APPENDIX A
THE NATIONAL SURFACE WATER SURVEY

NAPAP initiated the National Surface Water Survey (NSWS) to quantitatively assess the acid-base status of surface waters potentially sensitive to acidification throughout the United States. The survey was based on probability sampling of explicitly defined surface water populations in regions that were believed to be potentially susceptible to acid deposition effects. These regions were identified from existing alkalinity maps developed using historical water quality data and physiographic characteristics (i.e., areas of the country known to contain surface waters with little capacity for neutralizing acids). Surveyed regions included the Northeast, Upper Midwest,, West, Mid-Appalachians, Interior Southeast, Mid-Atlantic Coastal Plain, and Southeastern Coastal Plain. The sampling design of the NSWS allows the extrapolation of characteristics of well-defined regional populations of surface waters and provides nearly comprehensive regional coverage of potentially sensitive surface waters.

The NSWS, conducted between 1984 and 1986, defined the population of interest to be lakes with surface areas greater than 4 hectares in the East, or greater than 1 hectare in the West. and less than 2,000 hectares. The stream population contained stream reach segments with drainage areas less than 150 km^2 that were large enough to be represented as blue lines on 1:250,000-scale U.S. Geological Survey topographic maps. Both lakes and streams in urban areas were excluded from the populations of interest.

Lakes were sampled during the fall because the chemistry is generally stable then and reasonable comparisons among lakes could be made. Streams were sampled in the spring to avoid storm episodes. Acid Neutralizing Capacity (ANC) and pH are usually lower in the spring than in other seasons, and sensitive life stages of many fish species are present. Overall, 2,300 lakes and 500 stream reaches were sampled in the NSWS, representing a target population of 28,000 lakes and 59,000 stream reaches.

Aquatic resources not measured in the NSWS were lakes with surface areas less than 4 hectares in the East. The population was restricted because available evidence indicates that in the Upper Midwest, Mid-Atlantic Highlands, and New England, ANC and pH distributions for small and large lakes are similar. In Adirondack State Park, the percentage of acidic lakes is higher among the small lakes (36 percent) than among NSWS target-size lakes (20 percent). However, small Adirondack lakes are more boglike and are more strongly influenced by organic acidity than arc larger lakes (SOS/T 9). Large lakes (greater than 2,000 hectares) and rivers were excluded from the NSWS because they are unlikely to be affected by acidic deposition. About two-thirds of the streams sampled in the NSWS are headwaters. The upstream sites of these headwaters represent the smallest streams that have year-round flow. Streams not depicted on 1:250,000-scale maps were not included in the NSWS population. Available data suggest that for the portion of unmapped tributaries large enough to provide important fish habitat, the percentages of acidic and low-ANC reaches are similar to those of NSWS streams mapped on 1:250,000-scale maps (SOS/T9).

These data have the following advantages:

- the regional samples are representative of the target populations,
- similar data are gathered in the different regions, and
- the variables are measured consistently.

The following are disadvantages:

- the sample sizes are small relative to the sizes of the target populations, and
- the sample sites may not intersect with the sites actually visited by anglers.

The NSWS may not include all of the site characteristics that influence anglers' recreation decisions.

Data from the states can augment site characteristic data from the NSWS. The advantages of this method are the following:

- the variable list can be expanded, and
- sites of interest for recreation are likely to be included in state data sources.

The disadvantages are the following:

- the samples are not likely to have well-defined statistical properties,
- whether variables were measured consistently across sites or across states is not clear, and
- the data are likely to be scattered over numerous places and may not have consistent identifiers to facilitate merging.

APPENDIX B
OUTLINE OF THE MODELS USED IN THE NAPAP INTEGRATED ASSESSMENT TO ESTIMATE THE RECREATIONAL FISHING DAMAGES FROM ACIDIC DEPOSITION IN THE NORTHEAST

This appendix is a condensed description of the models used in the report *Valuation of Damages To Recreational Trout Fishing In The Upper Northeast Due To Acidic Deposition,* hereinafter referred to as the "Valuation Report." The Valuation Report documents the related analysis that supported the NAPAP Integrated Assessment Report, 1990. This brief summary focuses on the basic structure of the welfare calculations in the Valuation Report including the linkage among changes in acidic deposition, water chemistry, recreational fishing behavior, and economic welfare.

DATA BASES

The Valuation Report incorporated three primary data bases in various parts of its analysis. The bulk of the analysis was carried out using two of these-a survey of lake and pond characteristics in the Northeast, and a survey of anglers who visited lakes and ponds in that area. We describe these briefly below.

- **The Eastern Lake Survey** (ELS): This is a sample of lakes-over 4 hectares in area-that provides detailed data on water chemistry characteristics. We used the ELS data to link water chemistry to reduced catch of recreational fish (as described below). The effect of air deposition on water chemistry is estimated using a random subsample of these lakes drawn for analysis by the Direct/Delayed Response Project (DDRP). This subset is referred to below as the **DDRP lakes.**

- **The Aquatic-Based Recreation Survey** (ABRS): This survey covers randomly selected individuals who made recreational trips to lakes in Maine, New Hampshire, New York, or Vermont during the summer of 1989. It includes 5,724 people. Their behavior forms the basis of the analysis of welfare loss from reduced fish catch resulting from acidic deposition. Some of these anglers visited lakes that were surveyed in the ELS. This (critical) set of overlapping lakes is referred to below and in the Valuation Report as the **intersection lakes and ponds.**

- A third source of data was used (solely) to estimate the relationship between fish catch rates and people's participation in fishing recreation. This analysis relied on the **National Survey of Fishing, Hunting, and Wildlife Recreation** (NSFHWR).

The specific uses of these data sets are described in the next section, which outlines the various models used in the valuation analysis.

THE MODELS

The basic assumption underlying the valuation models is that the location choice on any given fishing trip and the number of trips a person takes are functions of the catch per unit of effort (CPUE). Total economic welfare over the course of the fishing season depends on the overall attractiveness of the alternatives the individual faces on each fishing trip choice occasion and on the total number of those occasions. The CPUE, which is a measure of site attractiveness, is a function of the Acidic Stress Index (ASI) of the water body visited. The ASI, in turn, is influenced by the level of acid precipitation.[1] For individual, i, the welfare associated with fishing can be expressed as

$$Welfare_i = TRIPS_i(CPUE[ASI]) \times WTP_i(CPUE[ASI]) \tag{1}$$

where WTP is willingness to pay for a given trip. This measure of welfare per trip is derived from the economic model of recreational fishing, which explains the angler's choice of a particular fishing site from among the available alternatives. In this equation, each item in parentheses (or brackets) determines the thing immediately outside the parentheses(or brackets). As the equation suggests, the welfare of the angler is ultimately determined by the acidic stress index. (Additional model details are provided in the attachment)

The ASI in a lake is itself determined by the pH of the water, and the levels of calcium (CA) and aluminum (AL) dissolved therein.[2]

$$ASI = ASI\ (pH, CA, AL) \tag{2}$$

The ASIs corresponding to Eq. (2) can be calculated for lakes and ponds in the ELS, only. However, the economic model of recreational fishing behavior requires this variable and the CPUE for all lakes and ponds in the ABRS to relate fishing behavior and economic welfare to the lake-specific level of acidic stress. In addition, the policy-relevant changes in the ASI must be computable for each of the ABRS lakes and ponds.

So linking the relevant water chemistry to recreational fishing behavior and economic welfare involves the following steps:

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[1] **Naturally both the welfare of a trip and the CPUE are also influenced as well by other factors that we ignore because they are held constant throughout.**

[2] **In fact each lake has *three* ASIs-one for species that are sensitive to acidity, one for species that are tolerant of acidity, and one for species of intermediate tolerance. In this document whenever we refer to an analysis involving ASI, we mean all three types of ASI, respectively. The index represents the percentage of fish fry that die when exposed to water with this level of acidity. It is there fore a number between zero and 100, inclusive.**

1. Construct lake-specific ASIs for ELS lakes using Eq. (2);

2. Relate changes in ASI to changes in catch rates for fish (CPUE) using the intersection data set (see the attached Table A.6); and[3]

3. Relate ASIs from the intersection data set to variables from the ABRS (see Table A-2).[4]

The ASIs are calculated for all lakes in the ABRS using the regression from Step 3 and substituting into the CPUE equations from Step 2 to provide estimates of the lake-specific baseline values for CPUE. Of interest is a measure of the extent to which CPUE is changed by the acidic deposition scenarios as CPUE changes influence recreational fishing behavior and economic welfare in our model (recall Eq. [1].) The additional steps required for computing CPUE changes due to changes in acidic deposition are as follows:

1'. Calculate the average changes in ASI for each of ten baseline ASI classes (i.e., 0 < ASI < 10, 11 < ASI < 20, ..., etc.) using the forecasted changes in pH, CA, and AL from the DDRP (see Table A.5);

2'. Assign the relevant average change in ASI to each lake in the ABRS based on the baseline value for the ASI as determined above;

3'. Calculate the percentage change in CPUE due to the change in ASI for each of the trout species and for each lake in the ABRS;

4'. Calculate the average percentage change in CPUE for all four trout species combined using the weights implied by the relative catchability of the different species from the intersection data set.

These CPUE percentage changes are then used to adjust the baseline CPUE in the welfare formula derived from the economic model of recreational fishing (see attached model) to arrive at the change in welfare on any given fishing choice occasion. Lower catch rates (from acidic damage) will influence not only the value of an angler's trip to a lake (estimated in Step 4 above) but also the number of trips taken. So to estimate the welfare loss from a lower catch estimating how catch rate influences the number of trips is necessary. For this purpose the Valuation Report used data from the NSFHWR to estimate models of *participation* in fishing recreation. The NSFHWR data set contained surveys of outdoor recreators for different years, thus providing an intertemporal look at participation patterns. Changes in CPUE affected the number of trips taken in two ways, directly and indirectly through an affect on distance traveled to fish for cold water

[3] Catch rates are related to ASI changes through a regression equation that predicts catch per unit of effort of the targeted species (i.e., Rainbow Trout, Brown Trout, Lake Trout, and Brook Trout, respectively) as a function of ASI, and a vector of angler and lake characteristics.

[4] ASI values are estimated statistically using ASI regressions. These regressions relate ASI (where it can be observed) to lake characteristics reported by the anglers in the ABRS. This produces equations that can generate estimates of ASIs for lakes not included in the ELS and, therefore, with missing data on pH, CA, and AL.

species. The relationship between CPUE and distance was estimated using a regression equation.

The various models described above are summarized in Table B-1. The table gives the model name, the model's purpose, the dependent variable (i.e. the variable that is the model's output), the unit of observation in the analysis, the population on which the model operates, and the sample size (number of observations being analyzed).

TABLE B-1. SUMMARY OF MODELS IN THE EVALUATION OF DAMAGES REPORT

Model	Purpose	Dependent Variable	Unit of Observation	Sample Population	Sample Size
Acidic Stress Index					
DDRP Models (forecasts of CA, pH, AL)	To create chemical scenarios	CA, pH, AL	Lake or pond	The DDRP lakes and ponds	91
Calculation of ASIs by applying toxicity models	Forecast ASIs given levels of CA, pH, AL	ASI	Lake or pond	Intersection lakes and ponds	64
ASI regressions (predictions of sensitive and intermediate ASI)	Predict baseline ASI for lakes in ABRS which aren't in ELS	ASI	Trip	Trips to intersection lakes and ponds	1,208, 986
Calculation of average change in ASI (for DDRP lakes) by baseline ASI category	To forecast change in ASI for lakes in each of 10 ASI categories for each deposition scenario	Average change in ASI for lakes in a baseline ASI category	ASI category (10 total)	The DDRP lakes and ponds	91
Catch Per Unit of Effort (for rainbow, brown, lake, and brook trout, respectively)	To estimate the effect of ASI changes on catch rates	[(Targeted specimens caught)/(hours fished on trip)] (logged for RB and BRK)	Trip	Trips to intersection lakes and ponds with expected catch in target species	237, 405, 250, 299
Travel Costs	To estimate the effect of changes in catch rates on angler welfare per trip	Probability of selecting a site	Trip	All trips to ARBS lakes and ponds	629
Participation[a]	To estimate the effect of changes in catch rates on number of trips	# of trips per annum	Average person in an cohort	Age cohorts in NSFHWR	504

[a] Within the participation model, miles traveled to fish for trout are predicted as a function of the TROUT CPUE.

VISIBILITY VALUATION: ACID RAIN PROVISIONS OF THE CLEAN AIR ACT

Lauraine G. Chestnut and Robert D. Rowe*

ABSTRACT

Congress requested an assessment of the benefits and costs of the acid rain provisions of the 1990 Clean Air Act Amendments. Researchers will probably have to rely, at least in part, on benefits transfer to conduct an assessment of this magnitude and complexity. The benefits of expected visibility improvements may be a significant portion of the total benefits. We present the background information and case description sent to each work group member before the workshop, the conclusions, and the suggestions the work group developed during the workshop process. The majority of the work group concluded that a benefits transfer for this case would be feasible and useful if all available information is appropriately interpreted and if uncertainties are accurately communicated to Congress. Concerns about the accuracy and reliability of results from contingent valuation studies. the primary source of original benefits estimates for this case, dominated the group's reservations about this benefits transfer.

As part of the 1990 Clean Air Act Amendments, Congress requested an assessment of the expected costs and benefits of the acid rain provisions (Title IV), which require reductions in acid rain precursor emissions from current levels and set a cap on future emissions. Emissions allowances will be tradeable with the intent of minimizing the costs of the specified emissions reductions. The assessment of expected costs and benefits of the program is to be completed in 1992 and updated every two years. The legislation does not designate how this assessment will be used, but presumably it will influence future evaluations of the effectiveness of the legislation and might stimulate future changes in legislation.

The list of potential benefits is long, and the scientific and economic issues involved in quantification of these benefits are complex. Given time and research resource constraints, considerable incentive exists for using benefits transfer wherever possible, especially as a fast step. This approach has two advantages: providing approximate estimates of the magnitude of expected benefits as cheaply and quickly as

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possible and identifying questions that merit further research for future assessment updates. Beginning this assessment process by asking the question, "What do we know now?" is quite practical.

Title IV calls for about a 10 million ton reduction in national annual SO_2 emissions and a 2 million ton reduction in NO_x emissions. About half of the reduction is required in 1995 and the remainder by 2000. Although the provisions apply nationwide, a large share of the reduction will occur in the midwestern and eastern United States where use of high sulfur coal for electricity generation is most common. Estimates provided in the *1990 Integrated Assessment Report* by the National Acid Precipitation Assessment Program (NAPAP) suggest that about 80 percent of current SO_2 emissions in the United States occur east of the Mississippi River (NAPAP, 1991).

One potentially large component of the benefits of Title IV is the expected improvement in visibility conditions in the eastern United States due to reductions in ambient sulfate and nitrate aerosols. These aerosols are particularly efficient at scattering light and are a major contributor to current regional haze conditions in the eastern United States. Table 1 shows estimates of the percentage contributions of sulfate and nitrate aerosols to light extinction (a measure of visibility impairment) in different locations.

TABLE 1. SHARE OF TOTAL LIGHT EXTINCTION ATTRIBUTABLE TO SULFATE AND NITRATE AEROSOLS (%)

Location	SO_x	NO_x
Urban East	55	10
Rural East	60	7
Urban West	15	25
Rural West	30	10

Source: Trijonis, J., M. Pitchford, W. Maim, W. White, and R. Husar. 1990. *Causes and Effects. of Visibility Reduction: Existing Conditions and Historical Trends*- National Acid Precipitation Assessment Program (NAPAP) SOS/T 24.

The NAPAP (1991) *1990 Integrated Assessment Report* provides some estimates of the expected change in average visual range in the rural eastern United States from the proposed reduction in SO_2 emissions. The estimates suggest that a 45 percent reduction in SO_2 emissions would result in about a 40 percent reduction in sulfate aerosols. A 40 percent reduction in sulfate aerosols is predicted to result in a 30 percent improvement in visual range in eastern rural areas. The improvement in urban areas in the eastern United States would probably be somewhat smaller than this because sulfates account for a somewhat smaller share of total light extinction in eastern urban areas. The proposed reductions in NO_x emissions would be expected, to increase this improvement in visual range by a relatively small amount.

Detailed quantitative monetary estimates for the predicted visibility changes were not developed in the Integrated Assessment for two reasons. One was the high level of uncertainty perceived to exist in the economic valuation studies available at that time for changes in visibility. The second reason was uncertainty about the air pollution transport models' ability to predict changes in visibility in urban areas. Illustrative estimates were developed based on the information provided in NAPAP SOS/T 27 (Trijonis et al., 1990). The Integrated Assessment tentatively suggested a range of willingness to pay (WTP) per household for a 30 percent improvement in visual range of $13 to $52 ($1988) but did not aggregate these numbers with the other quantitative benefits estimates developed.

Economic Benefits of Visibility

Visibility has a value to individual economic agents primarily through its impact on the viewing activities of consumers. Consumer values for changes in regional haze can be divided into use and nonuse values. Use values are related to the direct influence of visibility conditions on the individual's well-being. Nonuse values are the values an individual holds for protecting visibility for use by others (bequest value) and for knowing that it is being protected regardless of current or future use (existence value). For this discussion, we further separate visibility impacts in terms of residential and recreational settings. Residential settings include urban, suburban, and rural areas where people live, work, and participate in everyday recreation such as ball games, waking, and picnics, for example. Recreational benefits relate to major state and federal recreational sites such as state and national parks and wilderness areas. Therefore, for the purposes of reviewing existing literature, we define the following categories of benefits:

- residential use values related to impacts to individuals at work, home, and recreation near their home or when they are in other cities;
- residential nonuse values related to impacts to other individuals or purely for the sake of improved visibility;
- recreational use values related to expected impacts when a person visits a major recreational site such as a national park or wilderness area; and

- recreational nonuse values related to bequest and existence values for visibility conditions at major recreational sites.

To effectively focus on quantification issues likely to be the most significant as a result of Title IV, researchers should know the expected relative magnitudes of the above benefit categories. Some work has been done that allows researchers to begin determining the relative magnitudes of these benefit categories, although no single study has considered all of these benefit categories. Figure 1 illustrates a current judgment about the approximate relative magnitude of visibility benefit categories for changes in regional haze in the eastern United States based on existing sources. The most important category to focus on, in terms of reducing inaccuracy in estimates of the total value for changes in visibility, appears to be residential use values.

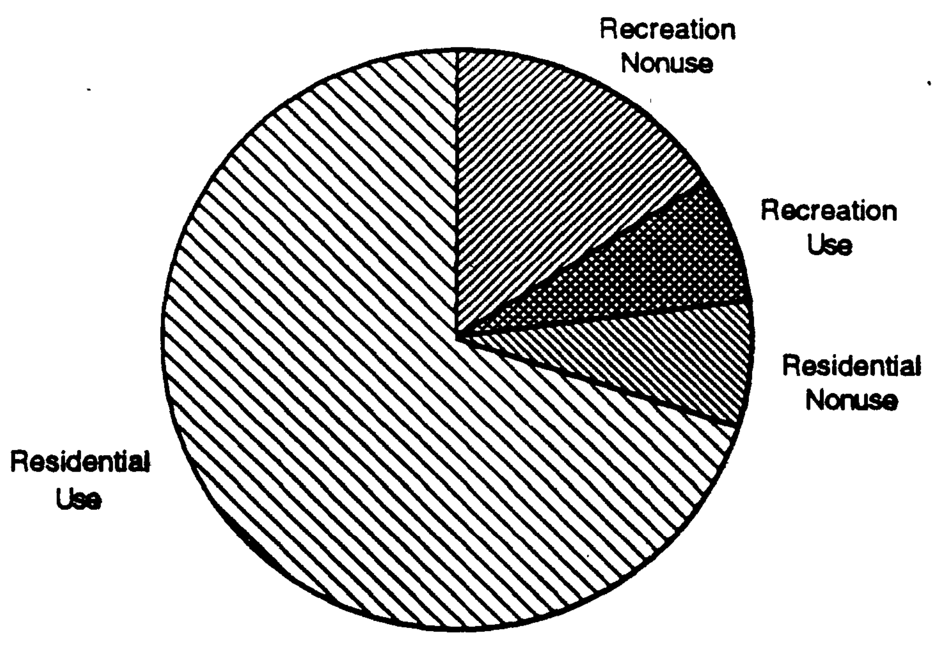

Figure 1. Possible Relative Size of Eastern Visibility Benefit Components

Source: Chestnut, L.G., and R.D. Rowe. 1990a. "Economic Valuation of Changes in Visibility: A State of the Science Assessment for NAPAP." In *Methods for Valuing Acidic Deposition and Air Pollution Effects.* Section B5. 'National Acid Precipitation Assessment Program, Washington, DC.

Available Benefits Studies

Chestnut and Rowe (1990a) review available original economic benefits studies concerning visibility impacts associated with acid rain precursors. The work group received copies of this chapter so we do not repeat details of the review here. Available studies fall into the following categories:

- **Urban resident contingent valuation or contingent ranking.** These studies typically provide estimates of annual household WTP for visibility improvements in metropolitan areas where respondents live (use values).
- **Urban property value studies.** These studies provide estimates of that portion of the average residential property value attributable to differences in air quality across neighborhoods. Visibility aesthetics is expected to be one reason people value better air quality.
- **Park/recreation area visitors contingent valuation.** These studies provide estimates of how much park visitors are willing to pay for better visibility conditions during their visit to a particular scenic area (use values).
- **National park general population contingent valuation.** These studies provide estimates of household (including visitors and nonvisitors) WTP for visibility protection at national parks (preservation values).

Three new contingent valuation studies relevant to this topic have been completed since this review. For participants unfamiliar with these studies, we provide brief summaries. The Two Cities Study (McClelland, et al., 1991) provides new estimates of WTP for improvements in visibility in urban residential areas that are directly relevant for the Title IV assessment. The Brown Cloud Study (McClelland, et al., 1990) is another new use value study for changes in urban visibility, but because of the study location the results provide only methodological and interpretation insights rather than quantitative estimates relative to Title IV. The National Park Visibility Values Study (Chestnut and Rowe, 1990b) provides new estimates of total preservation values (use and nonuse) for changes in visibility at national parks in several regions in the U.S.

Two Cities Study

Researchers conducted a mail survey in 1990 in Chicago and Atlanta and obtained about 500 completed responses. Respondents were provided photographs illustrating three different air quality levels in their area and were told how many days per year each level currently occurs on average. Respondents were asked what their household would be willing to pay annually to have air quality on 25 of the worst days shown improve to the best air quality level shown. This increase resulted in about a 14 percent improvement in average annual visual range. Respondents were asked to say what percentage of their response was attributable to concern about health effects, soiling, visibility, or other air quality impacts. The average raw response was about $225 annually with respondents attributing about 20 percent of their responses to visibility.

The authors conducted two analyses and adjustments on the responses. One adjustment estimated and eliminated the potential selection bias in responses due to nonresponse to the WTP questions by some respondents (including what has been called protest responses). The other adjustment accounted for the potential skewed distribution of errors due to the skewed distribution of responses (the long tail at the high end). Both of these adjustments caused the mean WTP value to decrease. The raw annual average household value for visibility was $39 before the adjustments and $18 after the adjustments. The authors interpreted the adjustments as providing a lower bound on the "true" WTP value. The analysis of the WTP responses also found that income, education, and age were significant in predicting WTP responses. No statistically significant differences were found between the two cities, although different scenes (specific to each city) were used in the photographs.

Table 2 summarizes available estimates obtained from previous studies for residential use values. This table updates a similar table presented in the NAPAP SOS/T 27 (Chestnut and Rowe, 1990a) and now includes the results of the Two Cities Study. This comparison table was the basis for much of the work group discussion. We had difficulty comparing the mean results for the different studies because they are for different changes in visibility. In a beginning effort to examine for consistent values and patterns across studies, we used the following function in the NAPAP SOS/T 27 to put these mean WTP results from the different studies into a common metric. The b coefficient shown in Table 2 for each study's results was calculated using this function. This function has been called a consensus function, because it can be used to determine the degree of consistency that exists between the results of the different studies.

$$\text{Mean Annual Household WTP} = b * \ln\left(\frac{VR_2}{VR_1}\right) \qquad (1)$$

where

VR_1 = starting average visual range
VR_2 = hypothesized alternative average annual visual range
ln = natural log
b = estimated coefficient

TABLE 2. COMPARISON OF RESIDENTIAL VISIBILITY VALUATION STUDY RESULTS

Study	City	Mean WTP ($1990)	Starting VR (miles)	Ending VR (miles)	b coefficient	WTP for 20% Change VR ($)
Eastern CVM Studies						
McClelland et al. (1991)	Atlanta and Chicago	18	17.6	20	140	26
Tolley et al. (1986)	Chicago	-318 305 379	9 9 9	4 18 30	367	67
Tolley et al. (1986)	Atlanta	-265 255 381	12 12 12	7 22 32	414	75
Tolley et al. (1986)	Boston	-196 187 231	18 18 18	13 28 38	372	68
Tolley et al. (1986)	Mobile	-212 227 266	10 10 10	5 20 30	275	50
Tolley et al. (1986)	Washington, DC	-314 323 410	15 15 15	10 25 35	560	102
Tolley et al. (1986)	Cincinnati	-78 77 86	9 9 9	4 19 29	106	17
Tolley et al. (1986)	Miami	-134 120 141	13 13 13	8 19 29	226	41
Rae (1984)	Cincinnati	175	11.4	16.4	531	97
California CVM Studies						
Brookshire et al. (1979)	Los Angeles	115 294 161	2 2 12	12 28 28	105	19
Loehman et al. (1981)	San Francisco	-186 109	18.6 16.3	16.3 18.6	1,172	214
California Property Value Study						
Trijonis et al. (1984)	Los Angeles					216 - 579
Trijonis et al. (1984)	San Francisco					437 - 487

The Brown Cloud Study

The Brown Cloud Study (Chestnut and Rowe, 1990b) was conducted in Denver, where the visibility issue is different compared with the eastern United States. A layered, rather than a regional, haze is most common in Denver. The quantitative WTP results are not, therefore, very relevant for the Title IV assessment, but the study carefully considered several methodological issues of importance. In particular, the study examined the question of respondents' ability to isolate WTP for changes in visibility aesthetics from other concerns about air quality, such as potential health effects. The authors concluded that simply asking respondents to consider only visibility when estimating their WTP is not adequate and is likely to result in the inclusion of some value for health protection as well as visibility by some respondents. They recommend that the WTP question be asked about changes in air quality as a whole, and then a second question asked to partition the value to pay into percentages for various concerns including visibility and health.

National Parks Visibility Values Study

Researchers conducted a mail survey in 1988 with a sample of residents in Arizona, California, Missouri, New York, and Virginia and obtained a total of 1,647 completed responses. National parks in three regions were considered in different survey versions: California, Southwest U.S, and Southeast U.S. Respondents giving WTP estimates for each region were selected from a state within the region and from four states outside the region. Respondents were shown photographs illustrating four levels (current 10th, 50th, 75th, and 90th percentiles) of visibility conditions at a prominent national park in each region (Yosemite, Grand Canyon, and Shenandoah). Respondents were asked what they would be willing to pay annually per household to have average visibility conditions at all national parks in one of the regions improve from the 50th to the 75th or to the 90th percentiles or to prevent a degradation to the 25th percentile. Respondents were asked in a follow-up question whether their WTP was entirely for visibility rather than for other park protection concerns, and, if not, what percentage was just for visibility. The average response for all regions was that about 60 percent was just for visibility.

Table 3 shows the mean annual household WTP responses for each region, after adjusting for the percentage reported as just for visibility and for identified protest responses. Analysis of the WTP responses found that respondents who lived in the

TABLE 3. MEAN ANNUAL HOUSEHOLD WTP ESTIMATES FROM NATIONAL PARKS VISIBILITY VALUES STUDY

Region	Change in Percentile	Change in Visual Range	Mean WTP ($)
Southeast	50th to 75th	25km to 50km	41
(n = 346)	50th to 90th	25km to 75km	58
	50th to 25th	25km to 10km	52
Southwest	50th to 75th	155km to 200km	42
(n = 332)	50th to 90th	155km to 250km	56
	50th to 25th	155km to 115km	49
California	50th to 75th	90km to 125km	46
(n=330)	50th to 90th	90km to 150km	56
	50th to 25th	90km to 45km	53

region or had higher household income gave significantly higher responses. Responses were lower for older respondents and male respondents.

WORK GROUP RESULTS/BENEFITS TRANSFER PROTOCOL

The work group started with an overview discussion of the purpose of this assessment and the nature of the physical impact being assessed. Although the exact intent of Congress in requesting the assessment of the acid rain provisions of the 1990 Clean Air Act Amendments is not known, clearly an assessment of this magnitude must rely on benefits transfer to some extent to keep the assessment costs at a practical level. The geographic breadth of the area under consideration alone requires some benefits transfer because economic estimates arc not available for the entire area, and the costs of collecting such detailed information for each location in the study area would be enormous. The assessment will presumably be used in determining the effectiveness of the legislation and for broad policy analysis objectives. The assessment should be based on an evaluation of the best available information that includes professional judgment about the level of uncertainty in the estimates provided. The level of uncertainty that can be tolerated in the quantitative estimates is higher than in some benefits assessments, as long as the level of uncertainty is communicated along with the estimates.

The primary physical impact of interest for this case study is the expected reduction in regional haze in the eastern United States. Economic values that might result include residential use values, recreation use values, and nonuse values. The group discussed the available information for each type of value and decided to focus on residential use values for two reasons:

- Sufficient information appears to be available to consider a benefits transfer for residential use values.
- Residential use values represent probably the largest component of total use values (and maybe even of all values).

The work group agreed that available estimates of residential use values probably include values related to day-to-day recreational activities near the home. We were unsure about how far such estimates may extend to, or overlap with, recreation use values at major parks and recreation areas such as national and state parks.

Assessment of Available Studies

Table 4 shows the groupings of available economics studies regarding WTP for visibility aesthetics related to air quality. The only study method judged as providing potential quantitative information on WTP for visibility was the contingent valuation method (CVM). Because of differences in the characteristics of landscape, natural background visibility conditions, and visual air pollution impacts, we judged that, for this application, studies conducted only in the eastern United States should be used for quantification. Studies conducted in the western United States might provide some useful information that would help interpret some of the eastern studies, such as the relative importance of health concerns versus visual aesthetics when respondents give WTP estimates for improvements in air quality.

Participants expressed concerns about the credibility and reliability of CVM results and concluded that market-based approaches, such as hedonic property value studies, should be reviewed to determine if any quantitative or qualitative information can be gleaned that would help to verify the CVM results. Participants acknowledged that the hedonic property value studies do not, at this time, provide quantitative information about WTP for changes in visibility that can be separated from concerns about the other adverse effects of air pollution, such as human health effects. Some group members were reassured that the hedonic property value study results shown in Table 2 generally exceeded the CVM results for a comparable change in visibility by a factor of 2 or more. This result is consistent with the expectation that the hedonic results would include

TABLE 4. JUDGED USEFULNESS OF AVAILABLE STUDIES

Study Method	Study Groupings		Usefulness
Contingent Valuation	Eastern:	Two-Cities Cincinnati Six-Cities	Quantification
	Western:	Brown Cloud San Francisco Los Angeles	Interpretation
Hedonic Property Value	Visibility Air Quality		Verification
Behavior	Handcock Tower		Verification

concern for all air quality impacts and with previous CVM results suggesting that WTP to protect visibility aesthetics is about one-quarter to one-half of total WTP to protect air quality.

INTERPRETATION AND TRANSFER ISSUES

We identified interpretation and transfer issues as most important for this application. Each was assessed in terms of the extent that it could be resolved with available information from visibility value studies or other sources.

Separation of Visibility from Health and Other Air Pollution Effects

Recent CVM studies have focused on this question and have concluded that the best approach is to ask respondents to give WTP for changes in air quality and then to use one or more methods to isolate the visibility aesthetics component. Researchers have concluded that this approach is less likely to result in visibility values that are incorrectly Mated by concerns about other air pollution effects. Questions remain about the accuracy of this isolation process, but a comparison of results from several different studies is now possible and may suggest some broad consistency. The recent results suggest that studies that have not used the total-and-then-partition approach for visibility have probably obtained estimates of WTP for visibility protection that are too high. These studies include the Six Cities Study and the Cincinnati Study. A work group member suggested that the results of the Brown Cloud study might indicate how big the upward bias in results of these two studies might be.

Quantitative Definition of Visibility for Use in Adjusting Results from Various Studies to the Change in Visibility in this Application

Visual range is the visibility metric used in most economic assessments because it can be linked to changes in air pollution emissions and can be linked to available economic estimates of WTP for changes in visibility. Although visual range is not the best predictor of human perceptions of visual air quality (various contrast measures are preferable in terms of human perception), visual range is correlated with these measures under many circumstances and is probably still the best choice for this type of assessment. Contrast measures are, for the most part, scene specific and therefore not useful for characterizing changes in visibility over a broad geographic region.

Potential Geographic Differences in WTP due to Different Demographics and/or Topography

Other than confining the quantitative estimates used for the transfer to studies conducted in the eastern United States, researchers can do little to take account of potential differences in demographics or topography in the eastern United States. Few clear and consistent influences on the WTP responses have been found across available studies, other than possibly household income.

Appropriate Aggregation of Values from Study Sites to the Policy Relevant Area

Available studies have been conducted primarily in selected urban metropolitan areas, while the changes of interest for this assessment are expected to be region-wide. Researchers do not know whether aggregation of values per resident household for metro areas will fully reflect values for region-wide changes. Available evidence is limited but suggests that people may hold some value for changes in locations other than where they live. Values are considerably higher for changes where they live. We do not have enough information to answer this question, but posing alternative assumptions and placing upper and/or lower bounds on the estimates may be possible.

Level of Consistency of Results from Available Studies

We discussed a previous review of available studies (summarized and updated in Table 2) in terms of consistency of previous results. The group agreed that when adjusted for the percentage change in visual range in the study photographs, the results of available studies for the eastern United States look roughly consistent. The work group found the "consensus function" approach useful for comparing the results of the studies. Questions remain about how certain study design features may have affected results. We also discussed the possibility of incorporating some weights based on judged confidence in the study and/or study design characteristics into the consensus function analysis.

Appropriate Level of Confidence in CVM Results for Quantitative Use

The results of one hedonic property value study available to the group were reasonably consistent with the CVM results. These results reassured some group members but many concerns remained about the accuracy and reliability of CVM results in general.

RECOMMENDED TRANSFER GUIDELINES

Use all Available Information with Appropriate Weights

Available studies can he reasonably ranked in terms of study design quality and closeness of study scenarios to the changes expected because of Title IV. Although one recent study was designed with the acid rain policy question in mind, the group did not lean toward using only this study for quantitative assessment. The group believed the assessment would be stronger if it was based on as much evidence as possible with appropriate weighting for accuracy and relevance. A previous review that combined all available results into a single function showing mean WTP responses as a function of the percentage change in visual range in each study scenario was judged as one reasonable starting point for combining information from different studies. Participants suggested that adjustments for known biases and/or weights for the quality of the study design might be considered to see if available estimates might converge to a tighter range of values.

Include an Assessment of Uncertainty in the Results

The group believed that uncertainty assessment was an important part of the process. Uncertainty assessment might include consideration of a broader range of quantitative information than just mean WTP from available studies. Use of other summary statistics such as confidence intervals should be considered. In addition, consistency of all available study results, possibly adjusted for known biases or omissions, would be an important contribution to the quantitative and qualitative uncertainty assessment. Group participants also recommended sensitivity tests to determine the most critical uncertainties in terms of the effect on assessment estimates. Participants' optimism about assessing uncertainty depended to a large extent on judgments about the appropriate level of confidence in CVM results.

JUDGED USEFULNESS OF THE POTENTIAL TRANSFER

After discussing available information and a strategy to conduct the most defensible possible benefits transfer for this policy question, we tested the group's opinion of the results' usefulness. All group members were asked to respond to the following question anonymously on paper: "Accepting the economic quantification goal, how comfortable are you that an enhanced benefits transfer along the lines discussed will provide order of magnitude information that is more useful than not to the mandate?"

	Not at all comfortable	Slightly comfortable		Somewhat comfortable	Moderately comfortable		Very comfortable
	1	2	3	4	5	6	7
Number Responses	1	0	0	2	4	4	1

Question 2 stated, "Please comment on your response to Q1." About half the participants indicated that CVM was useful or that acceptable consistency across the CVM studies, hedonic studies, and other information plus subjective judgment suggested that such a benefits transfer would be more useful than not having any quantitative information for this mandate. One participant indicated that the results may not be sufficient for exact benefit cost analysis but were useful as an input into a multiple factor examination of visibility control. One participant, who responded "not at all comfortable," indicated little or no confidence in the results of any CVM study-visibility or otherwise. The remaining comments suggested that technical issues or concern in interpreting the CVM visibility results as discussed above influenced their responses.

Question 3 asked, "What are the one or two most important things that would enhance the reliability and defensibility of this benefits transfer?" Nearly half of the participants indicated that improving the overall reliability and defensibility of CVM studies in general was important, which indicated a general concern with CVM rather than just with the specific visibility applications in this benefits transfer. The remaining comments focused on technical issues such as rehabilitation of existing studies, weighting of results, and sensitivity analyses, for example.

GENERAL BENEFIT TRANSFER ISSUES

In the process of discussing this case study, group members raised several general benefit transfer issues. Although we chose to focus on the specifics of our case study, we list these more general issues to provide a more complete picture of the concerns/thoughts about benefit transfer raised by the group.

- **Values through time:** Changes in values, changes in income, and discounting questions must all be addressed when projecting benefits over some extended time period.
- **Peer review:** Questions about whether to use study results that have not been fully peer reviewed or published in peer-reviewed journals are frequently encountered. Questions were also raised about what sort of peer-review process is appropriate for benefit transfer. Some review is always desirable, although peer-review publication is not always practical.
- **Statistics:** We generally agreed that more information than only mean results of available studies should be used when conducting transfers. Some quantitative characterization of uncertainty or distributions of study results should be carried into the transfer.
- **Economic theory:** Concerns were raised about the consistency of implicit assumptions in benefits transfer with economic theory.
- **Costs of being wrong:** Costs of being wrong should be considered in evaluating the efficacy of a benefit transfer.
- **Underlying study issues:** A benefits transfer cannot ignore and is at risk of amplifying uncertainties in the results of underlying studies. This uncertainty includes limitations of each study method, such as CVM, travel cost, or hedonic property value. Questions of aggregation and total values versus component values may also be important. Before we transfer estimates we need to evaluate thoroughly what the available estimates tell us about the original study scenario.
- **Role of expert opinion:** Most transfer exercises involve some judgment on the part of the researcher. Expert opinion should be acknowledged and key assumptions identified.

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ISSUES IN BENEFITS TRANSFER

Trudy Ann Cameron*

ABSTRACT

These comments cover four separate issues in benefits transfer. The first is an idea for using weighted maximum likelihood estimation to recalibrate *study* sample models to reflect *policy* population relative frequencies of different sociodemographic groups and environmental attributes. These recalibrated models are then transferred to the study context. The second issue highlights the substantial value for benefits transfer of an estimation methodology proposed in the international development literature by Edward Leamer. The third issue is a description of a recent survey and evaluation prepared for the National Research Council concerning the “combination of information” (CI) in a wide array of different disciplines. This report very closely parallels the insights drawn by many of the participants in the 1992 AERE workshop. Finally I make a recommendation concerning competitive funding for the incremental effort necessary for documenting and preparing data associated with primary studies that have substantial promise for benefits transfer applications.

Environmental benefits assessments are now mandated for many benefit-cost analyses of public projects, and these assessments also form an essential component of much environmental litigation. Original studies, unique to the particular valuation problem in question, are typically very expensive and highly time-consuming because household surveys must usually be conducted to gather the appropriate data. As a consequence, researchers are pressured to look for “good enough numbers" provided by some existing, sufficiently similar assessment.

The demand for benefits estimates that can be selected "off the shelf" from an inventory of estimates is overwhelming. For example, if an oil spill kills 200 sea birds, researchers would find simply averaging the dollar values attached to dead sea birds in half a dozen existing studies convenient to estimate a satisfactory dollar value of each of these particular birds, in this particular area.

Of course, the advisability of this strategy of borrowing estimates for the new valuation problem will depend on the similarity of the two contexts. In a few cases, finding a similar study may be relatively easy. In other cases, arguing that the values from the “study” case are transferable to the “policy” case may be less valid. In still other cases, no existing values may be available for any similar scenario (i.e., species, type of damage or enhancement, or locale). Given that benefits transfer is widely practiced, assessing suitable protocols for making such transfers is important.

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Benefits transfer practices were the subject of a recent special section of the journal *Water Resources Research.* This collection of papers maps out many important issues in this area. It also showcases work on the overall practice of benefits transfer, rather than specific examples.[1]

This paper addresses four distinct issues relevant to benefits transfer. I describe an idea for using weighted maximum likelihood estimation to recalibrate *study* sample models to reflect *policy* population relative frequencies of different sociodemographic groups and environmental attributes.[2] These recalibrated models are then transferred to the study context. I review and highlight the substantial value for benefits transfer of an estimation methodology proposed in the international development literature by Edward Leamer. I then describe a recent survey and evaluation prepared for the National Research Council concerning the "combination of information" (CI) in a wide array of different disciplines. This report very closely parallels the insights drawn by many of the participants in the 1992 AERE workshop. Finally, I advocate competitive funding for the incremental effort necessary for documenting and preparing data associated with primary studies having substantial promise for benefits transfer applications.

REWEIGHTING STUDY SAMPLE TO REFLECT POLICY POPULATION

In ordinary least squares estimation (OLS), a sample that is nonrepresentative only in terms of the distribution of an exogenous variable presents no problem for estimation. In contrast, if the sample is nonrepresentative in terms of an endogenous variable, potential exists for sampling bias in the estimation results. In general, in any estimation algorithm, if an observation's presence or absence in the estimating sample is in any way related to the magnitude of the outcome researchers are trying to explain, potential exists for bias in the estimates.

The case study in which I participated emphasized random utility modeling (RUM) of recreational site choices. These models are estimated by maximum likelihood (ML) methods. A long tradition in models like this is employing weighted exogenous sample maximum likelihood (WESML) estimation when the estimating sample is not representative of the desired study population, but the approximate distribution of respondent attributes in the study population is known.

[1] These papers include Atkinson, Crocker and Shogren (1992), Boyle and Bergstrom (1992), Brookshire and Neill (1992), Desvousges, Naughton, and Parsons (1992), Loomis (1992), Luken, Johnson, and Kibler (1992), McConnell (1992), Smith (1992), and Walsh, Johnson, and McKean (1992).

[2] This terminology-"study" versus "policy" samples and/or populations-was adopted during the Workshop and will be adhered to throughout this paper.

Suppose that the study population distribution is defined over attributes X and choices $j \in C$. This is a joint distribution, which can be decomposed as a conditional distribution times a marginal distribution:

$$f(j, X) = P(j \mid X)\, p(X) \tag{1}$$

Now, if the study sample happened to be truly representative of the study population, the likelihood function for the individual choices observed in the sample would be given as follows (where $y_{ij} = 1$ if individual i chooses alternative j and $y_{ij} = 0$ otherwise):

$$\pounds = \pi_i \, \pi_{j \epsilon C} \;\; f(j, X_i)^{Y_{ij}} \tag{2}$$

$$= \pi_i \, \pi_{j \epsilon C} \;\; P(j \mid X_i, \beta)^{Y_{ij}} \;\; p(X_i)$$

This calculation results in a formula for the log-likelihood given by

$$\log \pounds = \Sigma_i \, \Sigma_{j \epsilon C}\, y_{ij} \;\; \log P(j \mid X_i, \beta) + \Sigma_i \; \log p(X_i) \tag{3}$$

By exploiting the decomposition of the joint distribution into a conditional distribution times a marginal distribution, the log-likelihood function in Eq. (3), to be maximized over the unknown parameters β, consists of a sum of two components. The second component does *not* depend on the parameters β, so it can be ignored, and the optimization of log $\pounds$ can proceed simply by maximizing the first term in Eq. (3). Weights are unnecessary.

However, most benefits assessments require voluntary participation of members of the affected study population in the survey necessary to gather the data. In RUM models, researchers now generally acknowledge that nonparticipation should be included as a relevant choice along with specific site choices conditional on participation. Whether contacted individuals opt to comply by completing their questionnaire or interview will determine their presence in the final estimating sample for the study.[3] Nonparticipants in the associated recreational activity are typically less likely to be interested in the survey and hence less likely to appear in the final sample. Because of this tendency, most modern RUM applications involve fundamentally choice-based samples.

Ben-Akiva and Lerman (1985) demonstrate that unweighted MLE is still feasible for the standard multinomial logit specifications typically used to estimate RUM models, providing the

[3] Intended observations can end up being omitted from the estimating sample because of item nonresponse or complete nonresponse.

choice model has a full set of J-1 alternative-specific constants (i.e., site-specific dummy variables plus a nonparticipation dummy variable). Exogenous information concerning the true study population distribution of attributes X is still required for the process of adjusting the estimated probabilities after the estimation process. Manski and Lerman (1977) call this approach "exogenous sample maximum likelihood" (ESML).

However, in benefits transfer applications, the last thing a researcher wants in the model for the original study sample is a set of site-specific dummy variables, for the following reason. Using these dummy variables is akin to estimating entity-specific fixed effects in a panel data model for pooled time-series and cross-section data. Providing no new entities appear in the data set for which a policy forecast is desired, these fixed effects are fine. But if new entities will appear, the researcher will have no fixed effects to use for them. Random-effects models for the study sample are preferred under these conditions.

Benefits transfer exercises require, by definition, that models calibrated for one set of site choices be applied to different sites (or at different time periods). This feature precludes using ESML estimation for RUM models destined for transfer exercises. A formal choice-based sample maximum likelihood estimator is clearly indicated in this context. Unfortunately, this estimator is somewhat intractable. A consistent estimator for β that represents a tractable alternative is the WESML estimator.

The WESML estimator is typically implemented by partitioning the estimating sample into G groups (or "cells") defined over intervals of the values of some subset of the exogenous variables. The group-specific weights, w_g, are given by f_g^{pop}/f_g^s, where the numerator is the population relative frequency of individuals in group g, and the denominator is the sample relative frequency of individuals in group g. With N_g designating the number of sample observations in group g, the WESML log likelihood function is given by

$$\log \pounds^* = \sum_g \sum_{i=1}^{N_g} \sum_{j \in C} \; y_{ij} \, w_g \log P(j \mid X_i, \beta) \tag{4}$$

Proving that this estimator for β is consistent under very general conditions is daunting. Furthermore, the WESML estimator is not fully efficient even asymptotically, so its variance-covariance matrix is matrix complex than that of a true maximum likelihood estimator (see Manski and Lerman, 1977). Even its corrected variance-covariance matrix (outlined in Ben-Akiva and Lerman (1985, p. 239) does not attain the Cramer-Rao lower bound. Thus these are compromise estimators; computational tractability is gained at the expense of full statistical efficiency. They are nevertheless highly practical.

To illustrate how WESML estimators might apply in benefits transfer situations, a simple numerical example may be helpful. Consider a RUM model where only two variables affect choice: respondent income and catch rates. Suppose that the study population is one million people with joint frequencies for income and catch rates as given in Table 1A. (Note that the groups in this example are extremely coarse and that frequencies are measured in 10,000's.) Suppose that a study sample of 50 respondents yields the joint sample frequencies shown in Table 1B. To inflate or deflate the influence of each sample observation so that the weighted study sample mimics the study population distribution of attributes, the weights will be as given in Table 1C.

WESML estimation will produce a set of utility parameters, β, that can be argued to represent the best parameterization of a "typical" or "average" set of preferences for the study population. For benefits transfer, however, we would prefer to have a set of parameters, β, that represent the typical preferences of the "policy" population. If the researcher has access to the full set of data used to calibrate the original study sample model and obtaining an approximate joint distribution of the exogenous variables for the policy population is possible, the following modified weighting scheme seems appropriate. Intuitively, researchers would simply construct a set of weights for use in the WESML algorithm that serve to make the study sample representative of the *policy* population, rather than the study population.

To continue the simple illustration, suppose that the policy population (also one million people) has the joint distribution of exogenous variables given in Table 2A. The set of weights necessary to make the sample with frequencies as in Table 1B representative of this alternative population appears in Table 2B. WESML estimation of the RUM specification using these weights will produce a different set of estimates for the β vector of preference function parameters-one that better approximates the typical preferences of this new population.

Reviewing the data requirements necessary to make this reweighting scheme work is useful. First imagine the ideal case. With unlimited data on a vector of individual-specific sociodemographic variables, X, and a vector of individual-specific environmental amenities, Z, researchers might imagine calibrating a full parametric continuous joint density function $f^P(X, Z)$ based on exogenous sample data for the policy population. Researchers would analogously calibrate a full parametric continuous joint density $f^*(X, Z)$ for the study **sample.**[4] With these

[4]In our earlier numerical example, fundamentally continuous distributions for income and catch rates were aggregated into four cells so that a simple discrete distributions could be used to form the weights.

TABLE 1A. STUDY POPULATION FREQUENCIES (10^4)

Income Catch	Low	High	Total
Low	40	10	50
High	20	30	50
Total	60	40	100

TABLE 1B. STUDY SAMPLE FREQUENCIES

Income Catch	Low	High	Total
Low	10	5	15
High	10	25	35
Total	20	30	50

TABLE 1C. WEIGHTS TO MAKE STUDY SAMPLE ESTIMATES REFLECT STUDY POPULATION FREQUENCIES

Income Catch	Low	High
LOW	2	1
High	1	0.6

TABLE 2A. POLICY POPULATION FREQUENCIES (10^4)

Income Catch	Low	High	Total
Low	25	15	40
High	25	35	60
Total	50	50	100

TABLE 2B. WEIGHTS TO MAKE STUDY SAMPLE ESTIMATES REFLECT POLICY POPULATION FREQUENCIES

Income Catch	Low	High
Low	1.25	1.5
High	1.25	0.7

two continuous joint densities, researchers could then calculate (unique) individual-specific weights based on the ratio $\frac{f^P(X, Z)}{f^*(X, Z)}$ for each individual's own vector of values for X and Z.[5]

This level of detail is highly improbable for current real applications. Multivariate joint densities are simply too difficult to calibrate unless normality is invoked and even this assumption may often be questionable. Furthermore, the raw data necessary to calibrate the full joint density function $f^P(X, Z)$ are not typically available, at least with current information technologies. For sociodemographic variables, official Census descriptive statistics will sometimes provide two- or even three-way cross-tabulations of variables such as age, income, and ethnicity, but these cross-tabulations are rarely available for specific subpopulations. Much of the raw data exist; the infrastructure for extracting arbitrarily designated subsets of the population is simply not yet as readily accessible as researchers might like. Data on the environmental attributes are even more scarce, and when they are available, researchers must frequently assume statistical independence between the X and the Z variables because these are typically drawn from different sources. Because full vectors of both X and Z values are not

[5] **Recall that the weights in our numerical example were only group-specific, not individual-specific, and that only four groups were defined.**

extracted from the same individuals, the joint density cannot be estimated. Information technology promises great strides in this area in the future, however.

In the meantime, researchers will have to make do with nonparametric frequency information over matching "cells" in the policy population and the study sample. This method requires comparable domains for $f^*(X, Z)$ and $f^p(X, Z)$. If the domains did not overlap, weights could not be constructed. The number of partitions along each dimension of (X, Z) will be dictated by the study sample's size. If some cells are empty, they can frequently be merged with adjoining nonempty cells for both the study sample and the policy population. However, if too many cells that are well-represented in the policy population are empty in the study sample, researchers will have problems. In general, the more refined the cells, the better, but a tradeoff exists between resolution (the fineness of the cell partitions) and cell frequency deficiencies. Cell designations are entirely subjective.

Researchers have argued that simply transferring *point estimates* of benefits from a study area to a policy area is generally not wise (Loomis, 1992). Point estimates depend on a vector of estimated parameters as well as a matrix of exogenous variables. Thus, this argument recommends (correctly) that transferring the point estimate of mean value from the study to the policy area is unwise because fundamentally different values of the exogenous variables may apply in the policy area. Instead, transferring the *entire model* is preferable, applying it to new (mean) values of the exogenous variables for the policy population. The reweighting scheme described here goes one step further than "model transfer." It avoids not only the assumption that the exogenous variables are identical in the two regions but also the assumption that typical preferences for the study region and the policy region are identical.

Preferences may indeed be systematically different if the study involves endogenous location choice or if fundamental preferences are not uniformly distributed across the entire country (we usually assume that they are). The disadvantage is that recalibration of the study model with different weights requires that the full study data set be available. The full data set will not always be available, although pressure is mounting in the economics discipline to preserve estimating samples and documentation as a condition for publication.

LEAMER'S BAYESIAN DATA-POOLING MODEL

Edward Leamer (1991) has recently proposed a Bayesian econometric methodology that appears to have much to offer benefits transfer practitioners in terms of focusing our agenda for improving quantitative procedures. The current framework for Leamer's model is OLS regression, and the application he uses to illustrate the approach is a convenience sample of data pertaining to GNP growth in developed and developing countries. His application tests the so-called "convergence hypothesis" (that higher initial GNP implies slower growth rates across countries). His two samples are developed countries (assumed to provide good quality data) and developing countries (assumed to provide poorer quality data). Although Leamer's application is not benefits transfer, he injects valuable rigor into the explicit modeling of many judgments similar to those made in every application of benefits transfer.

The problem is one of combining information about some economic quantity from two data sets of differing quality. Data pooling appears in benefits transfer exercises when alternative study samples are combined either to provide transferable benefits estimates or transferable models. It also takes place when study samples are pooled with small-scale policy samples to "update" the study information with policy area information.

Leamer's method is Bayesian and uses prior information about regression coefficients. Estimates from pooled data depend on three types of parameters:

δ = the investigator's lack of confidence about the prior,

ρ = the subjective degree of similarity between the "study" and the "policy" relationships;

λ_i = the amount of contamination of (for example) the "study" (i = 1) and the "policy" (i=2) data caused by such things as measurement errors, left-out variables, and simultaneity, for example.

Leamer's basic specification for the pooling of contaminated data across data sets i=1,2 is as follows:

$$y_i = X_i\beta_i + X_i\theta_i + \varepsilon_i, \qquad \varepsilon_i \sim N(0, \sigma_i^2 I) \tag{5}$$

where the β_i are the true parameters and θ_i is a bias vector due to the statistical pathologies of the data. From this specification, extreme multicollinearity clearly exists. Nevertheless, Leamer shows that the informational deficiencies of the underidentified model can be overcome with prior information. He assumes that $\theta_i \sim N(0, V_i)$ and resorts to the random coefficients model given by

$$\begin{bmatrix}\beta_1\\ \beta_2\end{bmatrix} \sim N\left(\begin{bmatrix}p\\ p\end{bmatrix}, \begin{bmatrix}U & \rho U\\ \rho U & U\end{bmatrix}\right) \tag{6}$$

where p is the most likely common structural parameter vector and U measures departures from this vector. Leamer notes that this parameterization conveniently allows a relative lack of information about β but confidence that the difference between β_1 and β_2 is small (i.e., for large U and ρ near unity).

The prior covariance matrix for the model in Eq. (5) is then given by

$$V = Var\begin{bmatrix}\beta_1\\ \beta_2\\ \theta 1\\ \theta 2\end{bmatrix} = \begin{bmatrix}U & \rho U & 0 & 0\\ \rho U & U & 0 & 0\\ 0 & 0 & V_1 & 0\\ 0 & 0 & 0 & V_2\end{bmatrix} \tag{7}$$

Still, depending on the number of variables in the vector X, this can represent a daunting number of unknown parameters about which prior values must be asserted. The number of prior parameters can be reduced substantially by adopting the constraint $V_i = \lambda_i U$ where λ_i measures the relative importance of experimental contamination (i.e., a high value of λ_i means that the investigator wishes to discount the information in that sample).

The number of prior parameters can be further reduced by making U = $\delta^2 U_0$, where U_0 is the prior on the amount of noise in each of the β_i vectors. δ is then interpreted as the "discount rate" on the prior variances. With these simplifications (for greater tractability), the researcher now needs to specify priors only for the vector p and the matrix U, as well as the scalars δ, ρ, λ_1, and λ_2 (in the two-sample case).

The innovations in Leamer's approach (despite the current estimator being demonstrated only for the OLS context) include the following:

- specifying a general&d random coefficients model for combining information;
- incorporating errors-in-variables concerns and other pathologies, which allow assumptions about the extent of these pathologies to differ across samples; and
- adhering to the desirable Bayesian econometric paradigm.

Conceptually, this approach has much to offer benefits transfer research. It formalizes explicitly what we all do while searching for "relevant" studies to be used for benefits transfer. Consider the λ_i (unreliability) parameters. The larger λ_i is, the less weight is put on sample i's results in averaging its information with the prior. By discarding studies, we implicitly assume that λ_i goes to infinity; by using a study, we implicitly assume that λ_i goes to zero. A better strategy would be to use expert judgment about the qualities of different studies (and their relevance) to assign

$0 < \lambda_i < \infty$ appropriately for each study. Leamer's conceptualization forces us to reveal our assumptions explicitly and allows for intermediate values of the λ_i parameters, rather than limiting them to the extremes of zero or infinity.

It will be some time yet before Learner's OLS procedures are adapted to MLE contexts and then to RUM parameter estimation tasks. The computer algorithms are complicated even in the context of OLS. However, Leamer offers benefits transfer theorists and practitioners something to strive for. His insights could lead to some very useful dissertation work in the hands of an environmental econometrician. The benefits transfer literature directly needs statistical methodologies that force practitioners to be specific about their priors overall (as on p and U) and their priors as they embark on the blending of multiple sources of information (namely δ, ρ, and the λ_i's).

NATIONAL RESEARCH COUNCIL REPORT ON CI

A subcommittee of the National Research Council recently convened a panel to study and report on "Statistical Issues and Opportunities for Research in the Combination of Information" (Gaver et al., 1992). This report has just recently been completed, and almost all of its findings are relevant to the discussion at the AERE benefits transfer workshop.[6] The practice of combining information apparently takes place in almost every quantitative discipline with important lessons being learned at different rates by different groups. The terminology varies across fields. For example, it is called "data fusion" in the defense industry and "meta-analysis" in several social sciences. The report provides a wealth of information and insight into research opportunities by examining a broad range of case studies in different disciplines.

Because the report will be readily available, this paper merely summarizes and paraphrases its main conclusions, many of which echo the sentiments of the different teams working on case studies at the AERE workshop. (The quotes in the following points are drawn from the conclusions section of Gaver et al., 1992).

- "Authors and journal editors should attempt to raise the level of quantitative explicitness in the reporting of research findings." Documenting data and models is a clear necessity for improved benefits transfer exercises. Ideally, all study sample data would be freely available, allowing the widest variety of transfer techniques, including re-weighting.

- "CI based only on P-values should be avoided in favor of estimates of quantities of direct decision-making relevance, together with uncertainty estimates." The crudest methods of CI across studies will ascertain whether a particular explanatory variable is

[6] I am grateful to David Draper (of RAND and UCLA) for providing a preliminary copy of this report.

a significant determinant of the outcome variable and allow these results to be "ballots" in a vote on whether the variable explains the outcome. Slightly more sophisticated methods use the unit-free prob-value (or P-value) associated with the coefficient on the crucial variable in different studies, averaging these continuous quantities, possibly with sample-size weights, to ascertain the overall judgment of whether the variable explains the outcome. This recommendation advocates that significance or nonsignificance is not the important issue; rather, the *magnitude of the effect* of the variable on outcome ought to receive the attention in CI exercises.

- "It is worth investigating the costs and benefits associated with going beyond numerical summaries to data registries or archives (for both published and unpublished studies)." This issue is addressed by David's (1992) paper on data accessibility.

- "Increase the explicitness in the formulation of models that express judgments about how information sources to be combined (subjects, variables, research studies, bodies of expert opinion) are similar (exchangeable) and how they differ." This point corresponds directly to the advances offered in the paper by Leamer (1991) outlined in the previous section.

- "The practice of CI could benefit from increased use of sensitivity analysis and predictive validation."

- "Hierarchical statistical models are a useful framework for CI. Use in fields where they are not yet routinely employed is to be encouraged, as is an increase in the coverage of such models in intermediate and advanced statistics courses." Econometricians do not routinely teach or use these methods, but these methods merit close scrutiny for application to benefits transfer.

- "CI modeling could be improved by increased use of random effects models in preference to the current default of fixed effects." This terminology is somewhat confusing to econometricians.[7] Translated, this recommendation advocates random coefficients models, rather than the more familiar nonrandom coefficients models. "At a minimum, we believe that researchers will often find it useful to perform a sensitivity analysis in which both kinds of models are fit, and the substantive conclusions from the two approaches are compared."

- Researchers need a "general-purpose computing package allowing researchers to perform *interactive Bayesian analysis* in hierarchical models in a routine manner." Leamer has advocated interactive Bayesian software, but these algorithms clearly need to be enhanced and disseminated more broadly.

- More meta-analysis should be undertaken. Researchers need to do "more work on the design of meta-analyses and related CI exercises" and pay "increased attention to alternative analytic approaches."

- "Workers using CI procedures. . ." in benefits transfer would profit from a study of CI methods used in other fields, and funding agencies should give a higher priority to "cross-disciplinary conferences on methods for combining information."

[7] **It is used differently in the econometric analysis of panel data.**

THE PUBLIC GOODS NATURE OF WELL-DOCUMENTED DATA SETS

Well-documented data sets in general machine-readable form are a valuable public good. They are rarely available because the private costs to researchers of providing the data almost always outweigh private benefits. Journals are now making an effort to internalize some of these costs by requiring either that the data be available or that they be supplied on diskette when the paper is submitted for review.

In addition, establishing competitively allocated resources to support post-study data documentation and archiving for future benefits transfer exercises would be very useful to these exercises. This program would have to be on-going, selecting only those data sets each year that clearly have promise for future use in transfer exercises by other researchers. The incremental cost of cleaning up and annotating a data set for public consumption rises quickly with the time elapsed since completion of the original study. But in many cases, the incremental cost to the research team of retaining a research assistant for an additional month after completing the main project is relatively small (at least compared to the cost of going back to the data after several years have passed or of collecting new data).

In many cases, the research team responsible for collecting and processing the data set will have a proprietary interest in using that data for a set of studies before they become widely available to everyone. We must acknowledge that the compensation for much contract work is often taken (by academics) in the form of future publications employing the data made available by the original survey study. In these cases, proprietary interest might be a negotiable item in a proposal for incremental data documentation funding. The research team could include a time limit within which the delivered cleaned-up data would not be disseminated to other users. This time limit would allow the documentation phase to proceed in a timely fashion without the possible cost to the original research team of lost proprietary rights to the data conferred implicitly by unintelligible or nonexistent documentation.

CONCLUSIONS

Benefits transfer, a widespread practice that has been ongoing, will continue to take place. In the face of tightening budgets, the need for “off the shelf” estimates of economic-environmental benefits for policy and litigation will continue to increase. Therefore formulating and promulgating a set of guidelines for these exercises ate valuable endeavors. These guidelines could he similar to the accepted standards for antitrust litigation. Without such protocols, highly varying standards of accuracy might implicitly be applied in different cases.

Workshop participants did not expect to produce a completed set of such protocols, and they did not. However, the participants seemed to experience a collective "consciousness-raising" concerning the problems of benefits transfer. The opportunity for each group to conduct an intensive post-mortem on a particular benefits transfer case emphasized the common problems; the summary presentations allowed each group to articulate its own unique findings for the benefit of members of other groups. At a minimum, all participants left the workshop with a greater appreciation for the enormity of the challenge.

This area is ripe for productive applied research in this area. The subject of benefits transfer protocols may be less glamorous than alternative theoretical topics in the area of environmental economics. "Publication bias" favors new research on new topics, rather than pragmatic issues such as benefits transfer. However, the workshop highlighted the scope of applicability of research on the problem. In terms of influencing potentially huge reallocations of society's resources through policy making or litigation, the benefits transfer research has profound relevance.

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BENEFIT TRANSFER AND SOCIAL COSTING

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ABSTRACT

Increasing demand for benefit analyses that are too comprehensive for original research to be feasible and static or falling research budgets put a high value on the wise use of existing benefit studies to estimate benefits associated with new policies and problems. In this paper I define the sources of the increased demand for benefit analyses, identify the types of benefits most useful to benefit transfer now, examine the protocols for conducting benefit transfers, and suggest a future research agenda.

Interest in developing and applying techniques for benefit transfer is growing rapidly. Benefit transfer is the application of original damage or benefit studies made in a given policy context and location (what Desvousges, Naughton, and Parsons [1992] refer to as a *policy site)* to another context and/or location (what these authors refer to as a *study site).* Burgeoning demand for benefit analyses that are too comprehensive for original research to be feasible together with static or falling research budgets put a premium on the wise use of existing benefits studies to estimate benefits associated with new policies, problems, or simply new locations. The idea of designing future original research to enhance the reliability of benefit transfers presents particularly interesting challenges.

This paper has three purposes: to delineate the sources of this burgeoning demand, with particularly attention to the movement led by Public Utility Commissions (PUCs) to incorporate all of the externalities of electricity generation into utility decision making; to identify the types of benefits that are most amenable to benefit transfer now; and to examine protocols for conducting benefit transfers and suggest a future research agenda to make benefit transfers easier, reliable, and more consistent with welfare economics.

SOURCES OF DEMAND FOR BENEFIT TRANSFER

Since environmental and natural resource economics began as a discipline in the early 1970s, the primary demand for analyzing the benefits of environmental improvement came from U.S. government agencies interested in establishing "unit-day" recreation values for evaluating projects and policies affecting water resources and from agencies needing to comply with E.O. 12291, which mandates benefit -cost analyses for all "major" regulations. These needs translated into research budgets for original research in estimating policy-related environmental benefits, while also giving rise to using the original research results in what we would now label “benefit

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transfer" exercises to comply with the Executive Order. One of the most visible and successful of these secondary studies was EPA's benefit-cost analysis of the lead-phasedown regulations (U.S. Environmental Protection Agency, 1985), which used original benefit studies to provide estimates of the value of statistical lives and values of avoiding a variety of acute health effects to argue that the phasedown made economic sense.

More recently, passage of the CERCLA (Superfund) law has propelled interest in benefit transfer and resulted in the embodiment of this concept in the Type A natural resource damage assessment model (now being updated), which estimates damages to recreational and commercial fishing from a given type and size of oil spill in a given location using existing literature (see Jones, 1992).

But each of these needs is relatively narrow, involving damage to, at most, a few nonmarket commodities and usually by only one cause (e.g., lead or an oil spill). The limited scope of these demands sets them apart from the newest demand for benefit transfers-that of state PUCs who wish to formally introduce estimates of the external costs of alternative means for generating electricity into utility decision making. All externalities associated with the fuel cycle supporting each generation technology need to be addressed. For the coal cycle, this means addressing externalities from acid mine drainage to environmental effects of air emissions at the generation stage. Some 29 states are considering or requiring that the planning for new investments accounts for residual environmental damages from alternative generation technologies (Cohen et al., 1990).

Unfortunately, but not surprisingly, no original studies provide comprehensive estimates of these **damages;**[1] even imagining how an original study would be conducted, assuming that the money to pay for it could be found, is difficult. Even if some studies of this type were conducted, the location specificity of environmental damages (i.e., their sensitivity to the location of the new power-plant, irrespective of the technology creating these damages) would still necessitate using techniques for transferring the comprehensive results of these studies to the *study site.* Thus, assuming that states are prepared to implement social costing, researchers must devise and codify methods for consistently using benefit transfer techniques to estimate

[1] Ottinger et al. (1990), like other work in this area, use crude benefit transfer to estimate damages and ignore the location-specificity of impacts. Other comprehensive estimates of the external costs of electricity use abatement costs as a proxy damage (Bernow, Biewald, and Marron, 1991).

incremental damages in each state as well as across different potential power plant sites within a state.

Major on-going studies are already codifying benefit transfer techniques but without carefully considering the models they are using. The U.S. Department of Energy (DOE) is funding a study conducted by Oak Ridge National Lab and Resources for the Future that is designed to develop methods and estimate the externalities from alternative fuel cycles used in generating electricity at two "reference environments." No original research is in the work plan; rather benefit transfer (as well as health, biological, and meteorological science transfer) is to be used to the fullest extent possible in the context of a damage function approach.[2] Economists, engineers, and natural scientists in Europe, with funding from the European Community, are following the identical work plan and methods while sharing some of the research effort to estimate comparable externalities for potential power plant sites in Europe.

New York State is funding Hagler, Bailly to do a more ambitious external costing study that builds on the DOE research to develop a computer model for utilities to use in estimating the external costs associated with any proposed new capacity expansion. In addition, smaller studies with similar objectives are on-going in Wisconsin (Research Triangle Institute) and California (National Economic Research Associates and Regional Economic Research, Inc.). For the most part, each of these studies, facing the enormity of their tasks, which take in virtually all the benefit estimation literature, is primarily assembling and evaluating literature to provide any estimates of damage, without paying much attention to theoretical prerogatives and constraints discussed at the workshop.

A final, potentially major source of demand for benefit transfers comes from international aid organizations such as the World Bank and the U.S. Agency for International Development. These groups are responsible for capturing the environmental effects of their lending in developing countries, but with very few exceptions (Whittington et al., 1989), no original studies of the benefits of environmental improvements in these countries exist. Here, protocols for benefit transfer that take into account different personal and market characteristics are

2. At the valuations stage, this approach involves monetizing impacts (e.g., acute health effects) rather than monetizing changes in environmental quality, implicitly including impacts, to the extent that individuals are aware of them. The latter type of study-for example, a hedonic property value study-is problematic for a benefits transfer for social costing purposes because the absolute and relative magnitudes of environmental changes associated with a power plant or an entire fuel cycle will, in general, be quite different for the pollutants generally examined by property value studies (air pollutant concentrations), and the complex of changes is much broader. The damage function approach is not without its problems, however, because this approach cannot capture WTP of those who avoid impacts. We may say that the damage function approach is good for identifying WTP in the short run (e.g., for effects caused by air pollution and other effects where avoidance behavior may not be pervasive) but not in the long-run, where avoidance opportunities, such as residential location decisions, are more viable and available.

particularly important, as differences in incomes, institutions cultures, climate, and resources, for example, are surely far larger between a developed and developing country than among states in the U.S. (in the case of social costing of electricity). The existence of widespread subsidies on energy and other commodities greatly distorts relative prices, adding the identification of shadow prices to the long list of challenges to benefit transfer.

Researchers even debate whether benefit transfer is legitimate for certain types of nonmarket commodities affected by programs in developing countries. The basic tenet of individual sovereignty underlying benefit estimation may not be applicable in societies that emphasize group welfare. And the profound influence of poverty in developing countries on willingness to pay raises questions about whether any benefit transfer technique involving U.S. income elasticities of demand can be justified.

WHICH BENEFITS CAN BE TRANSFERRED NOW?

Benefits can be characterized into four groups by their effects on the following: health, output, economic assets, and environmental assets-with my subjective ratings on the ease with which benefit transfers can be conducted, given the existing state of the original research literature, the characteristics of the commodity being valued (e.g., its dependence on personal characteristics, site and regional characteristics, and extent of the market questions), and the degree of codification of the literature for benefit transfer. The perspective in making these judgments is that of the PUC evaluating the methods used to provide estimates of social costs. It is recognized that the scope of the task requires some degree of “quick and dirty” analysis, rather than the courtroom-proof reliability of natural resource damage assessment estimates.

Two of the four categories can be pretty much ignored: damage to output and to economic assets. Damages to output, for example crop damage from air pollution or damages to commercial fishing from a spill, are easy enough to estimate using original research and gathering market price and supply and demand elasticities, for example, for the products, as warranted. On the other hand, damages to economic assets cannot reliably be estimated in original studies, let alone in a benefit transfer. Materials inventories are still lacking, and no major modeling efforts for valuing the complex behavioral linkages necessary for a defensible materials benefit estimate have been undertaken in many years.

Probably the health effects category is the easiest for making credible benefit transfers. Once atmospheric or other natural processes are taken into account (e.g., when estimating the effect of reduced emissions on ambient, air quality), the researcher can presume to a first approximation, that the health effects the values people place on avoiding these effects are reasonably similar across locations. The extent of the market is clear: people living in the air basin in which the postulated air quality change occurs.

Codification has proceeded for many years. Estimates of the value of a statistical life taken from summary reviews and specific studies are widely used, multiplied by expected deaths "delayed" to obtain the mortality benefits from a particular program, investment, or other exogenous change in baseline conditions. A similar protocol is followed in using the literature on the values of avoiding acute health effects to estimate the benefits of baseline pollution reductions (see Hall et al., 1989; Krupnick and Portney, 1991; and National Economic Research Associates, 1990) for benefit transfer studies for improving air quality in Los Angeles that include estimates of mortality and morbidity benefits). Indeed, "spreadsheet" models are available that first match estimates of changes in air pollution concentrations to dose-response functions for a wide variety of health effects and then match these to unit values for avoiding these effects to obtain health benefit estimates for environmental improvements.

Yet, the benefit transfers are of the crudest type: they use unit values and unaided judgment to combine the different values obtained from the literature. Few of the spreadsheets use valuation functions in the benefit transfer, for example, of the kind arising from regression analysis explaining variation in willingness-to-pay (WTP) responses. The methods for establishing error bounds and best estimates are *ad hoc* and heterogeneous across benefit transfer studies.

The original studies do not always lend themselves to transfers. Virtually the entire mortality risk valuation literature addresses accidental deaths in prime-age adults, a setting inappropriate for all environmental mortality except perhaps accidental toxic waste releases and similar catastrophes. One study (Mitchell and Carson, 1986) addresses the latency issue so important to valuing deaths due to cancer but is silent on the effect of prior health status and age on valuation. These issues are important in environmentally related deaths to those with heart disease and chronic lung disease. Further, researchers trying to use this study to value noncancer related deaths may find that it postulated risk changes outside the risk changes associated with power plant emissions. Also no reliable studies are available to value life-years saved (except in occupational accidents) even though this health endpoint can be estimated by health scientists.

The most problematic area for benefit transfer is damage to environmental assets, although there is some differentiation among these subcategories. Benefit transfer of recreation values or demand functions presents one of the greatest challenges. Accounting for regional factors (such as the range and quality of substitute sites) and site-specific factors (such as congestion) is likely to be difficult. Furthermore no acceptable procedures exist for determining the “spatial extent of the market.” That is, debate is still lively on methods for determining the size of the population that would be or is affected by a recreation quality or quantity change.

Codification of the chain of effects from concentration change to valuation is absent, with the exception of the Type A model noted above. Because benefit transfers have generally followed the procedure of using unit-day values, these values exist in great profusion for all types of uses and environments (Walsh, Johnson, and McKean, 1988). But applying these values to specific sites is problematic, more so than applying unit values to health because of the presumption that WTP to avoid health effects is less influenced by region and site variables than WTP for recreation. Codification of recreational fishing damages from oil spills in the Type A model represents a useful prototype for the future development of portable, PC-based models for use in benefit transfer. However, this particular model uses a unit-day value approach for the valuation step.

Likewise, the recreation literature is of somewhat limited usefulness in estimating social costs because the majority of the literature focuses on changes in the availability of resources not on changes in their quality. Few studies incorporate explanatory variables that map back into readily measured physical quantities, such as water turbidity, nutrient concentrations, and the like. Most of the literature values catch rate changes.

Benefit transfer for valuing visibility also presents formidable challenges because of the sensitivity of values to region, site, and personal characteristics. Characterizing the policy and study site is particularly difficult for visibility benefit transfers. Although visual range can be characterized in a relatively straightforward way, the vista being affected is particularly difficult to characterize, beyond “urban," "rural" and “recreational area,” which is unlikely to be sufficient. In addition, the extent of the market problem is even more difficult than that for recreation because “use” as a function of distance to the site can be observed for recreation, but not for some visibility problems (e.g., urban visibility).

The literature on visibility benefits is fairly conducive to benefit transfer (see Chestnut and Rowe, 1992). Studies of visibility values in multiple cities (Tolley et al., 1988) are available, which then permit examination of city-specific factors effecting values and derivation of functional relationships to predict WTP, given the baseline visual range and the size of the change (National Acid Precipitation Assessment Program, 1989). A number of examples of benefit transfers involving visibility (Rowe, Chestnut, and Skumanich, 1990; Chestnut and Rowe, 1988) are available. The Electric Power Research Institute (EPRI) (1991), which examines benefits its from improved visibility in the eastern U.S. from reductions in SO_2 emissions. is a particularly good example of a benefit transfer where all the steps of the damage function approach were linked together (i.e., emissions to concentrations, concentrations to optics, optics to perceptions, and perceptions to value).

The major problem with benefit transfer in this category is the original studies. Significant debate surrounds protocols for eliciting values in contingent valuation studies. For example, the size of photographs shown to respondents appears to influence WTP. Concerns about joint valuation of visibility and health (i.e., that visibility is used as a proxy for health effects) and about embedding are also important. From the perspective of the social costs of electricity issues, research efforts have concentrated too much on national parks in the southwest and nut enough on valuing visibility effects at more mundane locations, both rural and urban.[3]

The literature on nonuse values for environmental assets clearly cannot yet support benefit transfers associated with social costing of electricity, because most of the studies are for non-marginal changes in unique environments (species extinction, loss of an ecosystem) while the effects of a single power plant on *any* species or ecosystem is likely to be small and on unique areas or species (after compliance with the Endangered Species Act and other federal legislation) negligible. An exception might be nonuse values for visibility at national parks, such as the Grand Canyon, associated with power plant emissions (Decisions Focus, Inc., 1990).

Admitting nonuse values into the benefit transfer exercise has the potential for complicating matters enormously. For instance, in the presence of altruism about people's health, the "extent of the market" issue, which is so easy to dismiss when researchers are considering only "use" values, must be addressed anew.

For social costing of electricity, the bottom line is that environmental benefit transfers are most feasible and reasonable for the health benefit category (although some serious problems remain) and are not needed for crop damage estimation. Recreation damage estimation associated with a new power plant is, generally, beyond our abilities, not because the economics isn't up to it but because of gaps in the science and the lack of baseline recreation participation information specific to reference environments of interest. Visibility damages fail for similar reasons-scientific linkages between emissions and changes in visual range are absent. Nonuse value estimation studies for marginal changes in resource quality or quantity are virtually nonexistent Given these problems, researchers must conclude that estimates of damages resulting from benefit transfers are not sufficient or reliable enough to support more than a rank

3. California cities and Denver have also been the subject of multiple benefit studies.

ordering of new generation technology options on the basis of social costs. That is, reliance on benefit transfers to support social cost dispatch or social cost pricing of electricity is probably pushing benefit transfer (and original study) techniques beyond their capabilities.

PROTOCOLS

Researchers confronting the need to estimate the benefits of environmental improvements but who, for one reason or another, cannot conduct original research to estimate such benefits, currently either must rely on simplistic protocols for conducting their benefit transfer study or find no guidance, except from what they can glean from other examples of benefit transfers. For instance, the U.S. Forest Service sanctions the use of "unit-day values" for estimating recreation benefits. But such values are averages over a wide range of site characteristics and policy scenarios (most examining the value of recreation at a site rather the change in value associated with a change in site quality) that may be inappropriate for the *study site.*

Reliance on existing benefit transfer studies is also risky because such studies are not designed for educating the practitioner on how a reasonable benefit transfer should he (or was) done, making communication about such protocols dependent on the often haphazard and incomplete reporting of such procedures. Further, as different benefit transfer studies use different protocols, the researcher is left with the task of sorting them out. This task should be a subject of a generalizable research effort not reinvented every time by each researcher.

The papers published in *Water Resources Research* as well as the participants in the workshop are in close agreement on general protocols for using existing studies, so I do not need to recount them in detail here. The care and effort used in conducting a benefit transfer-indeed. whether researchers should attempt it at all-depend on the commodity being valued; differences in regional, site, and personal characteristics; and the nature of the original literature being relied on for the benefit transfer. Given that a benefit transfer is called for, much emphasis is placed on using demand or value functions where possible, as opposed to using average unit values-be they for a day of recreation or a day of coughing avoided. Using the function approach puts some additional burden on the researcher (data must be gathered on the variables at the *study site* found, by the original study to affect WTP, for instance); indeed, without careful reporting of results in the original study, this approach may be impossible.

Nevertheless, in the practical application of these broad guidelines, many choices are available with few guidelines to follow. What does the researcher do when the valuation literature is based on changes in physical effects (e.g., catch rates) but no link exists from catch rates to fish populations or changes in water quality? When the underlying science is poor, should the researcher spend much time guilding the valuation lily, knowing that the final benefit estimate is only as good as its weakest component? When all of the original valuation studies have significant problems, either in their own right or for benefit transfer, does the researcher press ahead or refuse to play? While refusal to come up with an estimate may not be an option for a benefit analysis on a single pathway (assuming the decision to begin the study embodies some judgment that some type of estimate will result), it is a real option for social costing, where many pathways will clearly be left blank. Therefore, adding one more to the list is unlikely to raise serious objections.

Protocols are perhaps most needed to guide the use of multiple studies on a given effect, each study with significant flaws, to establish a range of uncertainty. Existing practices vary widely. Take the use of symptom-day values in a benefit transfer. Three contingent valuation studies provide such values, each with significant problems, each giving values that are in a range of a *priori* plausibility. But because the values themselves are small ($2 to 20/day), small absolute differences between them can translate into large percentage differences and significant dependence of the benefit estimates on the values chosen. Some researchers average the midpoint values and obtain a range by averaging 95 percent values. Others use only midpoint values from the three studies to represent low, mid, and high estimates of unit values. Others give up and use judgment. Others go with one study judged to be the "best."

Although the above areas could benefit from analysis and codification, one particular area suggested for codification may not yield many benefits: establishing detailed criteria for evaluating original studies. Beyond stating the obvious-that studies are "good" if they are based on acceptable theory, the theory links to well done empirics, and essential results are reported-what more can we do to evaluate studies? The weighting of these criteria is the crucial element; yet weights depend on the use to which the studies will be put, the policy setting, and the skills of the researcher in getting around problems or supplementing a study with other data, for example. A premium should be placed on flexibility for the researcher to include studies felt to be most appropriate for the problem at hand; the major responsibility in return for this freedom being to document choices.

The NUSAP system (based on work by Funtowicz and Ravetz) being used for the DOE Fuel Cycle study may be a useful tool for documenting choices of studies and, in particular, the uncertainties felt by the researcher in making benefit transfers. NUSAP is an acronym for the evaluative categories in this quality and uncertainty message system (Numerical entry, Units, Spread of values, Assessment of values, and Pedigree). A separate set of entries would be used to document choices about emissions, concentrations, impacts, and monetization. Each of these elements contains subelements, ratings are given for some of the subelements, and the researcher is encouraged to provide comments explaining the ratings and any other information provided by the entries (see Table 1). The system as we use it does not involve weighting the various entries to come up with a score associated with each choice. Rather, it is used to qualify the choice for the reader or ultimate user of the benefit transfer analysis. This tool would work equally well for documenting the quality and uncertainties of a single original study as for documenting choices in the benefit transfer exercise.

RESEARCH AGENDA

To meet the demand for reliable benefit analyses based on secondary sources, major research efforts are needed. The research agenda spans the following options:

- Develop methods to make better use of existing studies in the benefit transfer process.
- Improve the quality of original studies so that the results of secondary studies will be more credible.
- Routinely include in the original study design elements to aid in benefit transfers.
- Design original research with the sole purpose of obtaining results to be used in benefit transfers.
- Develop incentives for researchers to engage in research supporting benefit transfers.

Making Better Use of Original Studies

To use original valuation studies, researchers must know about them. Many literature reviews of the benefits of environmental improvements exist, but focus varies and is generally limited to one category or subcategory. Major efforts are beginning to develop bibliographies covering the benefits analysis literature. The Environmental Protection Agency's (EPA's) bibliography is available on diskette, but it is still by no means comprehensive. Bibliographies that cut across all benefit categories are being developed in the above cited efforts associated with estimating the social costs of electricity. Efforts to standardize these databases and perhaps merge them are needed. In addition protocols for indicating where reports and other unpublished materials can be obtained are sorely needed. Once the studies are obtained, protocols for their use in a benefit transfer are needed but currently do not exist, as noted above.

Original studies can also be more efficiently used to the extent that their results can be combined into either a meta-analysis or, if the original data can be obtained, into new analyses on the combined samples. Such analyses could, in theory, estimate values or functions that eliminate (or at least reduce) the need for *ad hoc* consideration of multiple studies for

TABLE 1. NUSAP DATA ENTRY FORM EXPLANATION

N: Enter the number, notation, variable name, or note about practice.

U: 1. Enter the measure for the number, upper and lower bound, or variable (e.g., pounds). Also enter the time period for the entry (e.g., per hour).

2. Enter the statistic which the number or variable is (e.g., mean, median, no distribution).

S: 1. Enter the degree of confidence of the spread. Use 90 percent whenever possible for standardization.

2. Enter the upper and lower bound or ± % range, ± standard deviations, or factor of variation of the spread.

A: Enter the assessment ratings for each applicable category (i.e., H, M, or L). Enter N/A for not applicable.

I_1: Assess the informative value based on spread. That is, assess the extent to which the entry narrows the spread of plausible values over what was known before the study that produced the entry was conducted (prior).

- L: Many prior plausible values exist in spread.
- M: Spread is a fair amount narrower than range of prior plausible values.
- H: Spread is much narrower than range of prior plausible values.

I_2: Assess the informative value based on the foreseen application for the entry. That is. how informative are the results of calculations with this entry expected to be given the current persisting (posterior) uncertainty about the entry. (I_2 here is a first guess, to be refined when the particular application is considered.)

- L: The existence of other posterior plausible values (i.e., values in spread) matters for application.
- M: The existence of other posterior plausible values matters marginally.
- H: The existence of other posterior plausible values does not matter.

G: Assess the generalizability of the entry to other applications, locations, or sample spaces different from the application for which it was originally generated.

- L: does not generalize to other applications
- M: can be generalized with limitations
- H: easily generalized

R: Assess the entry's robustness over time.

- L: highly perishable
- M: moderately perishable
- H: time independent

(continued)

TABLE 1. NUSAP DATA ENTRY FORM EXPLANATION (CONTINUED)

<u>P</u>: Enter the pedigree ratings for the applicable categories (i.e., 1 to 5). Enter N/A for any inapplicable pedigree category.

T: Assess the theoretical basis of the entry and the tenability of the theory's application to produce the entry.

1: no theory or concepts
2: weak theory or concepts, controversial empirical support
3: weak theory, good empirical support
4: good theory, but one of competing theories
5: well-understood and accepted theory

D: Assess the quality of the data inputs used to generate the entry.

1: unacceptable
2: poor
3: fair
4: good
5: excellent

E: Assess the estimation methods used to generate the entry.

1: unacceptable
2: poor
3: fair
4: good
5: excellent

M: Assess the estimation metric (i.e., proxy or indicator for what we want to measure.)

1: unacceptable
2: poor
3: fair
4: good
5: excellent

Comments: Enter any comments about the NUSAP categories. The level of spread may require explanation such as "conidence level corresponds to +/-2 standard errors corresponding to multiplication or division by a factor of 1.7 for the upper and lower bound." The reasons why assessment ratings and pedigree rating were received should be explained here.

establishing error bounds. Smith and Kaoru (1990) performed one of the first meta-analyses of the environmental benefits literature analyzing 77 studies of recreation demand. Nevertheless, because the authors purpose was to see if methodological choices made a difference in value rather than to explain differences for reasons of site, regional, or personal characteristics, this study is not particularly useful for a benefit transfer.

These approaches need not be confined to the valuation step. Morton and Krupnick (1988) obtained original data on ozone dose-response studies conducted in four laboratories. By combining the samples and accounting for differences in protocols, the authors were able to estimate a composite dose-response function for use in EPA's ozone Regulatory Impact Analysis.

Although researchers should not be overly optimistic that data or uncited reports underlying previously published benefit studies are available and researchers are willing to part with them, an effort to collect (for payment) and analyze old but useful databases and reports could pay off, particularly for studies that did not estimate or report on variables or analyses capturing mediating factors on WTP. Contingent valuation studies that report central tendency WTP values but not regression results explaining these values or studies that use linear functional forms that result in mediating factors dropping out for marginal valuation would be good candidates, provided data on mediating factors were collected in the first place.

Improve the Quality of Original Studies

Undoubtedly better original studies will make for more credible benefit transfers. In the context of social costing, a "better" study is one that makes explicit linkages between its valuation starting point and the science endpoint. The case of recreation quality change is the classic case, where much of the recreation literature uses “catch rate” as a starting point, while the scientific literature ends with water quality changes or changes in fish populations. Only the NAPAP studies (Englin et al., 1991) explicitly account for all of the linkages, from emissions to concentrations to impacts to values, in its analysis of the recreational benefits of SO_2 emissions reductions. In the contingent valuation literature, a study that makes very clear the commodity being valued is not only a better study than one that is unclear about the commodity, but the former is likely to make for a more reliable benefit transfer.

As I noted in several places above, improvements in protocols for natural science studies are needed if benefit transfers are to be broadly successful. Better protocols would include designing endpoints for the studies that map into economic starting points. For instance. in the health area, much of the literature on the acute effects of air pollution measures lung function, primarily because it is easy to measure and is "scientific." However, no one values a change in lung function: people need to know what this means in terms of their everyday health. A focus on symptoms effects is an improvement.

Change Original Study Reporting/Designs for Use in Benefit Transfer

If researchers engaged in original benefit analysis would consider how the results of their study will be used, other researchers would benefit enormously. At a minimum, reporting of results would be affected. Many articles omit mean values for independent variables and the equations used to estimate changes in consumer surplus, but this type of information would help enormously in a sophisticated benefit transfer exercise. Even if journal space limitations preclude publishing such information, journals such *as* the *Journal of Environmental Economics and Management (JEEM)* could require that a diskette with the data and/or key regression results (if these are unpublished) be submitted as a condition for publication. Or EPA could monitor article publication and request such data.

Studies' designs could also change, focusing much more on site, region, and person-specific variables that might influence valuations and using functional forms or interactive terms that permit examining confounding factors on marginal valuations. In addition, most studies examine the benefits of environmental improvements rather than the WTP to avoid further environmental degradation. The former is certainly more germane to analyses supporting environmental policy analyses. But, for social costing, the premise is that the environment will worsen, at least in some dimensions (absent tradable permit programs, for instance). In general, we have no reason to expect that the benefits of a given environmental or health improvement are equal but opposite in sign to the damages from an equivalent decrement in environmental quality or health.

Conduct Major Benefits Studies for Use in Benefit Transfers

Because commodity characteristics and regional, site, and personal characteristics are likely, a *priori*, to affect WTP, designing studies from the bottom up would be helpful to capture these differences, investigate which factors matter most, and report results to facilitate benefit transfer.

For instance, in the health area, valuation studies that provide estimates of WTP for reductions in premature mortality risks of the type associated with environmental exposures-presence of latency periods, effects on the elderly and the very young. allowance for values to differ by cause of death, for instance-would reduce reliance on the largely inappropriate accidental death hedonic wage/contigent valuation literature. The effects of age and sex on such values are particularly important to establish. Work on estimating WTP for life-years saved directly would supplant the *ad hoc* approaches currently used to modify the current average lifetime valuation literature in benefit transfer exercises.

Morbidity studies, primarily using contingent valuation, are out-of-date and not risk-based. Changes in health risks are often so small that the approach of calculating number of days of effects and multiplying by a unit value per certain day of effect may seriously mislead researchers. In addition, most studies seek values for single symptoms of types of effects rather than illness complexes or episodes. Studies that provide values on the latter would help in aggregating values over multiple acute health effects, although the health science literature provides little guidance as yet on the relationship between health episodes and air pollution.[4] Taking a broader view, studies that seek WTP estimates for a multiple set of effects, such as acute and chronic effects of chronic disease and mortality risks (while being explicit on the effect being valued, unlike property value studies), would also aid benefit transfer, while obviously being important in their own right.

In the recreation area a promising, if expensive, approach would be to conduct national studies of recreation benefits from site-quality changes that consider as much as possible regional differences in site availability and baseline site qualities, as well as the relevant personal characteristic variables with a regional dimension (such as recreator experience). Recreation benefit analysis has a tradition of examining the benefits of large changes in quality, for example an improvement in stream quality from fishable to swimmable. Such analyses have their uses, but the changes in quality associated with social costing of electricity are much smaller than this.

Continuing the pioneering work of NAPAP researchers on the linkages between pollution concentrations and changes in catch rates and the generalization, of this work into portable computer models would also greatly facilitate benefit transfers in involving this category of benefits.

Develop Researcher Incentives

Professional academic economists will not conduct benefit transfers or go out of their way to make their work more helpful and accessible for others to conduct benefit transfers unless it is in their interest to do so. Professional journals put a premium on original research and, as in any other endeavor, opportunity costs and risks of preemption of making data available may be seen as large. Participants at the workshop recommended developing a new peer-reviewed

[4] A new study by Resources for the Future is taking this tact in its epiderniological analysis of panel data on a sample of Taiwanese.

journal for presenting benefit transfer results and methods. Making additional funds available to increase the usefulness and accessibility of contract and grant-based research to the broader research community would obviously help in inducing cooperation. However, for this strategy to work, government needs to have in place a system for accepting data, unpublished reports, and unpublished results for easy cataloging, retrieval, and use.

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