excluding Oklahoma		
Estimates for Oklahoma		
Weighted least squares	4·38	−8·9%
Weighted Tobit	4·68	−2·7%
Actual estimate from survey	4·81	–

survey data obtained from Fort Peck Rural County Water Districts and northwest Oklahoma residents are also presented in Table 6 for comparison. The benefit transfer applications indicate that the pooled models provide reasonable estimates of water supply improvement benefits for the two transfer sites. The actual survey based estimates are within the 95% confidence intervals for all of the models. However, the pooled model applied to Fort Peck consistently over-estimates benefits by about 16–23%, while the pooled model under-estimates northwest Oklahoma benefits by approximately 3–9%.

Willingness to pay is also estimated using the rural South Dakota and Fort Peck models using the same procedures as for the pooled models. Using these two models to estimate benefits helps determine the sensitivity of benefits transfer to site similarity. The results are presented in Table 5.

The rural Lewis and Clark model based estimates under-estimated 'true' benefits by about 6% and over-estimated by 19·5%. These results are similar to the pooled model results presented in Table 4. The Fort Peck model did not perform well in estimating willingness to pay for the northwest Oklahoma area. The Fort Peck based estimates resulted in consistently high estimates of northwest Oklahoma willingness to pay, with some estimates more than double the survey average.

Table 5. Benefit transfer estimates for northwest Oklahoma

Model used for estimation	Estimate (US$)	Percent from actual
Oklahoma estimate based on Rural Lewis and Clark model		
Weighted least squares	5·75	+19·5%
Weighted Tobit	4·54	−5·6%
Actual estimate from survey	4·81	–
Oklahoma estimate based on Fort Peck model		
Weighted least squares	11·98	+149·1%
Weighted Tobit	9·07	+88·6%
Actual estimate from survey	4·81	–

The benefit transfer results indicate fairly consistent estimates for the pooled models and the rural Lewis and Clark model. The pooled models are based on data with enough explanatory variables and sufficient variation to be capable of estimating benefits within 25% of the actual survey values. The poor performance of the Fort Peck model in estimating northwest Oklahoma benefits indicates model selection criteria must be applied to produce reasonably accurate benefits transfer based estimates.

The results of the pooled model applications for Fort Peck and northwest Oklahoma provide support for using general willingness to pay models

Table 6. Pooled data set results

Variable	Estimated coefficient	*t*-statistic	Expected sign
Pooled model - Weighted least squares			
Household size	0·56523	2·37*	Yes
Water cost	0·026282	2·61*	–
Age	0·010315	0·37	–
Income	0·00003659	2·01*	Yes
Haul water	6·2537	5·47*	Yes
Ceremonial use	6·1305	4·65*	Yes
Constant	1·0050	–	–
Adj. R^2=0·131			
F=88·73*			
Model observations=1006			
Weighted Tobit model			
Household size	0·87744	2·37*	Yes
Water cost	0·014813	0·93	–
Age	−0·067553	−1·52	–
Income	0·000098311	3·44*	Yes
Haul water	9·9740	5·60*	Yes
Ceremonial use	7·1349	3·51*	Yes
Constant	−4·3845	–	–
Log-likelihood Ratio=141·6*			
Model observations=1006			

*Significant at the 5% level.
**Significant at the 10% level.

to estimate rural water supply benefits. Therefore, a model based on data from all four study areas that could be used by others to estimate water supply improvement benefits in other rural areas of the western US is presented in Table 6.

Factors affecting the accuracy of the benefits transfer method

Previous studies have indicated that there is a need for specifying the conditions under which benefits transfer is an acceptable procedure and to establish guidelines that can be followed when applying benefits transfer (Boyle and Bergstrom, 1992; McConnell, 1992; Smith, 1992). Studies by Boyle and Bergstrom, 1992; Desvousges *et al*., 1992; Loomis *et al*., 1993; Kask and Shogren, 1994; National Oceanographic and Atmospheric Administration (NOAA), 1994 have included the following criteria for applying benefits transfer.

(1) The need for identical or very similar resources in the study and policy sites
(2) Identical or very similar demographic and socio-economic characteristics
(3) Similarity of property right assignment and market conditions at the study and policy sites
(4) The use of explanatory variables for which data are readily available
(5) Accounting for changes in general attitudes from the time of the original study to the time when the benefit transfer is completed

The optimistic assessment of using a national meta-analysis model for benefits transfer (Rosenberger and Loomis, 2000), the promise of using value estimator models for benefits transfer (Bergstrom and DeCivita, 1999), and the positive results of using a pooled model in this analysis also provide important information for guidance in applying the benefits transfer method. These more recent studies generally indicate that the more general pooled models and meta-analysis types of applications are more likely to produce reliable benefit estimates. Table 7 provides a list of general characteristics for ideal, good, and poor benefits transfer based on the review of previous studies and the results of this analysis. Ideal benefits transfer

Table 7. Benefits transfer characteristics

Ideal benefit transfer scenario characteristics
(1) Identical resource at original site and transfer site or a pooled model based on extensive data.
(2) Identical population characteristics at both sites.
(3) Market area is the same (within area transfers).
(4) Change in resource is the same at both sites or the variable of change is included in the general model.
(5) Detailed and accurate data are available at both sites to allow valid comparisons between regions.
(6) Same number/type of substitutes at both sites or substitute variable is included in the general model.
(7) The time period under consideration must be the same or within two to three years.
(8) Transferred model is sophisticated and includes all relevant variables and tests of significance.
Good benefit transfer scenario characteristics
(1) Resource is in the same broad category at both sites or a general pooled model is available.
(2) Population characteristics are similar at both sites or variables are included in the transferred model so differences can be accounted for.
(3) Market areas similar in size and characteristics (outside of area transfers) or benefit model is based on a variety of market areas.
(4) Change in quality or quantity is in the same direction and over the same thresholds at both sites, or model variables are available in a general model to account for differences.
(5) A consistent and well documented source of data for use in the transferred model is available.
(6) Substitutes are available at both sites or not available at both sites (yes/no).
(7) The original study and time of the transfer must be similar enough that attitudes and institutional relationships have not changed. Price indices can be used to update estimates.
(8) Model to be transferred includes most important variables and tests of significance.
Poor benefit transfer scenario characteristics
(1) Resources are not similar and no pooled model is available.
(2) Populations are not similar and model variables are not available to account for differences.
(3) Market areas are not similar and cannot be accounted for in a transferred model.
(4) The change in quality or quantity is not the same or is unknown or the variables are not included in the general model.
(5) Data are not available or are only available from unreliable source.
(6) Substitutes are not consistent.
(7) Time period from time of original study to time of benefit transfer is long and consumer preferences and institutional relationships have probably changed.
(8) Model to be transferred is not well documented.

cases are not likely to occur very often because the conditions at both sites must be identical and the policy analysis must be desired at the same time as the original study. Benefits transfer under these conditions would be very straightforward and would require simple economic analysis.

The most important categories of benefits transfers fit in the good and poor categories. These are the most likely conditions that an analyst will encounter when attempting to value a resource or environmental change through benefits transfer. Although the characteristics of good and poor benefits transfers may be intuitive, defining the threshold at which a characteristic changes from good to poor is difficult. Professional judgment will always be required when applying the benefits transfer procedure (McConnell, 1992).

Conclusions

The over-riding consideration in the application of a benefits transfer model is the applicability of the transferred model to the policy site and including all explanatory variables that are theoretically important. If a site-specific model is going to be used for benefits transfer to estimate water supply benefits, then the water supply and socio-economic variables must be the same or very similar at the original study site and the policy site to generate reasonable benefit estimates for the policy site. Relatively simple site specific models that include only a limited number of variables are of limited value in estimating water supply benefits because values for variables not included in the model must be assumed to be the same at the study site and the policy site. These results agree with the results from previous studies.

The use of pooled models using data from a variety of sources allows for more flexibility in the application of the benefits transfer method. The results of this analysis indicate that relatively good estimates of the benefits from rural water system improvements can be obtained using a pooled model. The pooled benefits transfer model used in this analysis included six explanatory variables: household size, age, income, the cost of water, if water is hauled, and the use of water for ceremonial purposes. The pooled data set has the advantage of including data from a variety of water quality and supply areas that widens the applicability of the model.

The variables included in the pooled model allow for variation in the characteristics of the policy site where the model is being applied. Household size can be a proxy for use and can also be a measure of water supply importance, where larger households represent greater dependence on supplies. Age may be a reflection of attitudes, where experience with problems and situations affects how people perceive and react to problems. Income reflects the resources available to spend on all goods and services purchased by the household. The cost of water indicates the current amount that must be spent for water at the current level of quality and reliability. The haul variable is an indication of the inconvenience associated with current water supplies that can be applied to many households. The ceremony variable reflects a use that is a necessity and has no substitutes.

The above variables included in the pooled model do not cover every social, economic, and water resource characteristic that influences the willingness to pay for water supply improvements. However, the factors included do cover a wide range of conditions. The primary shortcoming is the absence of a water quality variable. Water quality was included as a variable in the four data sets. However, the water quality response is based on perceptions, which may or may not correlate with actual water quality measurements. In addition, water quality was not a consistently significant explanatory variable in the willingness to pay models. Therefore, one constraint with the pooled model is that it cannot be reliably applied to areas with extreme water quality problems, such as an area where a Giardia outbreak has occurred or other severe public health problems exist such as contamination of domestic water sources from industrial pollution. The pooled model is most appropriate for areas with relatively moderate supply and quality problems.

The variable value that should be plugged into the model for benefits transfer to a policy site should be a representation of the central tendency of that variable at the site. This value could be a mean, median, or some other estimate. Combinations of these values could also be used as a sensitivity analysis. The guide should be to use the number that best represents the population under consideration. For example, if there is a bimodal distribution of income in a region (a large number of wealthy and poor households but very few middle income families), then the best method may be to make two separate estimates based on the two sub-populations and summing the two groups.

The benefit transfer technique was analyzed and guidelines for successful benefits transfer are presented. Benefit transfer appears to provide reasonably accurate estimates of natural resource benefits if a broad based benefit model is used. The benefits-transfer-based estimates are accurate as long as a model based on data from a wide variety of conditions is used or the model is based on data from a very similar region. The wide-based data modeling approach has the greatest practical application.

The range of conditions included in the four study areas is limited to differences in socio-economic variables, hauling, part-time residence, and ceremonial water use. Differences in other variables such as overall health, concern about the environment, objective measurements of water quality, and the availability of substitute water supplies would help improve the estimation of an overall willingness to pay model. In addition, additional data that can be used for logit modeling could improve the performance of benefit transfers. Further studies are needed to increase the willingness to pay database over a wider variety of conditions.

Decisions are frequently made without a sufficient understanding of the benefits from implementing a particular policy. Given the budget constraints existing in evaluating benefits and the increased need for benefit analyses, benefits transfer techniques have the opportunity to provide decision makers with additional information on the benefits associated with a particular policy. The information provided through an effective benefits transfer methodology represents a cost effective means to support informed decision-making.

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Appendix

Willingness to pay questions asked in each study area

Lewis and Clark

Groundwater aquifers represent the primary source of domestic water in eastern South Dakota and western Minnesota and Iowa. The quality of these aquifers varies and some may be overdrawn to meet the demands of a growing population. Concerns have arisen as to the ability of these aquifers to provide a safe and reliable source of water in the future.

Construction of a Missouri River regional water supply system would help meet future water needs for the region. Such a system would include a raw water diversion, treatment system, and a delivery system to existing utilities. A large number of users would share the system, lowering the average cost per user of system construction. This system would meet current and future water quantity demands and improve drinking water quality for several communities and rural water systems in the area. The system would also provide an alternate source of water in the event of contamination of shallow aquifers that currently serve as a primary water supply to many water utilities in the area.

The Lewis and Clark Rural Water System membership is interested in the value water users would place on such a water system as measured by willingness to pay. Assume that if there is an overall unwillingness of water users to pay for the system, a project would not be built. Without the system, water supplies would continue to be provided primarily by groundwater sources, possibly resulting in a future decline of available water supplies and water quality.

Given the above scenario, would you be willing to pay an additional US$ X for this system on a monthly basis through increases in your water bill? Your individual responses will not be reported, nor do they create a monetary obligation on your part. Your responses will be used only to develop an overall indicator of willingness to pay. (Circle your answer)

1 YES

2 NO

Taking this one step further, what is the maximum additional amount you would be willing to pay for this system on a monthly basis.

$__________ Additional dollars each month

Northwest Oklahoma

Most of the water used for domestic purposes in northwest Oklahoma comes from underground sources (aquifers). The quality of these aquifers varies, with water treatment necessary in certain areas. In addition, these aquifers are being overdrawn in some areas due to heavy use. Concerns have therefore arisen as to whether these aquifers can meet northwest Oklahoma's future water supply needs.

Water planners believe domestic water supplies must be provided by dependable sources. They suggest consideration of a water supply system for the counties of Beaver, Cimarron, Dewey, Ellis, Harper, Texas, Woods, and Woodward. Such a system could involve underground and surface water sources with the following options being reviewed: well systems, water transfer from other regions, increased surface water storage, pipelines for local water transfer, and improved water treatment.

The Oklahoma Water Resources Board is interested in determining the value regional water users would place on this water system as measured by willingness to pay. Assume that an overall unwillingness to pay will result in the system not being constructed. Without the system, water will continue to be provided primarily by underground sources, possibly creating further declines in both quality and quantity in certain areas.

Given this scenario, would you be willing to pay an additional US$ X for this system on a monthly basis through increases in your water bill? Your individual responses will not be reported, nor do infer a monetary obligation on your part. Your responses will only be used to develop an overall indicator of willingness to pay.

1 YES

2 NO

To better define your willingness to pay, what is the maximum amount you would be willing to pay for this system on a monthly basis?_______/month. This amount is a total willingness to pay, not an amount added to your existing cost.

$__________ Additional Dollars Each Month

Fort Peck County Rural Water District

Hauled water represents the primary source of domestic water in the Fort Peck Rural Water District. The high cost and inconvenience of hauling water have prompted the consideration of constructing a surface water treatment plant and rural water distribution system for water users in the District.

Construction of a water supply system would help meet future water needs for the area. Such a system would include a raw water diversion, treatment system, and a delivery system to existing homes and businesses. A large number of users would share the system, lowering the average cost per user of system construction. This system would meet current and future water quantity demands and improve drinking water quality for the rural water users in the area.

The Fort Peck Rural County Water District is interested in the value water users would place on such a water system as measured by willingness to pay. For the purpose of this survey, assume that if there is an overall unwillingness of water users to pay for the system, a project would not be built. Without the system, water supplies would continue to be provided primarily by hauling water and by the limited groundwater sources.

Given the above scenario, would you be willing to pay $X on a *monthly* basis for your water? This cost would be for construction, and operation and maintenance of a rural water distribution system and a surface water treatment plant. The water system would be similar to what is found in a city or town. Your individual responses will not be reported, nor do they infer a monetary obligation on your part. Your responses will be used only to develop an overall indicator of willingness to pay. (Circle your answer)

1 YES

2 NO

To better define your willingness to pay, what is the maximum amount you would be willing to pay for this system on a monthly basis? ________/month. This amount is a total willingness to pay, not an amount added to your existing cost.

New Mexico portion of the Navajo reservation

Many communities in the eastern half of the Navajo Nation are currently experiencing problems associated with groundwater in terms of adequate quantity and quality. This applies not only to people who currently have water piped to their homes, but also to the many people of the Navajo Nation who must haul water. Hauling water is costly. In view of the current and future water supply problems faced by the Navajo Nation communities listed below, the Nation is giving consideration to constructing a pipe line from the San Juan River with water distribution systems and associated treatment facilities, to supply water to those communities.

NAPI	Burnham	Huerfano
Nageezi	White Rock	Lake Valley
Becenti	Crownpoint	Whitehorse Lake
Pueblo Pintado	Dalton Pass	Standing Rock
Coyote Canyon	Twin Lakes	Tohatchi
Mexican Springs	Naschitti	Sheep Springs
Fort Defiance	St. Michaels	Window Rock

Other Navajo communities may be served directly from the main pipeline with associated laterals. The City of Gallup will also be served.

Construction of a pipeline to supply water would help meet future water needs for the area. Such a system would include a raw water diversion, treatment system, and laterals to the communities mentioned above. A large number of users would lower the average cost per user. This system is intended to meet the current and future water quantity demands and improve drinking water quality for the users.

The Navajo Nation Department of Water Resources Management is interested in the value water users would place on such a water system as measured by willingness to pay. For the purposes of this survey, assume that if there is an overall unwillingness of water users to pay for the system, a project would not be built. Without the system, water supplies and quality would continue as they are currently.

Would you be willing to pay an additional amount *over and above* that which you are *currently spending per month* to obtain a stable, clean water source for current and future use?

Based on the water supply and quality information provided above, please indicate on the list below the highest amount you are willing to pay each month for a reliable and good quality source of water above what you are currently paying. Please circle the highest *additional* amount you are willing to pay each month.

Circle One			
US$0	6	20	50
1	7	25	60
2	8	30	70
3	9	35	80
4	10	40	90
5	15	45	US$100

If your true willingness to pay falls between two of the categories listed above, please indicate your full willingness to pay per month US$_______ total additional willingness to pay per month.

Due to declining–federal,