United States
Environmental Protection
Agency

Policy, Planning,
And Evaluation
(PM-221)

EPA 230-R-93-018
April 1993

EPA

Benefits Transfer

Procedures, Problems, And Research Needs

Printed on Recycled Paper

Benefits Transfer: Procedures, Problems, and Research Needs

1992 Association of Environmental and Resource Economists Workshop

Snowbird, Utah

June 3 - 5, 1992

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FOREWORD

The 1992 Association of Environmental and Resource Economists (AERE) Workshop was the third in a series of important recent activities related to benefits transfer. In November 1992 the National Oceanic and Atmospheric Administration (NOAA) hosted a workshop directed toward developing databases to support benefits transfers. The U. S. Environmental Protection Agency (EPA) has taken a key first step in this development by compiling a bibliography of their environmental benefits studies (see Appendix A). In March 1992 a special section of *Water Resources Research* was dedicated to papers addressing issues related to benefits transfer. The AERE workshop sought to expand on this base by addressing questions related to the adequacy of existing methods and valuation studies for performing benefits transfer and by identifying the research needed to enhance benefits transfers.

Appreciation is extended to the workshop sponsors-EPA, NOAA, and U.S. Department of Agriculture's Economic Research Service-for their continuing support of the workshop series and for this workshop in particular.

"Benefits transfer" is the use of information from existing nonmarket valuation studies to develop value estimates for another valuation problem. It can reduce both the calendar time and resources needed to develop original estimates of values for environmental commodities. These estimates are used to evaluate the attractiveness of potential governmental policies, to assess the value of policies implemented in the past, and to identify the compensation required under CERCLA when toxic substances, such as oil or PCBs, are released to the environment.

Benefits transfer is not new. In any ex ante studies of policy options, researchers must transfer information from other times and places to the present question. The policy researcher straddles two points in time-the past and the future-attempting to apply experience from the past to a future situation. For example, the economist evaluating the likely effects of a possible minimum wage increase on employment must draw on previously conducted research to forecast the effects of the specific policy under consideration. This research may have analyzed a "natural experiment" in a past setting. From this research the economist may conclude that a 10 percent increase in the minimum wage above the equilibrium wage caused employment to fall 5 percent in the affected labor markets. The economist offering advice on the specific policy under consideration may use this information to forecast that the same (a lesser or greater) effect is expected this time because the present situation is like (unlike) the past

For hypothesis testing purposes, frequently only the sign of the variable(s) of interest is critical for supporting a theory. But for policy analyses the magnitude of the effect is critical

Indeed in formal benefit-cost analysis, quantification is virtually the sine non qua. Benefits transfer provides a means of economically obtaining these magnitudes. However, the process of benefits transfer is complex, and a “science“ of benefits transfer does not now exist. One purpose of the workshop was to increase our awareness of the types of decisions involved in performing benefits transfer and the research needed to close some of the gaps in our knowledge.

The workshop consisted of three formal papers, six benefits transfer case study protocols. the concluding remarks of three discussants, and an after-dinner speaker who outlined the utility of an information system to support benefits transfers. The case study protocols were selected to provide a forum for evaluating the potential for conducting benefits transfer in specific applications and to identify research needs. The case study groups comprised workshop participants and a leader(s) who provided the initial case study materials to the members of the group, presented the results of the group’s discussions to the entire workshop, and wrote the final case studies presented herein.

David Brookshire in his opening remarks to the workshop observed that the question we face is not whether benefits transfers will be done but rather how. The imperative for such studies is simply too strong to resist. He highlights the complementary relationship between many of the issues the researcher must address in benefits transfer and in original nonmarket valuation studies. Furthermore, he raises questions regarding the adequacy of the existing research base to support benefits transfer applications.

Leland Deck and Lauraine Chestnut consider how good benefits estimates must be for transfer purposes. Taking a value of information approach, they look at the “market” for benefits estimates and the costs of developing them. They identify several stages in the development process, each of which represents a possible stopping point in developing benefits estimates.

Edward Morey investigates the relationship between consumer’s surplus and consumer’s surplus for a day of recreational use. Estimates of consumer’s surplus for a day of use are commonly used for benefits transfers. He shows that compensating variation per day of use is a well-defined concept for a change in the price of visiting a recreational site but is not, in general, well-defined for a change in the characteristics of a site. He identifies sufficient conditions for when it is well-defined for characteristics changes and uses simulations to demonstrate the biases from using approximations for the compensating variation.,

In the first case study, John Bergstrom and Kevin Boyle develop a protocol for estimating the value of protecting groundwater in a rural area dependent on it for its water supply. They identify several studies that provide information for their benefits transfer problem, provide a catalogue of the characteristics of these studies, and present a benefits value from the transfer process. An actual policy site study serves as a validity check on the estimates they derive through the benefits transfer process. That study supports their benefits transfer value.

Bill Desvousges and his coauthors examine the use of benefits transfer to value use damages from the Arthur Kill oil spill. Their group evaluated the adequacy of existing studies for several categories of water and wetlands use. They identify several important gaps in the data, one of the more important of which is in wetlands values-especially nonuse values for wetlands preservation/restoration.

Carol Jones describes the Department of Interior's Type A oil spill model and evaluates its adequacy for estimating the value of recreational fishing losses in a natural resources damages context. The Type A model, which provides a computerized approach to predicting the fate and effects of spills and to valuing injuries, is the major benefits transfer model for natural resource damage assessments. Her paper identifies some of the improvements to the model, especially the valuation component, that the case study participants thought would make the results more valid.

Susan Kask examines the potential for transferring health benefits estimates to a study site involving health risks from surface water contamination. She describes a theoretical model and identifies a number of factors that may influence the value estimate. She finds that a major problem with health benefits valuation is the absence of studies addressing both morbidity and mortality in a comprehensive fashion.

Mary Jo Kealy and her coauthors develop a protocol for estimating the recreational fishing benefits of reductions in acid deposition. This is an ex ante analysis because it examines the expected benefits from implementing the Clean Air Amendments of 1990 (CAAA). They base their protocol on the Deck and Chestnut staged process: each stage represents a decision point at which the researcher asks if the expected value of the benefits of the information gained from proceeding with the next stage exceeds its costs:

Lauraine Chestnut and Robert Rowe also conduct an ex ante study of the CAAA. They examine the potential to transfer previous studies of the value of visibility improvements to a study of the value of the expected reduction in regional haze in the Eastern United States. They argue for a protocol that incorporates all available information, properly weighted, and assesses the uncertainty of the results. Their group was relatively comfortable with the availability of information for their benefits transfer problem; however, they all felt the contingent valuation method could be significantly improved.

Trudy Cameron's remarks draw from the literature and from experiences outside environmental and resource economics to suggest both technical and institutional changes that would improve benefits transfers. She shows that the benefits transfer issue is not an activity unique to us; it has much in common with other efforts to develop more rigorous procedures for combining information. She addresses the issue of sample bias that may be present in original studies when applied to a policy site and suggests a procedure for reweighting the original data based on the policy site variables. She also describes a way to develop estimates from pooled data using prior information that has potential application for benefits transfer. Finally, she proposes some institutional changes that would result in improved archiving and sharing of original data sets for others to use in their research.

Alan Krupnick discusses the demand for benefits transfer studies, in particular their use for developing estimates of the external costs of electric power. He considers several types of benefits and offers his opinions on those for which the research base is strong enough to support their transfer to other contexts. He also raises some important issues regarding the value of standard protocols for documenting the choices benefits transfer practitioners make so that their choices and reasoning are clear to readers. He concludes his remarks with a suggestion for research that would improve the quality of benefits transfers.

Jim Opaluch's and Marisa Mazzotta's concluding remarks argue that a valid and reliable research base of original studies is complementary to benefits transfers. They also identify the need to provide empirical tests of benefits transfers and to develop better methods for transferring benefits estimates.

Martin David points out in his remarks that, once collected, data have many of the characteristics of a public good. A system for archiving and sharing data would promote good science, learning, and better policy analysis. He provides some suggestions for an information system based on his experience with other complex data sets.

The papers, case studies, and discussants' remarks highlighted several concerns researchers have about performing benefits transfers. The workshop participants' concerns and suggestions for a research program and some of my own are provided below.

Because benefits transfer begins with original studies many of the issues raised applied as well to them. Specifically, workshop participants were concerned that both the scope of the studies and the reporting of data, methods, and findings in both the published literature and in reports are not complete enough to perform good benefits transfers

More original studies are needed that address the human health effects of the environment. The available information on morbidity and mortality values is very limited and tends to focus on adult health and life expectancy. Additional research is also needed on the value of reducing infant and children's morbidity and mortality, including the value of reducing the risks of reduced IQ and physical effects from both the pregnant mother's exposure to environmental pollutants and the infant's or child's subsequent direct exposure. Both parents and prospective parents would probably place a high value on risk reductions in this area, but the literature provides virtually no estimates of these values.

More work is needed on specific services provided by the environment and the characterization of how the value of these services is affected by changes in the quality of the environment. Workshop participants specifically identified the need for additional studies of water resource use, including boating and beach use and wetlands values. Also the link between injury to the environment and damages needs to be clearer in both the original and benefits transfer studies. Achieving this clarity may require an expanded role for economists in the modeling of physical systems and their relationship to human activity.

Only one case study at the workshop touched on nonuse values, yet they are the most controversial component of benefits studies. Part of the reason for interest in nonuse values is clear-even a small value when multiplied by a large number of affected individuals can result in a number large enough to dwarf use values. The nonuse issue begins by asking when nonuse values are relevant and extends to both technical and policy issues. Both the values elicitation process and the extent of the "market" for nonuse values are controversial issues. More research is needed on the way nonuse values enter individuals' utility functions and on the values elicitation process.

Systematic implementation of improved benefits transfers is probably impossible without better access to well-documented data. AERE should develop a standardized protocol for documenting survey procedures used in original studies. For example, the protocol would provide information on sample sizes and selection, data coding and checking, response rates and steps taken to minimize nonresponse bias, and the treatment of outliers in the estimation phase. A completed protocol could be required for all *Journal of Environmental Economics and Management* papers submitted for review. The completed form could be attached as an appendix to papers accepted for publication; the journal editor could keep copies of the completed form, or the authors could be required to express their willingness to provide them to other researchers when so requested.

Related to the issues of documentation for both original and policy studies is the importance of providing clear definitions of the baseline quantities of resource services, of reporting value functions not just means, and of employing sensitivity analysis for key parameters when performing benefits transfers.

Many participants discussed the lack of incentives to share original data such as survey information. This problem will be hard to solve. One approach that may result in lower costs of sharing and may promote communication is to develop a standardized approach to managing survey data. Again AERE could play an important role: it could design a universal information system to provide a standard format for electronic data files for benefits studies. The system would have to be flexible enough to meet a wide range of researcher interests yet structured enough so that users unfamiliar with the details could still find their way through the data with little need to involve the original researchers. Such a system would not solve the proprietary interest that developers of the data may have, but, given their willingness to share their data, it would lower their and the recipient’s cost of that sharing.

We should consider the value of studies that replicate the work of others. Too often existing editorial policies are opposed to replication; then when the “right” signs are found, the opportunity for publishing papers confirming the results of others is very limited. But the parameter estimates are at best just that-estimates. The estimates are conditional on the institutional context and constraints impinging on the individual decision makers. A broader base of empirical studies is needed to support benefits transfer. Further research may help to develop the preponderance of evidence needed for theories to have broad acceptance.

A benefits transfer must assess the extent to which the following are “similar" between the study and policy site contexts: affected resource(s), damage(s), substitutes, and affected population. Studies will be similar in some features, different in others. How should we weight studies for use in benefits transfer, and how should we communicate those weights to our audience? Can this weighting be done objectively? Quantitatively? Meta-analysis and some of the literature cited by Trudy Cameron may be useful in addressing these questions.

Most benefits estimates have been developed in the United States and to a lesser extent in Europe. More research is needed to evaluate the extent to which these estimates are transferrable across societies where preferences, constraints, and institutions differ. Similarly, more work is needed to identify the circumstances for which intergenerational benefits transfers are appropriate and the procedures that should be used to modify current estimates to express the values and constraints appropriate for future societies.

Changes in environmental quality are likely to affect both the intensity and quality of resource use. For example, a beach with oil on it may experience reduced visits by beachgoers; however, some people may still frequent it. In both original and policy studies we should explicitly value the losses in utility for the foregone visits as well as the reduction in the value of the remaining visits.

Benefits transfers will not have the elegance of pure theory or the rigor of hypothesis testing. This method seems likely to emerge as a different science, one that uses the results from original research but is based on interpreting economic history and applying it to current problems. It can provide useful input to policy issues that directly affect resource allocation and to compensation questions that may indirectly change resource allocation as liability rules are internalized into future choices.

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CONTENTS

ISSUES REGARDING BENEFITS TRANSFER

David S. Brookshire*

ABSTRACT

Although benefits transfers are not new, many issues remain unresolved. In this paper I make three arguments: most, if not all, of the issues regarding nonmarket valuation are also relevant to developing protocols for benefits transfer; considering the required level of accuracy for different uses of nonmarket values is central to the benefits transfer process; the existing set of nonmarket studies does not form an adequate base for benefits transfer.

Benefits transfer has been a widely used methodology in policy analysis and natural resources decision making for decades. The process involves

> focus[ing] on measuring (in dollars) how much the people affected by some policy will gain from it. They are not forecasts, and they usually do not attempt to predict other exogenous influences on people's behavior. Instead, a predefined set of conditions is assumed to characterize the nonpolicy variables. Then benefit estimates are derived by focusing on the effects of the conditions assumed to be changed by the policy. (Smith, 1992, p. 686)

Viewed simplistically, the benefits transfer process applies a data set that was developed for a unique purpose to an application for a different purpose.

The use of benefits transfer has increased recently and is thus receiving renewed attention. The renewed interest stems from various sources, including recent court decisions (State of Ohio, 1989), increased federal agency interest, and financial pressures due to increased costs and limited funding for primary studies. As recently as fall 1991, an environmental database workshop held in Washington, DC, assessed the availability of existing nonmarket valuation studies and considered means to enhance the availability of these studies for purposes of benefits transfer.[1]

My renewed interest in benefits transfer was rekindled by two papers on the topic that I received approximately two years ago for possible publication in *Water Resources Research* (Luken, Johnson, and Kibler, 1992; Desvousges, Naughton, and Parsons, 1992). The review process raised a relatively unique problem for an editor. The reviews ranged from "publish this paper, it is great, timely etc." to "you cannot do this, benefits transfer make no sense." The distribution of recommendations was so highly bimodal that I decided to edit a special issue of

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[1] The workshop was funded by the EPA, USDA Forest Service, USDA Economic Research Service, and NOAA.

Water Resources Research to directly address the benefits transfer process. I believed the Luken and Desvousges papers were controversial and represented a challenging contribution to the literature. Too often controversial papers never make it into the literature because they are, in fact, controversial. Further, after reflecting about the notion of benefits transfer, I believed we had already become committed to this method: the issue was not whether, but how benefits transfer should be conducted. We needed a forum for discussing possible issues and protocols for benefits transfer. Hopefully, the special *Water Resources Research* section was a step in that direction.[2]

This paper builds on the issues already identified in the extant literature (see, for instance, Smith and Kaoru, 1990; Walsh, 1992) and those brought forth in the special *Water Resources Research* section,[3] and raises additional issues regarding the benefits transfer process. I argue that

- most, if not all, of the issues regarding nonmarket valuation are also relevant to developing protocols for benefits transfer;
- a consideration of the required level of accuracy for different uses of nonmarket values is central to the benefits transfer process; and
- the existing set of nonmarket studies does not form an adequate base for benefits transfer protocols;

PROTOCOLS FOR BENEFITS TRANSFER[4]

Innumerable benefits transfer studies and guidelines have assigned values through using expert opinion as well as results from observed behavior and direct elicitation models.[5] Why attempt to develop benefits transfer protocols? Why not just conduct a primary study? Two reasons justify developing these protocols: primary studies can be time consuming and costly.

Studies based on original data require developing survey instruments, selecting and drawing a sample, administering the instrument, and analyzing the data collected, for example. In some cases the calendar time required is simply not available. For instance, both

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[2]Thanks to the efforts of many contributors and reviewers, the special section was published in the March 1992 issue of *Water Resources Research.*

[3]See Atkinson Crocker, and Shogren (1992); Brookshire and Neill (1992); Boyle and Bergstrom (1992); Desvousges, Naughton, and Parsons (1992); Loomis (1992); Luken, Johnson, and Kibler 1992); McConnell (1992); Smith (1992); and Walsh, Johnson, and McKean (1992), *Water Resources Research,* Vol 28, March 1992.

[4]The Brookshire and Neill (1992), Loomis (1992) and McConnell (1992) papers explore the issues in this section.

[5]Consider as a case in point the U.S.Water Resources Council guidelines on recreation (U.S. Water Resources Council, 1983).

governmental policy makers and litigants in damage assessment cases do not always have the time to conduct primary studies.

Financial resources are also limited. Recognizing this, the U.S. Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA), and the U.S. Forest Service (USFS) are actively addressing data and protocols for benefits transfer.

Local and state governments also have a growing need for nonmarket valuation information. Many environmental matters are addressed at the state level, yet financial resources are very limited. For instance, New Mexico has a large natural resource portfolio with many competing needs. Developing countries, including eastern Europe, also lack the financial resources for primary studies. Mexico is a case in point: it has a great need to obtain an understanding of the overall environmental problems (McIntosh, 1991). In general, applying nonmarket valuations across differing national economies is a relatively unexplored area. An obvious place to start would be with benefits transfer rather than costly primary studies.

METHODS FOR ASSIGNING NONMARKET VALUES

An overview for benefits transfer must begin with a consideration of the methods available for initially assigning nonmarket values, the accuracy of the methods, the diversity of nonmarket commodities of interest, and the existing databases. Additional issues might include the existing form of research agendas, the availability of data, and the role of judgment.

Observed behavior methods (direct or indirect), such as the travel cost and hedonic methods, and/or hypothetical behavior, such as the contingent valuation approach, form the core of desirable methods. The literature reveals that many variants and much discussion of the robustness of each exist on nonmarket methods.[6]

The available, primary nonmarket valuation methods are not completely reliable or accurate. In my opinion, accuracy concerns preclude a cookbook approach to benefits transfer, as is true for nonmarket valuation efforts in general. Further, not all applications of nonmarket techniques are created equal. The more recent studies are not necessarily superior, more accurate, or more useful as some would seem to imply. We have not reached a consensus about the correct procedures with which to conduct all of our nonmarket valuation investigations, judgment issues not withstanding. Nor have we reached a consensus on valuing various types of component values. For instance, is the appropriate valuation framework a total value framework.

[6] See for example Cummings, Brookshire, and Schulze, (1986), and Mitchell and Carson (1989) for commentary on the contingent valuation method.

or are specific nonuse values the appropriate focus, or both? Thus, we should not expect all nonmarket valuation techniques to be equally useful in all cases of benefits transfer.

In addition to nonmarket valuation methods, the nature of the commodity is central to the reliability of the benefits transfer process. When researchers think of a study site (the primary study) and policy site (the site for which benefits are being transferred), they immediately must consider questions of uniqueness and substitute and complement availability. For example, if not all groundwater is just groundwater, then the specific nature of the commodity at the study and policy sites is important.

The quality of existing nonmarket data also is important. Given that primary studies are far from perfect, benefits transfer studies more than likely compound the accuracy problems of primary studies. The accuracy problems that exist in the primary studies do not disappear when the benefits transfer process is undertaken. This general theme has been with us for years (see Morgenstern 1973).

Although a large number of studies exist, the number available for specific nonmarket commodities might be limited. At best the current valuation database is a collection of studies that represent a serendipity of perceived needs. To some extent, funding agencies find coordinating research agendas difficult. Further, data have been lost through the process of changing affiliations of researchers as well as through changing computer technology. Perhaps not all of the raw data actually exist in our ever-expanding bibliography of studies.

Researchers should be concerned about extending the base of available studies. A systematic and coordinated research program is needed as well as a change in how we characterize productive research. Recently the legal community has become a significant source for the funding of new studies. In some sense the legal community is pacing our research efforts. This pacing and direction of efforts with specific agendas in mind may outstrip our actual abilities to assign sufficiently accurate values.[7] Further, replication is often viewed as not productive to journal editors and reviewers and thus not rewarded by the profession.

As the database expands and benefits transfer become more prevalent, another issue that will come to the fore more frequently is the issue of when primary data will be made available to other researchers. This issue has not been completely resolved. Should the database that an

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[7] As pointed out by McConnell (1992), some of these studies will only see the light of day in the adversarial setting, otherwise not at all.

article directly reported on be made available, or should the complete data set be made available even if the authors intend further work?[8]

Finally, what is the role of judgment in the benefits transfer process, both in the original studies as well as in the process itself? Can we be judgment free and purely scientific?

ADEQUACY OF EXISTING SET OF STUDIES

A wide range of measurement issues is associated with all nonmarket valuation techniques. Consider the contingent valuation method, in part, because of the recent court rulings (State of Ohio, 1989). Let us ask a version of the question put forth by Burness, Cummings, and Ganderton (1991): "Which households place what value (or types of values) on which nonmarket goods?" (p. 432, emphasis added). We might add: Are households accurate in revealing their preferences and how do households form values and how should these values be elicited?

In light of the recent court rulings potentially leading to compensable damages as well as efforts to include externality costing for utilities, these issues are becoming increasingly important. These issues implicitly include the aggregation issue and the scope of the market question. To my knowledge we have never completely agreed on how to designate the market area nor agreed on appropriate aggregation procedures. This issue becomes especially difficult when we move from considering use values to existence values. For instance, what is the appropriate population to aggregate over for the Grand Canyon or El Morro National Monument? Further, one might include design concerns such as the level of specificity of the commodity that is described and issues of embedding.

In listening to the exchanges at the recent AERE 1992 sessions in New Orleans, I can only conclude that a serious debate continues over the accuracy levels that we can tolerate in primary nonmarket studies and how these studies should be designed. Thus, we might ask: Can we tolerate the additional accuracy concerns that are necessarily involved in the benefits transfer process?

One answer is to assert that the stability of the foundation for the benefits transfer process depends on the intended use of a particular application of the benefits transfer process. As an illustration, consider a juxtaposition of perceived needs and purpose of a benefits transfer

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[8] I understand that the provision rule for *JEEM* is that at least the data directly utilized in the reported results must be made available.

exercise. Figure 1 illustrates a stylized continuum of uses representing alternative applications of benefits transfer.

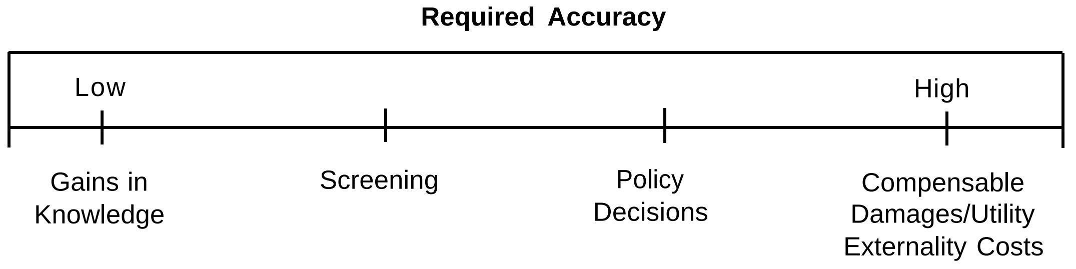

Figure 1. A Continuum of Decision Settings from Least Required Accuracy to Most Required Accuracy

Viewing the required level of accuracy for a benefits transfer within a conditional framework provides two insights. The use of the information inherently determines the underlying accuracy requirements. This insight applies in both the primary data collection case and the benefits transfer cases. For instance, gains in knowledge might be represented by benefits transfer uses such as the scope of the U.S. Geological mapping program. Screening efforts might be represented by the CERCLA Type A analysis. Policy decisions might involve regulatory rule making, and compensable damages might involve cases associated with large-scale natural resource damage assessments and externality costing for electric utilities. A difference between the policy decisions and the compensable damage cases is that, while in both cases real dollars are exchanged, we do not know precisely whom in the policy case. That is, the policy case includes a hidden distributional issue. In the compensable case, real dollars are exchanged and the parties are relatively more easily identifiable.[9]

A continuum such as this suggests accuracy tempered by the use of the valuation information. For instance, in the case of gains from knowledge we might argue that some decisions, if incorrect, will not result in too high a cost to society. In the cases where large dollar amounts are involved the response is sometimes different. Often one hears that, as real dollars become involved, the information (either from a primary or benefits transfer study) is not precise enough. That is, as the real economic commitment becomes more real, we should not use that information for decision making. The argument that we cannot undertake a policy response without knowing the exact nature of the functional relationships echoes the earlier implication of

[9] The issue of compensable damages and real economic commitment has come to the fore recently. I suggest that we have been making real economic commitments for years through regulatory policy that relies on nonmarket valuation.

the theory of second best. Reaction to nihilism of the theory of second best was swift. Several researchers argued that piecemeal welfare policies could be pursued for those sectors satisfying separability from the original distorted sector. Relevant to the benefits transfer issue is the work of Yew-Kwang Ng (1977 and 1979) regarding a third best allocation. Ng demonstrates that. in the absence of perfect information, correcting a distortion will always improve social welfare in an expected value sense. Decisions based on even imperfect information, as from a benefits transfer, are superior to no decisions.

SOME SAMPLE GENERIC GUIDELINES FOR BENEFITS TRANSFER PROTOCOLS

The original site study must be scientifically sound in the use of conceptually correct economic methods, experimental design, and implementation procedures. The original site study should report, maybe in an appendix, the empirical procedures, including details regarding all of the information collected, and whether the information was useful in the empirical process.

The commodity of value should be similar between the study and policy site. Assessing this similarity might include quality and quantity considerations as well as the property right structure. In addition the study and policy site markets should be similar, an assessment that could include innumerable considerations. The overall issue becomes, what is similar enough?

To address the degree of similarity, consider a simplified benefits transfer framework. For the study site (A) the results of a study enable one to estimate the following:

$$V^A = \beta_0^A + \beta_1^A X_s^A + \beta_2^A X_g^A + \beta_3^A X_m^A$$

where

V^A = individual valuation regarding site A;

X_s^A = vector of socioeconomic characteristics (e.g., income, age, cultural);

X_g^A = characteristics of the commodity (physical-quality and quantity and economic relevant notions [such as complement's, substitute's uniqueness]);

X_m^A = market conditions (size and composition).

The β's are the regression coefficients and are instrumental in the benefits transfer process.

For the policy site we estimate the following:

$$V^B = \beta_0^A + \beta_1^A X_s^B + \beta_2^A X_g^B + \beta_3^A X_m^B$$

where

V^B = individual valuation at site B, based on the β's of site A;

X_s^B = vector of socio-economic characteristics at B;

X_g^B = vector of characteristics of the commodity at B; and

X_m^B = vector of market conditions at site B.

We are interested in the β coefficients. That is, is it acceptable to use the coefficients and implicitly the underlying distributions from the study site to estimate the value for the policy site? The research question is characterized in Figure 2. Given the array of information used in valuation studies, what conditions are necessary for us to rely on the V^B estimated from the V^A equation? That is, for site A each of the subelements (e.g., for X_s, a subelement is income), and site B will have a corresponding distribution. The diagonal squares represent identical variables. If this were to occur then the benefits transfer process would not be of concern because the study and policy sites would be essentially identical. However, this condition is highly unlikely. The question then becomes: How similar are these distributions? How similar must they be for different uses of the benefits transfer process for alternative uses?

Can the issues raised in this paper be answered by the existing base of nonmarket studies? The base of studies from which a benefits transfer study can build is quite thin, at least for contingent valuation applications. This paucity stems, in part, from the existing incentive structure to publish and obtain research funds. The funding environment and the publishing environment have encouraged, if not required, studies that are unique. Often this uniqueness can be found in the nature of the good valued. As such not enough studies address the same issue.

The overall number of studies that are not replications is large; thus, the number of off-diagonal studies is large. That is, we will be typically off the diagonal. Unlike the more traditional science-oriented disciplines, replication in economics and the publication of data are not viewed as, worthwhile. This attitude is not bad. However, we might need to consider other forms of research acceptable and publishable as contributions to the literature, especially in a discipline that contributes so heavily to the policy arena. Editors *and* reviewers must confront this issue. Essentially, for the case of benefits transfer, we might want to consider what constitutes a substantive contribution to the literature

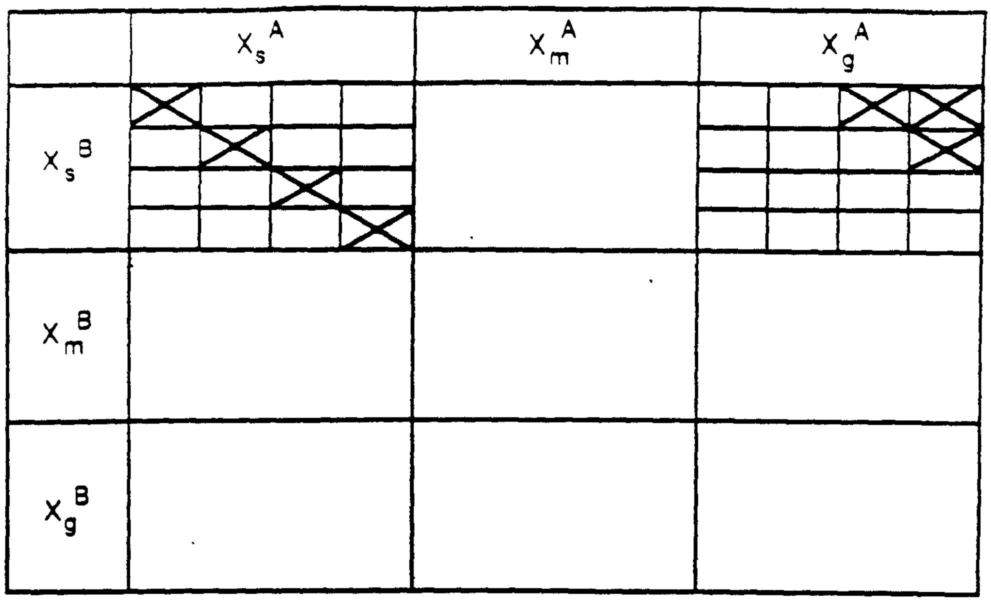

Figure 2. Distribution Issues

DESIGNING A META-ANALYSIS

Further research is necessary if we are to more fully understand the reliability requirements of the benefits transfer process. Using meta-analysis can further our understanding of the importance of various components of existing studies and help focus our research efforts. The laboratory and field settings also offer the opportunity to explore various protocol guidelines under varying degrees of control and realism. As such, I suggest a combined effort involving all three settings. We have at least two ways of conducting a benefits transfer. Researchers could simply take the value elicited at the study site and apply it directly to the policy site. For example, a value for a change in clean air in Los Angeles may be applied directly to a similar change in air quality in Denver. This application is clearly simplistic, and most researchers would not wish to follow such an approach. A more technically valid strategy is to employ the coefficients estimated with the study site data to the variables describing the policy site. We need a protocol to judge sufficiently similar pairs of policy and study sites to employ benefits transfer. To this end I offer a first hypothesis.

> H1: Benefits transfer are robust to differences in site characteristics-whether $\mathbf{X_s}$, $\mathbf{X_g}$, or $\mathbf{X_m}$ or a combination of differences.

If H1 is not refuted then we are able to conduct defensible benefits transfer although the policy and field sites may have substantially different characteristics. Researchers may conduct the following tests to evaluate this hypothesis:

- examine previous value elicitation (CVM, TCM, or HPM) studies to determine the elasticity of estimated values with respect to the independent variables. Lower elasticities imply that we may employ the obtained values across sites that are different in terms of those variables for which the elasticities are low:

- conduct laboratory investigations in which values are elicited in different institutions where X_s, X_g, and X_m are varied individually to determine the impact of these differences. Again. this will indicate the characteristics critical to successful application of benefits transfer; and

- investigate the linearity of the valuation relationship obtained at the study site. The more linear this relationship the more critical are similarities in site characteristics between the study and policy site to successful benefits transfer.

Hypothesis 2 relates to the need to conduct and publish studies replicating previous work.

> H2: The values generated with the coefficients from the study site applied to the policy site characteristics are identical to the values that would be obtained from a primary study at the policy site.

A test of this hypothesis requires conducting at least a pilot study at the policy site. Essentially, we would then have original site estimates at both the study and policy sites. The values obtained via benefits transfer, V^B given β^A and X^B, would be compared with the primary estimates, V^B given β^B and X^B. If this hypothesis is not refuted through repeated investigations, the validity of benefits transfer would be supported for settings similar to those studied.

If values for a particular good obtained at a single site are not consistent across time, preferences are not stable and imply that benefits transfer is a questionable practice because it depends on the stability of preferences over both time and location. This characteristic gives rise to a third hypothesis:

> H3: The values from the study site are robust over time if underlying site characteristics have not changed

Robustness might be viewed as representing stable preferences. Whittington et al (1992) has addressed the effects of “time to think" and Kealy, Montgomery, and Dovido (1990) the stability of willingness-to-pay values over time. Here we are interested in the shelf life of any given set of studies. What are the limits? Are recreation values sufficiently stable over a 10-year period? We might consider replicating some of the earlier applications to address this question. Repeated work with a fixed pool of subjects could also possibly give us some insights. The time-to-think issue is relevant here because it implies the primary estimates are themselves subject to accuracy problems; most contingent valuation method studies do not provide much of a thinking period between the presentation of information and the elicitation of values.

If we argue that the institutional setting is not important in individual valuations, then we should not observe interactive effects between the vector components, X_s, X_g, and X_m, of our valuation studies. This characteristic suggests a fourth hypothesis:

> H4: No interaction effects occur between X_s, X_g, and X_m. Thus differences in *some* of these variables between the study and policy site do not imply that we are unable to use the coefficients estimated for the remaining variables in a benefits transfer.

One possible test of this hypothesis would involve econometrically checking for interaction effects with the primary data from the study site. Another test would involve using the meta-analysis technique as suggested by Smith and Kaoru (1990) and Walsh, Johnson, and McKean (1989). A series of laboratory experiments could also be designed to investigate the interactions of the components of the institutional setting with the values elicited from individuals.

The more significant the interaction effects the more similar we will require settings to be if we are to employ benefits transfer. An investigation of these (and possibly other) hypotheses generated by a systematic investigation of benefits transfer applications will move us toward protocols for benefits transfer.

CONCLUSION

In sum, no matter how well developed the benefits transfer process becomes, it will still have the accuracy problems of the original studies. The accuracy needs of various types of benefits transfer studies will vary. Overall accuracy can only be expected to deteriorate. The current collection of original studies is not sufficient for fine tuning the benefits transfer process We may need to conduct additional primary studies in various settings such as the laboratory and the field and to continue using meta analyses to improve our understanding and the accuracy of benefits transfer.

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BENEFITS TRANSFER: HOW GOOD IS GOOD ENOUGH?

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ABSTRACT

Transferring benefits estimates developed in one context to other contexts to analyze related valuation questions is appealing because it can save time and resources. However, fundamental questions regarding the accuracy of the transfer must be addressed to determine first whether the transfer should be done at all, second how it should be done, and third how much confidence to place in the transferred results. The answers to these questions will depend on the purpose of the analysis. Assessing the basic purpose of the analysis is a value of information question. Reducing uncertainty in benefits estimates requires time and money. The benefits of reduced uncertainty are finite and probably diminishing at the margin. The political/institutional context for the benefit analysis is an important factor in determining how much accuracy is needed. In some cases a clear demonstration of positive net benefits may be required, but in other cases evidence supporting the likelihood that benefits fall within a given range may be sufficient. Judging whether the uncertainty involved in a transfer is acceptable requires considering the decision-making context, as well as the economic valuation questions involved. This paper raises and discusses the following questions in this context:

- Is the likely direction of potential error in the transferred results clear?
- Is a benefits transfer analysis better than no benefit analysis at all?
- Does the regulatory or other decision-making context require that benefits be demonstrated to exceed costs or are other factors more central to the decision?
- What is the actual feasibility of conducting a new study?
- How much might a new study be realistically expected to reduce uncertainty?
- What are the chances of being so far wrong that a different decision would result?

The markets for benefit practitioners' analytical products are people making decisions. Decision makers obviously prefer to obtain defensible benefits information for as little expenditure as possible. Benefits transfers offer quicker and less expensive results than undertaking original benefit analyses, but they extract a price in terms of reduced accuracy, validity, and acceptability of the results. The question then becomes, under what circumstances does a benefits transfer provide adequate information for decision making?

Sufficient accuracy cannot be objectively defined independent of the context. Adequacy is not a matter of simply defining acceptable confidence intervals on the estimates and assuring the estimates meet that standard. The institutional context motivates the need for benefit analysis

*Abt Associates, Inc. and RCG/Hagler, Bailly, Inc., respectively. The opinions expressed in this paper are solely the authors' and do not necessarily represent the views of the U.S. Environmental Protection Agency. Allen Basala, Tayler Bingham, Bill Desvousges, and Bob Rowe provided many helpful comments and suggestions, but the authors are responsible for any shortcomings or inaccuracies.

and must be considered when determining a sufficient level of accuracy. "Good enough" can be determined only by considering the the role of benefit analysis in the decision-making process, and the tolerance for uncertainty in the benefits estimates in that setting.

In some situations, more sophisticated analysis, even if the results are statistically different from previously available estimates, simply may not make a difference to the decision at hand. In other cases more detailed study and analysis, even if it merely confirms previous results with a greater degree of certainty, may alter the decision. A judgment that more analysts won't make any difference to the decision at hand provides a clear stopping point. Given the time and money required for additional benefit analysis, the question is best stated as a value-added question: Will it make enough of a difference to justify the cost?

In this paper we explore several analytical and institutional issues in deciding how good is good enough. The following section describes a spectrum of benefit analysis choices into which benefits transfer fits and discusses factors to consider when determining the appropriate level of benefit analysis to meet the need of the decision maker. Next, we describe some of the institutional settings where benefit analysis is used and how these uses differ. Finally, we make a few comments about strategic considerations that can play a role in the benefit analysis process.

THE BENEFIT ANALYSIS SPECTRUM

Discussions about benefits transfer have tended to focus on conducting a benefits transfer versus conducting an original study, as if these are the only two options. In reality, a wide range of options for benefit analysis can be matched to each setting, depending on how much new information needs to be generated, how much can be borrowed, and how much detail is needed in the results. A benefit analysis spectrum may be defined as follows, with detail and effort increasing from first to last:

- qualitative benefit analysis
- transfer scoping analysis
- full benefits transfer
- original pilot study
- full original study

A *qualitative benefit analysis* is the lowest level of the benefit analysis spectrum. Qualitative analysis presents as much information as possible on the physical, social, and economic impacts of the policy option, as well as information on the demand for the policy's effects, but it does not attempt to estimate the monetary benefits. The next level of the spectrum *is transfer scoping analysis,* which locates and examines existing relevant benefit studies for method, results, and relationship to the decision option in question. Transfer scoping includes analyzing the possibility of preparing a benefits transfer but stops short of adopting the existing results to the current situation. The next level is a *full benefits transfer,* including designing an approach for applying the information from existing studies to the current decision, obtaining additional necessary information on the current question, preparing a quantitative benefits estimate, and assessing the quality of information in that estimate. The level of effort for a benefits transfer can vary considerably: it can range from a simple threshold or bounding analysis to detailed procedures to adjust and interpret results from previous studies and analysis of the sensitivity of results to specific transfer assumptions. The fourth level is an *original pilot study*. Pilot studies involve method and instrument development with a small-scale application. An original pilot study can address some of the questions raised by a benefits transfer, such as the degree to which changes in the specific scenarios affect the willingness-to-pay (WTP) estimates, and provide preliminary new benefits estimates. A pilot study also can address the feasibility of conducting a full benefit analysis. The final level is *full original benefit analysis,* involving extensive data collection among a representative sample of the affected population.

This spectrum is laid out in the same order as the steps an researcher typically takes in preparing a benefit analysis. In most cases, a full-blown original benefit analysis is not prepared, but even when it is, some amount of transfer scoping is usually done first. Researchers usually decide that somewhere along the spectrum a study short of a full original study is adequate for the current purposes and that additional steps are either impossible (usually because of time or money constraints), infeasible (e.g., focus groups indicate tremendous difficulty with evaluating the decision in a monetary context), or that the value of potential improvements in the quality of information from the next level of analysis is limited for the decision at hand.

Despite the level of effort judged adequate for a given benefit analysis, researchers will help ensure the professional credibility of the analysis and results by including the following steps:

- carefully reviewing and reporting the underlying studies;
- providing the underlying studies and data as part of the administrative record;
- discussing and documenting all transfer assumptions, omissions, and known biases;
- supporting assumptions with data and literature;
- characterizing uncertainty in the results;
- providing other supporting data/literature;

- ensuring consistency with scientific and economic theory; and
- providing specific transfer algorithms or programs.

This kind of quality control and full reporting is required for any benefits transfer to be good enough; bad analysis is never good enough no matter how tangential to the decision at hand. When two parties come up with different benefit estimates, this kind of reporting of the analysis allows third parties to sort out the sources of the differences.

MEETING THE NEED: WILL MORE ACCURATE BENEFITS INFORMATION MAKE A DIFFERENCE?

Everyone faced with an option to expend greater effort to obtain more precise benefits information must confront the fundamental question: Will more accurate benefits information make a difference to the decision at hand? Although moving up the benefits analysis spectrum can provide additional information and diminishing uncertainty, it is not necessarily the better option. Whether it is better to move up the benefits analysis spectrum is a judgment that can be made only in the specific context of the situation. If a more complex study would be costly and delay the decision but could not influence the outcome because of institutional factors, it is not a *better* study for that situation. The decision maker faces a constrained optimization problem where the optimal solution is rarely the unconstrained global maximum.

In many situations a benefits transfer may provide adequate information for the decision at hand and, therefore, be the preferred level of analysis even though an original study might provide more precise benefit estimates. For example, a benefits transfer will likely provide a range of plausible benefit estimates (maybe even a probability distribution). If the entire range of plausible estimates falls above or below the costs of the action under consideration, *and* if the decision criterion is based on positive net benefits of any magnitude, then increased precision in the benefit estimates cannot change the decision

Value of Information Considerations

Deciding how far to go along the benefits analysis spectrum can be analyzed from a value of information perspective. Each step along the spectrum represents a greater level of effort that hopefully, will provide more information about the benefits of the program under consideration but at a cost of a greater investment of resources, including time. The value of information analysis says that additional information gathering (in this case benefits analysis) should be undertaken as long as the benefits of the additional information exceed the costs of obtaining it (Freeman, 1984). Estimating the expected costs of additional levels of effort required for another step along the continuum is probably fairly straightforward, but estimating the expected benefits of additional effort is probably not so straightforward.

What are the expected benefits of the additional information obtained when additional effort is put into benefits analysis? Let's focus on the additional effort required for an original benefits analysis relative to a benefits transfer. A value of information analysis suggests that an original study would eliminate (or reduce) the uncertainty in the benefits estimates. We expect that a benefits transfer might, at best, provide a probability distribution of benefits estimates due to various sources of uncertainty. If some part of the benefits distribution falls below the costs of the program, while the expected value of the benefits exceeds costs, then there is some risk that a wrong decision is being made if the program is undertaken. The reverse situation of expected benefits falling below costs, while part of the distribution exceeds costs, might also occur. (As noted above, if the full benefits distribution falls entirely above or below the estimated costs of the program then there is little risk of making a wrong decision, and additional benefits analysis is not needed.) The benefit of additional information is a function of the probability of a wrong decision and the magnitude of the negative net benefits that will be incurred if a wrong decision is made.

If the researcher has the following information, the value of information framework can provide a clear direction about whether an original benefits study should he undertaken:

- *a probability distribution for expected benefits* so that the probability of making a wrong decision can be reasonably estimated,
- *an estimate of negative net benefits* if a wrong decision is made,
- *an estimate of the reduction in uncertainty* in the benefits estimates that could be obtained with an original benefits study, and
- *an estimate of the cost* of an original benefits study.

Clearly, in many situations much of this information will be unknown or highly uncertain. Designing this decision framework and filling in plausible ranges for unknown elements may be useful in judging the sensitivity to the different elements of the decision to do an original study.

Reductions in Uncertainty Expected From an Original Study

An interesting link in the value of information framework is the question of how much an original benefits study can be expected to reduce the uncertainty in the benefits estimates relative to a benefits transfer. Much of the discussion of the pros and cons of benefits transfer has presumed that an original study could be conducted and would provide reliable benefits estimates. Given that available economic techniques for estimating benefits related to nonmarket goods are subject to considerable uncertainty, and in some cases considerable controversy, this presumption may not be appropriate in many instances. The state of the art in benefits estimation is such that uncertainty in the benefits estimates remains high even if an original benefits study is undertaken.

Estimating how much an original study may reduce uncertainty in the benefits estimates before the study is completed and the results thoroughly evaluated is very difficult. If we knew enough to accurately predict the effects of the specific circumstances of the original study on the uncertainty in the benefits estimates, we would probably also know enough to predict how the benefits estimates would change as well, so a new study would not be needed. More likely, the researcher begins with a set of benefits estimates for similar, but not exactly the same, circumstances. Some evidence may exist about how certain characteristics of the site or good in question affect the benefits estimates, at least in terms of the direction of the effect (positive or negative), but this evidence is often not very precise. For example, consider the benefits of protecting a recreational fishing spot. Predicting that benefits are higher at a site where the average size of the catch is higher may be possible, but uncertainty about how much higher the benefits are may also exist. The researcher may assume that a site with a prettier view would have greater benefits, but perhaps no evidence on this is available. A new study may find that the view has no significant effect on what fishermen are willing to pay to protect a given fishing spot. More studies over time might actually result in greater acknowledged uncertainty in the benefits estimates if the estimated effects of certain characteristics on the benefits estimates are not consistent and if the amount of unexplained variation in estimates across studies increases. The designers of an original study can count on having more information when the study is completed, but having reduced uncertainty in the benefits estimates for the specific question at hand is only one of several possible outcomes.

In most cases an original study should not be treated as supplanting all previous work but as adding to the body of available information. The evaluation of the results of an original benefits study should consider the results of previous similar studies. Atkinson, Crocker, and Shogren (1992) conclude that given uncertainty in all the benefits estimates, the best estimate of benefits consider, in some appropriately weighted fashion, estimates from past studies as well as from an original study designed specifically for circumstances at hand. This conclusion, based on an empirical Bayesian approach, appeals to common sense. Most available benefits estimation techniques involve considerable latitude on the part of the researcher in terms of study design features, some of which may have unexpected and inadvertent influences on the results. Researchers and decision makers would be well advised to evaluate results of any original benefits study in light of previous related studies to help determine how much weight to place on the original study results for the decision at hand.

Different Sources of Uncertainty

Discussions about uncertainty in benefits transfers often focus primarily on the uncertainty in the average benefit to the affected individual or party and on the characteristics that determine this average benefit. This focus implies that the ideal benefits transfer can be undertaken if we have a value function that includes all relevant individual and site or good characteristics. For example, the focus for visibility benefits transfer has been the WTP function for the household, which might incorporate income, education, and other characteristics of the household, and location, use patterns, and other characteristics of the site where visibility is expected to change. As Smith (1992) notes, uncertainty about the size of the market (i.e., number of households affected) may have a greater impact on results than uncertainty in the average WTP per household.

Noneconomic Sources of Uncertainty

Benefits analysis related to a change in environmental quality typically involves a physical science component as well as an economic component because characterizing the environmental impact in physical terms is usually necessary before the economic value of the change can be estimated. For example, for the Best Available Retrofit Technology (BART) analysis of the Navajo Generating Station, the environmental impact of concern for the benefits analysis was the change in visibility that might be expected at the Grand Canyon as a result of reduced emissions from the power plant. Therefore, estimating the predicted change in visibility conditions at the park was necessary before the value of this change could be estimated.

Considering the level of uncertainty that exists in the physical science component of the benefits assessment may be important for the economist when determining the appropriate level of benefits analysis to undertake (Smith, 1992). The decision maker may have little advantage in having fine-tuned economic estimates if the physical science component is associated with a wide range of uncertainty.

THE MARKET FOR BENEFITS ANALYSIS: WHAT IS THE NEED?

Benefit analysis has both formal and informal roles in many decision-making processes in the private and public sectors, including the judicial, executive, and legislative branches of the government. The roles of benefit analysis vary substantially among and within the different government branches. Our basic contention in this paper is that the appropriate level of benefit analysis must be determined within the context of the specific institutional setting. The potential influence on the outcome, legal limitations on using benefit analysis, time and money constraints, amount and quality of available benefits information from previous studies, propensity of individuals and institutions to consider benefits information, and even strategic considerations are all factors in determining what is “good enough” for each situation.

Various institutional settings ask very different questions of benefit analysis. Clearly, the question being asked influences the appropriate level of effort. At one extreme are situations ultimately requiring a single dollar amount, such as efforts to incorporate environmental externalities in utility planning. Here a direct link can be made between the magnitude of the benefits estimates and utility rates. Marginal changes in the estimates can result in a marginal change in the outcome, so reducing uncertainty is highly desirable. In this case, only very good transfers or new studies may be good enough.

In other settings, the benefit analysis question requires selecting among options. This situation is most analogous to the neoclassical model, where the goal is to maximize net benefits (benefits minus costs). Executive Order (E.O.) 12291 emphasizes this point of view, directing federal agencies to examine the most important alternative options in some detail. Within the full legal range of options, agencies should let the primary criterion be to maximize expected net benefits. Uncertainty tolerance is set by the ability to distinguish between the net benefits of the options.

A third type of question arises from a dichotomous choice situation: should we do this or not? A classic example is the analysis of whether to build a dam in the Snake River’s Hell’s Canyon (Fisher, Krutilla, and Cicchetti, 1972). The key question involves the *sign* of the net benefits, but not necessarily the magnitude, and the direction of the likely error. Uncertainty tolerance is determined by the perceived likelihood that the true net benefits have the opposite sign of the estimate.

A fourth type of question is, what is the least costly way to meet legal requirements for analysis that may be tangential to the final decision? Certain situations require some form of benefit analysis, but simultaneously legally preclude considering benefits or render any analysis of alternatives moot by legally mandating and specifying all the relevant features of the action For example, the National Ambient Air Quality Standards for criteria air pollutants are set to protect public health with a margin of safety regardless of costs as mandated by the Clean Air Act. EPA conducts benefit analyses for proposed regulations under this statute to meet administrative requirements such as E.O. 12291, but demonstrating that benefits exceed costs is not required under this legislation, which creates a low threshold for sufficient accuracy.

A fifth situation is where benefit analysis is not directly tied to an immediate decision but is part of an information gathering or disseminating function. Fact finding can be sponsored by any interested party very early in the policy process with a goal of attracting sufficient interest to get an issue on the agenda or moved up in the schedule. Benefit analysis can be one part of a scoping process that questions what we know, what we don't know, and what we need to know to proceed. Sponsors motivated for their own reasons to attract broader attention to an issue may want to use benefit analysis to influence relevant people about the importance of the issue. Benefit analysis can also play a role in setting research agendas by indicating where better information would be most likely to make a difference.

At the other end of the policy process, public agencies charged with implementing an already decided policy need to build and maintain public consensus among affected parties about the desirability of the policy. Benefit analysis can help focus public and private attention on the reasons for undertaking costly or burdensome activities. "Selling a program" does not end when a decision is made but must be continually pursued as long as the decision is reversible. Benefit analyses may be useful, and very simple benefits transfers may be good enough

Judicial Branch

Judicial proceedings are one setting where the outcome is potentially directly tied to the magnitude of the estimated benefits. A familiar example is monetary damages in a natural resource damage assessment under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA or "the Superfund law"). Of all the settings for benefit analysis, uncertainty tolerance may be lowest in litigated damage assessment cases. When a CERCLA case is decided in court, the judge, the trustees, and the potentially responsible parties have a keen interest in the size of the final judgment. Marginal changes in the benefit estimate can affect the marginal size of the damage judgment, increasing the need for reducing benefit uncertainty. The U.S Department of the Interior published guidelines *(Federal Register,* 1980) on the CERCLA benefit analysis, describing acceptable approaches for benefit analysis. Benefits transfers are permissible in the "Type A" model but only between fairly well-matched situations because the cost of new studies is presumed to be large relative to the potential damages associated with a relatively small pollution incident. The incentive for original work is fairly high.

Another role of benefit assessment in damage assessment cases can tolerate more uncertainty and hence often relies on benefits transfer. Either party in a potential litigation must establish a broad strategy they will follow. Each party may want to have the issues decided in court based on a detailed presentation of the evidence. Conversely, the case could be settled out of court. When considering whether to settle, each party considers an acceptable settlement, the likelihood of winning in court, and the likely size of the court's decision. In doing so, each party may consider the magnitude of available benefit estimates from either transfers or original studies.

Executive Branch

The executive branch's responsibilities to prepare, implement and enforce regulations have a number of very different institutional settings that include benefit analysis as one consideration. Each potential application of benefit analysis has its own set of legal, procedural, practical, and political issues that affect the possible role benefit analysis can play. The specific framework sets either upper or lower limits (or both) on the influence of benefits estimates even before considering the quality of the potentially available benefit information.

Relatively few regulatory situations legally or procedurally allow using benefit analysis as a central tool in the decision process. One notable exception is the Toxic Substance Control Act (TSCA), which explicitly allows the use of benefit analysis in setting chemical compound exposure regulations. The basic TSCA objective is to prevent "unreasonable risk," and benefit analysis is one way of assessing reasonableness. Although no legal or procedural impediments exist to using benefit analysis, many actual TSCA regulations have relied on health risk or cost-effectiveness criteria, rather than monetized benefits. However, in 1991 the federal court overturned EPA's ban on asbestos under TSCA and found that EPA insufficiently examined alternatives to an outright ban. The court ruled that although a strict quantified benefit-cost criterion is not required, unsubstantiated statements that benefits clearly exceed costs are not a sufficient rationale to justify a very costly program. How EPA will respond to the court ruling in the future use of benefit analysis under TSCA remains to be seen.

The best known use of benefit analysis in the federal executive branch is Regulatory Impact Analysis (RIA) documents. E.O. 12291 requires benefit-cost analysis of all "major rules" (regulations or requirements with annual costs over $100 million that cause a major increase in prices or have significant impact on competition, employment investment, or international competition)[1]. E.O. 12291 charges government agencies with the role of the neoclassical benevolent social planner in traditional economic models by directing the agencies to select, as permitted by the law, the policy option with least net cost to society. The guidance issued by the Office of Management and Budget (OMB) on the benefit analysis required in an RIA encourages selecting the highest level of benefit analysis by stating "[A]n attempt should be made to quantify all potential real incremental benefits to society in monetary terms to the maximum extent possible" ("Regulatory Impact Analysis Guidance," 1989. p. 568). But the 12291 guidance also recognizes the choice depends on the situation, by saying, "The amount of analysis (whether scientific, statistical, or economic) that a particular issue requires depends on how crucial that issue is to determining the best alternative and on the complexity of the issue. Regulatory analysis inevitably involves uncertainties and requires informed professional judgments" ("Regulatory Impact Analysis Guidance," 1989, p. 561).

The E.O. 12291 guidance recognizes that in some regulatory situations the law prohibits considering the monetary benefits, or any other economic factors, in determining the best regulatory decision. This principle is commonly embedded in many of the United States' health-based statutes and has been upheld in federal court. Thus, the potential for a dichotomy exists: an Executive Order requires preparing a benefit cost analysis, but the implementing legislation prohibits considering such information in the regulatory process. Even when more accurate benefits information could be obtained, the legal barriers to using benefit analysis often discourage the government from committing significant resources to preparing benefits analysis for E.O. 12291. The legal status, combined with chronically short budgets and pressing time constraints, often limits the federal government to relatively quick and low-cost forms of benefit analysis. The legal limitations and budget constraints result in relatively greater uncertainty in many RIAs.

On the other hand, any benefit information included in an RIA is not ignored. The OMB examines the benefits information presented when fulfilling their duties under E.O. 12291 to examine the economic efficiency of all proposed regulations. Federal agencies, aware of the role

[1] The role of benefit analysis has been reaffirmed and expanded in additional Executive Orders and several policy statements from the President's Council on Competitiveness. On March 15, 1991, then Vice President Quayle wrote to EPA reaffirming the Administration's position that E.O. 12291 applies to "all agency policy guidance that affects the public. Such policy guidance includes not only regulations that are published for notice and comment, but also strategy statements, guidelines. policy manuals, grant and loan procedures, Advance Notices of Proposed Rule Making, press releases and other documents announcing or implementing regulatory policy that affects the public." E.O. 12498 directs the agencies to consider benefit analysis in setting regulatory priorities. Further, the 1991/92 regulatory moratorium directs federal agencies "to estimate the likely costs and benefits of legislative proposals under active consideration by Congress or to be proposed by the agency."

of benefit analysis in the OMB review process, try to allocate their scarce benefit estimate resources to issues where the benefit information is most likely to make a difference.

The need to prioritize the level of effort has led to an informal set of "acceptable" cost-effectiveness (e.g., cost per unit risk reduction or cost per unit effluent reduction) cutoffs in some broad categories.[2] Policy options with costs clearly below the "going rate" are good candidates for minimal benefits analysis. Options with costs in excess of the cutoff warrant additional benefits analysis or other justification. Cost-effectiveness cutoffs are really one type of transfer, applying the same criteria of implicit benefits from one setting to another. Cost-effectiveness cutoffs are only a benefits transfer to the extent that benefits information is considered when establishing the cutoff levels. However, cutoffs are typically applied as a coefficient transfer not a benefits function transfer, which limits the ability to custom fit the cutoffs to the specifies of each situation. thereby increasing the uncertainty.

One recent regulatory action did not have significant harriers to considering benefit analysis as a central part of the regulatory process. The Clean Air Act §169A protects visibility at national parks and wilderness areas, for example. If EPA determines that a visibility impairment exists, then EPA must determine the appropriate response. In selecting the BART level of abatement effort, the Clean Air Act §169A states that the decision "shall take into consideration the costs of compliance, the energy and nonair quality environmental impacts of compliance, any existing pollution control technology in use at the source, the remaining useful life of the source, and the degree of improvement in visibility." Although this legislative language does not require using economic benefit analysis, it clearly opens the door.

Although §169A was added to the CAA in 1977, EPA has required emission abatement to protect visibility only once. In 1990 EPA proposed a determination that the Navajo Generating Station (NGS), a large coal-fired electric generating facility in Page, Arizona, caused significant visibility impairment at the Grand Canyon National Park. When EPA proposed the emission reduction in February 1991 EPA said that it "was not required as a part of the BART analysis to estimate monetary benefits associated with improving visibility in the Grand Canyon. However, as a check of reasonableness for its approach, EPA evaluated and considered the benefit analysis developed as a part of the RIA" (Federal Register, 1991, p. 5,182). EPA used a benefits transfer based on an existing contingent valuation study to estimate monetary benefits. The draft RIA concluded that benefits may exceed costs with a fairly wide uncertainty range.

[2] For instance, in 1985 EPA established "policy-derived" cost-effectiveness guidelines for air pollution New Source Performance Standards of $3,000/megagram for particulate matter and $1,250/megagram for both sulfur dioxide and volatile organic compounds (Elkins and Russell, 1985).

Prior to proposal the NGS commissioned a pilot contingent valuation study directly concerned with the benefits of reducing sulfur dioxide emissions from NGS. The NGS study concluded that costs exceed benefits. EPA invited comments during proposal on both benefit studies. However, in the final rule, EPA stated, "[b]ecause the benefits analysis forms no part of [the] legal basis for today's action, EPA is not responding to those comments" (*Federal Register,* 1992, p. 50,184). The final rule requires NGS to reduce its sulfur emissions by 90 percent. It seems that each side used sufficient benefit analysis to counter the benefit-cost conclusions presented by the other, perhaps causing the benefits analyses to be side-stepped in the official decision-making process.

State and local agencies are also becoming more interested in benefits analysis. For example, the South Coast Air Quality Management District (SCAQMD) is the local air pollution control authority in the Los Angeles area. Under the California Clean Air Act, in 1989 the SCAQMD approved a massive plan to reduce air pollution in the South Coast. As part of preparing the plan, the SCAQMD asked the California State University Fullerton Foundation to prepare an economic evaluation of the potential health benefits of improving air quality in the South Coast. The report examined the benefits from a number of health and welfare endpoints associated with various pollutants (Hall et al., 1989). Part of the motivation for this study was to help build public support for the pollution control measures set forth under the plan by demonstrating that substantial benefits would accrue as a result of the control costs incurred.

Another example of state interest in benefits is the New York State Energy Research and Development Authority (NYSERDA). New York has a policy of considering the full social costs in electric utility planning. NYSERDA asked the Pace University Center for Environmental Legal Studies Energy Project to prepare a study of the environmental externality costs of electric utility operations (Ottinger et al., 1990). The study examines the social costs of available methods of generating electricity as well as the social costs of demand-side management programs.

Legislative Branch

Legislative development is the third broad government arena for benefit analysis. The U.S. Congress or state legislatures make many fundamental choices long before the specific regulations are promulgated or damage suits litigated. Congress is increasingly interested in benefit analysis and has recently either prepared or required several major benefit studies. Three examples of Congress's recent interest in benefits are the inclusion of benefits assessment in the change to the National Acid Precipitation Assessment Program (NAPAP), the Office of

Technology Assessment (a congressional entity) report *Catching Our Breath: Next Steps for Reducing Urban Ozone,* and a retrospective and prospective report on benefits and costs required by §812 of the Clean Air Act.

The NAPAP State of Science and Technology (SOS/T) reports include a review of the state of knowledge about physical and economic benefits for environmental effects categories associated with acid rain (Brown et al., 1990). The NAPAP *1990 Integrated Assessment Report* develops a "quality of information" ranking system for all information in the SOS/T, including monetized benefits information. In general, NAPAP used fairly rigorous criteria for assessing the quality benefits information. The *Integrated Assessment* includes monetized benefit information on only four environmental endpoints: national agriculture, forests in the southeast, recreational fishing in the Adirondack Mountain region, and urban visibility in the east. Eight other endpoints[3] of concern are qualitatively discussed, but monetized benefit estimates are not developed because of NAPAP's assessment of inadequate information on physical damages. valuation, or both. The benefits estimation techniques used in the *Integrated Assessment* include supply/demand analysis for commercial crops and forest products, travel-cost for recreational fishing, and a blend of meta-analysis, expert judgment and benefits transfer for visibility.

The congressional committees working on reauthorizing the Clean Air Act requested that the Office of Technology Assessment prepare the analysis in *Catching our Breath.* Ozone is the United States' most widespread and persistent air pollution problem. In spite of considerable effort and much progress, 45 percent of the U.S. population lived in metropolitan areas that did not meet the ozone air quality standards in 1988 (EPA. 1990). Because of the abatement activities already in place, further progress on ozone will be increasingly expensive. OTA's analysis focused on two environmental endpoints of ozone. The benefits analysis used expert judgment based on existing literature for the value of reducing health effects and supply/demand analysis for commercial crop effects.

Section 812 of the Clean Air Act Amendments of 1990 expands the scope of the existing § 312 report on the cost of federal air pollution programs. The goal of the expanded *Cost of Clean Air* report is to include monetary benefit analysis in a comprehensive examination of the full social and private costs and benefits of the Clean Air Act. The first report must estimate the costs and benefits of all air programs prior to the 1990 Amendments. After the "retrospective" report is issued, EPA must periodically update the retrospective report and prepare a "prospective" report, with projections of the costs and benefits of further progress in reducing air

[3] other terrestrial ecosystems, water-based recreation, commercial fishing, other aquatic ecosystems, building material, cultural materials, and human health.

pollution. The Amendments create an Advisory Council on Clean Air compliance Analysis to peer review the data methodology, and findings in the report and to make recommendations to EPA.[4]

Nongovernment-Sponsored Benefit Analysis

Recognizing that benefit analysis plays a role in the public decision process, various groups outside the government also produce benefit analyses.. These efforts range from publicizing existing work to undertaking substantive new efforts. Affected parties in legal or regulatory proceedings have various legal and procedural opportunities to provide benefits information. But outside groups also provide benefits information in other settings as well. The motives for providing such information likely range across the spectrum, from pro bono provision of information to narrow strategic advocacy. Sometimes the analysis is obviously tied to a particular action pending in Congress or an issue emerging in the national environmental or political landscape. Two recent examples are the series of articles written by Portney and Krupnick (Portney, 1990; Krupnick and Portney, 1991). and the American Lung Association's latest survey of studies on the health costs of air pollution (Cannon, 1990).

STRATEGIC CONSIDERATIONS: BENEFIT ANALYSIS IN THE REAL WORLD

The acceptable level of "good enough" benefit analysis is not determined solely by the particular legal situation. A number of strategic or tactical issues face all the interested parties who have the option of producing benefit analysis. Economic researchers are seldom the ultimate public policy decision makers, and economic efficiency is not necessarily the primary concern of all parties. Benefit analysis is typically prepared at the request of, and for the purposes of, someone else. The "client" must decide to accept a given level of benefits effort (perhaps a level already provided by someone else), or to undertake more extensive analysis. That decision is basically driven by the question. "Are further efforts likely to make a difference that I will like?" The researcher can provide useful opinions about what additional efforts will likely produce and an evaluation of the influence on uncertainty from more information, but the decision to go forward or not rests with the client's evaluation of whether the analysis will further their interests. Ideally, of course, the client's interests include making rational and socially beneficial decisions based on objective information. However, this is not always the case, and the researcher may be more vulnerable to manipulation and/or misinterpretation if unaware of all the client's motives for requesting benefit analysis.

[4] The initial members of the Council are R. Cummings, D. Dudek AM. Freeman, R. Mendelsohn, W. Nordhaus. W. Oates, P. Portney, R. Schmalensee, T. Tietenberg, and K. Viscusi.

Benefits researchers are doing a great disservice to themselves, their client, and the profession in general if they allow strategic or tactical considerations to influence the content of a benefit analysis. Current standard practices of careful reporting of data or results taken from other sources, open disclosure of new data, survey instruments and methods, detailed descriptions of assumptions, biases and omissions, careful attention to economic theory and statistical procedure, and adequate quality control procedures are important to maintain, no matter how the client intends to use the results. Bad analysis is never good enough, despite the client's interests.

However, even if benefit analysis can be totally inoculated from deliberate strategic mis-preparation, the client may still face various strategic considerations. For instance, an argument that a new analysis must be prepared because the level of uncertainty in the existing benefits transfer is unacceptable may be a pretext, where the real motivation is a stalling tactic. A new benefit study that costs less than the present value of a delayed decision can be an economically rational move by a client with adequate resources to invest.

Another strategic consideration that a client must carefully evaluate is the amount of scrutiny that the benefit analysis will undergo. If the client could be assured of an impartial review by knowledgeable people, the decision could focus on issues of reducing uncertainty and providing better information, for example. However, in the real world benefit analysis is often reviewed in an adversarial setting where the audience (e.g., decision makers, juries) may not have a great deal of technical expertise. A greater level of effort may be required, not because more information is really needed, but to protect the analysis from being discredited in the eyes of the nonexpert audience by voluminous criticisms.

Setting a precedent can also be an important issue that influences the level of analysis one side or the other is willing to support. The total return to an investment in additional research may be much greater than the expected return from the current situation. If one side establishes a precedent in a small case on whether benefits can be measured, determines the appropriate way to estimate benefits, or a benefits function, the larger payoff may come later in a different and larger case.

Our final point on strategic issues is the different ability of parties to afford additional efforts. Consider a David and Goliath situation, where a government or a court is considering whether to require a solution to a particular pollution problem. The affected parties may not have equal ability to provide additional analysis. If the side with the largest resources perceives the outcome may be more favorable if they provide additional information that reduces the benefits uncertainty, they can provide the further analysis. The other side's income or wealth limits can prevent them from exercising a similar option. This issue does not only exist in "big corporation versus the little guy" settings: the resources of a well-funded national advocacy group can far surpass the resources of a property owner or small business. The "decision maker" must keep these tactical issues in mind when reviewing additional information that has been submitted. Silence from one side may be more reflective of current wealth than of the magnitude of the actual benefits. Newly provided analysis may reflect as much information on the submitter's analysis of the likely outcome as it does of the real issues in the case.

FUTURE DIRECTIONS

Benefit estimation is both an art and a science, combining theory from the social sciences, techniques from statistics, and sound judgment on the part of the practitioner. Progress will be made as we improve our art, our techniques, and our science. One often noted weakness in the current state of economic science in general is the relative infrequency with which results are tested. One cornerstone of the scientific method is the replicability of results, but the economics profession does not usually emphasize repeating analysis. The aversion to repeating analyses is not due to malicious intent but to scarce resources, ever expanding research agendas, and a pressing need to try to provide answers to the crucial problems confronting society. However, it does result in greater uncertainty in our results, frequently conflicting conclusions, and diminished acceptability of our results. This problem is endemic to most of economics but is particularly relevant to the issue of benefits transfer. Much of the uncertainty associated with benefits transfer comes from the limited knowledge we have about how different specifics about the assessment situation in question will influence the estimates. As we gain a better understanding of the effects that variations in our techniques have on benefit estimates for a single situation and on the differences identical techniques produce when used in different situations, we will improve our ability to use benefits transfer techniques and understand the associated uncertainties. Consequently, our ability to meet the need of the decision maker at the lowest possible cost will also improve.

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WHAT IS CONSUMER'S SURPLUS *FOR A DAY OF USE?* AND WHAT DOES IT TELL US ABOUT CONSUMER'S SURPLUS?

Edward R. Morey*

ABSTRACT

Compensating variation *for a day of use* is a well-defined concept for a change in the price of a recreational site but is not, in general, a well-defined concept for a change in the characteristics of a site. Sufficient conditions for when it is well-defined for characteristics changes are identified. These sufficient conditions are assumed in most discrete-choice models of recreational participation and site choice. When well-defined, compensating variation for a day of use multiplied by the number of days in the original state (proposed state) is a Laspeyres index (Paasche index) that bounds the compensating variation (CV) from below (above). The first approximation is a linear approximation to the CV, and the second approximation is a linear approximation to the equivalent variation. The average of these two approximations is an *almost* second-order approximation to the CV and is akin to the Harberger triangle. Simulation results indicate the bias in the linear approximations can be small or large, and the bias in the average of these two linear approximations while often quite small can be large if the proposed changed will result in a large percentage change in the predicted number of days.

Consumer's surplus *for a day of use* is a common way to express the benefits a representative individual derives from a recreational site. The U.S. Forest Service uses consumer's surplus for a day of use as the basic measure of a site's recreational value. Walsh, Johnson, and McKean (1991) surveyed twenty years of empirical research on the recreational value of our national forests. They note, "The standard unit of measurement is an activity day, defined as one person on-site for any part of a calendar day" (p. 176). Derivation of *day of use* measures is common in both the travel-cost and contingent valuation literature and is particularly common in the discrete-choice variants of these methodologies. A few examples are Bockstael, Hanemann, and Strand (1984); Carson, Hanemann, and Wegge (1987); Cameron (1988); and Cameron and James (1987).

Why the attraction to consumer's surplus for a day of use when the desired welfare measure for policy analysis is not consumer's surplus for a unit consumed but instead consumer's surplus? For a given time period such as a year, the policy maker wants to how how each individual values a change in prices or site characteristics rather than his or her value

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per day of use for that change.[1] However, policy makers and economists alike are attracted to for a day of use measures for a number of reasons, one being consumer's surplus day of use lends itself to use in *benefit transfers.* The notion is that once a representative individual's consumer's surplus for a day of use has been estimated for *X-ing* at one site where "X" is a recreational activity such as fishing or hiking, the analyst can obtain that individual's consumer's surplus for the site or any similar site by multiplying consumer's surplus for a day of use at the first site by the number of days spent *X-ing* at the site to be valued.

This paper examines the concept of consumer's surplus for a unit of use and identifies its relationship to consumer's surplus per unit of time. Does consumer's surplus for a unit of use stand alone as a well-defined concept, and if so, should it be the standard-bearer for transferring benefit measures from one site to another?

We begin our examination of these issues with a thought experiment. Consider the maximum you would pay to have the price you pay for the next Coke you drink reduced by $0.50. Your answer is $0.50. Further note that this is how much you would pay each and every time you purchase a Coke to have the price of that Coke reduced by $0.50. Fifty cents is your consumer's surplus for a unit of use for having the price of Coke reduced by $0.50 (i.e., it's your *per-Coke* consumer's surplus for the price reduction).

Consider now a similar thought experiment for a reduction in the cost of a day at a recreational site.[2] For simplicity, assume a world of three commodities: two types of activities, days at a recreational site and days at home, and a numeraire good that can be consumed anywhere. What is the maximum amount an individual would pay each time he or she spent a day at the site to have the cost of that day reduced from P_t^0 to P_t^1 where P_t is the cost for the day? The answer is $(P_t^0 - P_t^1)$, which is the individual's day of use compensating variation (CV) for the price change, denoted CVDU.[3]

CVDU is represented graphically in Figure 1 as the vertical distance ab, whereas the individual's CV associated with the change is the area $P_t^0 acP_t^1$. Obviously, CVDU $\neq$ CV. The issue is, therefore, how CV can be derived, *or approximated*, from the CVDU.

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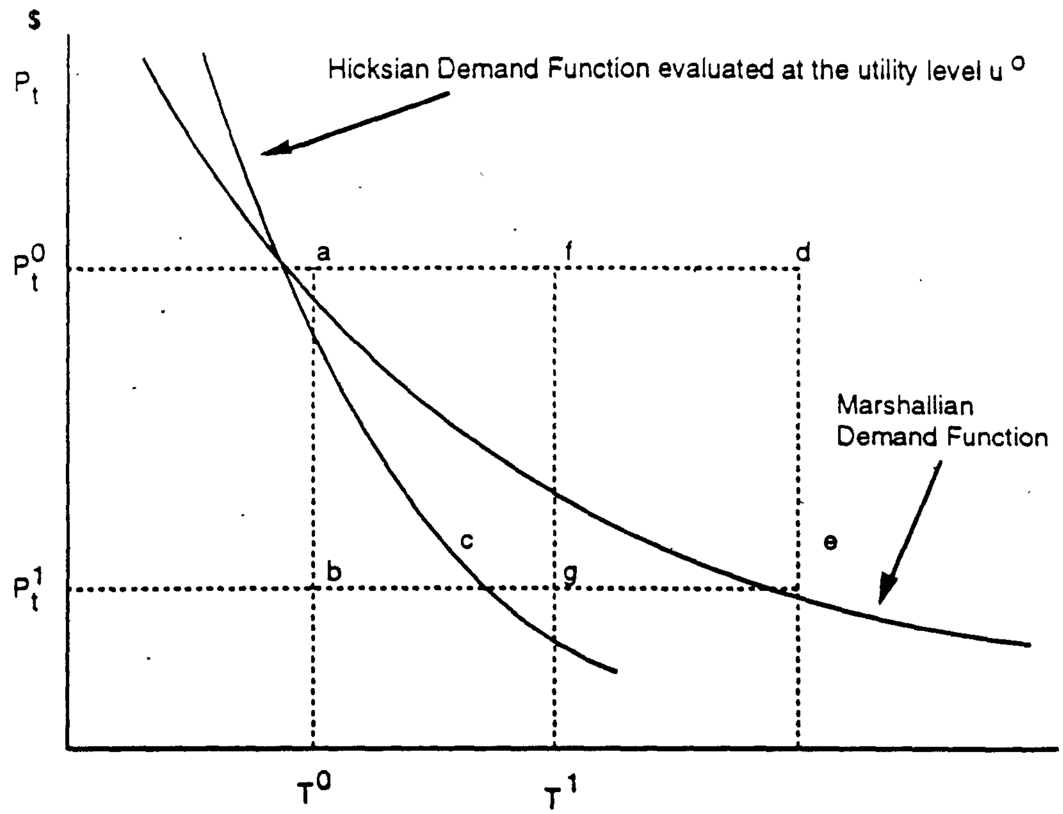
[1] Consumer's surplus is defined here as either the compensating variation or the equivalent variation associated with the change. It is defined for a specific time period such as a year or season.

[2] Later, I consider the more complicated issue of the consumer's surplus and the consumer's surplus for a unit of use for a change in the characteristics of a recreational site.

[3] Note that CV for a day of use, CVDU, is not the same as the CV for a day.



T = Number of days at the site

Figure 1. Per Day of Use Compensating Variation

Consider multiplying CVDU by the number of days at the site.[4] The figure obtained depends on whether CVDU is multiplied by the number of days at the site in the original state, the number of days in the proposed state, or some average of the two. Define $CV^o_t \equiv (T^o \times CVDU)$, where T^o is the number of days when $P_t = P^o_t$. Graphically, CV^o is the area $P^o_t abP^1_t$. Define $CV^1_t \equiv (T_1 \times CVDU)$, where T^1 is the number of days when $P_t = P^1_t$. Graphically, CV^1_t is the area $P^o_t deP^1_t$. As

[4]Considering day of use consumer's surplus measures, Bocksteal, Hanemann, and Strand (1984) state, "The calculation of CV according to equation (20) yields an estimate of the compensating variation *per choice occasion* for the household. To obtain annual or seasonal benefit estimates this number must be multiplied by the number of trips the individual takes" (p. 10-28). In the same vein, Carson, Hanemann, and Wegge (1987) state, "The benefit is measured in terms of the maximum amount of money the individual would be willing to pay to ensure that the alternative is available whenever he makes a fishing choice. We therefore obtain an estimate of benefit per choice occasion, i.e., per fishing trip to any site, not just per-trip to the particular site of interest. Because our resident angler model is estimated on a weekly basis, the benefit to an individual is the benefit per choice occasion during that week, multiplied by the predicted number of trips (choice occasions) that week" (p. 8-23).

Figure 1 suggests, CV_t^o is a Laspeyres index that bounds the CV from below, and CV_t^1 is a Paasche index that bounds the CV from above.

Theorem 1:

$$CV_t^o \equiv \left[T^o\left(P_t^o - P_t^1\right)\right] \leq CV \tag{1}$$

and

$$CV_t^1 \equiv \left[T^1\left(P_t^o - P_t^1\right)\right] \geq CV. \tag{2}$$

Proof that $\left[T^o\left(P_t^o - P_t^1\right)\right] \leq CV$

Define the indirect utility function for the season as V = $V(Y, P_h, P_t)$ where Y is income. P_h is the cost of each day at home, $V^o \equiv V(Y, P_h^o P_t^o)$, and $V^1 \equiv V(Y, P_h^o P_t^1)$. Dual to this indirect utility function is the expenditure function E = $E(V, P_h, P_t)$. Define T as the number of days at the site, H as the number of days at home, and let N denote the quantity of the numeraire consumed (i.e., N $\equiv$ Y $- P_t T - P_h H$).

By definition, the CV for a change from $\left\{P_h^o, P_t^o\right\}$ to $\left\{P_h^o, P_t^1\right\}$ is

$$CV = E\left(V^o, P_h^o, P_t^o\right) - E\left(V^o, P_h^o, P_t^1\right) \tag{3}$$

By definition of the expenditure function

$$E\left(V^o, P_h^o, P_t^o\right) = P_t^o T^o + P_h^o H^o + N^o \tag{4}$$

and

$$E\left(V^1, P_h^o, P_t^1\right) = P_t^1 T^1 + P_h^o H^1 + N^1 \tag{5}$$

Substitute Eq. (4) into Eq. (3) to obtain

$$CV = \left(P_t^o T^o + P_h^o H^o + N^o\right) - E\left(V^o, P_h^o, P_t^1\right) \tag{6}$$

Now note that

$$E\left(V^o, P_h^o, P_t^1\right) \leq P_t^1 T^o + P_h^o H^o + N^o \tag{7}$$

because T^o, H^o, and N^o are by definition capable of producing V^o. Therefore, $P_t^1 T^o + P_h^o H^o + N^o$ are sufficient expenditures to produce V^o given P_t^1 and P_h^o. However, $E(V^o, P_h^o, P_t^1)$ is by definition the minimum expenditures required to produce V^o given P_t^1 and P_h^o.

Given Eq. (6) and Eq. (7),

$$CV \geq \left(P_t^o T^o + P_h^o H^o + N^o\right) - \left(P_t^1 T^o + P_h^o H^o + N^o\right) = T^o \text{ x } \left(P_t^o \text{ and } P_t^1\right) \quad \textbf{q.e.d.} \tag{8}$$

The proof that $[T^1 \text{ x } (P_t^o - P_t^1)] \geq CV$ is analogous to the proof that $[T^o \text{ x } (P_t^o - P_t^1)]$ $\leq$ CV.

Further note that from Eq. (6), Eq. (7), and the definition of CV_t^o, it follows that

$$CV - CV_t^o = P_t^1 T^o + P_h^o H^o + N^o - E\left(V^o, P_h^o, P_t^o\right) \geq 0 \tag{9}$$

As Eq. (9) indicates, the bias in CV_t^o is how much the expenditures to produce V^o would decline at the proposed prices if the individual is allowed to adjust his allocation from $\{T^o, H^o, N^o\}$ to $\{T^1, H^1, N^1\}$.

CV_t^o also a linear approximation to the CV for a change in P_t, that is

$$CV = E\left(V^1, P_h^o, P_t^1\right) - E\left(V^o, P_h^o, P_t^1\right) \tag{10}$$

$$\approx E\left(V^1, P_h^o, P_t^1\right) - [E\left(V^o, P_h^o, P_t^o\right) + \frac{\partial E\,(V^o, P_h^o\, P_t^o)}{\partial P_t}(P_h^1 - P_t^o)]$$

by Taylor's Theorem

$$= - \frac{\partial E\left(V^o, P_h^o\, P_t^o\right)}{\partial P_t}\left(P_h^1 - P_t^o\right) \quad \text{since } E\left(V^1, P_h^o, P_t^1\right) = E\left(V^o, P_h^o, P_t^o\right) = Y$$

$$\equiv T^o\left(P_t^o - P_t^1\right) \equiv CV_t^o$$

by Shepard's lemma

By an analogous argument, CV_t^1 a linear approximation to the equivalent variation.

Note that CV_t^o is akin to a linear approximation to the CV that is essentially due to Hicks (1942 and 1946). The Hicksian approximation to the CV, which is in terms of quantity changes rather than price changes, is

$$CV \approx P^1(X^1 - X^0) \text{ (Diewert, 1987)} \tag{11}$$

where $X \equiv (H, T, N)$ and $P \equiv (P_h, P_t, 1)$.[5] Therefore CV_t^o might be labeled Hicksian price-change approximation to the CV.

Summarizing to here, $[T^o(P_h^o - P_t^1)]$ and $[T^1(P_h^o - P_t^1)]$ are respectively lower and upper bounds on the CV, and $[T^o(P_h^o - P_t^1)]$ is, in addition, a linear approximation to the CV. These results make consumer's surplus for a day of use, $(P^o - P^1)$, useful.

Unfortunately, neither CV_t^o or CV_t^1 will always closely approximate the CV. Put simply, the actual degree of bias in these linear approximations depends on the individual's preferences and the magnitude of the price change. The bias can be small or large. For example, in Figure 1 the bias is significant visually. Intuitively, the bias in CV_t^o and CV_t^1 results because neither measure considers the substitutability between days at home and days at the site. The degree of bias in each of these measures is an increasing function of the *marginal rate of substitution* between days at home and days at the site and of the magnitude of the price change; the greater the change in T that will result from the proposed price change, the greater the bias.

In contrast to these linear approximations, the average of CV_t^o and CV_t^1 is *almost* a second-order approximation to the CV for a change in P_t. Denote this average CV_t^{ave}

$$CV_t^{ave} = \frac{1}{2}\left(CV_t^o + CV_t^1\right) = \left(P_t^o - P_t^1\right)\frac{1}{2}\left(T^1 + T^o\right) \tag{12}$$

$$= T^o\left(P_t^o - P_t^1\right) + \frac{1}{2}\left(P_t^o - P_t^1\right)\left(T^1 + T^o\right)$$

CV_t^{ave} **will** almost always better approximate the CV than either CV_t^o or CV_t^1.

In contrast to CV_t^{ave}, an exact second-order approximation to the CV for a change in P_t is

$$CV = E\left(V^1, P_h^o, P_t^1\right) - E\left(V^o, P_h^o, P_t^1\right) \tag{13}$$

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[5] If we restrict the change in P to a change in P_t, Eq. (10) simplifies to

$$P^1(X^1 - X^o) = P_t^1(T^1 - T^o) + P_h^o(H^1 - H^o) + (N^1 - N^o)$$

$$= E\left(V^1, P_h^o, P_t^1\right) - \left[E\left(V^o, P_h^o, P_t^o\right) + \frac{\partial E\left(V^o, P_h^o P_t^o\right)}{\partial P_t}\left(P_h^1 - P_t^o\right)\right.$$

$$\left. + \frac{1}{2}\frac{\partial^2 E\left(V^o, P_h^o P_t^o\right)}{\partial P_t^2}\left(P_t^1 - P_t^o\right)^2\right] \qquad \text{by Taylor's Theorem}$$

$$= -\frac{\partial E\left(V^o, P_h^o P_t^o\right)}{\partial P_t}\left(P_t^1 - P_t^o\right) - \frac{1}{2}\frac{\partial^2 E\left(V^o, P_h^o P_t^o\right)}{\partial P_t^2}\left(P_t^1 - P_t^o\right)^2$$

because

$$E\left(V^1, P_h^o, P_t^1\right) = E\left(V^o, P_h^o, P_t^o\right) = Y$$

$$= T^o\left(P_t^o - P_t^1\right) + \frac{1}{2}\frac{\partial T\left(V^o, P_h^o P_t^o\right)}{\partial P_t}\left(P_t^1 - P_t^o\right)\left(P_t^o - P_t^1\right)$$

by Shepard's lemma

Comparing Eq. (12) and (13), the difference between CV_t^{ave} and an exact second-order approximation to the CV is the difference between $(T^1 - T^o)$ and the change in P_t, $(P_t^1 - P_t^o)$, multiplied by the slope of the Hicksian demand function for T evaluated at the initial utility level and prices,

$$\frac{\partial T\left(V^o, P_h^o P_t^o\right)}{\partial P_t}$$

Note that a different almost second-order approximation to the CV is the well-known Harberger triangle,[6] $(P^o(X^1 - X^o) + \frac{1}{2}(P^1 - P^o)(X^1 - X^o))$. The difference between CV_t^{ave} and the Harberger triangle is CV_t^{ave} is an almost second-order approximation to the CV in terms of the price change, and the Harberger triangle is an almost second-order approximation to the CV in terms of the quantity changes. In this sense CV_t^{ave} might be labeled the price-change equivalent to the Harberger triangle

Summarizing the last few paragraphs, CV for a day of use can be used to obtain an almost second-order approximation to the CV by multiplying CV for a day of use by average

[6] For more details on the properties of the Harberger triangle see Harberger (1971), Diewert (1976 and 1987), and Weitzman (1988).

number of days at the site in the initial and proposed states. In general, this approximation is better than the approximation obtained by multiplying CV for a day of use by the number of days at the site in one of the states.

To get a feel for how large biases in CV_t^o, CV_t^1, and CV_t^{ave} can be, I ran 100 simulations. Simulations tell us nothing about how small or large the bias will be in any particular real world example. They are by definition assumption-specific; a particular preference ordering is assumed, and then the bias is determined for different price changes for that preference ordering. The simulations reported here are based on a simple repeated discrete-choice random-utility model that explains the probability of visiting the site on any given day. No claim is made that this discrete-choice model reflects truth. The largest bias I generated is a case where the price reduction causes the probability of visiting the site each day to increase from effectively zero to 2 percent. For this case, CV = \$18.25, CV_t^o = \$0.0025, and CV_t^1 = \$203.40.

For comparison, a case where the price reduction causes the probability to increase from 4 to 9 percent resulted in a CV of \$58.95, a CV_t^o of \$35.34, and a CV_t^1 of \$90.56, and a case where a price increase causes the probability to decrease from 4 to 1 percent results in a CV of -\$22.59, a CV_t^o of -\$35.34, and a CV_t^1 of -\$13.30. For the 100 simulations, neither CV_t^o nor CV_t^1 closely approximate the CV unless the price change caused the probability to change by less than 10 percent, and then CV, CV_t^o, and CV_t^1 are all effectively zero. For example, a price decrease that caused the probability to increase from 2 to 2.04 percent (a 2 percent change) resulted in a CV of \$0.3233, a CV_t^o of \$0.3205, and a CV_t^1 of \$0.3262, but a price decrease that caused the probability to decrease from 34 to 26 percent (a 30 percent change) resulted in a CV of -\$101.30, a CV_t^o of -\$113.60, and a CV_t^1 of -\$89.50. These simulation results are just an example, but they do indicate the potential for a bias and one that increases as the significance of the price change increases.

CV_t^{ave} much more closely approximates the CV. For the eight simulation results noted above, the CV's and their corresponding CV_t^{ave}'s are {\$18.25 and \$101.70}, {\$58.95 and \$62.95}, {-\$22.59 and -\$24.32}, {\$0.3233 and \$0.3234}, and {-\$101.30 and -\$101.50}. Except for the first set, CV and CV_t^{ave} are all similar. In the first case, a five-fold difference exists between the CV and the CV_t^{ave}. Again, these simulation results should not be taken too seriously, but they do suggest that the CV_t^{ave} closely approximates the CV except in cases in which the price change will cause a great change in the number of days at the site. However. bias is significant because any policy that increases demand from effectively zero to a small number of days will involve a large multiplicative change in total demand.

Up to this point we have only considered the CV associated with a change in the price of a day at the site. However, often we need to estimate or approximate the CV associated with a change in the characteristics of a site. How much of the argument above generalizes to cases involving changes in characteristics?

To begin our investigation of this question, again consider our Coke-drinking thought experiment, but now determine how much you would pay to have the number of calories in the ith Coke that you drink reduced by 50 percent (with all other product characteristics unchanged). Without loss of generality, I'll denote your answer α_i. This amount, α_i, is your CV for this calorie reduction *for the ith Coke drank.* Contrast this amount with a *per-Coke* CV for this calorie reduction that is independent of the number of Cokes you choose to drink. A *per-Coke* CV independent of the number of Cokes you choose to drink only exists if $\alpha_i = \alpha \; \forall$ i, in which case is the per-Coke CV. In cases such as our first thought experiment where the change is solely a price change, $\alpha_i = \alpha =$ the price reduction $\forall$ **i,** but typically $\alpha_i \neq \alpha \; \forall$ i if the change involves a change in the characteristics of the commodity. For example, how much I would pay to have the calories reduced in the last Coke I drink will increase as I drink more Cokes.

By definition, $\alpha_i = \alpha \; \forall$ i only if how you value the change in monetary terms is independent of the number of Cokes you choose to drink. This must be true for a change in the price of a Coke, but what would be sufficient to make it true for a change in the characteristics of the Coke? A *sufficient* but not *necessary* condition is a world with the following **properties:**[7]

- Assume a world of only three commodities: two activities, drinking a Coke and not drinking a Coke, and a numeraire good.
- Both activities take all day.
- If you choose not to drink a Coke you spend all of your income for the day on the numeraire. Otherwise you allocate to the numeraire your income for the day minus the price of the Coke.
- How much utility you receive on a day is only a function of whether you drink a Coke that day, the amount of the numeraire consumed that day, and the characteristics of Coke. If these four conditions hold, you will always have a CV *per Coke drank* for a change in the price and/or characteristics of Coke, which is independent of the number of Cokes you choose to drink.

Now consider a similar thought experiment for a change in the characteristics of a recreational site. As before, assume a world of three commodities: two types of activities, days at the recreational site and days at home, and a numeraire good that can be consumed anywhere.

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[7] The reason I choose these properties rather than some other set of sufficient conditions will become clear.

What is the maximum amount an individual would pay each and every time he or she spends a day at the site to have characteristics of the site be C^1 rather than C^0? As our last thought experiment indicates, the individual will not in general be able to answer this question because there is no such amount. For changes in the characteristics of a site, a constant CV *for a day of use,* α, does not usually exist.

In a world with a recreational site but no Coke, $\alpha_i = \alpha \; \forall$ i only if the manner in which the individual values the change in the site in money terms is independent of the number of days he or she spends at the site. $\alpha_i = \alpha \; \forall$ i must be true for a change in the price of a day at the site but does not have to be true for changes in the characteristics of the site.

A constant CV for a day of use will exist for an individual in our world of three commodities only if we make the additional assumption that the utility the individual receives on a day is only a function of whether he or she spends that day at the site, the amount of the numeraire consumed that day, and the characteristics of the site. In this case, $\alpha_i = \alpha \; \forall$ i for any change in the price of a day and/or change in the characteristics of the site. Note that when this assumption is made a price change always exists that would make the individual indifferent between that price change and the proposed change in the characteristics, and this price change is independent of the number of days spent at the site. We might denote this price change as the *quality-equivalent price change.* Therefore, when we adopt the additional assumption outlined above, any change in the characteristics of a site can be *converted* into its *quality-equivalent price change,* and Theorem 1 and all the approximation results apply in terms of this price change. The fact that a characteristics change can be converted into an equivalent price change when these restrictive assumptions hold makes Theorem 1 and the approximation results particularly relevant to discrete-choice models of recreational demand.

The assumption that the utility the individual receives on a day is only a function of whether he or she spends that day at a site, the amount of the numeraire consumed that day, and the characteristics of the site is the basic assumption of many discrete-choice models of recreational demand. Therefore a constant CV for a day of use can be derived for changes in both prices and characteristics from most discrete-choice models of recreational demand.[8] Consider a simple dichotomous Logit or Probit model designed to predict the probability that an individual will visit a particular site on a given day. Such models are based on two conditional indirect utility functions. One function specifies the utility received for the day if the site is visited, and the other function specifies the utility received for the day if the site is not visited.

[8] **For example see, the earlier references to Bockstael, Hanemann, and Strand (1984) and Carson, Hanemann, and Wegge (1987).**

From such a random-utility model we can derive an expected CV *per day* for any change in the price or characteristics of the site. This constant CV per day can, for example, be multiplied by the number of days in the year to get the CV for the year. From this discrete-choice model we can also derive a CV for a day of use. Note CV for a day of use is not the same thing as CV per day. CV for a day of use is what CV per day would be if the individual were constrained to spend the day at the site. The individual is not constrained in this way.

Theorem 1 and the approximation results imply the following for this simple discrete-choice model of recreational demand: CV for a day of use multiplied by the number of days each year to the site in the original state is both a lower bound and a linear approximation to the yearly CV associated with the change; CV for a day of use multiplied by the number of days each year to the site in the proposed state is both an upper bound on the yearly CV and a linear approximation to the yearly equivalent variation, EV, associated with the change; and CV for a day of use multiplied by the average of the number of days at the site in the two states is almost a second-order approximation to the CV associated with the change. The simulation results discussed earlier were all derived from a discrete-choice random utility model. Therefore, even though the original discussion of simulation results described the CVs as those for price changes, they could for this model also be described as CVs resulting from changes in the characteristics of the site. This assertion is true because any change in the characteristics of the site has a *quality-equivalent price change* if we assume that the utility the individual receives on a day is only a function of whether he or she spends that day at a site, the amount of the numeraire consumed that day, and the characteristics of the site.

CONCLUSIONS

Care is required when using consumer's surplus for a day of use. Consumer's surplus for a day of use exists for any change in the price of a day at a recreational site and is equal to the price change. However, if the change involves a change in the characteristics of the site, a constant CV per day of use does not, in general, exist. In addition, even when a constant consumer's surplus for a day of use does exist, multiplying it by the number of days at the site in the original state provides only a lower bound on the consumer's surplus, and multiplying it by the number of days at the site in the proposed state provides only an upper bound on the consumer's surplus. Simulations show the bias in these approximations can be small or large. The average of the two bounds often closely approximates the consumer's surplus, but even this average can be significantly biased for numerous proposed policies.

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GROUNDWATER VALUATION: DOUGHERTY COUNTY, GEORGIA

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ABSTRACT

The benefit transfer problem addressed here involves using existing valuation data to transfer estimates of groundwater quality benefits to Dougherty County, Georgia. Groundwater provides the sole source of almost all drinking water supplies in the county. In addition, the availability of abundant groundwater supplies, combined with good sandy soil and a mild climate, make this county a major agricultural production region. In the Dougherty County region, a high potential exists for chemical fertilizers and pesticides used in agricultural production to leach through the soil and contaminate groundwater supplies,

We evaluated groundwater valuation estimates from several previous studies as potential candidates for transfer to Dougherty County. Because of a number of limitations, the valuation estimates reported in previous studies provide, at best, "ball park" estimates of groundwater protection benefits in Dougherty County and therefore are suitable for only a "scoping" type analysis. The "transferability" of existing valuation estimates to Dougherty County might be improved by reestimating valuation models from existing data, obtaining additional secondary data from each existing study site, and conducting a small and inexpensive survey at the policy site (Dougherty County) to collect primary data on a limited number of key valuation variables (e.g., subjective supply and demand uncertainty). Benefit transfer holds promise as a potential alternative for valuing groundwater protection. However, much more research is needed to establish acceptable protocols for transferring benefit estimates from one site to another.

In many regions of the U.S. groundwater provides the major source of water for municipal, industrial, and agricultural activities. The continued use of groundwater to support these economic activities can be threatened by the activities themselves. For example, toxic chemicals from municipal and industrial waste dumps may leach through the soil and contaminate groundwater supplies. Chemical fertilizers and pesticides applied on agricultural land may also result in toxic chemicals leaching through the soil and contaminating groundwater supplies. One question of general interest is, "What are the benefits to the general public in a specific area of 'safe' groundwater quality (where safe implies that chemical concentrations in

*University of Georgia and University or Maine, respectively. We would like to thank Steven Edwards and Bruce Lindsay for providing information from their studies of groundwater protection benefits. Members of the case study group included David Brookshire (University of New Mexico), Lon Carlson (Argonne National Laboratory), Steve Crutchfield (USDA, Economic Research Service), Martin David (University of Wisconsin), Richard Dubourg (University College London), Stephen Farber (University of Pittsburgh), John Hoehn (Michigan State University), Linda Langner (USDA, Forest Service), Michael LeBlanc (USDA, Economic Research Service), Marc Ribaudo (USDA, Economic Research Service), and Rodney Weicher (NOAA). All errors, omissions, and opinions are solely attributable to the authors.

the water are within EPA health advisory levels)? Benefit transfer provides a potential means of addressing this question.

This paper proposes a protocol for transferring existing groundwater quality benefits using a case study approach. We present background information on the valuation problem for the case study "policy site" and discuss individual and aggregate values. We present a proposed benefit transfer protocol for the case study and assess the applicability of existing groundwater valuation data at "study sites." Finally we conduct a validity check of the proposed protocol and discuss implications for future benefit transfer research.

VALUATION PROBLEM BACKGROUND

Dougherty County, located in southwest Georgia on the southern Atlantic Coastal Plain, is underlain by a deep succession of sand, clay, and carbonate rocks that form a large aquifer system (Rouhani and Hall, 1988). Groundwater provides the source of almost all drinking water supplies in Dougherty County, which includes the City of Albany (Pierce, Barbar, and Stiles, 1982). The geographic and physical features of Dougherty County are illustrated in the maps provided in Appendix A.

The availability of abundant groundwater supplies, combined with good sandy soil and a mild climate, makes agriculture the largest industry in the county. Major agricultural products in the county include peanuts, soybeans, wheat, and corn. This crop production in the county involves heavy use of chemical fertilizers and pesticides. Some of these chemicals may be persistent and eventually leach through the soil and contaminate groundwater supplies. Because of the way groundwater moves underground, surface contamination in one area can spread to groundwater supplies many miles away (Cohen, Creeger, and Enfield, 1984; Kundell, 1980; Sun, 1990).

Contamination of groundwater by agricultural chemicals was first discovered in the late 1970s. By 1986, EPA groundwater testing studies had detected 19 pesticides in groundwater supplies in 24 states where the source of contamination was most likely agricultural application (U.S. EPA, 1987). Farms in Georgia and across the U.S. commonly apply large amounts of nitrogen fertilizer to crops. Nitrogen in fertilizer, after it leaches through the soil, may show up as nitrate in groundwater supplies. In 1986, an EPA study found that 2.7 percent of rural wells in the U.S. had nitrate concentrations exceeding the EPA health advisory level of 10 ppm (parts per million). Nitrate has been found in groundwater samples tested in Georgia, Florida, North Carolina, South Carolina, and Virginia (Hayes, Maslia, and Meeks, 1983; McConnel et al., 1984; Williams et al., 1988).

The empirical evidence from groundwater testing studies which is fairly sparse suggests that concentrations of agricultural chemical contaminants (pesticides and nitrates) in the Dougherty Country area are within EPA standards for safe drinking water (Georgia DNR, 1989; Nielson and Lee, 1987; Sun, 1990; Williams et al., 1988). Nielson and Lee (1987). however, identify the Dougherty County area as a region with potential for groundwater contamination by agricultural chemicals. Because groundwater is the major source of drinking water in Dougherty County (including both municipal and private wells), groundwater contamination by agricultural chemicals is a potential public health threat. Potential negative health effects associated with ingesting chemical contaminants are summarized by the U.S. EPA (1989).

Using the potential Pareto-improvement criteria as a decision rule, a groundwater protection program would be justified if the benefits of the program exceed the costs. The overall objective of this case study is to estimate the benefits of groundwater protection in Dougherty County via benefits transfer. The major challenge is to develop a protocol for using existing groundwater valuation data at identified study sites to address the specific valuation problem in Dougherty County (the policy site).

VALUE MEASURE CONCEPTS

A theoretically appropriate individual value measure requires a clear definition of the commodity or service to be valued. Figure 1 illustrates how we can define the commodity or service of interest in our case study. The initial concern in the case study is with the uses of chemicals by the agricultural industry in Dougherty County. These uses involve human activities such as mixing chemicals at wholesale and retail farm stores, mixing and applying chemicals on farms, and disposing of used chemical containers.

Chemical uses combine with physical pathways to create potential groundwater contamination situations. For example, improperly mixing highly concentrated chemical solutions near unprotected wellheads create a situation in which groundwater contamination may easily occur. Groundwater contamination may also occur when negligence on the part of chemical users is not apparent. For example, farmers may be properly and safely mixing and applying agricultural chemicals. The soil on the their farms, however, may be relatively porous and located directly above a groundwater aquifer. In this situation a high potential exists for agricultural chemicals to leach through the soil into the aquifer.

Assessment of chemical uses and physical pathways can help scientists to identify areas-like Dougherty County-where groundwater contamination may be a problem. As illustrated in Figure 1, groundwater monitoring (e.g., test wells) provides information on current

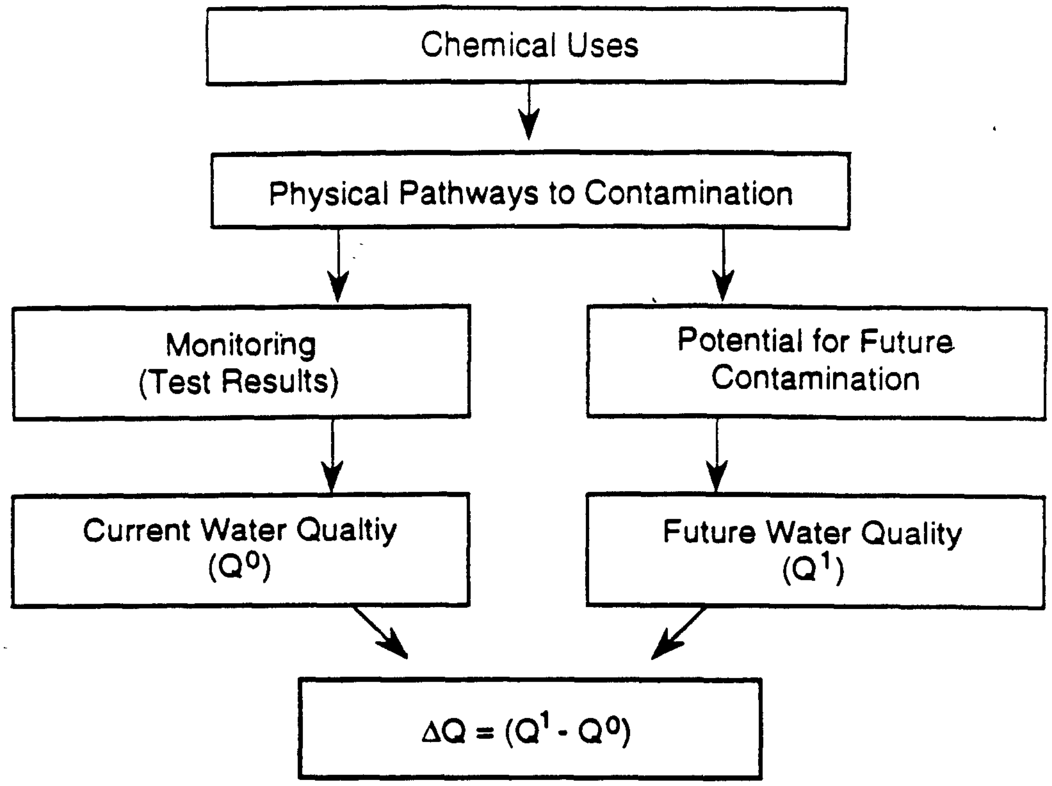

Figure 1. Definition of Commody of Service to be Valued

groundwater quality (Q^0). The results of current groundwater monitoring, combined with an assessment of future chemical uses and potential pathways to contamination, provide information on probable future water quality (Q^1). The probable-change in water quality (ΔQ) is then defined as $(Q^1 - Q^0)$.

As discussed earlier, monitoring data suggests that groundwater quality in Dougherty County is currently "safe." However, because of existing chemical uses and physical features, a relatively high potential exists for groundwater quality to become "unsafe" in the future from increased agricultural chemical contamination. Hence, $Q^1 < Q^0$, which implies that ΔQ represents an uncertain decrease in water quality. Uncertainty enters the policy analysis in terms of whether Q^0 will be maintained or Q^1 will occur. In addition, if Q^1 occurs, the timing of this water quality degradation may be a random event

Suppose next that a groundwater protection policy, denoted as Z, is proposed for Dougherty County to prevent a degradation in water quality from Q^0 to Q^1. Thus, in this case study the objective is to value the groundwater protection services provided by Policy Z. We assume that without Policy Z groundwater will not be treated for chemicals by any other public policy or program. We also assume that Policy Z will be 100 percent effective at protecting current water quality. Thus, the service provided by Policy Z is certain protection of current groundwater quality (Q^o) from uncertain degraded water quality (Q^1) in the future.

Individual Valuation Model

To define the theoretically appropriate measure of welfare change associated with Policy Z, we must make assumptions about the structure of groundwater quality property rights. If households have rights to water quality level Q^1, the theoretically valid measure of welfare change would be a citizen's willingness-to-pay (WTP) for Policy Z. If households have rights to water quality Q^o, the theoretically valid measure of welfare change would be a citizen's willingness-to-accept (WTA) compensation to face the threat of Q^1 by forgoing Policy Z.

In the case of Dougherty County, property rights to groundwater quality are ambiguous. Because of this ambiguity, we select WTP as the welfare change measure for this case study. This selection is based on two considerations. First, when property rights are ambiguous, the public is likely to pay for environmental protection rather than receive compensation to forgo environmental protection. Second, the accuracy of using empirical valuation techniques, such as contingent valuation, to measure WTA has not been well established (Cummings, Brookshire, and Schulze, 1986; Mitchell and Carson, 1989).

WTP for Policy Z is subject to both demand and supply uncertainty. Demand uncertainty arises, for example, if a current resident is uncertain as to whether he or she will reside in Dougherty County in the future. Supply uncertainty, as noted above, arises from the random nature of Q^1. When demand and supply uncertainly are present, the theoretically appropriate measure of WTP is option price (Bishop, 1982; Smith, 1983). Here, option price, OP, is defined as an individual's maximum WTP to ensure the protection of current water quality. An individual valuation model for OP can be specified generally as

$$OP = f(P_w, M, S, \gamma, \eta, Z) \tag{1}$$

where P_w represents the price of water, M represents income, S is a vector of socioeconomic variables, γ is a measure of demand uncertainty, η is a measure of supply uncertainty, and Z = 1 if Policy Z is in effect otherwise Z = 0.

Market Area Definition

Assuming that existing groundwater valuation studies provide estimates of Eq. (1), we can use these equations to estimate option price per individual for groundwater quality protection. To calculate total benefits, option price per individual is multiplied by the relevant population affected by Policy Z. To define the market area, determining all users and potential users of groundwater protected by Policy Z is necessary. In this case study, we are interested in the benefits of groundwater protection to Dougherty County residents. The county political boundary is, therefore, used to identify the number of current users and potential users in Dougherty County. Because nearly all county residents obtain their drinking water from groundwater supplies, all households in Dougherty County face the risk of drinking contaminated water now or in the future.

We also need to consider nonuse values when defining the market area. County residents may be willing to pay to provide uncontaminated groundwater for their future children or grandchildren (intragenerational transfer value). County residents may also be willing to pay to provide uncontaminated groundwater for the benefit of their relatives, friends, and neighbors (intragenerational transfer value) who live in the county. These nonuse values may represent a significant portion of a resident's option price for groundwater quality protection.

Nonresidents of Dougherty County may also have nonuse values that include existence values for an uncontaminated aquifer. Existence values are likely to be high for unique, irreplaceable natural resources (Krutilla, 1967). Uncontaminated aquifers can be found all over the U.S.; thus, nonresidents are not likely to view an uncontaminated aquifer in Dougherty County as a unique natural resource. In addition, cleaning up a contaminated aquifer may be possible (although the process would likely be time-consuming and costly). Therefore nonresidents may not consider an uncontaminated aquifer as a strictly irreplaceable natural resource. Thus, we assume that existence values for nonresidents are likely to be negligible.

Nonresidents may also be willing to pay to protect groundwater quality in Dougherty County for the benefit of relatives or friends who currently live in the county (itragenerational transfer value) or future residents of the county that they care about, for example, future grandchildren (intergenerational transfer value). We conjecture that nonuse values decline with distance from the county. Our assumptions concerning the magnitude of nonuse values (existence values and transfer values) require empirical validation in original valuation studies before they are widely implemented in benefit transfer studies..

PROPOSED BENEFIT TRANSFER PROTOCOL

Following terminology used in a recent special section on benefit transfer published in *Water Resources Research* (March 1992), we refer to "policy site" as the area to which we want to transfer benefit estimates. A "study site" is an area where an original valuation study has already been conducted to generate benefit estimates.

Before discussing the protocol let us briefly recall the criteria we have outlined for estimating values at the policy site, Dougherty County. We want to obtain WTP estimates of option price, which should allow for both demand and supply uncertainty. The estimates should also be total values that include use and nonuse components. We are not concerned in this particular case study with nonuse values held by individuals who reside outside of Dougherty County.

The increment of water quality to be evaluated starts with the presumption that groundwater at the policy site is currently safe (potable). The increment is the protection of water quality from nitrate and pesticide contamination. The probability of contamination and the time frame of potential contamination at the policy site are currently unknown from secondary data However, if contamination does occur, the potential for human exposure occurs throughout Dougherty County because most households derive their drinking water from groundwater supplies. The market area, therefore, for expanding transfer estimates is the county population.

Our proposed protocol involves two components. The fast is to assess the degree to which existing studies of groundwater benefits correspond to the criteria discussed in the previous two paragraphs and to evaluate the comparability of socioeconomic characteristics of residents of the study sites with residents at the policy site. The second component involves evaluating, in a qualitative manner, the credibility of existing value estimates in terms of economic theory, survey research procedures, statistical analyses, and reporting of research results.

An existing study that estimated option prices for improving already contaminated groundwater would not be deemed suitable for benefit transfer in the current case study. A study that does examine the protection of groundwater that is potable would need to meet the criteria of a threat to the same health endpoints as would occur from nitrate or pesticide contamination to drinking water. The quality of the study site valuation estimates should demonstrate linkages between the valuation issue, economic theory, survey design, and statistical analyses. These criteria, as shown below, are not hard and fast rules but subjective guidelines. They serve to demonstrate the complexity of actually conducting a defensible benefit transfer that is an acceptable substitute for a primary data study. The criteria also serve to identify issues that must be addressed to improve future benefit transfers.

BENEFIT TRANSFER DATA SOURCES

"Policy-Site" Data

For benefit transfer, we must have information describing the policy site. Important information to consider includes preferences and motivations for groundwater quality protection, perceptions of contamination risk (or actual risk estimates), availability of substitutes, physical features, basic socioeconomic characteristics of the population, and proportion of household relying on groundwater for drinking water supplies. We discussed physical characteristics of Dougherty County earlier. Table 1 provides information describing the population and households of Dougherty County. We constructed this table using readily available secondary sources (Bachtel, 1991; Salant, 1990; U.S. Bureau of Census, 1983; Hodler and Schretter. 1986).

"Study-Site" Data

We identified three studies in the published literature that estimated individual values for groundwater protection or cleanup. Edwards (1988) estimated option price, using WTP, for protecting potable groundwater from nitrate contamination in Falmouth, Massachusetts. Shultz and Lindsay (1990) estimated option price, using WTP, for protecting potable water from unspecified contaminants in Dover, New Hampshire. Finally, Doyle et al. (1991) estimated option prices, using WTP, for cleaning up contaminated groundwater in a generic city. We provide summary data on each of these studies in Table 2. We refer to these studies hereafter as the Edwards, Shultz, and Doyle studies, respectively.

All studies estimated option prices associated with uncertain future groundwater quality. Edwards and Shultz used dichotomous-choice, contingent-valuation questions in mail surveys to develop their estimates. Doyle used open-ended, contingent-valuation questions applied in focus groups. The Edwards and Shultz studies, therefore, represent original research with relatively large sample sizes-346 and 585, respectively. The Doyle study constitutes a survey pretest with small samples-two focus groups were conducted with sample sizes of 36 and 27.

The first screen we considered in evaluating the suitability of these studies for benefit transfer to Dougherty County was the theoretical construct measured. All three studies estimate option prices for use uncertainty with WTP. Thus, the studies do estimate the desired measure of value for the transfer protocol.

TABLE 1. POPULATION AND HOUSEHOLD CHARACTERISTICS, DOUGHERTY COUNTY, GEORGIA

Total Population (1989)	114,598 people
Number in Age Groups (1989)	
0-4	10,260 people
5-19	33,012 people
20-34	30,514 people
35-49	17,442 people
50-64	13,725 people
65 And Over	9,645 people
Median Age (1980)	26.0
Number of Households (1985)	35,400 households
Average Persons per Household (1985)	2.85
Per-capita Income (1988)	$12,624
Median Family Income (1979)	$17,631
Number of Households Receiving Less than $10,000 Annually (1988)	8,302 households
Median Education Level (1980)	12.2 years
Share of Population 25 Years Old or Over in Education Categories (1980) (%)	
0-8 Years	20.8
High School (1-3 Years)	20.7
High School (4 Years)	29.9
College (1-3 Years)	14.3
College (4 Or More Years)	14.2
Registered voters (1990)	39,707 people
Share of Population Living in Urban/Rural Areas (1980) (%)	
urban Areas	86.6
Rural Nonfarm	13.0
Rural Farm	0.4
Share of Population Living in Different Types of Housing (%)	
Owner-Occupied Housing Units	50.9
Renter-Occupied Housing Units	44.3

(continued)

TABLE 1. POPULATION AND HOUSEHOLD CHARACTERISTICS, DOUGHERTY COUNTY, GEORGIA (CONTINUED)

Mobile Homes	5.6
Housing Units Lacking Complete Plumbing	1.7
Share of Population in Types of Occupations (1980) (%)	
Managerial and Professional Specialties	21.6
Technical, Sales, and Administrative Support	30.6
Farming, Forestry, and Fishing	1.7
Precision Production, Craft, and Repair	12.9
Operators, Fabricators, and Laborers	20.0
Service	13.2
Share of Population in Racial Categories (1990) (%)	
White	48.8
Black	50.2
Other	1.0
Public Water Supply Use (1987)[a]	
Population Served by Public Supply	100,000 people
Public Use Per-capita	187.4 gallons per day
Leading Causes of Death (1989) (%)	
Cancer	22.2
Heart Attack	15.9
Stroke	6.5
Flu and Pneumonia	4.6
Emphysema and Asthma	2.5
Motor Vehicle Accidents	1.9
All Other Injury and Poisoning	6.8

[a]Groundwater provides the source of all public water supplies in Dougherty County.

Sources: Bachtel, D.C. 1991. *The Georgia County Guide*. 10th Ed. Cooperative Extension Service. Athens, GA: The University of Georgia

Hodler, T.W., and H.A. Schretter. 1986. *The Atlas of Georgia*. Athens, GA: The Institute of Community and Area Development, The University of Georgia.

Salant, P. 1990. *A Community Researcher's Guide to Rural Data*. Washington, DC: Island Press.

U.S. Bureau of Census. 1983. *Census of Population and Housing: General Social and Economic Characteristics.*

TABLE 2. EXISTING GROUNDWATER VALUATION STUDIES

Descriptive Variables	Shultz and Lindsay (1990)	Edwards (1988)	Doyle et al. (1991)
Valuation Issue	Protection of potable groundwater from contamination[a]	Protection of potable groundwater from nitrate contamination	Clean up contaminated groundwater
Water Source	Primarily private wells	Primarily public water supply (11% private wells)	50% of public water from groundwater
Probability of Contamination	Not specified	Various probabilities with 5 years time horizon	Various scenarios
Study Site	Dover, NH	Cape Cod, MA	Generic city
Population	4,980	NA[b]	NA
Value Estimated	Option price for use uncertainty (WTP)	Option price for use uncertainty (WTP)	Option price for use uncertainty (WTP)
Valuation Unit	Household	Household	Household
Valuation Method	Contingent valuation	Contingent valuation	Contingent valuation
Valuation Question	Dichotomous choice	Dichotomous choice	Payment card
Survey Format	Mail	Mail	Focus group
Response Rate	59%	78%	NA
Usable "n"	346	585	36, 27[c]
Median WTP	$40/year	NA	$6.8 - $8/month
Mean WTP[d]	$129/year	$363 - S1,437/year	$9.5 - $13.6/month ($114 - $163/year)
Variables Significantly Related to WTP (Direction of Effect)	Land value x = $10,420 (+)	Bequest motivation scale x = 5.2 (+)	NA
	Age x = 52 (-)	Cost of potable water scale x = 3.7 (+)	
	Family income x = $36,533 (+)	Income x = $55,413 (+)	

[a]Type(s) of contamination not specified.
[b]NA indicates that data are not contained in available publications
[c]Two focus groups were conducted.
[d]Standard errors of means were not reported for any of the studies.

The second screen involved the increment in water quality evaluated. Edwards and Shultz estimated values for preventing contamination of groundwater protection, while Doyle estimated values for cleaning up contaminated groundwater supplies. The Doyle study was therefore excluded from further consideration because the valuation issue in Dougherty County is the protection of groundwater supplies that are currently deemed to be safe. Exclusion of the Doyle study on this condition is also reinforced by the fact that the available publication reported a survey pretest using focus groups. Because the reported estimates represent results from a survey in the process of development, generalizing these results to any specific population would not be appropriate.

Although the Edwards and Shultz studies estimated option prices for protection of groundwater supplies, questions remain regarding the probability that the groundwater will be contaminated in the future and the probability that survey respondents will demand safe drinking water in the future. Edwards estimated option prices for supply uncertainty at probabilities of contamination of 0.25, 0.50, 0.75, and 1.00, and the probability of future demand ranged from 0 to 1.00. Edwards specified the probability of contamination for respondents in his survey instrument and assessed demand uncertainty by querying respondents regarding their subjective probability of residing in the affected area 5 years from when they completed the survey instrument. Shultz did not specify the probability of future contamination, nor were respondents' subjective probabilities of future demand measured.

Edwards also specified the time frame for contamination. For example, groundwater would be contaminated in 5 years without remedial action in the case of certain contamination (100 percent). Shultz left this important variable unspecified. Finally, the Edwards study considered a type of contaminant, nitrates, while the Schultz study did not.

In addition nearly all of the households in the Edwards and Shultz study areas derive their drinking water from groundwater supplies. This fact corresponds to the water supply characteristics in Dougherty County. As noted above, neither the probability of contamination nor the time frame of potential contamination of groundwater supplies in Dougherty County is known. If these data become available, the Edwards study provides more valuation data for transfer if the time frame of contamination (5 years) is similar at the policy site.

In addition, nitrates are the primary type of contaminant threatening groundwater supplies in the Edwards study and in Dougherty County. The Edwards study also seems the most appropriate study to consider for benefit transfer because of the level of detail provided in the measurement of individual values for the increment in groundwater quality evaluated. The limitations of the survey design in the Shultz study raise significant questions regarding the suitability of this study for benefit transfer.

The Edwards study has another advantage over the Shultz study in that a larger sample size was used and a higher response rate was obtained. The usable number of observations ("n") is nearly 70 percent larger in the Edwards study. The response rate of 78 percent for the Edwards study implies that his valuation can be applied to the population survey with more confidence than the Shultz results with a 59 percent response rate. This issue is relevant for benefit transfer because of concern over nonrespondent bias.

The Edwards study provides only descriptive statistics on income and the mean, $55,413. Shultz presented more descriptive statistics. The average income of respondents to the Shultz study was $36,533 and the average age was 52. They also reported data on land and house values, number of years living in the study area, knowledge of groundwater contamination, sex, and education. Average income at the policy site was $42,517 in 1989, and the average age was 47. Thus, income at the policy site falls between the reported income for the two study sites. Residents of the policy site are 5 years younger than residents at the Shultz study site.

Edwards estimated a bid equation in which income had a significant and positive effect on estimated option prices. Given this result, we speculate that the Edwards option prices might overestimate the benefits of groundwater protection at the policy site. Shultz estimated a bid equation in which option prices increased with income and decreased with age. Both of these variables were significant predictors of option price. Because residents of Dougherty County, on average, have higher incomes and are younger than residents of the Shultz study site, we speculate that the Shultz study might underestimate the benefits of groundwater protection at the policy site.

Our first priority in developing estimates for benefit transfer was to take data from Dougherty County and use study site equations to develop estimates for the policy site. This approach implicitly assumes that the preferences of Dougherty County residents are the same as those of individuals at the study sites. An additional implicit assumption is that option prices only vary because of differences in the distributions of explanatory variables between the study sites and the policy site. This assumption may or may not be true and should be tested in studies formally designed to validate benefit transfer estimates. We consider this type of transfer because it allows us to adjust transfer estimates for differences in the population characteristics shown to significantly influence values.

Transferring estimated equations is not possible because data for the explanatory variables are not available at the policy site. For example, Edwards' equation includes a variable that measured respondents' subjective rating of the cost-effectiveness of their water supply. Data on this variable are not available for Dougherty County residents. Shultz included variables measuring respondents' knowledge of groundwater pollution. These data are also not available at the policy site.

Given the above considerations and because we are attempting to accomplish a benefits transfer, we had to step back and transfer the estimated mean values. Shultz estimated a single mean of $129 annually per household. Edwards, on the other hand, developed multiple estimates of option price. Unfortunately, his reporting of these estimates in his journal article was not clear; estimated values are only presented graphically or as aggregate benefit estimates. Using his aggregate benefit estimates for his Case II in Table III (p.485) of his paper, we can work backwards to derive the estimates of individual values he used in these calculations. These annual values per household range from $363 when the probability of contamination is 25 percent to $1,437 when the probability of contamination is 100 percent. Intermediate values of $723 and $1,081, respectively, apply for intermediate probabilities of 50 and 75 percent. These estimates that vary with the probability of contamination are the reason we suggest that the Edwards study provides more information for accomplishing benefit transfer at the policy site when the probability of contamination is unknown. If these data were available for Dougherty County, the Edwards estimate could be manipulated to reflect the appropriate probability of contamination. We must, of course, keep in mind that the time frame of contamination in the Edwards study was 5 years.

Finally, we can make a crude comparison of the Shultz and Edwards studies. Given that the income effect in both equations was positive and average income in the Shultz study was less than the average in the Edwards study, we propose that the Shultz estimate should be less than the Edwards estimate. We make this comparison by using the average income from the Edwards study to recalculate the estimated mean from the Shultz study using the estimated option price equation. Because Edwards did not report data for other variables in his equation, we assume they are the same across studies for this comparison. The revised Shultz estimate is $361 per household annually, approximately the same as the Edwards estimate of $363 for protection from a 25 percent probability of contamination.

If we assume that preferences are comparable across study sites, the magnitude of the revised estimate implies that respondents in the Shultz study may have applied, on average, a subjective probability of contamination of 25 percent. At the very least, it appears that the Shultz study provides a lower bound value for protecting groundwater benefits. The Edwards study provides estimates that vary with the probability of contamination so transfer estimates can be refined to meet the needs in Dougherty County when the actual probability of contamination is identified.

In conclusion, three published groundwater protection studies provide a very thin library for conducting a benefits transfer. Two of these studies, however, measured values conceptually consistent with the desired welfare measures for the policy site. The design of the Edwards study and the variety of welfare estimates provided. we believe, makes it superior to the Shultz study for accomplishing the benefit transfer. However, using available data we suggest that Edwards' estimates might overestimate values at the policy site and Shultz's estimate might underestimate values. We suggest using both of these studies in the benefit transfer to provide bounds on the potential benefits of groundwater protection in Dougherty County.

VALIDITY CHECK

This case study provides a unique opportunity to perform a validity check of the benefit transfer estimate(s). A contingent valuation study was recently conducted to estimate household option price, via WTP, for groundwater quality protection in Dougherty County (Sun, Bergstrom, and Dorfman, 1992). The original benefit estimates reported by these researchers for the policy site can be compared to the estimates generated from the study sites. Such a comparison, as suggested by Boyle and Bergstrom (1992), can offer insight into the validity of benefit transfer techniques and suggest areas for improvement

The mean option price from the Sun, Bergstrom, and Dorfman (1992) study for a 50 percent probability (subjective probability of respondents) of contamination within a 5 year time-frame was $641, with a 95 percent confidence interval ranging from $493 to $890. A direct comparison with the Edwards study data reveals an estimate of $723, within the confidence interval. As noted above, we did expect the Edward& estimates to exceed values for Dougherty County, but the difference does not appear to be sufficient that a rigorous test of the null hypothesis of no difference in the estimates would be rejected. The available information in the Edwards study is not sufficient for us to modify the option price estimates for the policy site.

We proposed that the Shultz study provides a lower bound estimate, and this value of $129 per household annually falls below the lower bound of the 95 percent confidence interval. Adjusting the Shultz estimate for the higher average income and lower average age at the policy site results in an estimate of $353 per household annually, still below the lower bound of the 95 percent confidence interval.

This validity check demonstrates that the Shultz study provides a low estimate of option price at the policy site. Improved reporting in the Edwards study would have allowed us to modify his estimates using data from Dougherty County. In turn, the transfer estimate may have been a closer approximation to the reported value estimate from the Sun, Bergstrom, and Dorfman (1992) study.

IMPLICATIONS

Brookshire (1992) proposes a continuum when benefit transfer may be applicable. Scoping studies to develop "ball park" estimates of potential damages or benefits are at one extreme. Studies ultimately resulting in the expenditure of public or private funds are at the other end of the continuum. The analyses presented here fit in the realm of scoping studies. That is, are the potential benefits of better estimates large enough to justify a complete benefit analysis? The answer depends on the purpose of the study and its role in reaching decisions. In a sense, a scoping study is a crude benefit-cost analysis to determine the necessity of a full blown analysis.

If we were conducting a benefit transfer whose results were going to be used in a policy analysis that fell between the extremes on the Brookshire continuum, our experience working with the information available in the publications for the groundwater case study would motivate us to take three additional steps to improve the analysis. First, we would attempt to obtain the original data from the researchers to do some reestimation. We would also try to obtain data from secondary data sources for each study site. For example, the Shultz study includes property evaluations in their analysis, but these data were not included in the Edwards analysis. In turn, we would try to collect average property valuation data for residential units from municipal authorities in Falmouth, MA. Finally we would conduct a very small and inexpensive survey at the policy site, Dougherty County, to obtain data used in the analyses at the study sites but not available from secondary sources for Dougherty County. Examples, as noted above, are respondents' subjective evaluations of the cost-effectiveness of water supplies and respondents' knowledge of groundwater contamination.

With these suggestions, we imply that benefit transfer is not always fast and inexpensive. But it can save scarce monetary and time resources by avoiding an extensive primary data collection effort. However, we firmly believe that back-of-the envelope calculations, as we have done in the current paper, are not a suitable substitute for conducting a thorough analysis using the available secondary data

Our analysis contributes to the growing body of literature demonstrating that benefit transfer is a feasible analysis procedure. But we do not suggest that all of the problems with benefit transfer analysis are solved and that future research to improve the validity and reliability of benefit transfer estimates is not warranted. To the contrary, we are just beginning to open the doors of a new area of investigation that can have significant implications for conducting original valuation studies as well as for conducting benefits transfers.

In closing we would like to make a plea for improved reporting of valuation studies in journal articles and in other publications so that the study procedures and results will be more useful for benefit transfers. This request requires researchers and researchers to view their reports as more than end products: they are data for future benefit transfers and meta-analyses, for example. Recognizing these important uses can substantially enhance the returns to the initial research investment.

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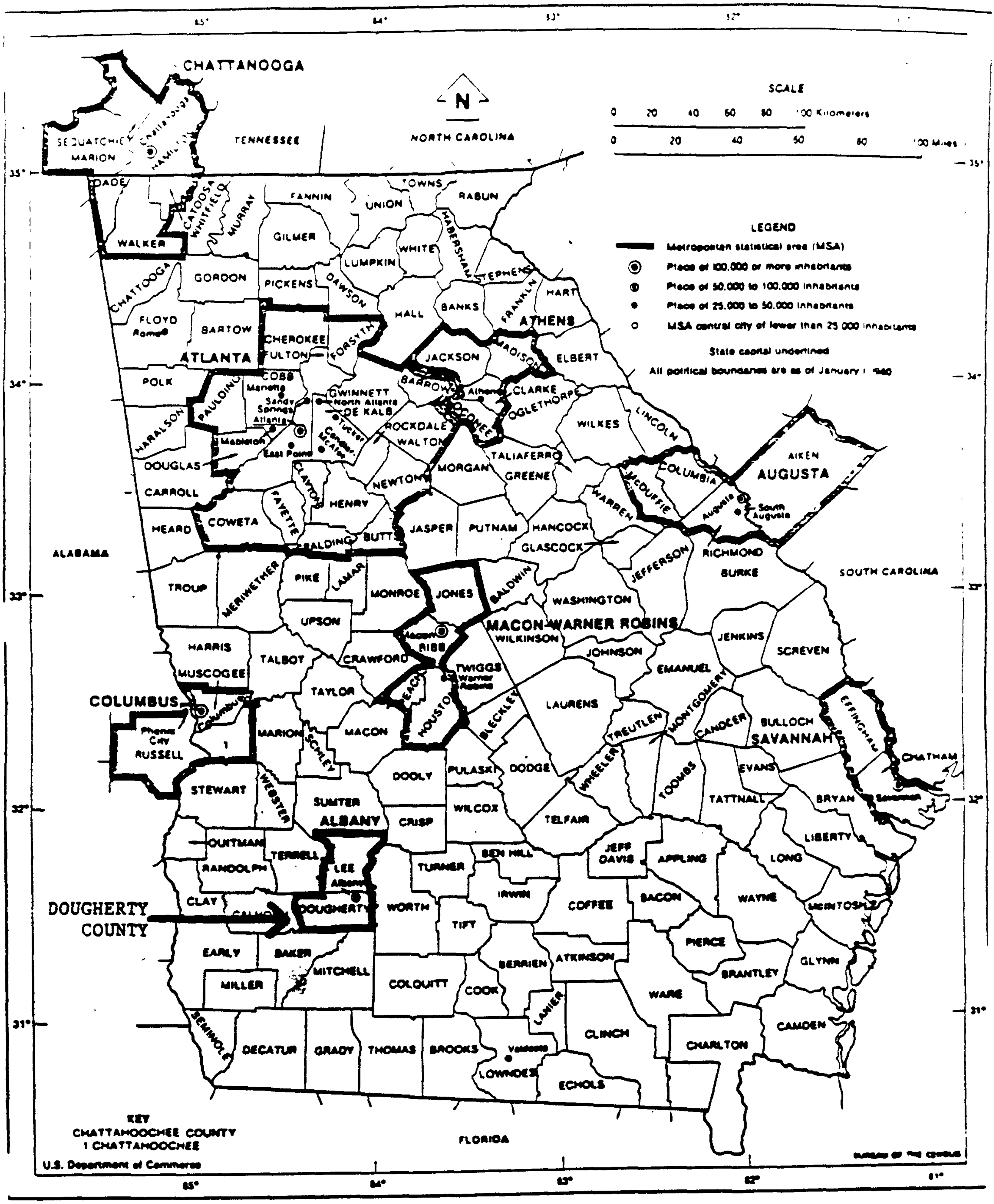
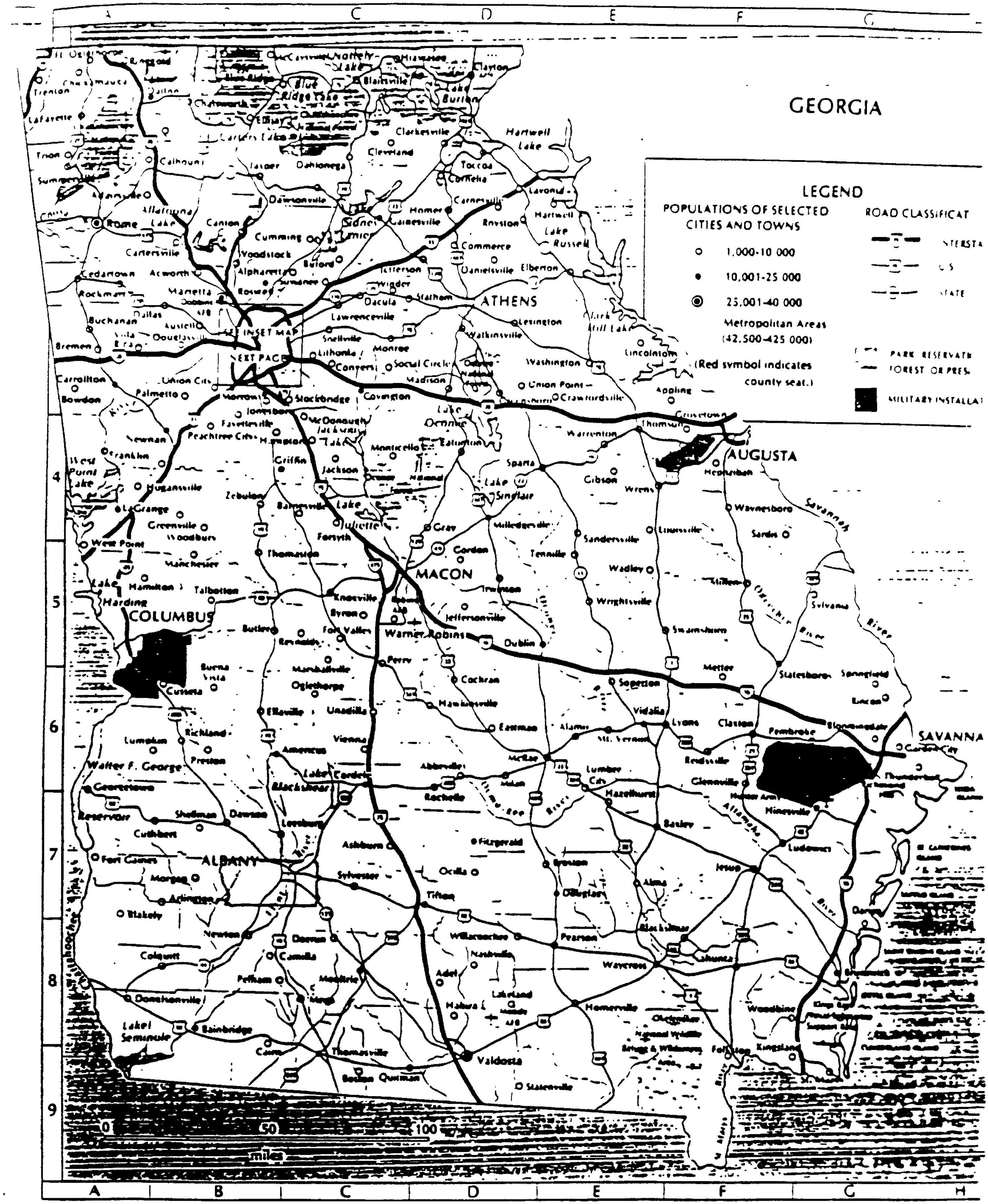
APPENDIX A

GEORGIA - Metropolitan Statistical Areas, Counties, and Selected Places



MSA boundaries are as defined on June 30, 1963



Hodler and Schretter. The Atlas of Georgia. 1986

FIGURE 11
Principal Artesian Aquifer

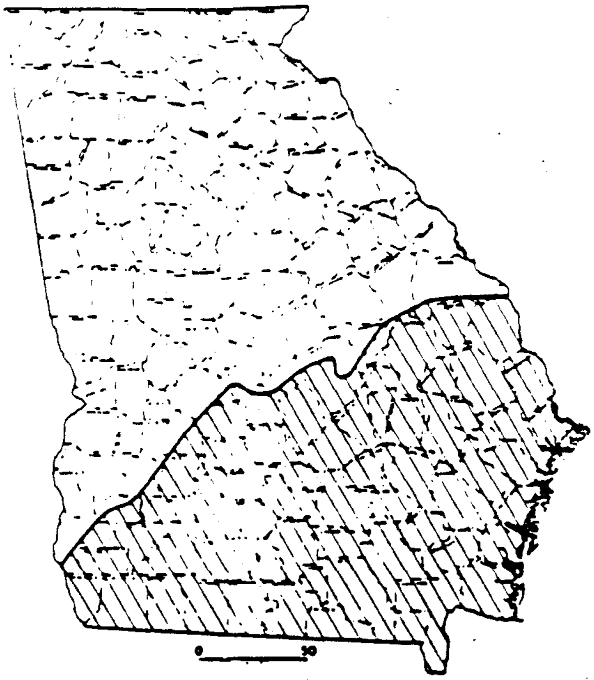


FIGURE 12
Claiborne Aquifer

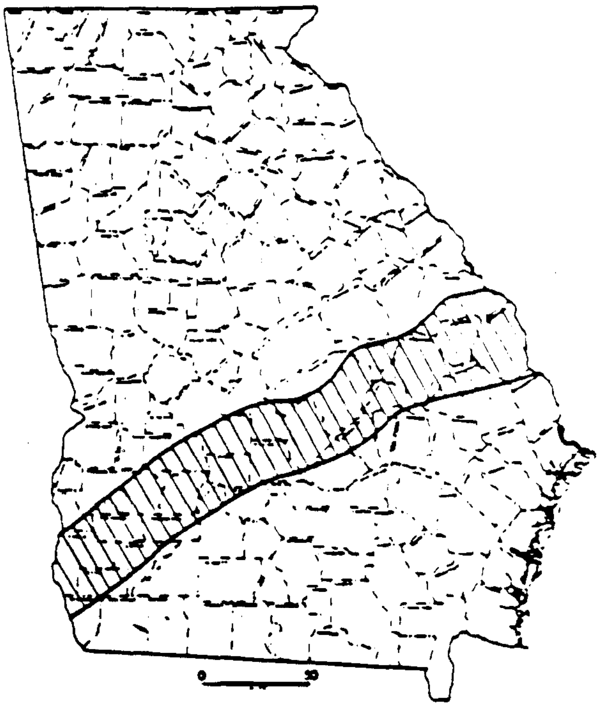


FIGURE 13
Clayton Aquifer

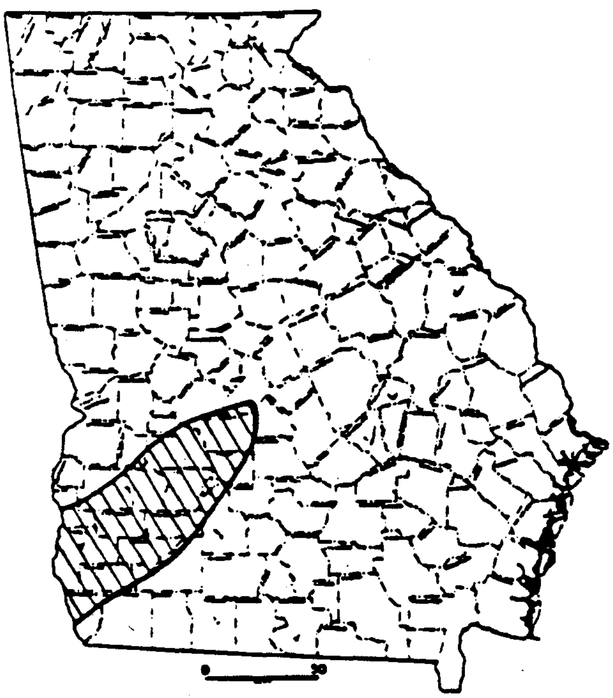
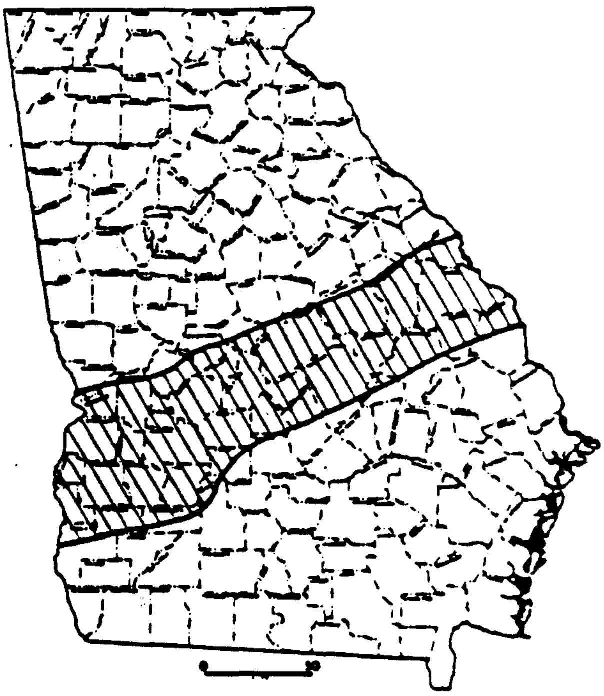
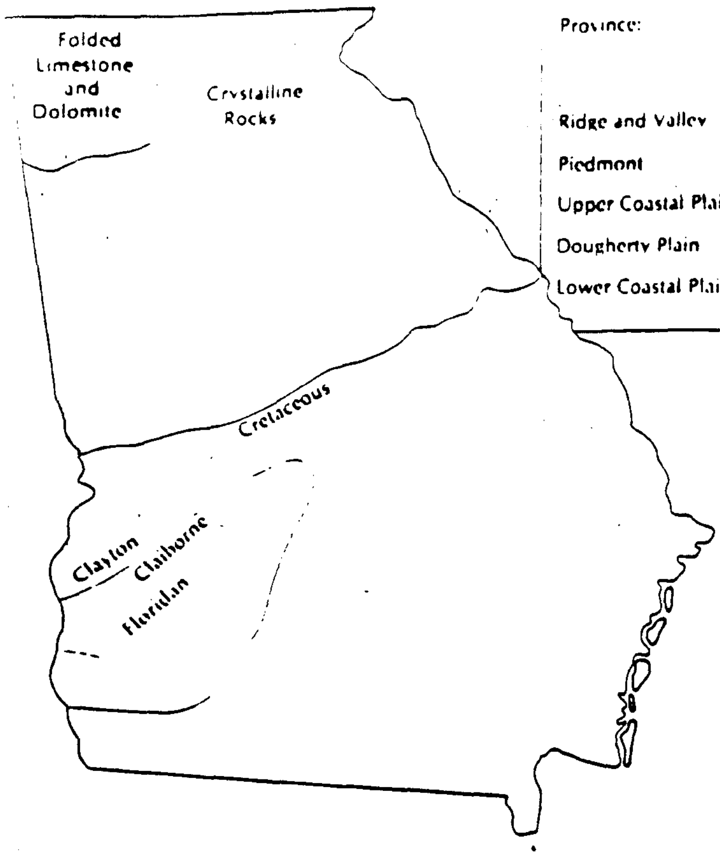


FIGURE 14
Cretaceous Aquifer



All of the above reprinted from James E. Kundell. Ground Water Resources of Georgia (Athens: Institute of Government, University of Georgia, 1978). Data from David Swanson, Status of Ground Water Knowledge in Georgia, unpublished internal report for the Georgia Department of Natural Resources.

GROUND WATER AQUIFERS



Province:	Well Yield (gal/min)
Ridge and Valley	5-50
Piedmont	1-25
Upper Coastal Plain	50-1200
Dougherty Plain	250-600
Lower Coastal Plain	1000-5000

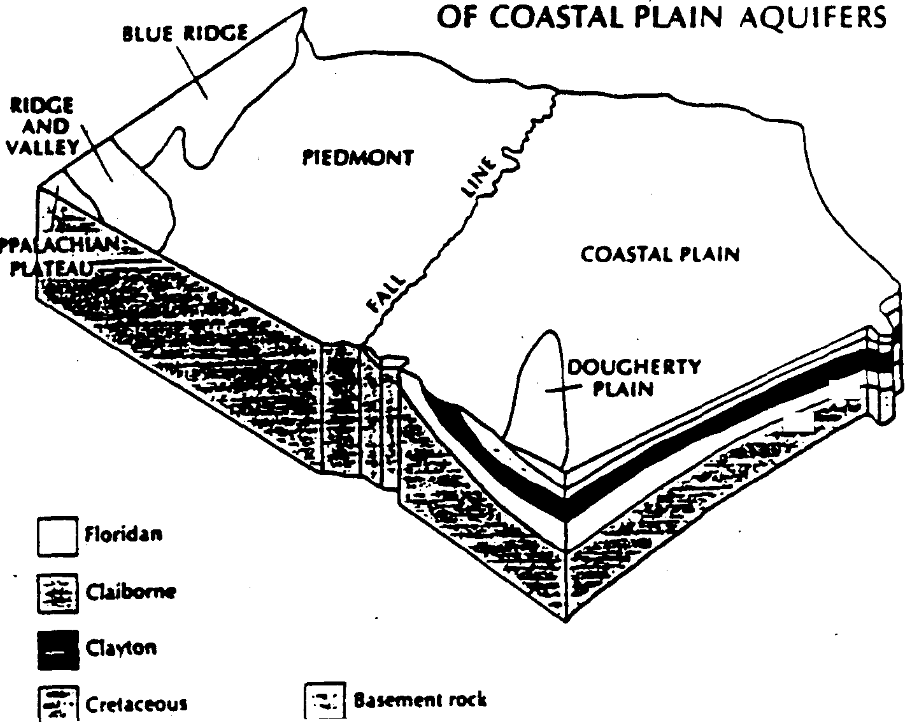
The Coastal Plain is comprised of alternating layers of sand, clay, and limestone. Overlying strata confine productive aquifers. Aquifers near the Fall Line, however, are exposed or lie near the surface. The four major aquifers are the Floridan, Claiborne, Clayton, and Cretaceous.

The Floridan aquifer is made of confined limestone, dolostone, and calcareous sand. It supplies approximately 50 percent of the state's groundwater (600 mgd); its major users include Savannah, Brunswick, St. Marys, Albany, and the Dougherty Plain area. Increased use of the aquifer in the last 100 years has caused a 110-foot drop in the potentiometric surface near Savannah and an 80-foot drop near St. Marys. At Brunswick, the decline has led to the intrusion of brackish water from deeper zones.

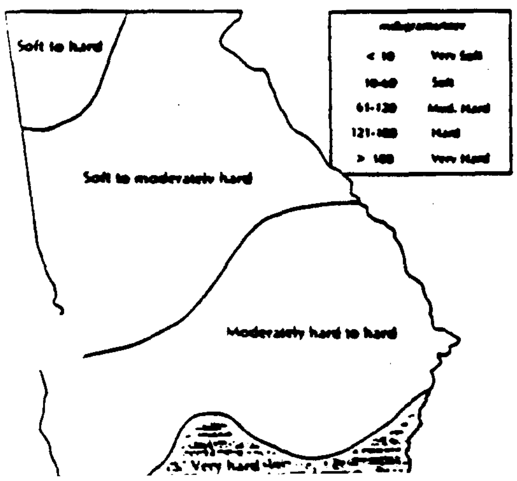
The Claiborne and Clayton aquifers consist of confined sand and limestone. They are the major sources of water for southwestern Georgia. The Cretaceous aquifer, a system of sand and gravel, is the major source of water in east central Georgia.

The map showing depth to the first major groundwater reservoir was created using a combination of topographic and piezometric surface maps.

THREE DIMENSIONAL SCHEMATIC OF COASTAL PLAIN AQUIFERS



HARDNESS OF GROUND WATER



NATURAL RESOURCE DAMAGES VALUATION: ARTHUR KILL OIL SPILL

William H. Desvousges, Richard W. Dunford, and Kristy E. Mathews*

ABSTRACT

The benefits transfer methodology is often used in regulatory settings. The relatively modest time and data requirements are advantageous, but those advantages must be weighed against the imprecision of the estimate. An important area for further evaluation is whether the transfer methodology can be used effectively in a natural resource damage assessment (NRDA). Because litigation is a possibility, the role of the transfer methodology needs to be carefully assessed for use in NRDAs. This paper discusses the Arthur Kill oil spill as a case study for such an evaluation.

The benefits transfer methodology is often used in regulatory settings because regulators find the relatively modest time and data requirements attractive. Although the transfer methodology allows a comparison of costs and benefits, it also has disadvantages. The primary disadvantage is the imprecision of the estimate; that imprecision becomes a major issue when the value of the estimate plays a major role in decision making. An important area for further evaluation is the role of the transfer methodology in natural resource damage assessments (NRDAs). NRDAs are undertaken when state or federal trustees file a legal suit to recover damages to natural resources caused by accidents such as oil spills. The possibility of litigation in such a setting creates some unique concerns.

This paper discusses the Arthur Kill oil spill as a case study for evaluating the transfer technique for NRDAs. It summarizes the discussion and conclusions reached by case study members at the 1992 AERE Workshop. The paper is organized as follows. After describing the background of the spill, we describe the transfers in an NRDA context. We follow with a discussion of data and methodology issues. Finally, we propose a research agenda to address key issues remaining in the evaluation of the transfer methodology in an NRDA context.

BACKGROUND OF THE ARTHUR KILL OIL SPILL

The rupture of an Exxon underwater pipeline an January 1, 1990, resulted in the release of 567,000 gallons of No. 2 fuel oil (not as light as gasoline but not as heavy as No. 6 fuel oil)

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Members of the case study group included David Campbell (National Wildlife Foundation), Jerry Diamantides (University of Rhode Island), Thomas Grigalunas (University of Rhode Island), Ross Hemphill (Argonne National Laboratory), Marisa Mazzotta (University of Rhode Island), Daniel McCollum (U.S. Forest Service), Norman Meade (NOAA), Clifford Russell (Vanderbilt Institute of Public Policy Study), David Waddington (U.S. Fish and Wildlife Service), and Katherine Wellman (NOAA).

into the Arthur Kill. The leak occurred from a 5-foot gash in the 12-inch pipeline that connects the Bayway Refinery at Linden, New Jersey, to the Bayonne Plant in Bayonne, New Jersey. The leak site is just south of the Goethals Bridge. The spill occurred near the New Jersey coast, but tides and winds moved the oil to the three islands in the Kill and the Staten Island coastline. The Coast Guard considered the spill to be “major” because it involved the release of more than 10,000 gallons (42 gallons = 1 barrel).

The clean-up crews recovered approximately 141,000 of the 567,000 gallons of oil. About 50 percent of the oil evaporated. Clean-up crews completed the clean-up on March 15, 1990. The Bird Rescue phase of the clean-up resulted in the treatment of 150 birds, of which 110 survived (Exxon internal company documents).

DESCRIPTION OF THE ARTHUR KILL AREA

Figure 1 provides a geographic description of the area, including the affected regions of the Kill and the extent of oiling. The Arthur Kill is a waterway located between Staten Island, New York, and the New Jersey coastline near the Newark airport. The Arthur Kill is approximately 15 miles long and almost 2 miles wide; it opens into the Raritan Bay at the south end and the Kill van Kull and Newark Bay at the north end. It provides access to New York Harbor, Raritan Bay, Lower Bay, Jamaica Bay, Newark Bay, the Hudson and East Rivers, and the Atlantic Ocean from the New Jersey coast of Newark, Linden, and Elizabeth.

The entire Arthur Kill is surrounded by salt marshes and salt- and freshwater creeks, which support harbor bird habitats on the three islands within the Kill: Prall’s Island, the Isle of Meadows, and Shooter’s Island. The area around the Arthur Kill is circumscribed with salt marshes and estuaries which serve as nurseries for well over 145 different species of fish and birds. Although the Arthur Kill is an intensely developed industrial area, several species of wading birds remain in the area in large numbers. Paradoxically the industrial activity actually provides relative seclusion from humans, making this an ideal breeding ground (The Trust for Public Land and New York City Audubon Society, 1990). Creeks run from the Kill onto Staten Island and New Jersey, creating wetlands areas that are essential feeding areas for the birds. The actual nesting sites for the bird species are located on the three rookery islands (The Trust for Public Land and New York City Audubon Society, 1990).

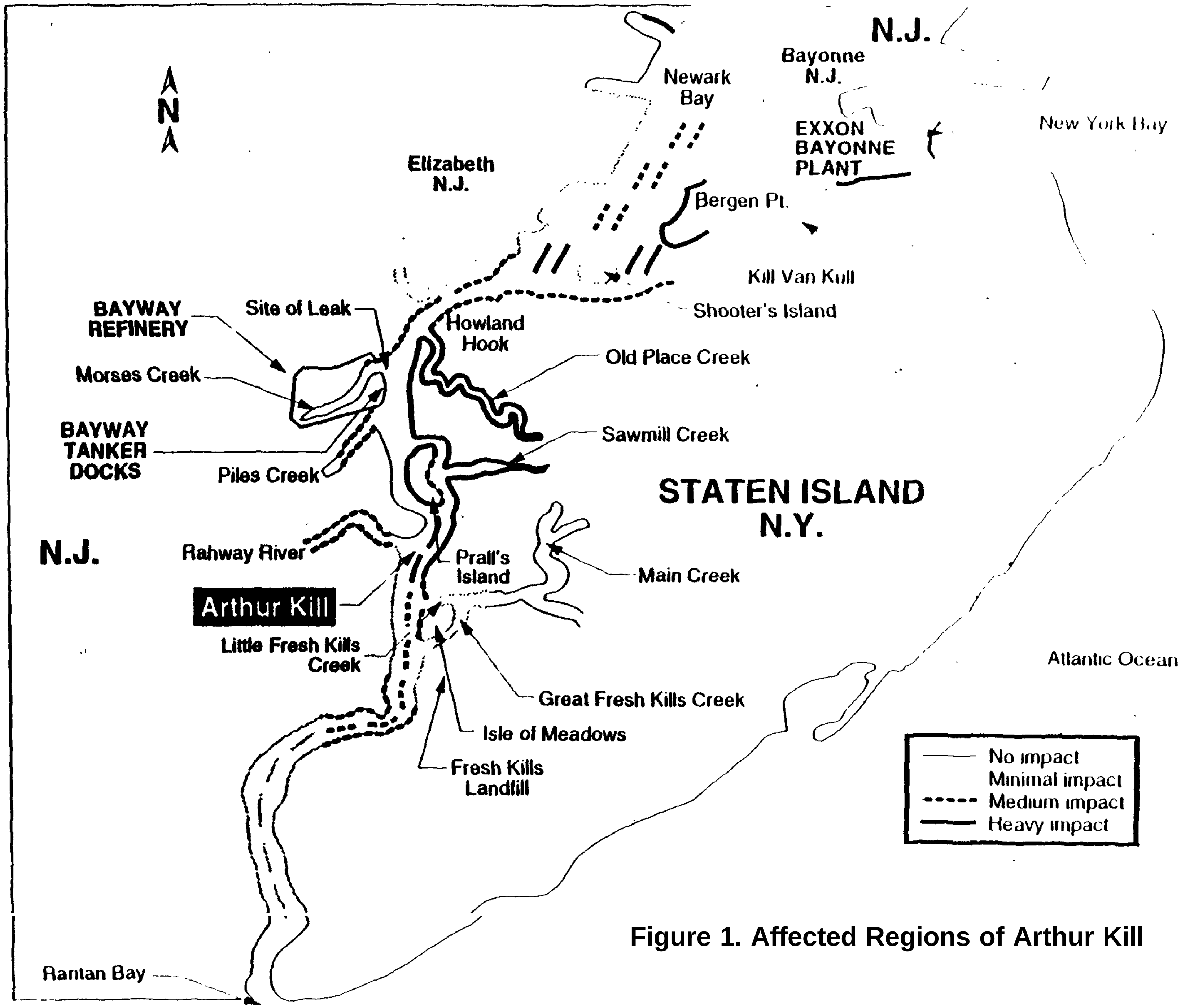

Figure 1. Affected Regions of Arthur Kill

The Arthur Kill and Kill van Kull are both bordered by a variety of industries, predominantly chemical manufacturing and oil refining. As a result of the intense industrialization and the proximity of the New York City and the Linden, New Jersey, landfills, the area is vulnerable to industrial and municipal pollution. The New York City landfill, Fresh Kills, is directly adjacent to the Kill and is the largest in the United States, towering about 500 feet above the Arthur Kill. City reports indicate that the water quality in the Arthur Kill is the poorest in the New York Harbor area as a result of the heavy industry and the presence of Fresh Kills and a smaller landfill nearby (Urbont, 1990).

The Arthur Kill connects other large bodies of water, as does the Kill van Kull. The Arthur Kill connects Newark Bay to Raritan Bay and the Atlantic Ocean. The Kill van Kull connects the Upper New York Bay to Newark Bay; the Upper Bay is adjacent to the Hudson and East Rivers, the Lower Bay, and the Atlantic Ocean. The waterways are narrow and are used frequently by commercial shipping tankers. Because this area is intensely industrialized and the water quality is fair to poor, recreation activities in the Kill itself are limited or nonexistent.

However, for the residents of New Jersey and to some extent New York, the Arthur Kill and Kill van Kull are important as access waterways to reach the adjacent areas where recreation opportunities are more abundant. They serve as an access for fishing in Raritan Bay, Lower Bay, Newark Bay, and the Hudson and East Rivers and for boating access in the same areas with the addition of New York Harbor. A great deal of water-based and land-based recreation takes place in and around Raritan Bay (south of the Arthur Kill), particularly near the New Jersey portion of the Gateway National Recreation Area. Likewise, the Atlantic Ocean side of Staten Island offers recreational activities at the Great Kills Park (eastern shore) and the other portion of the Gateway National Recreation Area. The Jamaica Bay Wildlife Refuge and several popular beaches are across the Lower Bay and adjacent to Brooklyn and Long Island. Because these recreation areas are so close to New Jersey, the Arthur Kill and Kill van Kull offer inexpensive, convenient access to popular recreation sites in the greater New York area.

Four marinas are located either on the Kill or within a mile of the Arthur Kill or Kill van Kull. One of the marinas offers a public boat ramp while the others predominantly provide slip storage for moored boats. In addition, six city and county parks are within the area. Park officials indicated that these parks were used for picnicking, bird watching, and other activities such as softball.

In addition to use services, the Arthur Kill area contains wetlands that may provide nonuse services. The wetlands system in the Arthur Kill area covers approximately 400 acres of freshwater and saltwater tidal marshes and creeks. The areas where potential effects may be found are along the Kill between Bridge Creek (north of Goethals Bridge) and the Isle of Meadows (at the mouth of Fresh Kills). This area covers approximately 127 acres of wetlands (B-Laing, 1900) and supports a variety of wading and seabird species as well as several hundred invertebrate species. The freshwater marshes support an additional 20 to 30 species of invertebrates and vertebrates suitable as food for the birds in the area. The area directly contributing to habitat functions covers approximately 25 to 40 acres (the sum of the acreage used for feeding and nesting).

Biologists assess wetlands in terms of their functions using a qualitative method of evaluation called WET, which stands for Wetlands Evaluation Techniques. WET analyzes the wetlands area in terms of social significance, effectiveness, and opportunity. The Exxon technical team conducted a WET analysis on the Arthur Kill region. Its results are cumulative for the many oil spills that occurred in the region in a short time period, implying that the effects are likely to be greater than just those from the Exxon spill. Conclusions about the functions of the Arthur Kill wetlands include the following:

- The Arthur Kill wetlands have a *limited* potential to nourish plant and animal life in the area as well as provide eutrophic effects downstream. This function is limited because the commercial and recreational traffic in the area is significant.
- These wetlands serve as a filtering system by trapping sediment, pathogens, and toxic substances and removing them from water transport. Again, the extent of this function is uncertain because of the water traffic.
- These wetlands provide an important educational and research function. In particular, the Harbor Herons Project has served to educate the public. The fact that these

interesting and beautiful creatures are increasingly populating two islands in a metropolitan area of more than 15 million provides a unique ecological case study. In 1986, volunteers engaged in heron projects involving the building of heronries and presenting information about the area and its species. This project generated a great deal of media coverage (Parsons, 1986).

- The last function the Arthur Kill wetlands provide is erosion control protection for the area. The region provides moderate erosion control, particularly along the shorelines of the wetlands where peat sediment is stabilized by the intertidal marshes, which contributes to a stable shoreline and deters erosion of the mainland (Winfield, 1990).

In summary, this natural resource setting provides the backdrop for a case study using the benefits transfer methodology in an NRDA context. The setting enables researchers to evaluate both use and nonuse natural resource services. Use values are the values associated with natural resource services where physical and/or visual contact between people and the natural resource occur. Nonuse values do not require contact; rather these services are the result of a resource providing well-being to people or other resources simply by existing.

Both National Oceanic and Atmospheric Administration (NOAA) and Exxon prepared damage estimates using the transfer methodology. The parties were able to reach a negotiated settlement based on these estimates. Because the estimates prepared by the NOAA have not been made public, this paper relies on the estimates prepared by Exxon's experts, which have been made public (Desvousges and Milliken, 1991).

TRANSFER STUDIES IN AN NRDA CONTEXT

The Arthur Kill oil spill is typical of many NRDA cases. The size and/or location of such spills often make a full-blown damage assessment inefficient because the assessment itself could cost more than the damage. In these instances using the transfer methodology to estimate the damage is more efficient. Benefits transfer methodology also can provide a useful screening devise for targeting assessments that will require more detailed Type B assessments.[1]

During the AERE workshop, participants discussed using transfer methodology in NRDAs. The level of comfort among participants in using the transfer methodology (or willingness to use the transfer methodology) depended on the status of the assessment and the amount of probable scrutiny it will receive. As part of this discussion, the participants discussed a continuum of NRDAs: on the left side are initial screening assessments and on the right side is

[1] The Type A model is a simple process that uses a standard computer model and requires minimal input data. It is most useful for small, short-duration marine and coastal spills. The Type B assessment applies to all other releases in coastal and marine environments and releases involving freshwater and land resources, including plants and animals. Type B assessments are more complex and comprehensive in which damages are determined through a three-step process: injury determination, quantification of service effects, and damage determination.

a full-blown study to support litigation (see Figure 2). The continuum depicts the role of the assessment. As the NRDA progresses from an initial assessment to negotiated settlement to litigation, scrutiny increases. Thus, the imprecision associated with using the transfer methodology may be more of an issue when litigation is bending.

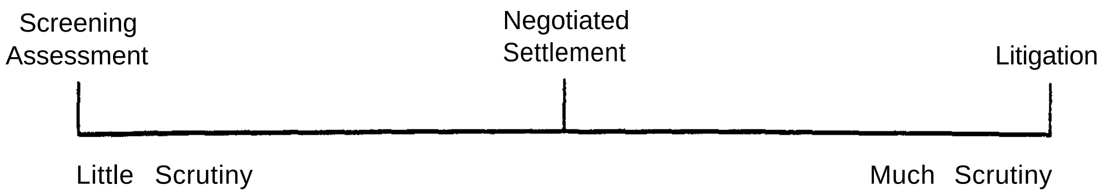

Figure 2. Continuum of Valuation Scrutiny in an NRDA Context

When the level of scrutiny is relatively low, the willingness to use the transfer methodology is high. None of our group members expressed any hesitation about using transfers for an initial NRDA or for a negotiated settlement. However, most members were reluctant to adopt the transfer methodology when litigation is involved. Because the level of scrutiny is much higher in a litigation context, most of our group members thought that the margin of error inherent in a transfer study was not defensible.

Finally, the transfer methodology can also be used in establishing and implementing NRDA policy. For example, the Type A[2] assessment used by NOAA to estimate the damage caused by certain types of oil spills is a transfer model. The budget and time constraints for NRDA policy making are similar to the types of constraints that make transfer methodology attractive to litigants. None of our group members expressed serious concerns about using transfer studies in a policy-related context.

DATA AND METHODOLOGY ISSUES

Like any transfer study, data and methodological issues need to be resolved for NRDA transfers to be effective. In our discussions, we identified three types of data and methodological problems likely to arise in NRDA transfer studies: development of the quantity data (the number

[2] See footnote 1.

of damaged resources or services), valuation of the interrupted or eliminated services, and the valuation methodology.

The development of the quantity data to be used in an NRDA transfer study often proves to be challenging. Recall that, in a transfer study, the value or price of the affected resource or service is transferred from other studies. However, the researcher must determine the quantity of affected resources or services before applying the transferred values. Determining the quantities for an NRDA typically requires judgment because the quantities of resources or services are not observable, or if observable, are not readily available. If historical data are available, they may provide some useful guidance, but judgment may still be necessary.

In the Arthur Kill oil spill, the Exxon estimate addressed three types of interrupted or lost services: fishing and boating access, near-water recreation (park use), and wetlands services. The access data used in Exxon's estimate were based on interviews with local marina operators. The number of marina slips and an estimate of typical occupancy during the winter months were combined to estimate the number of affected boats in marina slips.

The park-use data were also based on interviews with key informants (park officials in this case). They estimated park use in terms of the number of visitors during the off-season. Finally, biologists estimated the number of acres of affected wetlands based on their field assessment.

Relying on key informants to develop the quantity estimates is not unusual in an NRDA. In many cases, no better source of data is available. However, using key informants may introduce moral hazard into the picture because they may have a vested interest in the outcome of the damage estimates. Key informants may realize that the interviewer is somehow associated with the recent spill, and the informant may provide biased estimates.[3] When relying on key informants for the quantity data, researchers should use their best judgment and be aware of the possibility of moral hazard.

Biologists or other types of scientists often provide other types of data, such as quantity estimates. In many instances, estimates by scientists are the best source of the necessary data. Our group expressed some concerns about relying on this type of data also. Scientists often approach issues differently from economists, thus producing data that are not useful to economists. Our group discussion indicated that economists and scientists should coordinate their future efforts better than they have historically.

[3] Although commercial enterprises cannot bring an NRDA suit, they may make commercial claims. The data they provide may be biased to secure a larger commercial claim.

The second type of data issue we discussed was valuation issues. In a transfer study, the quality of the estimate depends partly on the availability and quality of the original studies and their suitability to transfer. These concerns are not unique to NRDA transfer studies. Adopting the transfer methodology means that the researcher adopts the values from the original study and any inherent weaknesses in them.

In addition to methodological issues, we confront issues of "sameness" as well. The NRDA estimate based on a transferred value has more credibility when the affected service is very similar to the service on which the transfer value is based. For example, an NRDA estimate for cold-water fishing in the Northeast may not be well represented by a value for warm-water fishing in California. Seasonality is an important consideration for many recreation estimates. Most recreation studies are based on the "high season," the season when that particular recreation activity is at its peak. Ignoring the seasonality issue in a transfer study can result in error in the NRDA estimate.

As part of the discussion, we informally polled our group members on their assessment of the adequacy of existing studies for transferring use values. We asked our group members to rate the existing studies on a scale of 1 to 5, with 1 being inadequate and 5 very adequate. This assessment included the number of studies, the quality of those studies (inclusion of substitute sites, assumptions, parameters), and the "transferability" of the studies. Table 1 shows the general adequacy ratings, although the adequacy of available studies will vary in particular cases (e.g., locations, season, activity). For many types of use services, the group consensus was that existing studies are generally not adequate for transfer. We concluded that existing studies on big-time sport fishing and big-game hunting are more adequate for transfer purposes than the other use categories considered. Existing studies on other uses such as swimming and wildlife viewing did not receive a favorable rating in terms of adequacy.

Data issues for nonuse values ate particularly controversial. Even in a full-blown analysis, nonuse values are extremely difficult to estimate. Economists have used contingent valuation (CV) to estimate nonuse values, and disagreement exists about its validity for this use. The difficulty of the situation is amplified in a transfer study.

TABLE 1. GROUP ASSESSMENT OF THE ADEQUACY OF EXISTING STUDIES FOR TRANSFERRING USE VALUES

Use Category	**Adequacy**[a]
Fishing	
Big time	4
Small time	3
Boating	
Motorized	1
Nonmotorized	2
Swimming	1
Beach Use	1
Shoreline Use	1
Wildlife Viewing	1
Hunting	
Big game	4
Waterfowl	3

[a] **1=inadequate;** 5=very adequate.

We specifically evaluated the adequacy of studies for wetland values. In the Arthur Kill study, the biologists determined that the wetlands in the Kill area were only serving some of their intended functions. A study that focused on this particular subset of functions in the same geographic area did not exist. The studies that do exist do an incomplete job of valuing wetlands, even in general terms. Table 2 summarizes the available wetlands studies.

The methodological issues we discussed focused on the unit of valuation. Use services studies have four possible choices for the unit of valuation. The first is the unit-day value, where, for example, the value of a fishing day or a boating day is transferred from a study to the NRDA site. Although this approach has the advantage of simplicity, the differences between the sites that may influence the demand for services are essentially ignored.

The second approach uses a valuation equation. In this type of transfer, the coefficients from an existing study are applied to the means (or representative values) of the same variables for the NRDA site. This approach offers an improvement over the unit-day value, but it is

TABLE 2. VALUATION STUDIES OF WETLANDS

Authors	Title of Study/Article	Scope of Study/Issues Addressed	Analysis Used	Conclusions
James G. Gosselink Eugene P. Odum R. M. Pope	"The Value of the Tidal Marsh"	Monetary evaluation of natural tidal marshes in Louisiana using energy methodology analysis.	Energy Analysis	The author concludes that by-product production yields lower per-acre values than more intensive uses that preserve the natural functions of systems. The author computed ecological life-support values based on gross primary productivity (in energy terms) of the natural marsh, using a conversion ratio from energy lo dollars based on the ratio of Gross National Product to National Energy Consumption The resulting wetlands values are $2,500-$4,000 per acre per year.
Leonard A. Shabman Sandra S. Batie Carl C. Mabbs-Zeno	"The Economics of Wetlands Preservation in Virginia"	Development of values of wetlands using value per la in Virginia Beach and value per acre of recreational home subdivisions to analyze permit decisions. Coastal states have frequently tried to establish legislation to diminish the rate at which coastal wetlands are being reclaimed for different forms of development. This article discusses the ecosystem services of a wetlands by developing a model of structures and functions. Then, it examines the process of development and permitting for development is examined.	Market Valuation	Two case examples are examined in terms of the development values of wetlands. In developing Virginia's wetlands, residential home development and recreation home development comprise the two main pressures. Two valuation studies provide insight into this type of development using hedonic price equation to estimate regressed land sale prices on a set of explanatory variables representing individual land parcel characteristics, including measures of water access and waterfront location created from filled wetlands.
John C. Bergstrom John R. Stoll John P. Titre Vernon L. Wright	"Economic Value of Wetlands-Based Recreation"	Valuation study to quantify the outdoor recreational value of wetlands. An empirical study was conducted on current recreational uses of a coastal wetlands area in Louisiana.	Willingness to Pay Expenditure Analysis	The study yielded $17.10 as an annual per-acre value of wetlands. The results suggest suggest economic impacts and net economic benefits associated with wetlands recreation.

(continued)

TABLE 2. VALUATION STUDIES OF WETLANDS (CONTINUED)

Authors	Title of Study/Article	Scope of Study/Issues Addressed	Analysis Used	Conclusions
Robert Costanza Stephen C. Farber Judith Maxwell	"Valuation and Management of Wetland Ecosystems"	Study of wetlands values in coastal Louisiana that employed willingness-to-pay and energy-analysis-based methodologies. This article discusses the fundamental theoretical and practical problems underlying resource valuation. It summarizes the methods and findings for the Louisiana wetlands study.	Willingness to Pay Energy Analysis	The authors were able to bracket a range of values. They estimated that $194.32 to $512.00 is the per-acre value of wetlands per year. The low end of the range is based on the willingness-to-pay approach, and the upper end is based on the energy-analysis approach. The largest value provided based on the energy-analysis approach was $848 per acre per year.
Robert Costanza Stephen C. Farber	"The Economic Value of Wetlands Systems"	This study uses a willingness-to-pay and an energy-analysis method of establishing the social value of a wetlands system. The economic approach considers the commercial, recreational, and storm protection value of wetlands. The energy analysis evaluates the energy processed by the wetlands system in south Louisiana.	Willingness to Pay Energy Analysis	The economic value of willingness to pay for an acre of wetlands by type tanged from $0.44 to $37.46 for the annual value per acre. The energy analysis evaluation considers the total amount of energy captured by natural ecosystems as an estimate of their potential to do useful work for society. This method provides a comprehensive upper hound on the economic value of the system's products. Using the transformation of salt marsh to open water, the annual value of loss of wetlands ranges from $509 to $847 per acre per year.

frequently difficult to find an appropriate equation to transfer and the comparable data for the NRDA site.

The third approach is a generalized model from which values can be transferred. Such a model requires much more information that the previous two approaches, but it offers the advantage of better estimating the site-specific value. The group members discussed the possibility of adapting the Random Utility Model (RUM) for transfer.

A final option for valuation is the meta-analysis approach. This approach compiles all available values and their influences and produces a value that accounts for the many possible influences. Like the generalized model above, the data requirements are extensive. (For nonuse values, whether such an analysis can be performed given the currently available studies is unclear.)

The methodology adopted in an NRDA transfer study depends in part on the timing, the funding, and the available data. Our group discussion indicated that we would like to see a movement toward using the generalized model.

RESEARCH AGENDA

Our group discussion revealed that much research still needs to be done on use and nonuse values for NRDA transfer purposes. We focused on three primary research items: the design and undertaking of a “grand” study, more and better original studies, and a technique to generalize RUMs.

The first research agenda item (deemed most important by the group) was the design of the grand study. Such a study would encompass all types of services and the influences on the demand for these services. The study would be suitable for transfer purposes and would be linked to ecological models.

The second research item is the need for more and better quality original studies. Our group thought more studies on use values would be helpful, particularly on those types of values for which few studies exist, such as swimming and boating. But more important are studies on nonuse values. Such research should address fundamental issues associated with credible valuation procedures. Consensus on transferring nonuse values depends on consensus on estimating credible nonuse values. The group concluded that good studies on wetlands and seabirds would go far in filling our needs for nonuse estimates. New studies undertaken should be designed with transfer in mind.

Finally, we decided that our discipline should take steps to generalize RUM models for use in transfer. The goal of this research would be to evaluate how a RUM could be used in the transfer process. For example, would it be possible to design a large-scale data collection, such as a multistate region, that would support a general RUM model? Alternatively, another strategy might be to divide the collected data into subsets that could be used to estimate a RUM for a specific set of sites relevant for the transfer problem. Finally, the group agreed that better data are essential for using RUMs in a transfer setting.

This agenda is ambitious and requires funding. Sponsors of new studies have their own specific needs, and those needs may not correspond with transfer study needs. This last point may be particularly true of NRDA litigation situations. Sponsors of any such study have their own timetable and agenda and may not be willing to subsidize the purely research components of a study.

Finally, our group concluded that, as a discipline, we need to change our attitudes about replication. Such studies would be extremely helpful for transfer purposes, but traditionally such studies are not publishable. Consequently, researchers do not undertake replicative studies, or if they do, they are not published and generally not readily available to other researchers. However, we discussed the need to consider using experimental designs to evaluate the validity and reliability of the previous study. Research progress from simple replications would be far less informative.

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RECREATIONAL FISHING VALUATION: APPLICATION OF THE TYPE A MODEL

Carol Adaire Jones*

ABSTRACT

The Type A model is the single largest benefits transfer model for natural resource damage assessment and the only one that has regulatory status for litigation under CERCLA and the Clean Water Act. In this case study, we focus on the Type A model procedures for valuing losses in recreational services due to fish kills and fishery closures resulting from an oil or chemical spill. In addition we discuss how to value recreational fishery injuries.

The natural resource damage assessment model for coastal and marine environments, the "Type A model," is the single largest benefits transfer model for natural resource damage assessment and the only one that has regulatory status for litigation under CERCLA and the Clean Water Act The model provides a simplified assessment procedure for short-term releases of oil and hazardous substances. It represents a low-cost alternative to Type B damage assessments, which may require detailed field observations and extensive collection and analysis of chemical, biological, and behavioral data.

The first-generation Type A model, under review here, was promulgated under rule-making by the U.S. Department of Interior (DOI) in 1987. It covers the coastal and marine environment of the U.S. DOI is required to revise the model every two years; this year, the agency intends to propose a new Great Lakes version, as well as a substantially revised coastal and marine version of the model.

In this case study, we focus on the Type A model procedures for valuing losses in recreational services due to fish kills and fishery closures resulting from an oil or chemical spill. The Type A model incorporates the data and algorithms to calculate fishery injuries, measured as the reduction in (fish stocks and) recreational fishery catch

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by weight due to direct kills, recruitment losses, food web effects, and closures. The problem posed in this case study is how to value such recreational fishery injuries.

BACKGROUND: TYPE A MODEL FOR COASTAL AND MARINE ENVIRONMENTS

The model relies on computer modeling to predict the fates and effects of spills and value the injuries. The essence of the operation is contained in three modules: physical fates submodel, biological effects submodel, and economic damages submodel (see Figure 1).

The physical fates module models the path of contamination as it disperses, determining the concentration of the spilled substance over time and by location within the study area. This module incorporates a chemical database with the physical and chemical properties of 469 substances, used in the species-by-species mortality calculations.

The biological effects module calculates losses to biological populations through time. The calculations include the following: the direct mortality to adult, juvenile, and larval biota due to toxic concentrations; recruitment losses due to stock effects; and the indirect mortality and weight loss to adult, juvenile, and larval biota due to the loss of foodstuff in the food web.

The economic damages module calculates the dollar values for injuries to biota based on use values. It also calculates the losses due to closures of fishing, waterfowl hunting, or beach areas.

The calculations rely on geographic data bases that contain average resource distributions for multiple habitat types within ten geographic regions throughout the coastal US, based on the classification scheme developed in Cowardin et al. (1979). Marine and estuarine systems are subdivided into subtidal and intertidal subsystems then broken down into additional habitat classes (based on shoreline type or bottom type). After the authors factored in the likelihood of each province-system-subsystem-class combination and the feasibility of collecting data for each likely grouping, they created a database with 36 intertidal and 55 subtidal ecosystem types with seasonal variations. Figure 2 provides a map of the ten regions, and Table 1 lists the habitat classifications.

The species in the database are classified into 13 categories, including nine fish categories. The nine fish categories represent 141 species, including both finfish and

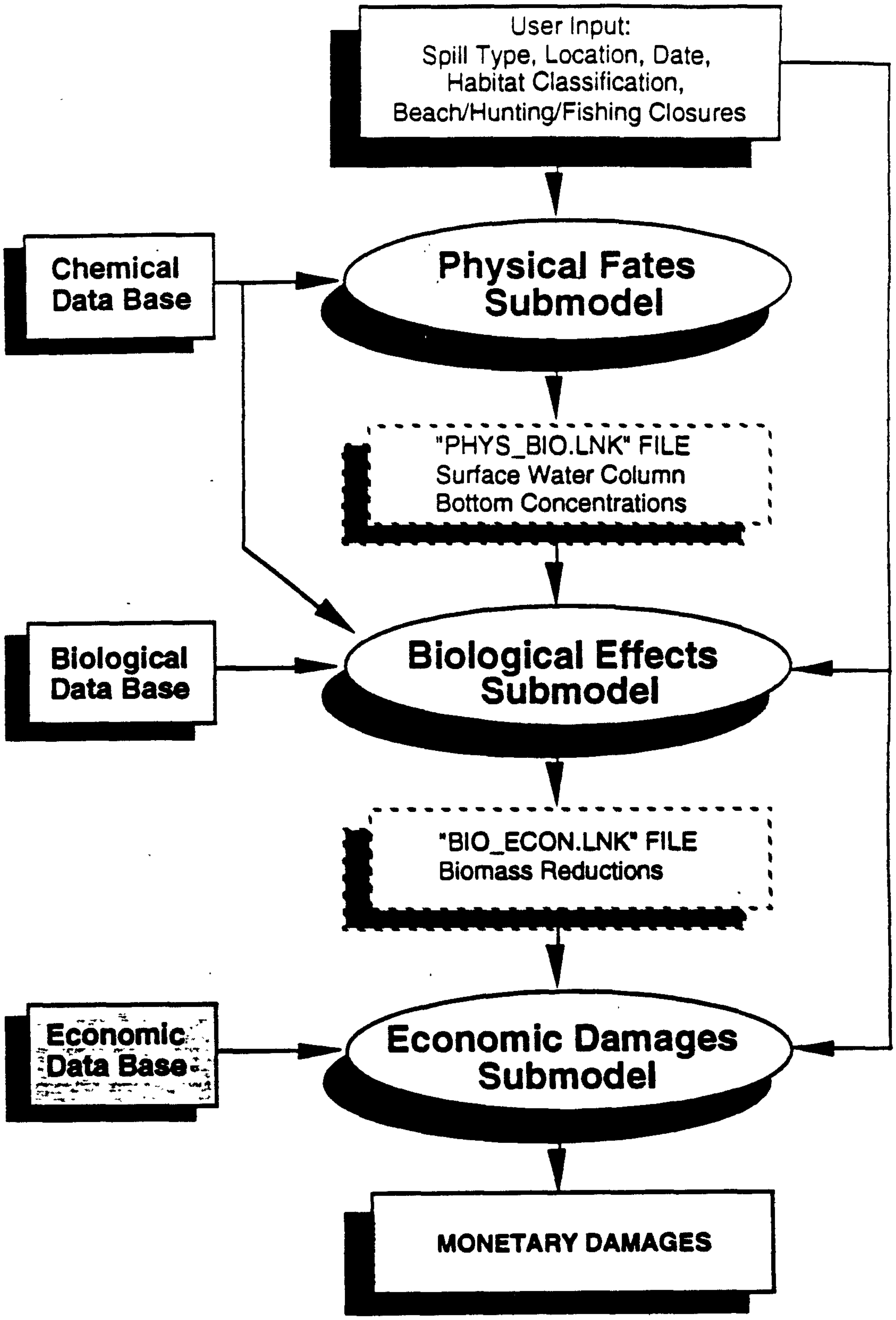

Figure 1. Model System Overview (NRDAM/CME)

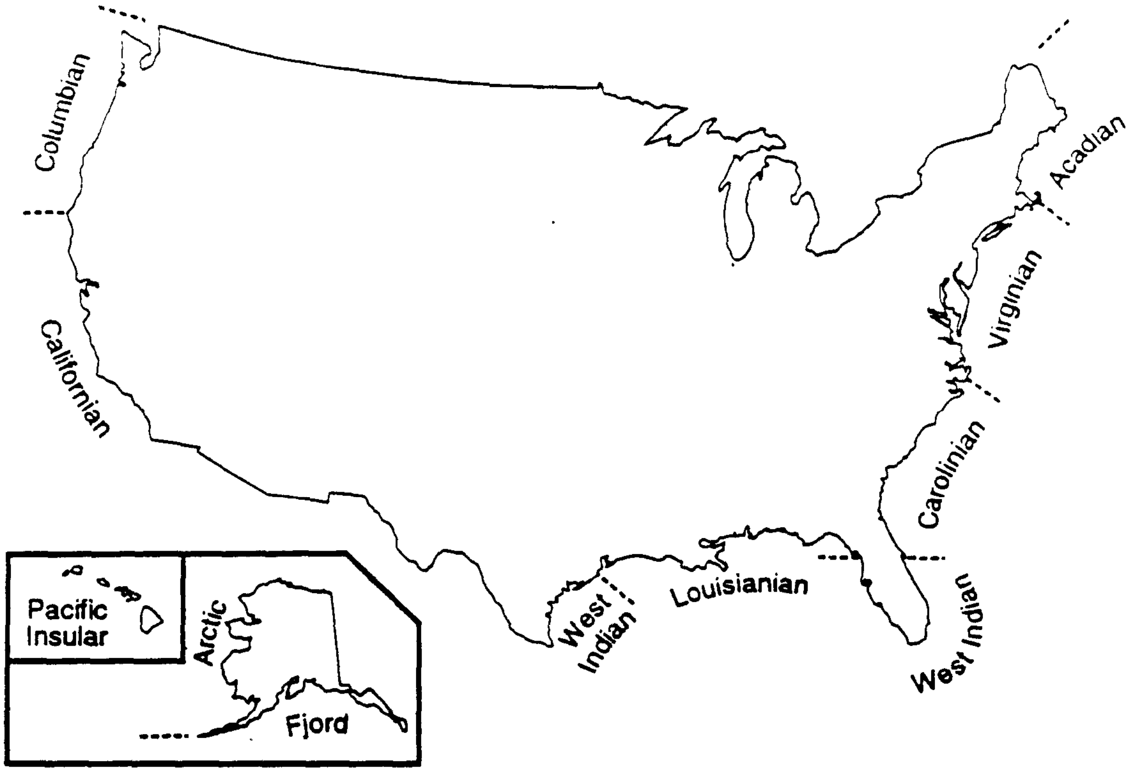

Figure 2. Boundaries of 10 Marine and Estuarine Provinces
Source: Type A Documentation

TABLE 1. HABITAT CLASSIFICATIONS

I. Ecosystem Types

A. 10 Marine and Estuarine Provinces

1. Atlantic and Gulf

P1. Acadian (Northeast: north of Cape Cod)

P2. Virginian (Mid-Atlantic: Cape Cod to Cape Hatteras)

P3. Carolinian (South-Atlantic: Cape Hatteras to Cape Canaveral)

P4. Louisianian (Gulf Coast: Cedar Key, Florida to Port Aransas, Texas)

P5. West Indian (South Florida, South Texas, West Indian Islands)

2. Pacific

P6. Californian (California: south of Cape Mendocino)

P7. Columbian (Pacific Northwest: Cape Mendocino to Vancouver Island)

P8. Fjord (Gulf of Alaska: south of Aleutian chain)

P9. Arctic (Alaska: North of Aleutian Chain)

P10. Pacific Insular (Hawaii and other Pacific islands)

a. Subtidal Bottom Types

S-B1. Rock bottom
S-B2. Cobble (unconsolidated)
S-B3. Sand (unconsolidated)
S-B4. Mud (unconsolidated)
S-B5. Rooted vascular aquatic bed (grasses)
S-B6. Macroalgal aquatic bed (e.g., kelp)
S-B7. Coral reef
S-B8. Mollusk reef
S-B9 Worm reef

b. Intertidal Bottom Types

I-B1. Rocky shore
I-B2. Cobbled beach
I-B3. Sandy beach
I-B4. Muddy shore
I-B5. Saltmarsh (cordgrass)
I-B6. Trees (coastal wetlands)
I-B7. Coral reef
I-B8. Mollusk reef

invertebrates (see Table 2). Four categories of species information are included: adult biomass, by species; larval numbers, by species category; mortality and growth parameters by species category; and primary and secondary productivity values.

The model is *not* intended to represent any specific localized populations of estuarine or marine situations: the databases represent *average* values for *representative* types of ecosystems. Consequently, to capture the necessary breadth of geographic coverage, the Type A Model has sacrificed geographic specificity.

CASE STUDY PROBLEM: VALUING RECREATIONAL FISH-KILLS AND FISHERY CLOSURES

Injury Quantification

Short-term (acute toxicity) losses are calculated separately for adults and larvae based on the toxicity information in the chemical database and the species distribution data. The model also calculates long-term losses due to the acute mortality to adult, juvenile, and larval biota due to toxic concentrations; the reduced recruitment into the adult fishery due to acute toxicity kills of larvae, juveniles, and adults; and the indirect mortality to adult, juvenile, and larval biota due to loss of foodstuff in the food web.

The fishery population dynamics in the model are based on the assumptions that the instantaneous catch rate (or catchability coefficient), the instantaneous natural mortality, and the growth function for individuals remain constant, and that egg production and larval numbers return to pre-spill levels immediately following dissipation of the spill. The architects of the model justify these assumptions on the grounds that the model is designed for spills of short duration.

Lost catch due to closure of an area to fishing is also calculated based on the biomass in the closed area. Because some of the lost catch in the closure area is due to mortality from acute toxicity, only the lost catch due to the closure in excess of the acute toxicity losses is added to the long-term losses to calculate total catch loss.

TABLE 2. SPECIES LIST AND CATEGORIZATION FOR BIOLOGICAL DATA SET

Species Number	Category[a]	Common Name	Scientific Name
1	1	American Shad	*Alosa sapidissima*
2	1	Alewife (and Blueback Herring)	*Alosa pseudoharengus, A. aestivalis*
3	2	Menhaden Atlantic and Gulf	*Brevoortia tyrannus, B. parronus*
4	2	Atlantic Herring	*Clupea harengus harengus*
5	2	Butterfish	*Peprilus triacanthus*
6	2	Pollock	*Pollachius virens*
7	2	Atlantic Mackerel	*Scomber scombrus*
8	3	Bluefish	*Pomatomus saltatrix*
9	3	Striped Bass	*Morone saxatilis*
10	3	Monkfish (Goosefish)	*Lophius americanus*
11	3	Weakfish (Grey Sea Trout)	*Cynoscion regalis*
12	4	Tuna	*Thunnus spp.*
13	4	Swordfish	*Xiphias gladius*
14	4	Sharks	Odontaspididae, Carcharhinidae, etc.
15	4	Dogfish	*Squalus acanthias*
16	5	Yellowtail Flounder	*Limanda ferruginea*
17	5	Summer Flounder (Fluke)	*Paralichthys dentatus*
18	5	American Plaice	*Hippoglossoides platessoides*
19	5	Witch Flounder	*Glyptocephalus cynoglossus*
20	5	Winter Flounder (Blackback)	*Pseudopleuronectes americanus*
21	6	Atlantic Cod	*Gladus morhua*
22	6	Haddock	*Melanogrammus aeglefinus*
23	6	Redfish (Ocean Perch)	*Sebastes fasciatus*
24	6	Silver Hake (Whiting)	*Merluccius bilinearis*
25	6	Red Hake	*Urophycis chuss*
26	6	White Hake	*Urophycis tenuis*
27	6	Scup	*Stenotomus chrysops*
28	6	Tilefish	*Lopholatilus chamaeleonticeps, Caulolatilus microps*
29	6	Black Sea Bass	*Centropristis striata*
30	6	Atlantic Wolffish	*Anarchichas lupus*
31	1	Hickory Shad	*Alosa mediocris*
32	2	King Mackerel	*Scomberomorus cavalla*
33	2	Spanish Mackerel	*Scomberomorus maculatus*
34	6	Harvestfish	*Peprilus alepidotus*
35	6	Atlantic Croaker	*Micropogonias undulantus*
36	6	Drums	*Sciaenidae*
37	6	Spot	*Leiostomus xanthurus*
38	6	Yellow Perch	*Perca flavescens*
39	6	Carp	*Cyprinus carpio*
40	6	Eels	*Anguilliformes*
42	2	Atlantic Thread Herring	*Opisthonema oglinum*
43	2	Anchovy, Atlantic	*Anchoa spp.*

(continued)

[a]Category Key

1 Anadromous fish
2 Planktivorous fish
3 Piscivorous fish
4 Top carnivorus
5 Demersal fish
6 Semi-demersal fish
7 Mollusks
8 Decapods
9 Squid
10 Mammals
11 Waterfowl
12 Shorebirds
13 Seabirds

TABLE 2. SPECIES LIST AND CATEGORIZATION FOR BIOLOGICAL DATA SET (CONTINUED)

Species Number	Category[a]	Common Name	Scientific Name
44	2	Striped Mullet	*Mugil cephalus*
45	6	Sheepshead	*Archosargus probatocephalus*
46	6	Spotted Sea Trout	*Cynoscion nebulosus*
47	6	Sand Sea Trout (White Sea Trout)	*Cynoscion arenarius*
48	6	Sea Catfish	*Arius felis*
49	3	Atlantic Halibut	*Hippoglossus hippoglossus*
50	3	Bonito (Tunny)	*Euthynnus alletteratus*
51	3	Crevalle Jack	*Caranx hippos*
52	3	Greater Amberjack	*Seriola dumerili*
53	3	Jacks, Other	*Carangidae*
54	3	Blue Runner	*Caranx crysos*
55	3	Dolphins	*Coryphaenidae*
56	5	Flounder, Southern	*Paralichthys lethostigma*
57	5	Flounder, Gulf	*Paralichthys albiqutta*
58	6	Drum, Red	*Sciaenops ocellatus*
59	6	Drum, Black	*Pogonias cromis*
60	6	Porgies	*Sparidae*
61	6	Florida Pompano	*Trachinotus carolinus*
62	6	Grunts	*Haemulidae*
63	6	Pinfish	*Lagodon rhombodies*
64	6	Kingfish	*Menticirrhus spp.*
65	6	Sheepshead	*Archosargus probatocephalus*
66	6	Cuck	*Brosme brosme*
67	6	Tautog	*Tutoga onitis*
68	6	Groupers	*Epinephelus spp., Mycteroperca spp.*
69	6	Snapper, Red	*Lutjanus campechanus*
70	6	Snapper, Other	*Lutjanidae*
71	6	Whiting (Southern Hakes)	*Urophycis floridanus*
72	2	Spanish Sardine	*Sardinella aurita*
73	6	Silver Jenny	*Eucinostomus gula*
74	6	Bonefish	*Albula vulpes*
75	3	Barracuda	*Sphyraenidae*
76	6	Sea Bass	*Serranidae*
77	6	Triggerfish	*Balistidae*
78	1	Salmon, Sockeye (= Red)	*Oncorhynchus nerka*
79	1	Salmon, Chum (= Keta)	*Oncorhynchus keta*
80	1	Salmon, Pink	*Oncorhynchus gorbuscha*
81	1	Salmon, Chinook (= King)	*Oncorhynchus tshawytscha*
82	1	Salmon, Coho (= Silver)	*Oncorhynchus kisutch*
83	2	Mackerel, Pacific	*Scomber japonicus*
84	2	Mackerel, Jack	*Trachurus symmetricus*
85	2	Anchovy, Pacific	*Engraulis mordax*
86	2	Herring, Sea (Pacific)	*Clupea harengus pallasi*

(continued)

[a]Category Key

1 Anadromous fish	5 Demersal fish	8 Decapods	11 Waterfowl
2 Planktivorous fish	6 Semi-demersal fish	9 Squid	12 Shorebirds
3 Piscivorous fish	7 Mollusks	10 Mammals	13 Seabirds
4 Top carnivorus			

TABLE 2. SPECIES LIST AND CATEGORIZATION FOR BIOLOGICAL DATA SET (CONTINUED)

Species Number	Category[a]	Common Name	Scientific Name
87	5	Flounder, Pacific	*Pleuronectidae*
88	5	Halibut, Pacific	*Hippoglossus stenolepis*
89	6	Perch, Pacific Ocean	*Sebastes alutus*
90	6	Rockfish, Other	*Sebastes spp.*
91	6	Perch, Other	*Embiotoca spp., Amphistichus spp., Hyperprosopon spp.*
92	6	Sablefish (Black Cod)	*Anoplopoma fimbria*
93	6	Cod, True (Pacific)	*Gaus macrocephalus*
94	6	Lingcod	*Ophrodon elongatus*
95	6	Hake, Pacific (Whiting)	*Merluccius productus*
96	6	Sea Bass	*Serranidae*
97	2	Pollock, Walleye	*Theragra chalcogramma*
98	2	Mackerel, Atka	*Pleurogrammus monopterygius*
99	5	Sole, Yellowfin	*Limanda aspera*
100	5	Flounder, Arrowtooth	*Atheresthes stomias*
101	5	Turbot, Greenland	*Reinhardtius hippoglossoides*
102	5	Plaice, Alaska	*Pleuronectes quadrituberculatus*
103	7	Smelt	*Osmeridae*
104	6	Flounder, Starry	*Paralichthys stellatus*
105	6	Sole, Butter	*Isopsetta isolepis*
106	6	Sole, Dover	*Microstomus pacificus*
107	6	Sole, English	*Parophtys vetulus*
108	6	Sole, Rock	*Lepidopsetta bilineata*
199	6	Other Fish	*(generic)*
Invertebrates			
201	7	Surf Clam	*Spisula solidissima*
202	7	Ocean Quahog	*Artica islandica*
203	7	Atlanta Sea Scallop	*Placopecten magellanicus*
204	8	American Lobster	*Homarus americanus*
205	8	Northern Shrimp	*Pandalus borealis*
206	8	Red Crab	*Geryon quinquedens*
207	9	Squid, Atlantic	*Loligo pealei, Illes illecebrosus*
208	7	Blue Mussel	*Mytilus edulis*
209	8	Blue Crab (Hard Shell)	*Callinectes sapidus*
210	8	Blue Crab (Soft Shell)	*Callinectes sapidus*
211	7	Son Clam	*Mya arenaria*
212	7	Oyster, Atlantic	*Crassostrea virginica*
213	7	Hard Clam (Quanog)	*Mercenaria mercenaria*
214	7	Conch	*Strombus spp.*
215	8	Shrimp (Brown, Pink, White)	*Penaeus spp.*
216	7	Calico Scallop	*Argopecten gibbus*
217	8	Crabs (general)	*(generic)*
218	8	Stone Crab	*Menippe mercenaria*

(continued)

[a]**Category** Key

1 Anadromous fish
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5 Demersal fish
6 Semi-demersal fish
7 Mollusks
8 Decapods
9 Squid
10 Mammals
11 Waterfowl
12 Shorebirds
13 Seabirds

TABLE 2. SPECIES LIST AND CATEGORIZATION FOR BIOLOGICAL DATA SET (CONTINUED)

Species Number	Category[a]	Common Name	Scientific Name
219	8	Lobster, Spiny	*Panuliris spp.*
220	7	Abalone	*Haliotis spp.*
221	8	Crab, Dungeness	*Cancer magister*
222	8	Shrimp, Pacific	*Pandalus borealis*
223	9	Squid, Pacific	*Loligo, opalescens, Berryteuthis magister, Onychoteuthis boreali japonicus*
224	8	Crab, Snow (Tanner)	*Chionoecetes*
225	8	Crab, King	*Paralithodes camtschatica, P. platypus*
226	7	Clam, Butter	*Saxidomus nuttalli*
227	7	Clam, Horse	*Tresus capax*
228	7	Clam, Geoduc	*Panopea generosa*
229	7	Clam, Manila	*Tapes philippinarum*
230	7	Oyster, Pacific	*Crassostrea gigas*
231	7	Oyster, Olympic	*Ostrea lurida*
232	7	Atlantic Bay Scallop	*Argopecten irradians*
233	7	Pacific Sea Scallop	*Pecten caurinus*
299	7	Other Invertibreates	(generic)
Birds			
301	11	Marsh Ducks	Anatinae
302	11	Diving Ducks	Aythyinae
303	11	Mergansers	Merginae
304	11	Whistling Ducks	Dendrocygninae
305	11	Stiff-Tailed Ducks	Oxyurinae
306	11	Coots	Rallidae
307	11	Geese	Anserinae
308	11	Swans	Cygninae
311	12	Sandpipers	Scolopacidae
312	12	Plovers	Charadriidae
313	12	Turnstones	Aphrizidae
314	12	Oyster Catchers	Haematopodidae
315	12	Phalaropes	Phalaropodidae
316	12	Avocetes, Stilts	Recurvirostridae
321	13	Gulls, Terns	Laridae
322	13	Cormorants	Phalacrocoracidae
323	13	Auks	Alcidae
324	13	Shearwaters	Procellariidae
325	13	Storm Petrels	Hydrobatidae
326	13	Pelicans	Pelecanidae
327	13	Frigatebirds	Fregatidae
328	13	Gannets, Boobies	Sulidae

[a]Category Key

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Valuation of Damages

Translation from Change in Stock to Change in Trip Catch and Number of Affected Trips

In the biological submodel, the fish stock is allocated to recreational catch mortality, commercial catch mortality, and natural mortality based on share parameters for each species in the database. The predicted reduction in stock due to a spill is also allocated to those categories, assuming constant proportions. Jim Opaluch, one of the authors of the economic module (and a participant in the case study group), indicated that an assumption implicit in the valuation procedure was that all species are highly mobile; with this assumption, the change in fish stock will be spread over a wide geographical area and generally will produce a small change in catch rate (trip quality) over a large number of trips.

The value per fish, catchability coefficient, level of fishing effort, and cost per unit effort parameters are assumed to be unaffected by the spill. Consequently, the decline in recreational fishing catch due to a spill is calculated as the recreational fishing share of the stock (a parameter in the database) times the change in the fishery stock calculated in the biological module.

Valuation of the Change in Catch Rates

The valuation procedure then assigns the reduction in recreational stock size at a rate of one fewer fish per angler. In the calculation, the number of anglers affected just equals the change in the recreational stock size; there is no independent calculation of total trips affected. This procedure is a creative way to avoid explicitly characterizing the levels of fishing participation affected by the spill (which is likely to be larger than the spill area because of fish mobility).

To generate the recreational fishing values for the Type A model, the authors relied on two studies providing an estimate of the change in the value of recreational fishing trips with a unit change in catch rate. Rowe et al. (1985) provide consumer surplus estimates for trips to California, Oregon, and Washington marine fisheries from separate random utility models for each state. For selected species, the scenario valued was the increase in the catch rate of one species by one fish/trip at all site/mode combinations where the species is caught Norton, Smith, and Strand (1983) provide estimates of the changes in consumer surplus with changes in catch rates for several striped bass fisheries on the East Coast. They employed a single-equation travel cost model.

Because these two studies valued only a few species, the modelers needed a procedure to provide values for other species. They calculated the change in consumer surplus on a weight basis for the available species. Judging that the variation in the value per pound did not appear to vary greatly across the species valued in the studies, they employed the simple mean of the estimates ($1.84/lb) in the model to value losses of all species.

QUESTIONS DISCUSSED IN THE CASE STUDY SESSION

We discussed whether the current procedures for valuing recreational fishing injuries in the Type A model can be improved. We considered the adjustments that would contribute the most to improving the estimates and the adjustments that are currently feasible.

The group proposed separate discussions of the injury from fish kills, which we believed was appropriately valued as a change in quality of the recreational fishery, and the injury from fishery closures, which we thought might better be modeled as a change in the quantity of resources available. We consider each modeling context separately below. For most possible extensions, we concluded that data are insufficient to determine whether such changes would represent substantial refinements to the model calculations. The discussion produced a series of recommendations for further research. In the final section, we discuss criteria to be used in selecting studies for inclusion in the model database.

MODELING ISSUES

Population Effects Due To Fish Kills And Their Impact On Fish Population Dynamics

Currently, the effect of fish kills is modeled as a change in the quality of recreational fishing trips that affects the trip value but does not affect total participation in the fishery. A single value per gram of fish killed appears in the model: the variation across species in damages per fish killed is completely driven by variation in average weight across species. In addition, the value does not vary with the size of the spill (and the effect on stock and catch rates) or the extent to which available substitutes are similarly affected. We discussed several possible extensions to the modeling, as reported below.

- Expand the single recreational fish value included in the database to a matrix of values, including variations in the value of lost fish by

  -fish species,

  -geographical area of spill, and

  -user types.

Most members of the group thought incorporating species and geographical variations could be an important contribution to the model and believed that some additional values have appeared in the literature since the model was first developed. We did not think that incorporating variations in consumer surplus values by user types would make an important contribution.

- Adapt the modeling and expand the value database to incorporate variations in the change in consumer surplus per unit change in catch depending on

  -the level of the change in catch per trip (i.e., avoiding the assumption that the change in consumer surplus is linear in catch); and

  -the extent to which substitutes are affected (which will vary substantially depending on whether the affected species have localized populations or are highly mobile over a wide area).

To implement either, it would be necessary to change the modeling to identify the geographic zone of impact (taking into account the mobility of the species) and the number of trips taken to that zone. With this information, an estimated change in catch per affected trip could be calculated (rather than implicitly assigning a reduction of one fish per trip.). In addition, the Type A model would need a matrix of values in the database, capturing the nonlinearities and substitution possibilities in the values.

Are the size of the change in catch per trip and the extent of the substitutes affected important sources of variation in value? The group discussion was inconclusive: we concluded that research is needed to explore these issues. To the extent that spills valued with the model are relatively small and the species are mobile, nonlinearities in the change in consumer surplus with a change in catch rates are not likely to have a large effect on values. For spills heavily injuring highly localized species, the variation in the change in catch rate may be much greater; for this context, exploring the possibility of substantial nonlinearities is more important. Impacts on localized groupings of species also raise questions regarding the treatment of variations in substitution possibilities.

Some preliminary analysis by Graham-Tomasi and Sung with the Michigan recreational fishing model (Jones and Sung, 1991) suggests that variation in substitution possibilities has a far greater effect on the value per lost fish than variation in the quantity of fish lost per trip.

Are these changes feasible? Unfortunately, we had serious questions about the availability of necessary data. The NMFS marine recreational surveys were cited as a possible source of data on trips. In addition, we discussed how to implement the variations in value with nonlinearities and substitution possibilities. Because of the difficulty of establishing a formula, some individuals in the group suggested creating categories of “small/medium/large effects” and assigning spills to suitable categories. However the distinctions are to be implemented, additional research needs to be done to generate the necessary values for making such distinctions.

- Incorporate changes in fishing participation as a result of spill-induced quality changes in the fisheries.

Currently, the Type A model treats fishing participation levels as constant when fishing quality changes based on the assumption of mobile fish species. With this assumption, the population changes generally being modeled would yield small changes over a wide geographic area. We concluded that further research would be useful to identify how elastic trip participation is to quality changes (at the level of quality changes involved) and the extent to which damages are underestimated by excluding this category of effects.

Some recent preliminary analysis of the Michigan recreational fishery model performed by Graham-Tomasi and Sung indicates that, though the participation elasticity is not large, the share of damages contributed by that behavioral response may be substantial.

Incorporating this extension in the model would require developing a generic participation equation. Before this equation could be added, we would need to include the modeling and database adjustments required to implement it. Those adjustments would build into the model the capacity to identify the zone of impact on the fisheries (taking into account fish mobility) then determining the impact on trip catch in the affected zone and the total number of trips in the affected zone.

An additional requirement would be to ensure that the modeling in the fishery dynamics and the valuation portions of the model are consistent regarding trip participation. We believed ensuring this consistency would not be difficult.

Fishery Closures

Fish not caught because of a closure are valued using the same procedures as for fish kills, that is, the total number of trips is assumed constant, but the value of each affected trip is reduced because of the lower catch rate. This procedure implicitly assumes a small closure area and the existence of (perfect) substitute sites sufficiently nearby so that additional travel costs are essentially zero.

We believed considering modeling closures as a change in quantity of fishing resources would be appropriate. In this case, the correct calculation of damages for a change in quantity of recreational fishing services would be the change in trips times the consumer surplus per trip. Ideally, in the studies providing the basis for the consumer surplus of a lost fishing trip, the species and site characteristics are similar to the closure area, and the substitution possibilities are similar in both study and spill contexts.

This extension would seem to be more important in cases in which most close substitution opportunities are not available. The current procedures appear adequate in cases of a small area of closure.

Incorporating this extension would require trip participation rates and additional consumer surplus values on a per-trip basis. More studies are likely to be available for valuing fishing trips (as needed in this extension, modeling a change in quantity) than for valuing changes in the catch rate on trips (as needed for a change in quality).

RECOMMENDATIONS FOR FURTHER RESEARCH

We generally felt that additional work is needed to explore whether substantial variations exist in consumer surplus for a change in catch per trip by species, geographic area, size of the effect, and the extent of substitution possibilities that are affected. The group agreed that the current set of random utility models that have been estimated provides a good basis for such analysis. The participation question also needs to be explored; this research can be done with the participation models linked to random utility models or with the earlier generation travel cost models, employing equations estimating total trips.

SELECTION OF STUDIES FOR INCLUSION IN THE DATABASE

The selection of studies and specific consumer surplus value calculations from the studies is critical to the model database. We addressed the following issue: What criteria should be applied to exercise quality control in the choice of studies used to estimate consumer values? We identified three sets of criteria that may be relevant to the selection of studies:

- relevance of the consumer surplus measure to the context (change in quality, loss of access)
- quality of study (meets minimum standards)
- comparability of context between the study site and the spill site

However, we did not agree on how to apply the criteria. We did not believe that the current literature provides enough basis to decide what factors are operationally important in determining "comparability." And we concluded that the quality judgment needs to be made within the context of the study's objective and its use in the transfer.

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LONG-TERM HEALTH RISKS VALUATION: PIGEON RIVER, NORTH CAROLINA

Susan B. Kask*

ABSTRACT

Executive Order 12291 requires benefit-cost analysis for all government legislation. Does this mean that for each piece of environmental legislation we must provide new health benefits estimates for each illness and each toxin to value benefits? Estimating the benefits of a reduction in health risks is a difficult task for the policy researcher. In this paper we present a protocol for transferring health benefits from a study site to a different policy site and provide an example of its application.

Protection of public health is a primary goal of much of U.S. environmental legislation because environmental pollution can have a variety of negative effects on public health. For example air pollution can cause itchy eyes, chronic respiratory disease, and even death for those most sensitive. These effects, however, occur with some probability. Environmental pollution increases the risk of exposure to a contaminant, which in turn increases the risk of adverse health effects (see Figure 1). A benefit from reduced pollution is the reduction in the risk of these health effects. To evaluate the benefits from environmental pollution control legislation, we must account for these health benefits.

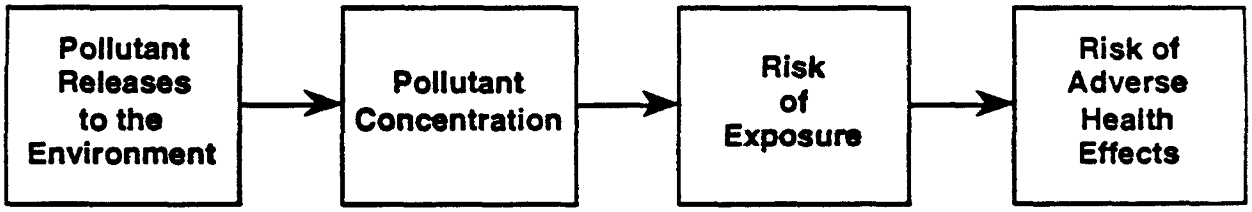

Figure 1. The Link Between Pollution and Health

Estimating the benefits of risk reduction is difficult for the policy researcher. How much individuals value a reduction in their future risk of contracting cancer or chronic illness from a reduction in pollution is a challenge to estimate. Furthermore, estimating the value of reduced

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risk of acute illness or discomfort from a variety of symptoms is equally problematic. Must we provide a new estimate for each illness, for each toxin, to value benefits? Studies exist that value accidental death, death at some future date, and reductions in illness days, for example. Can we use these studies as proxy estimates across illnesses and toxins? Can they be transferred spatially? This paper explores the potential to transfer health benefits.

We present a basic model underlying health benefit estimates. We also present the primary issues and a proposed protocol for benefits transfer. To demonstrate the protocol and illustrate the pitfalls of transfer, we consider a case study. Finally we present our conclusions and recommendations for future research.

CONVENTIONAL THEORY OF HEALTH BENEFITS MEASUREMENT

The typical model for measuring health benefits usually begins with a damage or production function that links self-insurance activities (e.g., medical treatment, purchase of air conditioners, diet, and exercise) to health. We denote this function as

$$H = H(Z)$$

where Z is a vector of self-insurance activities and H is a state of health. In some cases H is also a function of the level of pollutant (Shogren and Crocker, 1991). The production function may be represented with a two-state model with state 0 representing good health and state 1 representing death (Smith and Desvousges, 1987), or alternatively, H may represent an index or a continuum of health outcomes (Dickie and Gerking, 1991; Shogren and Crocker, 1991). Here we assume a two-state world for illustrative purposes.

As shown in Figure 1, pollution affects health through the risk of exposure and the risk of adverse health effects given exposure. We can include pollution into a probability density function Q, representing the probability of having good health. This probability depends on the level of pollution in the environment, which in turn affects the level of exposure of an individual, and the individual's level of private self-protection. This probability function is

$$Q = Q(X, Q)$$

where X is the level of private self-protection and Q is the level of some pollutant in the \environment. An alternative approach is found in Smith and Desvousges (1987) where they separate the risk of exposure and the risk of illness, and the level of pollutant affects the risk of exposure.

Each individual has an indirect utility function

$$V = V[M, H(Z)]$$

where M is their income and H is their level of health. In a two-state world where H_0 is good health and H_1 is poor health, consumers maximize expected utility given some level of pollution

$$\pi (X, Q_0)V[M, H_0(Z)] + [1\text{-}Q(\pi, Q_0)]V[M, H_1(Z)].$$

Their willingness to pay (WTP) for a small change in Q given self-protection is the difference between the level of utility in each state divided by the expected marginal utility of income.

$$WTP = \frac{V(M, H_0) - (M, H_1)}{\pi V_M^0 + (1-\pi) V_M^1} \cdot \frac{\partial \pi}{\partial Q} dQ$$

Alternatively, a discrete decrease in Q from Q_0 to Q_1 is represented as

$$\pi(X, Q_0)V(M, H_0) + [1 - \pi(X, Q_0)]V(M, H_1) =$$

$$\pi(X, Q_1)V(M - P, H_0) + [1 - \pi(X, Q_1)]V(M - P, H_1)$$

where P represents the WTP[1] to maintain the initial level of utility at the new level of pollution (a Hicksian compensating measure of welfare change). Using a variety of benefits estimation techniques, we can estimate the value of P given self-protection expenditures.

A PROTOCOL FOR HEALTH BENEFITS TRANSFER

The overriding concern for public health behind much of U. S. environmental legislation, and Executive Order 12291 suggests a significant demand exists, and will continue to exist, for benefit estimates of reduced risk to health. Evaluation of these benefits will require expensive and time-consuming projects for each substance and health effect. Benefits transfer may provide a solution to satisfying the need for benefits analysis for the variety of environmental legislation and regulation in the U.S. However, the transfer approach poses potential risks: poor quality

[1] Smith and Devousges (1987) refer to this value as an option price.

benefits transfers may lead to incorrect policy choices (Desvousges, Naughton, and Parsons, 1992). A sound approach to transfer is necessary.

Benefits transfers apply existing benefit estimates from a study site to a policy site. Researchers must transfer the issue or commodity from a particular policy site into something that can be interpreted using existing information (Smith, 1992). What criteria should we use to transfer health benefits from a study site to a policy site? Table 1 lists our general recommended approach for a transfer analysis. We focus on Stage 2, Transfer Criteria, in more detail below. We identify three areas as the primary focus for a transfer protocol: commodity specification, market and exchange mechanism, and site and sample characteristics. We discuss each below.

TABLE 1. GENERAL APPROACH FOR TRANSFER ANALYSIS

- Define the purpose of the estimates and the level of precision needed.
- Use proposed transfer criteria (commodity, sample, market, site) to describe study site.
- Select an existing benefit study or studies that satisfy the transfer criteria, keeping in mind estimates' purpose and precision.
- Determine the appropriate transfer method (e.g., point estimate or confidence interval, function transfer, Bayesian approach, or meta-analysis).

The Transfer Protocol: Commodity Specification

One of the most important steps in a benefits estimation and benefits transfer is careful specification of the commodity to be valued. How should we define our commodity when valuing health benefits? Table 2 identifies six areas for clarification in commodity specification.

Response/Causal Agent: Should we define our commodity based on the substance or the end result (morbidity/mortality or both)? We recommend that the commodity in health transfer studies be defined by the end result, the risk of illness or death. We posit that ultimately the consumer cares about the health effect (i.e., the itchy eyes, coughing, birth defects) and not so much the source or pollutant that causes the health effect. If this position proves defensible, then benefits transfer exercises become significantly less complicated because we can consider reductions in cancer risk from exposure to benzene in the air, for example, the same as a reduction of cancer risk from dioxin exposure in the water. This position, however, may not hold true for pollution sources that have variations in avoidance opportunities and, as discussed in

TABLE 2. RECOMMENDED COMMODITY SPECIFICATION CRITERIA

Response/Causal agent	Should we define our commodity based on the substance or the health effect?
Risk definition	Are we changing risk through changes in probability, in severity of a health effect, or both?
Temporal dimensions	Is there a latency period between exposure and occurrence of health effect?
Voluntary and involuntary dimension	Is exposure voluntary or involuntary?
Exposure pathway	Does exposure occur through water, air, and food, for example?
Exposure level	Is exposure cumulative or acute?

more detail below, morbidity effects. Thus, the role of the causal agent in risk valuation responses is an important research issue.

If we base our commodity specification on the end result, the illness, we then should consider the potential to transfer values across illnesses. For example, can we transfer the health benefit estimates for a reduction in the risk of death from lung cancer to liver cancer? To best answer this question let us consider the three general categories for valuation in health benefit studies: death, illness with no death, and illness followed by death. In the first case, individuals value mortality alone. A pure morbidity value is provided in the second case and a combined value in the third. Returning to our question above, an individual may not value death from lung cancer the same as death from liver cancer, because this is actually a combined value and the morbidity characteristics may vary across disease. Variation in morbidity across diseases may include differences in severity or timing for example.

This potential for variation in morbidity characteristics may also cause problems for transfer across pollutant sources for the same disease. For example, consumers may value reduced risk of lung cancer from dioxin exposure the same as reduced risk of lung cancer from asbestos, only if the morbidity characteristics and avoidance opportunities are the same between causal agents.

Symptoms and the potential for death should be the primary factors used to define the commodity in a health benefits transfer study. However, the pollutant source may be more important if avoidance opportunities, or morbidity effects, vary across sources. The cause of the symptoms, or death (e.g., lung cancer versus liver cancer) may also be important to value estimates because morbidity characteristics may vary.

Although we have three general categories for valuing health benefits, no studies have yet valued combined mortality and morbidity impacts. We recommend researchers use mortality estimates as lower bounds in the absence of combined studies. Because morbidity is already an element in these measures, adding morbidity and mortality values may result in double counting. Finally, the units of measurement for the commodity defined are important. If health risks are portrayed as unit days of a symptom, the researcher must consider the problems of over or under estimation surrounding unit day measures (Morey, 1992).

Risk Definition: Environmentally related health effects can range from acute illness and discomfort, which may occur with a high probability, to sudden death that may occur with a low probability. The components of risk include both the probability of a health effect occurring as well as the severity of that health effect. Ehrlich and Becker (1972) recognize that risk can be reduced by decreasing either element. In a laboratory environment, Shogren (1990) found reductions in probability were preferred to severity reduction. Whether policy changes the severity of the event or the probability of its occurrence can influence how consumers value a change in the overall risk. Therefore, when evaluating study and policy sites, researchers must clarify the component of risk that the proposed policy is changing-probability or severity. Secondly, considering the direction and magnitude of the risk change is important. Does the probability or severity of the policy under consideration increase or decrease? In the absence of information on symmetry, researchers should be cautious in transferring the health benefit estimates from an increase in probability at a study site to a policy site where a decrease in probability occurs.

Temporal Dimensions: Health effects from environmental hazards range from acute immediate effects to chronic latent health effects. The temporal dimension of health effects includes the length of time the illness occurs and the time period between exposure and occurrence of the illness or death. We cannot assume that consumers will value latent health effects the same as immediate effects nor assume they would value chronic and acute effects in the same fashion. Therefore, looking for similarities in the temporal dimensions of the health effects between the policy site and the study site is important. Presumably, temporal dimensions are similar when the health effect is constant across sites.

Voluntary and Involuntary Dimension: Although we have stated that the pollutant or source of a disease may be unimportant when transferring health benefit estimates, in one case characteristics of the source become important: the voluntary/involuntary nature of exposure to a health hazard. Environmental health risks are typically involuntary (a person is unknowingly exposed) as compared to health risks from smoking, drinking, and driving, for example (a person chooses to incur the risk). Valuation of voluntary risks may be quite different from involuntary (Starr, 1969; Starr, 1979); thus they should not be used interchangeably. The distinction occurs because voluntary risks imply some form of control over the risk, and perceived control can influence the value of risk reduction.

Exposure Pathway: Although we have ruled out the importance of the pollutant's source in value estimates, we may find that the exposure pathway affects consumer values. This effect would become relevant if exposure pathways influence our ability to avoid a hazard or the voluntary nature of exposure. For example, individuals may perceive greater control over the quality of their water and food than over air quality.

Exposure Level: Exposure to environmental pollutants can range from short time periods with high doses to long time periods with low doses. How consumers value a change in health risk will be influenced by these exposure levels, because they influence consumer probability perceptions and time preferences. Therefore, researchers must choose study sites with similar exposure levels as policy sites for benefits transfer.

Transfer Protocol: Sample and Site Characteristics

Researchers classify sample and site characteristics in two general areas: the socioeconomic characteristics of the sample and the location and temporal characteristics of the site. Characteristics that should be highlighted in a health benefits transfer study are discussed below.

Socioeconomic Characteristics: Sample characteristics such as income, education, age, awareness of risk, baseline health, and baseline risk may affect benefit estimates. Because the sample in a study site is probably not identical to the policy site, researchers must find study site value estimates that have well-developed valuation models. These models should include the socioeconomic factors that influence estimates and thus provide more insight into the relationship between demographic characteristics of the sample and values estimated. Good understanding and documentation of study site demographics will allow researchers to identify the sample characteristics that vary across study and policy sites.

Location and Temporal Characteristics: Just as socioeconomic characteristics affect benefit estimates, the researcher must also be aware of certain site characteristics that influence values. For example, location characteristics possibly important to health benefits estimation include the presence of insurance programs, access to medical care, potential for avoidance opportunities, climate, time period of exposure, and baseline exposure levels. The analyst should establish a relationship between these location and temporal characteristics and the values given at the study site. As above, reporting of these characteristics for the study site is important. Finally, as with an original benefits estimation study, analysts must consider the size of the population affected to calculate total benefits.

Transfer Protocol: Market and Exchange Mechanisms

Psychologists discovered that alternative means of framing a problem can systematically influence choice and values (e.g., Tversky and Kahneman, 1981). Three important factors regarding framing effects of a risk valuation problem are the risk reduction technology, the exchange medium, and the type of question (WTP/willingness to accept [WTA]). Finally, an additional market issue is the presence of nonuse values in the market. The importance of these issues for benefits transfer is discussed below.

Risk Reduction Technology: Evidence suggests that alternative risk reduction strategies influence valuation. Individuals can produce a given reduction privately or collectively. Individual preference for private or collective reduction depends on the payment's perceived productivity. Collective reduction may prove more efficient given scale economies, because many private actions are too expensive or complicated to be economically feasible (Shogren, 1990). However if excessive free-riding is perceived, private reduction may be valued more highly. Thus, determining the risk reduction strategies most appropriate for the policy site is important. Figure 2 illustrates the individual's choice of risk reduction actions.

Exchange Medium: One of the most important factors in designing a valuation study is the exchange medium (or "payment vehicle"). Consumers can pay to reduce the risk of adverse health effects through wages, taxes, or prices. The medium can influence values given; thus using a realistic medium for the policy site is important for both benefits transfer, as well as original benefits studies.

Nonuse Values and WTP/WTA: Analysts must determine whether nonuse values are relevant and what welfare change measure is appropriate for the policy site. Nonuse values include the health effects of children, other relatives, neighbors, and friends. Consumers may value the health of others as well as their own health. However, the extent to which these nonuse

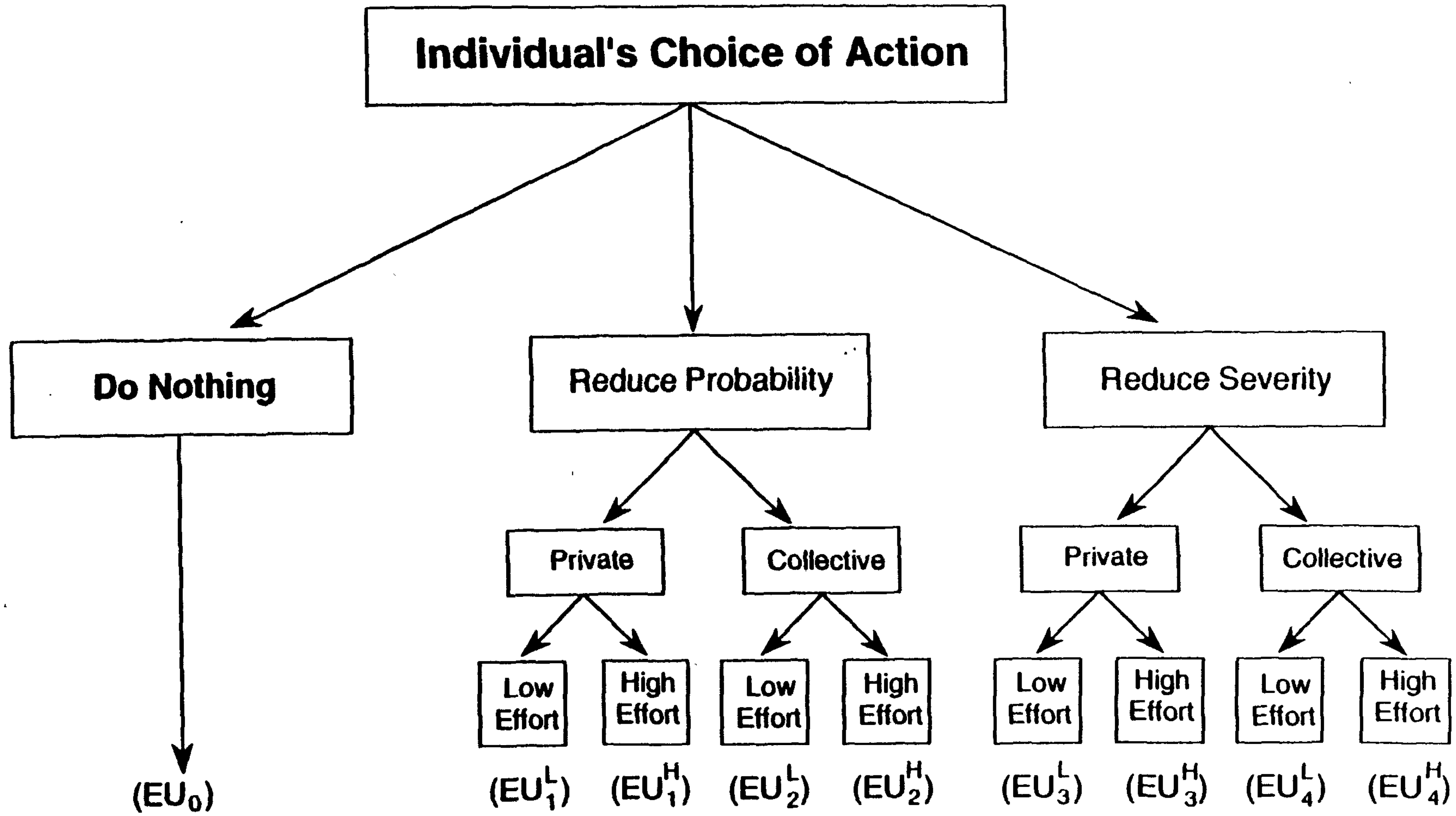

Figure 2. Individual's Choice of Risk Reduction Actions

values may be embedded within current value statements given by individuals is unclear. Although not readily available, some measure of nonuse values might be appropriate in health transfer studies.

Selecting between Hicksian compensating and equivalent measures and using WTP or WTA depends on the property rights allocation and the direction of the policy change for the particular policy site. Therefore, well-defined property rights and risk reduction should be consistent across the sites. Otherwise, extrapolating one value measure for another is questionable given the theoretically predicted and empirically observed divergence in WTP and WTA for improved health quality.

Study Selection

Following the transfer protocol suggested above, an analyst can select the study sites most appropriate for valuation at the new policy site. We recommend that existing contingent valuation method (CVM) studies be given priority because the alternative approaches have an array of problems. CVM studies are preferred because of their potential to capture morbidity and the diversity of possible samples (i.e., general population versus white male workers).

If CVM studies are unavailable, we recommend the few averting behavior studies and experimental laboratory studies. Hedonic wage models are given a lower priority because of the narrow sample group and the focus on risk of accidental death. Cost of illness is given the lowest priority because of its weak theoretical underpinning.

Additional selection criteria may include the theoretical soundness of the study, level of information reported, and purpose of estimates and level of precision required. Of course the study site should match policy site specifications to a level the researcher considers acceptable.

A CASE STUDY: LONG-TERM HEALTH RISKS FROM SURFACE WATER POLLUTION

A classic case of exposure to a long-term health risk is found in Western North Carolina. Champion Paper currently discharges approximately 43 million gallons of coffee-colored wastewater into the Pigeon River daily. In addition to the discoloration, a potentially more serious problem is the risk to public health from the dioxin and other toxins present in the discharge. The state of North Carolina is considering a weakening of the maximum allowable dioxin limit of 14 parts per trillion (ppt). What are the benefits of maintaining the limit or the costs of raising the limit? This case study provides a working example of the need to transfer benefit estimates and the many potential problems for the valuation of changes in long-term health risks from surface water contamination.

The Site: The Pigeon River originates in Haywood County, North Carolina, as a pristine stream in the Pisgah National Forest. The river flows north, 10 miles, to Canton, where Champion paper discharges their effluent. The river continues northwest, 16 miles, crossing the Tennessee state border past seven small communities in both states until it reaches Newport, in Cocke County, Tennessee. Thirty-six miles from the mill, the river empties into Douglas Lake. The 1990 mean flow rates, north of Canton, vary from a low fall flow of 88 cfs to a high of 10,900 cfs in the spring. The river is regulated by Lake Logan and Walters Lake.

The Pigeon flows through mountainous terrain between the Great Smokey and Bald Mountains. The river above Canton is used both as a municipal drinking water source, rated WS3, and for recreational activities such as swimming, boating, and fishing. Downstream from Canton, the river has been rated as Class C water for boating and fishing only; immersion is not recommended. A posted advisory recommends against eating fish caught in the river north of Canton. The 10-mile stretch from Walters Lake to the state line is considered a good "brown" water rafting run and is sometimes used by recreationists in the area. In Tennessee, the river is classified and protected for industrial water use, fish and aquatic life, recreational activities including swimming, irrigation, and livestock and wildlife watering. But, because of the present level of discharge the river does not meet state requirements for aquatic life or recreational uses. Tennessee has posted a warning against eating fish from the river. In addition, the present high color level prohibits any additional waste discharge; thus the river is not used for any other industrial discharge in Tennessee.

Water Contamination: In 1989, industrial water use accounted for 85.6 percent of water used in Haywood County. Fifty-one percent of industrial water is used by Champion Paper in a pulp mill[2], paper mill,[3] and their utilities and filter plants.[4] They produce food board and fine paper using an integrated bleached kraft pulp and paper manufacturing process.

Pollutants present in the discharge in either significant quantities or regulated by EPA are given in Table 3. In addition to the pollutants in Table 3, the discharge also affects the stream's temperature and acidity. The average winter effluent temperature is 29.8°C and the summer temperature is 37.9°C. Acidity levels range from pH 6.4 to 8.2. EPA temperature limits for effluent are between 29° to 32°C, with a 13°C maximum increase in stream temperature. The acidity limits are pH 6 to 9.

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[2] Includes chip cooking, pulp washing, screening and bleaching, recovery and generation of cooking chemicals, and production of chlorine dioxide for bleaching.
[3] Produces fine paper, food board, and dried pulp.
[4] EPA Forms 1 and 2C submitted by J. R. Kilpatrick to EPA Region IV Office, Atlanta, GA.

TABLE 3. DISCHARGE POLLUTANTS FOR CHAMPION PAPER MILL IN CANTON, NORTH CAROLINA (1989)

Effluent Characteristic	1989 Sample Values		
	Daily Average	Daily Max	Daily Average Standard Limits
Biochemical Ox Demand (5 Day)	12.5 mg/1	44.4 mg/1	30mg/1
Total Suspended Solids	11,331 lbs/day	38,449 lbs/d	42,012 lbs/d
Fecal Coliform	50/100 ml	650/100 ml	200/100ml
True Color	1,043 std. units	2,035 std. units	50 std unit
2,4,6 Trichlorophenol		< 10 µg/1	
Pentachlorophenol		< 50 µg/1	
Zinc (one sample)		80 µg/1	
Chloroform (w/ plant modification)		238 mg/1	3.3mg/1
2,3,7,8 TCDD (dioxin)		6.61 pg/1	0.014 pg/1
2,3,7,8 TCDF (furans)		5.62 pg/1	

Commodity Specification: Long-Term Health Risks from Dioxin

Response/Causal Agent: Dioxin exposure causes a range of health risks from life-threatening cancers of the soft tissues to nonlife-threatening skin problems, fertility problems. and birth defects.[5] In addition, evidence suggests dioxin can cause immune system suppression in mice at low dose levels, and it is a known promoter of other carcinogens.[6] Dioxin can contaminate the air, water, and soil, and exposure occurs through three possible pathways: inhalation, absorption, or ingestion. Dioxin is more easily absorbed in small doses.

Increasing the exposure levels of dioxin may increase the risk of immunosuppressant health effects,[7] and if accumulated exposure levels increase,[8] the population may have a risk of cancer. Therefore, we may specify our commodity as a particular set of symptoms such as increased disease days from failure of the immune system to fight colds, flu, and other common

[5] See Schmidt (1992).
[6] See Schmidt (1992).
[7] See Schmidt (1992).
[8] Dioxin has a long half-life, causing potential accumulation in the body.

ailments, and as an increase in the risk of chronic illness. We may also specify the commodity as an increased risk of cancer mortality.

Elevated cancer mortality risk is evident in the health statistics for the area. Both Haywood and Cocke Counties have cancer rates greater than the national average (see Table 4). Cancer mortality rates for the two counties range from 7 percent to 35 percent greater than the national average.[9] Chemical workers exposed to dioxin in the U.S. and Germany have been found to have cancer mortality rates 15 percent to 24 percent greater than their national averages for all cancers. In the U.S. those with long-term exposures to dioxin at chemical plants had rates 87 percent above normal in one study and nine times higher than the general population in another.[10]

TABLE 4. AGE-ADJUSTED CANCER MORTALITY RATES (PER 100,000 PERSONS)

Year	Haywood[a]	Cocke	U.S.[b]
1979 - 1981	135.44	141.2	132.0
1982 - 1984	167.89	158.4	133.0
1985 - 1987	179.24	153.7	132.7
1988 - 1990	NA	151.9	133.7

[a]These data are quoted for years 1979 through 1981, 1981 through 1985, 1984 through 1988.
[b]U.S. data are for years 1979, 1981, 1984, and 1989, respectively.

Risk Definition: The policy under consideration (increasing the maximum exposure limits) affects the probability of exposure and thus the probability of immune suppression health effects, as well as the probability of cancer mortality.

Temporal Dimension: Although the immune system effects occur soon after exposure, cancer has a latency period. The immune system problems persist as long as a potent level of the

[9]These figures do not correct for other cancer-causing behaviors and thus cannot be attributed solely to dioxin exposure.
[10]See Schmidt (1992).

chemical remains in the body and thus cause chronic problems given the long half-life of the chemical.[11] The cancers are also chronic.

Voluntary or Involuntary: Exposure to the hazard in our case study is both voluntary and involuntary. Paper mill workers and those who live in the communities surrounding the mill voluntarily expose themselves to the hazard, assuming they are aware of the chemical's presence.[12] Although we recognize their relative ability to relocate, downstream residents are involuntarily exposed.

Exposure Levels: The policy site population has been exposed to low dose levels for long time periods. Present exposure levels for the communities surrounding the mill and the downstream communities are considered low. Mill workers, however, may have higher exposure levels. A July 1989 EPA Fact Sheet (EPA, 1988) on the Pigeon River in North Carolina reported dioxin levels in fish fillet samples of 2.3 to 80 ppt and wholefish levels of 36 to 91 ppt. In Tennessee they found 0.17 to 29.3 ppt in fillets.[13] The NC state limit for dioxin is 0.014 pg/l or 14 ppt.

Both states have given advisories against eating fish from the Pigeon River, and neither state has classified the river for use as domestic water supply. Residents along the river or users of the river have had a lifetime of exposure if they have any regular contact with the river, for example, through recreational activities such as fishing and boating or through drinking from contaminated wells. Tests performed in 1987 by the Tennessee Health Department found toxins, such as furans, contaminating wells of Hartford residents.

Policy Site and Sample Characteristics

Socioeconomic: Both Cocke and Haywood Counties are rural areas. Table 5 summarizes the 1990 demographic data for these two counties.

Location and Temporal: Both government and private insurance programs are available to consumers in both counties; medical care is similar to that available in rural areas in the U.S. Exposure has occurred over a period of 80 years, the time frame in which the

[11] All references to immune system problems are presently hypothetical because evidence of this health effect has only been found in mice.

[12] This assumes these households can afford to move and choose not to. The costs of moving could be seen as conservative estimates for benefits of health risk reductions. See averting behavior literature (Abdalla, Roach, and Epp, 1992)

[13] The higher levels were obtained from the whole body of a bottom-feeding white sucker. Tests of surface-feeding sunfish yielded a dioxin level of 12 ppt. The variation in the levels could be partially explained by food source.

TABLE 5. 1990 DEMOGRAPHIC INFORMATION FOR HAYWOOD COUNTY NC AND COCKE COUNTY, TN

	Haywood County, North Carolina	Cocke County, Tennessee
Population	46,942	29,141
Mean Household Income	$22,698	$17,624
Mean Education	12.1	12 (median)
Male/Female Distribution	47/53	48/52
Racial distribution (W/B)	98/1.4%	97/2.1%
Age Distribution		
>65	18.2%	12.9%
<18	20.8%	24.0%
Median Age	39.9	35.2
Household Size (mean)	2.4	2.58

mill has been operating. Avoidance opportunities are limited but include staying away from the river, not eating the fish, not working at the mill, and moving. Although all of these would reduce exposure, airborne and soil contamination are unavoidable to area residents. Finally, the geographic extent of the market would include those who live in the vicinity of the contaminated portion of the river and in the vicinity of the mill. Given the central location of the river and/or mill in each county and the location of the mill in the two-county area, we can use the county boundaries for the market's geographic definition.[14]

Market and Exchange Mechanisms

Risk Redaction Technology: Dioxin has a half-life of 7 years, giving a long detoxification time frame. Thus, some type of reduction strategy is necessary. Source reduction must occur from either voluntary reduction by industry or government enforcement. Because of the limited number of highly contaminated sites the private sector has little incentive to provide

[14]We include Cocke County in this study because they are directly affected by North Carolina legislation relating to water quality.

the high incineration necessary for cleaning up toxic soils or sludge from rivers and streams. Collective action appears to be the most likely cleanup strategy for source reduction. Individuals can, however, pursue private averting behaviors such as purchasing bottled water or avoiding the river for recreational activities such as swimming and fishing. When transferring values we may consider either collective action or private action values, but the latter may not reflect reduction in the substance from all pathways (i.e., air, water, and soil).

Exchange Medium: The policy site medium would likely be a city water price or taxes, both of which can be applied to a collective reduction strategy.

Nonuse Values and WTP/WTA: Nonuse values are likely present for children, relatives, and possibly others for both the morbidity and mortality impacts. At the policy site, communities have the property right to clean water, but the state is responsible for enforcement of that right. Citizens must convince their government of their preferences; thus we would measure a consumer's WTP to avoid an increase in the dioxin limit (a Hicksian equivalent measure of welfare change).

Benefits Transfer: Valuing the Benefits of Maintaining 14 ppt Limit on Dioxin

In this case study we want to estimate the ex ante economic value to avoid an increase in dioxin limits. Because we have defined our commodity as the probability of morbidity and mortality effects from long-term low dose levels of exposure, we are estimating the value of avoiding an increase in the probability of chronic morbidity or cancer mortality, or both.

A significant amount of research estimates economic values for a reduction in the risk of morbidity or mortality (Gegax, Gerking, and Schulze, 1991; Gerking and Stanley, 1986; Smith and Desvousges, 1987; Viscussi, Magat, and Huber, 1991). Other studies, such as Berger et al. (1987). provide economic values for symptom-free days. Many of these studies have focused on short-term risks where the time between the cause and effect is immediate (accidental death) and on acute health effects such as burns and coughs. Few studies have looked at the chronic and/or latent health effects characteristic of our policy site. Using the criteria suggested earlier, we selected four studies as potential study sites: Viscusi. Magat, and Huber (1991); Gegax, Gerking, and Schulze (1991); Smith and Desvousges (1987); and Berger et al. (1987).[15] Table 6 summarizes the characteristics of these studies.

[15]Given the shortage of morbidity studies available, the Berger et al. (1987) study was selected although it focuses on short-term morbidity effects.

TABLE 6. POTENTIAL STUDY SITES FOR CASE STUDY

	Viscusi et al., 1991	Gegax et al., 1991	Smith and Desvousges, 1987	Berger et al., 1987
Valuation Issue	Morbidity (Mortality) reducing risk of chronic bronchitis	Mortality Increased risk of accidental death	Mortality reducing risk of death in 30 years	Morbidity value of additional sympton-free days for specific symptoms
Valuation Method	• CVM • Pairwise comparisons risk-risk and risk-cost of living • Interactive computer • WTP	• Market based • Hedonic wage model • Mail • WTA	CVM • Direct WTP question • Person to person • WTP	• CVM • Direct WTP question • Person to person • WTP
Risk Measure	Actual risk	Perceived (# workers/4,000)	Actual risk	NA
Study Site	Greensboro, NC	National	Boston Metro area	Denver & Chicago
Sample Size (usable)	389	737	609	137 (illustrative)
Demographics				
Mean Household Income	$35,000-$37,000	NA	$32,500	NA
Mean Education	14	NA	14	NA
Male/Female Distribution	50/50	NA	3961	NA
Racial Distribution (B/W)	—	NA	97/3	NA
Age (mean)	33	NA	42	NA
% > 65	—	NA	17.2	NA
Household size (mean)	2.7-2.8	NA	2.7	NA
% Household with child < 18	—	NA	36	NA

(continued)

TABLE 6. POTENTIAL STUDY SITES FOR CASE STUDY (CONTINUED)

	Viscusi et al., 1991	Gegax et al., 1991	Smith and Desvousges, 1987	Berger et al., 1987
Sensitivity of valuation estimate to individual Characteristics	Yes	No	Yes	No
Valuation estimates	$ per 1/100,00 decrease in risk of chronic bronchitis	Marginal value of safety for workers	See Table 2, p. 100 of Smith and Desvousges	Mean Daily Consumer Surplus
Mean Median	8.83 4.57 Implicit $ value per chronic bronchitis	Union-Blue $2,103,120 Union $1,180,304 All blue $1,180,304	Examples: $ per 5/50 dec. in exposure with combination end pt. risk of 1/100	Cough $75.98 Sinuses $27.32 Throat $43.92
Mean Median	883,000 457,000 $Value per $1/100,000 decrease risk of accidental death	All blue $1,180,304	Mean $14.19 Med. $10.00 End pt. 1/200	Eyes $48.48 Drowsiness $142.00 Headaches $108.71
Mean Median	81.84 22.86		Mean $26.20 Med. $10.00	Nausea $47.88
Mean value of Statistical Life (millions of $)	8.184	1.62	NA	NA

Both Viscusi, Magat, and Huber (1991) and Berger, Blomquist, Kenkel, and Tolley (1987) are CVM morbidity studies, while the Gegax, Gerking, and Schulze (1991) and Smith and Desvousges (1987) are mortality studies. Note Gegax, Gerking, and Schulze is a hedonic wage study and Smith and Desvousges is a CVM study. The Gegax, Gerking, and Schulze study measures WTA for an increase in perceived risk of accidental death. The other studies measure WTP for decreases in the health risks (Viscusi, Magat, and Huber and Smith and Desvousges) and WTP to get an increase in symptom-free days (Berger, Blomquist, Kenkel, and Tolley). Which study should we use for benefits transfer?

Study Selection: Given the specification of our commodity we choose Viscusi, Magat, and Huber (1991) and Smith and Desvousges (1987) as our possible studies. Both studies value chronic or latent health effects, which are similar to the same effects from dioxin exposure.16 Smith and Desvousges (a mortality study) and Viscusi, Magat, and Huber (a morbidity study) provide demographic information and a sensitivity analysis of their results. Both also value a change in probability not severity. Table 7 compares the Viscusi, Magat, and Huber and Smith and Desvousges study sites with our policy site.

Although several characteristics of the study sites make them appealing for a benefits transfer, the sites also have several important problems. First, a critical problem is the difference in the direction of change for the study sites and our policy site. Viscusi, Magat, and Huber (1991) looks at risk decreases; Smith and Desvousges (1987) look at both increase and decreases. Smith and Desvousges find that consumer values are higher for WTP to decrease risk than WTP to avoid an increase.

If we agree with their findings, we can consider the study sites as upper bound estimates. Second, the policy site includes both chronic morbidity and latent mortality effects, while the study sites include only one or the other. As recommended above, mortality figures may he considered lower bounds. Therefore, we might consider the economic values from both study sites as upper bounds but also consider the Smith and Desvousges (1987) study values as lower bounds. The transfer is imprecise because no benefit estimate applies perfectly. The analyst must now recall the purpose for the estimate and determine the need for accuracy. Finally, must we adjust for the demographic differences in education and income levels at the policy site?

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[16]Smith and Desvousges (1987) study probability of death from exposure to hazardous wastes, and Viscusi, Magat, and Huber (1991) study severe chronic bronchitis. Although chronic bronchitis may not be a specific effect from dioxin exposure, many of the symptoms may be similar but less severe.

TABLE 7. COMPARISON OF POLICY SITE TO STUDY SITE

	Viscusi et al., 1991	**Smith and Desvousges, 1987**	**Policy Site**	
Morbidity/Mortality	Morbidity	Mortality	Morbidity and Morality	
Risk def.	• Probability of chronic bronchitis (↓) (-1/100,000)	• Probability of exposure (↓) (-0.05/50 ... -5/50)	• Probability (↑)	
Temporal dimensions	Chronic Illness (serious)	Latent Effect (serious)	Chronic and Latent (mild-serious) (serious)	
Voluntary/involuntary	Involuntary	Involuntary	Involuntary/Voluntary	
Exposure pathway	Air not specified	Ingestion air	Air, Soil, Ingestion	
Exposure level	Low	Variable	Low	
Socioeconomic			A	B
Household income (mean)	$35,000 - $37,000	$32,500	$22,700	$17,500
Years education	14[a]	14[b]	12[a]	12[b]
Male/female distribution	50/50	39/61	47/53	48/52
Racial distribution W/B	—	97/3	98/1.4	97/2.1
% > 65	—	17.2	18.2	12.9
Household size	2.71	2.7	2.4	2.58
% Households with children < 18	—	36	30	38
Exchange Mech.	Paired Comparisons	Taxes Prices	Taxes or Utility Prices	
Reduct. Tech.	Private	Collective	Collective	
Nonuse	No	No	Yes	
WTP/WTA	WTP	WTP	WTP	

[a]Mean
[b]Median

Value Transfer: We must determine whether we are transferring an equation or a specific estimate from the study sites. Whether we use an equation or a specific estimate depends primarily on the information available from the study sites. If an equation and the relevant data are available from our policy site, transfer of an equation would be the preferred route.

In our particular case, a transfer equation exists for the Smith and Desvousges (1987) study for the risk increase case.[17] Given specific exposure and conditional risk levels,[18] age, income, the number of children in a household, and attitudes to hazardous wastes for the policy site population, a researcher can calculate an estimate for policy site WTP to avoid a probability increase. A transfer function is not readily available in the Viscusi, Magat, and Huber (1991) paper.[19]

If a transfer equation is not available, a specific estimate can be used. Our study values would depend on the dose response for dioxin, which establishes the relationship between proposed policy and probability of the health effect. This relationship can be used to determine the appropriate risk change for analysis.

The Smith and Desvousges (1987) mean values for WTP to avoid a 1/100,000 end point death risk increase range from $17.71 to $47.47. The Viscusi, Magat, and Huber (1991) observation values range from $1.50 to $80.00 per 1/100,000 decrease in probability of chronic bronchitis, with a mean of $8.83. The Smith and Desvousges and Viscusi, Magat, and Huber probability levels are significantly different with Smith and Desvousges levels ranging from conditional probability of death of 1/10 to 1/300. Given that these two studies use different approaches and our concerns for double counting raised earlier, these values should be neither compared nor added together.

Recall that both studies' estimates may be considered upper bounds. The Smith and Desvousges (1987) study uses probabilities higher than those we might expect for dioxin, the Viscusi, Magat, and Huber (1991) study is valuing acute morbidity effects that may be more severe than the acute effects expected from dioxin exposure, and Viscusi, Magat, and Huber measures values for risk reduction. In both studies the demographics may also suggest higher values for the study sites due to higher levels of income and education.

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[17] See Smith and Desvousges (1987), page 103.

[18] Conditional risk is the conditional probability of death occurring scaled by 1,000. The risk of exposure is also scaled by 1,000.

[19] Viscusi, Magat, and Huber (1991) do a sensitivity analysis but find the various demographic variables are insignificant. A transfer function is probably available directly from the authors.

The actual choice of a WTP figure must depend on the researcher's policy needs. If only rough estimates are required, the above studies may provide adequate guesses. However if more precise measures are needed, researchers may wish to conduct an original benefit estimation study.

CONCLUSIONS, LIMITATIONS, AND FUTURE RESEARCH NEEDS

Benefits transfer is significantly more difficult to apply than to discuss in theory. The most important limitation is the difficulty in finding reasonably similar commodity specification between the new policy and old study sites. The variation across studies in commodity specification makes transfers difficult. To ease this problem we suggested assuming the causal agent does not matter. However, in our study the variation in direction and magnitude of probability change, the severity of health effects, and the appropriate welfare measure posed significant challenges for transfer. Exacerbating this problem is the singular focus of studies on either morbidity or mortality. Although most long-term health risks from environmental substances include both categories of health risks, the relationship between them has not been examined in the literature. Aggregation through the independent valuation and summation of mortality and morbidity impacts may introduce a systematic bias in estimates (Hoehn and Randall, 1989). This topic is important for future research.

After the above limitations have been adequately addressed, we can then turn our research focus to the relationships between the demographic, location, and temporal variables to value estimates. Further research might also include more studies in developing nations to enhance our understanding of demographic and cultural variables on economic values and our potential for international transfers. In addition, the role of prior information on values and Baysian exchangeability should be studied in more detail (Atkinson, Crocker, and Shogren. 1992). The importance for benefits transfer of documentation and presentation of demand equations cannot be overstated. A collective effort to organize existing studies and databases is needed to enhance researchers' ability to conduct transfers.

Further study of disease attributes, causes, and source as they relate to values is warranted. Can we use hedonic methods to evaluate the relationship between disease attributes and values? Finally, researchers' have not exhausted the various questions surrounding valuation methodology as applied to health risk values nor the potential for nonuse values.

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RECREATIONAL FISHING VALUATION: ACID RAIN PROVISIONS OF THE CLEAN AIR ACT AMENDMENTS

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ABSTRACT

Our work group developed a research protocol to assess the likely magnitude of the economic benefits of improved or nondegraded recreational fishing that are expected to result from implementing the Clean Air Act Amendments of 1990. We used data for the study site from the 1990 NAPAP Integrated Assessment, which includes Maine, New Hampshire, Vermont, and New York. The policy site includes Pennsylvania, Virginia, West Virginia, Maryland, New Jersey, and Delaware.

Congress mandated in §812 of the Clean Air Act Amendments of 1990 (CAAA) that EPA conduct a comprehensive analysis of the impact of the CAAA on the U.S. economy, public health, and the environment. This analysis is to include costs, benefits, and other effects associated with compliance with each standard issued for emissions of sulfur dioxide (SO_2) and nitrogen oxides. Title IV of the CAAA mandates a reduction in SO_2 emissions of 10 million tons per year, with a national cap on SO_2 taking effect in the year 2000.

With the reduction in these precursors to acidic deposition, water quality improvements are expected. A potentially significant source of economic benefits from improved water quality is enhanced recreational fishing. This case study involves developing a research protocol to assess the likely magnitude of the economic benefits of improved or nondegraded recreational fishing that are expected to result from the implementation of the CAAA to control precursors of acidic deposition.

Although substantial improvements (nondegradations) in water chemistry and fish populations may be attributed to the CAAA for three regions of the country (i.e., Adirondack region in New York, Mid-Atlantic Highlands, and Mid-Atlantic Coastal Plains), a preliminary economic assessment has been completed for the Adirondacks only. This area together with

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three other northeastern states (i.e., Maine, New Hampshire, and Vermont) was studied as part of the National Acid Precipitation Assessment Program (NAPAP) and preliminary results were included in the 1990 Integrated Assessment.

At the time of the Assessment, the Adirondacks (and the rest of the Northeast) was the only affected region of the country for which all of the linkages from emissions to fish population declines were established. Therefore, the limited resources for the economic analysis were devoted to assessing damages to the recreational fishery in this region. Finally, the analysis was limited to losses to anglers, and researchers made no attempt to assess any potential nonuse values associated with the changed water chemistry and biota. The contingent valuation method of assessing nonuse values was considered too controversial to survive the NAPAP peer-review process.

The Assessment's National Surface Water Survey (NSWS) encompassed all of the regions of the country thought to suffer adverse water chemistry conditions from acidic deposition. However, the Assessment ascertained that only the Adirondack and Mid-Atlantic regions have potentially high losses in waters suitable for the survival of certain fish populations. The economic losses to recreational fishermen in the Mid-Atlantic regions still need to be assessed. Unfortunately, the linkages from emissions to fish populations are less definitive for the Mid-Atlantic regions, particularly the Coastal Plains, than for the Adirondacks. Moreover, relative to the costs of controlling emissions, the benefits of improved fish habitat and populations are likely to be quite small so that a full-scale original study may not be warranted.

However, two arguments can be made for a less ambitious analysis. First, on a regional scale, the damaged conditions of the fishery may represent a significant loss and a disproportionate burden. Second, recreational fishing damages from fish population losses are but one effect of acidic deposition to be considered along with other damages such as, health effects, impaired visibility, and materials damages. Note that with the probable exception of health effects, each of these effect categories includes uses and nonuse values that are affected by acidic deposition. Therefore, although a full-scale original study of recreational fishing in the Mid-Atlantic region may not be warranted by definitive science or the relative costs and benefits of §812 of the CAAA, a less ambitious assessment of the likely extent of damages is appropriate in this policy context. One of the goals of this benefit transfer research protocol exercise is to describe the extent of analysis required by the policy context.

Consistent with the Assessment, the research protocol described here does not address nonuse values. That topic warrants separate treatment and is beyond our scope.

THE BENEFIT TRANSFER RESEARCH PROTOCOL

A benefit transfer can involve a fairly simple practice such as applying estimates of benefits from one study to an entirely new situation. If multiple, related studies are available, researchers may construct weighted averages of benefit estimates. The original functions that generated the benefit estimates can themselves be transferred, and available data from the policy site can be used in place of the means from the study sites to simulate the models. Ever increasing levels of effort can be directed toward methods of assembling, analyzing, evaluating, combining, and interpreting existing information on how people are affected by a change in conditions, and these methods all qualify as benefit transfers.

In this paper, we develop a benefit transfer protocol for exploiting existing *data* collected in an original study, rather than the values or functions estimated from these data. By having access to the data, researchers are not restricted by the modeling assumptions of the original study. Furthermore, we can consider methods of combining the existing data with data from the policy site.

The four types of data needed in an assessment of recreational fishing benefits are

- behavioral data (e.g.. where do anglers fish and how often?);
- population and angler characteristics (e.g., income, age, tastes, and attitudes);
- site characteristics (e.g., fishing quality, size of the water body, cost of access, geographic distribution of waterbodies by type and in relation to the angling population); and
- policy variables (e.g., fish catch rates, presence of fish species, Acidic Stress Indexes).

Our original data for the study site are from the 1990 NAPAP Integrated Assessment, which includes Maine, New Hampshire, Vermont, and New York (Shankle et al., 1990). The policy site includes the Mid-Atlantic states of Pennsylvania, Virginia, West Virginia, Maryland, New Jersey, and Delaware. The data from the Northeast on recreation behavior, site characteristics, population and angler characteristics, and policy variables, may be used alone or in combination with policy site data on these parameters. Presently, population characteristics are readily available for the Mid-Atlantic regions, and we anticipate the future availability of some policy site data on angler characteristics and recreation behavior (e.g., National Recreation Survey). Site characteristic data exist for the policy site, but accessing these data and linking them with the recreation behavior model is a labor-intensive task. Finally, aggregate data on the range of changes in the policy relevant variables are available in the policy region, but these data may not import well into the recreation behavior models that rely on "site"-specific data.

We develop a benefit transfer research protocol that breaks the analysis down into stages. The progression from one stage to the next is based on a value of information analysis similar to the one presented in Deck and Chestnut (1992) and based on Freeman (1984). The titles for some of the stages of the research protocol have been generalized, however, to accommodate our more encompassing interpretation of the types of analyses that qualify as "transfers." At each stage of the analysis, we attempt to evaluate the benefits and costs of proceeding to the subsequent stage. We based the decision on the cost of obtaining increments in the quality of benefit information relative to an assessment of how important the quality increment is to the policy context. Finally, in our conclusions we suggest some changes in the way we do empirical research to make benefit transfer practical as well as defensible.

Stage 1 begins with the **Qualitative Assessment** of the economic significance of the damaged recreational fishery. Assuming significant damages have occurred and the policy will result in a reduction in damages, the **Transfer Scoping Analysis** is designed. The purpose of this second stage of the exercise is to assess the availability and relevance of existing information (e.g., studies, reports, databases). The third, or **Benefit Transfer Computation/Estimation,** stage is to determine how best to synthesize, analyze, and otherwise interpret the relevant information to quantify the economic benefits associated with the policy. Here, we attempt to specify and estimate recreational fishing demand models using study site data (i.e., the Northeastern states) alone or in combination with other available data sources. If these data sources are inadequate for providing credible estimates of the recreational fishing benefits of reductions in acidic deposition in the Mid-Atlantic Highlands and Mid-Atlantic Coastal Plains, then, moving to the fourth stage may be necessary. The **Update/Validate** stage involves at least some primary data collection (e.g., a pilot study) and model estimation most likely using procedures for combining data from different sources. The forthcoming National Recreation Survey is described briefly because it may provide relevant, but thin, site-specific data that can be combined with other data to update or validate an existing model. For completeness, the fifth step in the Deck and Chestnut (1992) proposed protocol is an original study. We omit this step because it does not involve a "transfer" at all.

Stage 1: The Qualitative Assessment

The objective of the qualitative assessment is to determine the likely economic significance of the changed condition due to the policy. Two important factors influence any conclusions that can be drawn at this preliminary stage of the analysis. The first relates to the magnitude of the change in the condition of the environment that results from the policy and whether an economically relevant endpoint can be measured. The second involves the sensitivity of economic behavior and/or economic welfare to the change in the measurable endpoint. This latter point includes both the responsiveness of individual agents and the overall number of agents (i.e., extent of the market).

Although these points may appear transparent, most scientific research proceeds while lacking sufficient interaction with economists to ensure that useful endpoints are measured. This criticism applies to the NAPAP in spite of an explicit charge to establish the linkages necessary for relating policy-induced changes in sulfur emissions to policy relevant endpoints. Fortunately, endpoints pertinent to an economic assessment of damages to recreational fishing were measured.

Changes in water chemistry are linked to changes in the viability of certain fish populations through an Acidic Stress Index (ASI), which was developed to reflect the combined effects of pH, aluminum, and calcium on aquatic biota. The ASI logistic models, which were estimated using data from laboratory experiments, predict the probability of larval fish mortality. Separate models were estimated for three species types with varying degrees of sensitivity to acidity: sensitive, of intermediate tolerance, and tolerant. The leap of faith for the scientists involved generalizing these results to the field. First, they constructed lake and stream-specific ASI values using index water chemistry from the NSWS. Second, they compared these constructed ASI values with other sources of information on fish response. Fortunately, these comparisons suggested approximate reference levels for acid-base chemistry considered unsuitable for survival of certain fish populations (see Table 1).

Using the ASI reference levels and given estimates of changes in water chemistry, the scientists could then predict the regional losses in waterbodies suitable for supporting the various fish populations. Figure 1 illustrates the percentage of NSWS lakes and streams unsuitable for two classes of fish species: tolerant and sensitive. Note that not all of the acidic stress is due to acidic deposition; the contribution of acidic deposition varies by region and in some cases is not known (see Table 2). We present the results of the NAPAP investigations below.

Adirondacks

Fourteen percent of the lakes in the NSWS are acidic (i.e., have low acid neutralizing capacity [ANC] and low pH) where the primary cause of acidity is attributable to acidic deposition. Acidification has resulted in loss of fish populations. Sixteen percent of the lakes studied have lost one or more fish populations as a result of acidification. Twelve percent of the potential brook trout lakes in this region are too acidic for survival of brook trout populations. In addition, the Adirondack Lake Survey (ALS) shows that up to 30 percent of small lakes (2 to 10

TABLE 1. ACIDIC STRESS INDEX REFERENCE VALUES FOR FISH POPULATIONS IN NSWS LAKES AND STREAMS

	Acid Stress Index[a]	
Fish Population Status	**Lakes**	**Streams**
Absence of all fish species	Tolerant species ASI > 30	Intermediate ASI > 30
Absence of brook trout	Tolerant species ASI > 10	Sensitive species ASI > 30
Absence of other sport fish, such as smallmouth bass and lake trout	Intermediate species ASI > 80	Not Applicable
Absence of acid-sensitive. species, such as minnows	Sensitive species ASI > 80	Sensitive species ASI > 10
Excessive mortality of acid sensitive anadramous fish in the mid-Atlantic Coastal Plain	Not Applicable	Blueback herring ASI > 50

[a]The laboratory toxicity data used to develop the toxicity models were generated by the University of Wyoming as part of the Lake Acidification and Fisheries (LAF) project sponsored by the Electric Power Research Institute.

Source: National Acid Precipitation Assessment Program (NAPAP). 1990. *1990 Integrated Assessment Report.* Washington, DC. p. 31.

acres) are acidic. A potential concern is with declines in a fishery resource unique to the Adirondack region, native brook trout populations in remote, high-elevation, pristine lakes and streams.

Other New England

Five percent of the NSWS lakes are acidic with about one-half probably due to acidic deposition. Little or no chronic acidification is indicated in the state of Maine. Assessments of the effects of acidification on fish populations are inferred from water chemistry conditions About 2 percent of the potential brook trout habitat is too acidic for survival of brook trout populations and 4 percent of the lakes have water chemistry unsuitable for the survival of other sport fish, such as lake trout or smallmouth bass. Chemical conditions in 6 to 7 percent of the lakes in the region are unsuitable for the survival of many minnow species. Northeast streams were not included in the NSWS, but other information suggests that approximately 1,700 (5,000

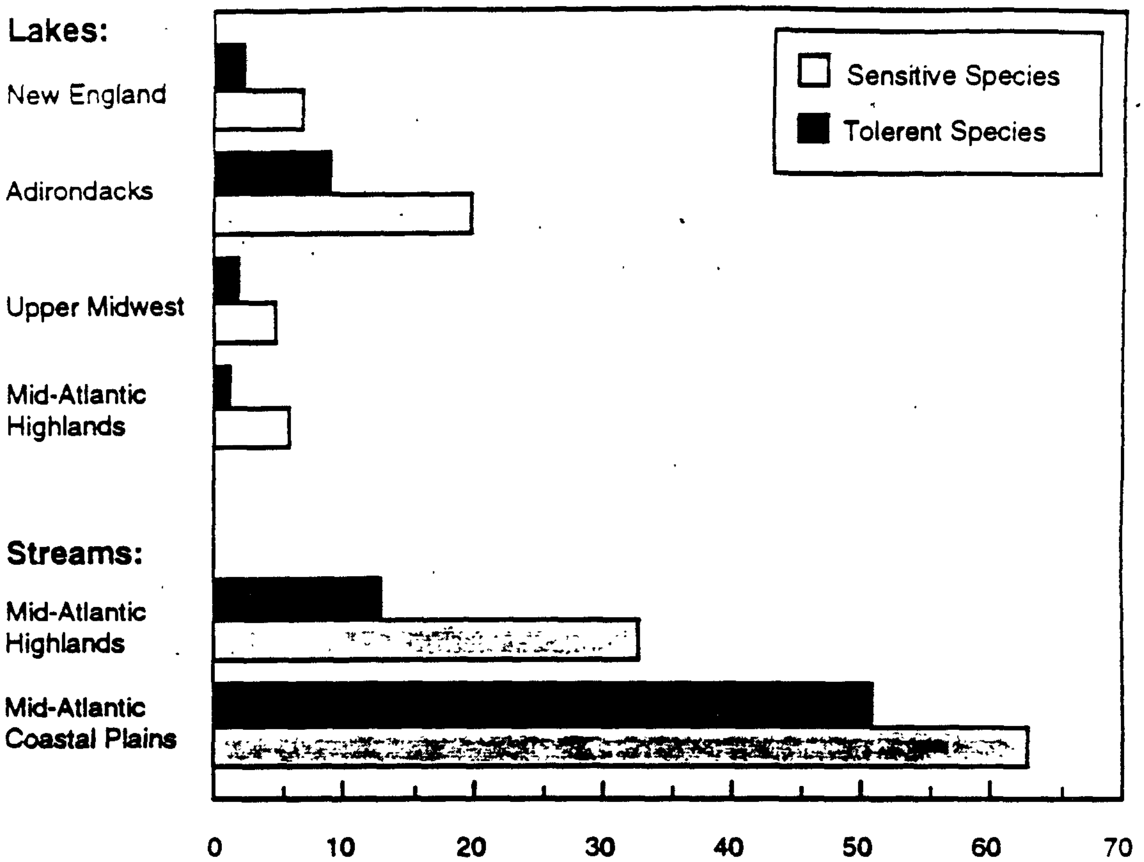

Figure 1. Percentage of NSWS Lakes and Streams Unsuitable for Tolerant and Sensitive Fish Species

Note: NSWS regional lake and stream populations unsuitable, due to acidic stress, for such species as brook trout and sensitive fish specks, such as rainbow trout, minnows, or blueback herring.

Source: National Acid Precipitation Assessment Program (NAPAP). 1990. *1990 Integrated Assessment Report.* Washington. DC. p. 31.

TABLE 2. EFFECTS INFORMATION AND LINKAGES AVAILABLE FROM NAPAP 1990 INTEGRATED ASSESSMENT, BY REGION

Region of Country (by state)	Existing Information/ Models to Estimate Effect of Changes in Deposition on ANC and pH	Existing Information/ Models to Estimate Effect of Changes in pH/ANC on Fish Populations	Expected Effects Due to CAAA
New England + Adirondacks (ME, NH, VT, MA, RI, CT, NY)	Yes	Yes	High
M. Atlantic Highlands (NY, PA, WV, MD, VA)	Yes	Yes	Moderate/High
S. Blue Ridge (GA, SC, NC, VA)	Yes	Yes	Moderate/Low
M. Atlantic Coastal Plains (NJ, DE, MD, VA)	No	Yes	High
Upper Mid-West (MN, WI, MI)	No	Yes	Moderate/Low
Florida	No	No	Low

km) acidic stream reaches exist in this region. This compares with 1,300 acidic upstream reaches in the Mid-Appalachian region. To our knowledge, the effects of stream acidity on fish populations in the Northeast were not investigated by NAPAP.

Mid-Atlantic Highlands (includes the southeastern comer of New York, most of Pennsylvania, and upland portions of Maryland, Virginia, and West Virginia)

Lakes were sampled in only a small part of this region (i.e., Southeastern New York and northeastern Pennsylvania) and 8 percent of the them were acidic. The stream survey covered the Mid-Atlantic region, and 6 percent of the streams were acidic. Chemical composition indicates that atmospheric deposition is the dominant source of acid ions in all the acidic lakes and slightly less than half of the acidic stream length. Data are lacking on the regional status of fish communities in Mid-Atlantic streams, but researchers can draw inferences from the physical and chemical characteristics of the streams when combined with geographical information. An estimated 18 percent of potential brook trout streams (i.e., 37 percent of the National Stream Survey target population) have chemical conditions unsuitable for brook trout survival. Acidity conditions in nearly 30 percent of the streams in the region render them unsuitable for more acid-sensitive species.

Mid-Atlantic Coastal Plain (includes parts of the Piedmont and coastal plain in New Jersey, Delaware, Pennsylvania, Maryland, Virginia, and North Carolina)

Only streams were sampled in this region because lakes are very uncommon. Six percent of streams are acidic, and nearly half the stream length has pH less than or equal to 6.0. Both organic acids and acidic deposition are major sources of acid anions. Unfortunately, numerous factors preclude establishing a causal relationship between acidic deposition and stream acidity, but acidic deposition could be responsible for almost half of current acidification. Indirect evidence does indicate that acidic deposition is a contributor to declines in fisheries and that acidification damages may have been increasing in the last decade. Several important anadromous fish species (e.g., blueback herring) are particularly sensitive to acid stress. Other sensitive anadromous species include striped bass, yellow perch, alewife, American shad, and white perch. Bioassays and models based on bioassays indicate that approximately 60 percent of the coastal streams surrounding the upper Chesapeake Bay in Maryland have a chemical composition during spring baseflow that is toxic for larval anadromous fish. The NSWS chemistry data indicate that acid tolerant fish species in approximately half of the total number of streams in the region may be affected adversely by the acidity. Much of the acid stress is due to acidic deposition; however, field evidence linking fish population declines to acidity or acidic deposition is inconclusive.

Southern Blue Ridge Province (subregion of Southeastern Highlands)

In the Southeastern Highlands, less than one percent of the NSWS stream populations are chronically acidic. Most streams have circumneutral pH (6.5 to 7.0), and fish exhibit little acidic stress under baseflow conditions. The Southern Blue Ridge streams receive sulfur deposition at levels higher than for Adirondack lakes, but the sulfur retention by soils is high and the current stream ANC is relatively high. At present, the number of streams with unsuitable chemistry cannot be modeled because of lack of field data on fish response for the Southern Blue Ridge.

Florida

Although one quarter of the lakes and 39 percent of the streams in Florida are acidic, organic acids and not deposition are the dominant cause. Therefore, acidic deposition is not responsible for the loss of fish populations in this region.

Upper Midwest

Results of the NSWS indicate acidic lakes are 9 percent of the lake population and both deposition and organic acids are contributing factors. The data on the relationship between acid deposition and fish populations are inconclusive, but scientists believe that the effect is minimal. Table 2 summarizes the current information available from the NAPAP 1990 Integrated Assessment by region of the country.

An assessment of the effects of acidic deposition on recreational fishing benefits could be limited to the Adirondacks and a few areas in the rest of New England, the Mid-Atlantic Highlands, and the Mid-Atlantic Coastal Plain: This preliminary qualitative assessment verifies that substantive changes in fish populations in these regions are due to acidic deposition. The extent to which the physical endpoint measured by the scientists (i.e., ASI) can be used for the economic assessment remains an issue. The chemical and biological analyses were intended to provide regional estimates of changes in fish populations (i.e., by percentage of target population of rivers and streams and/or lakes that could support certain fish populations) (see Appendix A for a description of the NSWS.) Economic behavior is influenced by the particular affected waterbodies and not by the quantity affected.

In practice, the economic analysis of recreational fishing damages in the Northeast that was included in the Assessment relied on regression analyses that related angler catch rates to lake-specific forecasted values of the ASI (see Appendix B). In turn, the ASI forecasts were obtained from a regression equation that used variables from the angler survey only. This method of linking the change in a physical endpoint to a change in recreation behavior may not be an option for the policy site. Therefore, we identify as one of the critical issues for this case study and for benefit transfer protocols in general the ability to relate the change in the policy region (i.e., Mid-Atlantic) to the behavior of the policy population.

At the qualitative assessment stage of the benefit transfer exercise, researchers can only ask the larger question: "What is the form of the data coming from the scientists and how can we use it together with available data on recreational anglers to bound the problem?" The discussion above provides detailed information on the form of the physical effect data available from

NAPAP, but we need to identify other scientific research conducted by the states. Moreover, until additional information is gathered on recreational fishery, delineating a protocol for using the information is difficult. However, economic theory and empirical evidence do indicate searching for the following types of information an estimate of the number of anglers; indications that the affected species are desired by the angling population; availability of substitute species; distribution of resource impacts relative to the distribution of the population; whether the problem of fish population losses is reduced by stocking programs; and reversibility of the changes.

By the end of the qualitative assessment the valuation problem should be stated clearly. The extent to which the science is capable of linking the policy change to the change in the physical resource should be described qualitatively, if not quantitatively. Finally, the expected magnitude and uncertainty of the economic consequences should be weighed against the use to which the information will be put to guide the next step of the valuation exercise. Let us assume the results of the qualitative assessment support the next level of analysis-the transfer scoping exercise.

Stage 2: The Transfer Scoping Exercise

A successful scoping exercise will accomplish one or more of the following objectives:

- bound possible values for the effects of the policy change;
- screen studies and other available information for inclusion in the more in-depth analysis of existing information (i.e., Stage 3); and
- determine the relative merits of proceeding to Stage 3, skipping directly to the collection of primary data or truncating the analysis at Stage 2.

The ability to construct bounds on the economic magnitude of the recreational fishing damages avoided because of the CAAA would not necessarily preclude the need for more sophisticated analysis. Additional analysis may be required to enhance the credibility of the estimates.

Two crucial assumptions are at the heart of any benefit transfer exercise. The first relates to the resource and the extent to which it is altered by the policy. Any meaningful benefit transfer relies on experience with evaluating similar changes in similar resources in other places and times. The second assumption involves the people affected by the changed resource. Valuations across populations, time, and space will hold information content for the population affected by the current policy only if a common distribution for underlying preferences exists. Benefit transfer also requires that the ranges of the distribution overlap somewhat.

The comparison of the existing studies on recreational fishing, including the NAPAP analysis of the Northeast fishery, with available information on the Mid-Atlantic states will identify the major similarities and differences in the resources, the extent of the change in the fishery to be evaluated, the populations, and fishing behavior. Considerable judgment will aid in ascertaining whether the study region contexts overlap sufficiently with the Mid-Atlantic to provide any credible information. The overall abundance of freshwater fishing sites, species availability, and the distribution of the fishing sites relative to the population centers are all pertinent factors. Additional characteristics that distinguish the policy regions from study regions are important to identify. For example, the Mid-Atlantic fishery involves rivers and streams only, whereas the Northeast offers lake fishing as well. In addition, both regions offer a variety of cold water, warm water, and anadromous species but not exactly the same species at the same levels of abundance. Do distinctions such as these threaten the homogeneity of the spectrum of fishing opportunities across the contexts?

Differences in fishing behavior will be even more difficult to determine and interpret. For example, conversations with state fishery managers may reveal different fishing patterns, but are they due to differences in preferences or constraints? Mid-Atlantic anglers now fish in rivers and streams, but would they fish in lakes, if available? Do anglers form their preferences based, in part, on the relative abundance of certain species and types of water settings? Currently, very little empirical evidence exists to confirm or deny the stability and uniformity of preferences or to determine how the preferences are formed. Therefore, at this stage of the analysis, maintaining the assumption of a common underlying preference structure is necessary. This assumption can be tested empirically using primary data collected at the policy site.

In summary, prior to engaging in involved computations with the existing data on recreational fishing, the transfer scoping exercise assembles and assesses the evidence on the extent of correspondence with the policy context. If the domains of the resources are similar, including the extent of the changes in the resources (e.g., species availability) to be evaluated, then the existing studies have some information content. Also important to the validity of benefit estimates derived from other contexts is the commonality of the preference distribution across people, place, and time. However, at this stage of the analysis, testing this assumption is not usually possible. To determine the appropriate level of research and analysis effort, the results of this preliminary assessment of the information content of related studies should be balanced against the role that the economic assessment will play in informing the policy debate. To proceed to Stage 3 in the present paper, we assume that we have identified promising information sources and that the cost of extracting and manipulating that information is justifiable.

Stage 3: Benefit Computation/Estimation

Overarching generalizations at this stage of the benefit transfer research protocol are necessarily more vague than at the earlier stages because the most advantageous manipulation of the data will depend both on the available information and the objectives of the analysis. However, for the current situation, where study site recreation demand data are available and descriptive of the policy site, we can be more specific. Furthermore, the following stages of the benefit transfer research protocol have wide applicability due to the numerous policies affecting the quality and quantity of recreation demand opportunities and the multitude of existing, if inaccessible, recreation behavior data sources.

Although our review of existing studies and data sources is incomplete, for the present purpose we assume that the study site data (i.e., the NAPAP recreational fishing survey data for Maine, New Hampshire, Vermont, and New York) exhibit characteristics that overlap with the Mid-Atlantic region. That is, the data have information content, and the challenge relates first to extracting it and second to validating it What distinguishes this benefit transfer research protocol from its predecessors, including the others in this proceedings, is the type of data we have to work with. Prior benefit transfers involved manipulating existing benefit estimates or functions from one or more studies; we have the raw data from an existing study. Therefore, our "transfer" benefit estimation method begins at much the same place as an original study.

First, we specify and estimate the study site model as if we were evaluating the policy change at the study site. This original model should be capable of predicting annual fishing participation rates and economic benefits as a function of quality attributes influenced by the policy. Second, we consider various design changes to facilitate transporting the model to the policy site, noting that restricting the simplified model to the intersection of characteristics across sites is neither necessary nor desirable. Third, we determine whether the design changes seriously affect the description of behavior and the welfare estimates in the study region. For example, the model restrictions are tested using log-likelihood ratio statistics, and the resultant welfare point estimates and ranges are compared. Fourth, in the event that the restrictions do compromise the fit of the model, methods for relaxing the restrictions (e.g.. construction of proxy variables) are investigated. Fifth, the simplified study site model is simulated using available data for the policy site. Finally, the model results are extrapolated to the policy population, which may or may not be well defined. If competing study site "best" models (e.g., alternative functional forms, alternative sample selection correction methods or different methods of integrating fishing site selection decisions with fishing participation decisions) exist, this process can be repeated for each of them.

For future consideration, we anticipate several simplifications for increasing the transportability of the study site model to the policy site. Recall that the policy site offers a different configuration and number of fishing opportunities with different quality attributes to a different population. In addition, the nature of the policy site data available for simulating the model is distinguished from the study site data. Therefore, some of the modifications are directed at accommodating differences in the resources and the populations whereas others stem from incompatible data:

One simplification relates to the differing abundance and types of water resources in the study and policy regions. The Northeastern states have a relatively large abundance of lakes and streams, whereas the Mid-Atlantic states have a large quantity of river and stream miles and very few lakes. One suggestion for modifying the study site model is to include the total number of lakes and/or stream miles (e.g., within driving distance of each county) as a shifter of preferences.

A second simplification involves the availability of fish species. The construction of species aggregates for the modified study site model may depend on the aggregates that best characterize the policy site. For example, both regions may support a warm water fishery and a cold water fishery, but the exact species found in each of the regions, or even within regions, may differ quite a bit.

The form of the data on the effect of the policy change suggests a third modification. The science can predict the percentage losses in stream miles that support certain fish species across the entire region, but determining which streams will be lost may not be possible and determining how stream specific catch-rates would change due to the policy would be even more difficult. Therefore, the study site model should be designed to accommodate "threshold" effects, where, for example, entire recreation sites are removed from the choice set.

Fourth, as is detailed elsewhere in this proceedings (see Cameron, 1992). the study site may be estimated after adjusting each observation by the extent to which it represents of the policy population. The objective of this exercise is to eliminate any bias in coefficients that may be due to a nonrepresentative sample. This is just a sampling of potential model modifications.

Imagining how we might simulate the model for the policy region demands additional simplifications to correct for remaining differences in the distribution and characteristics of fishing resources. For example, suppose we choose a representative individual from each of the counties in the policy region. We still must characterize her fishing opportunities and how they are affected by the policy. Clearly policy site information on the characteristics, quantity, and distribution of fishing opportunities (by species types) is needed, and the form of that data will influence the model design for the study region.

This very extensive exercise is undertaken because researchers believe that the underlying preference structure of the populations in the two regions is the same and because the water resources offer similar recreational fishing opportunities. We intend to use the information on preferences to construct the preference structure of the policy population for the policy site. If the underlying preference structure is not the same, this exercise can have no validity. Furthermore, if the resources in the two regions are not similar in substantive ways, then the study site cannot provide information on people's preferences for the policy resource.

Although employing sophisticated econometric tests of the validity of model estimates of the analysis is not generally possible, assessing the credibility and reasonableness of the estimates using informed judgment is important. The process of gathering the available data on the policy site resource and simplifying and then simulating the study site model forces us to directly address the differences in the recreational fishing resource. However, unless original recreational fishing behavior data are obtained for the policy site, the identical preferences assumption must be maintained. Focus groups involving members of the target population and discussions with officials charged with managing the resource may provide a useful credibility check, but econometric tests require additional data from the policy site. Data on recreational fishing behavior at the policy site, even if insufficient for validation purposes, can nonetheless be combined with existing data sources to update the model and hence increase the credibility of the estimates. Next, we provide a preliminary discussion of the Update/Validate stage of our benefit transfer research protocol.

Stage 4: Update/Validate

This last stage of the benefit transfer research protocol serves the dual purposes of improving and validating the benefit estimates. As with the previous stages of analysis, the extra effort required for increasing the credibility of results will not be necessary or desirable for all policy contexts. However, the more accessible are primary data for the policy site and the methods to manipulate these data, the more attractive and practical utilizing them becomes. Perhaps the first method of obtaining original policy site data that comes to mind is to conduct a pilot study or focus group that is tailored to the current policy context. An alternative approach is to take advantage of national surveys (e.g., National Survey of Fishing. Hunting, and Wildlife Associated Recreation) and secondary data sources (e.g., U.S. Census) that may have been designed with multiple objectives in mind. Finally, a hybrid of the first two data sources is to utilize survey data that were intended to support water-based recreation benefit transfers. One such hybrid is the forthcoming National Recreation Survey.

Devising the methodology for updating or validating the benefit transfer model is beyond the scope of his paper. Indeed, the benefit transfer demand model itself is not provided either. For further details, the reader may consult Parsons and Kealy (1992) who analyze the viability of transferring model estimates for lake recreation choices of Wisconsin residents to the urban sub-population of Milwaukee County. Although she does not include an empirical application, Cameron (in this proceedings) addresses state-of-the-art methodological and empirical issues involving updating and validating empirical models. Here, we describe briefly the National Recreation Survey, which is intended to provide data to support a wide range of methods for updating or validating recreation demand models for benefits transfer.

The Water-Based Recreation component of the National Recreation Survey (NRS) is intended to be administered to a population-weighted random sample of about 14,000 people in the U.S. over the course of a year beginning winter 1993. In addition to obtaining demographic characteristics the phone survey will request information on the total number of trips taken for each of the following primary purposes:

- to fish,
- to boat,
- to swim outdoors (in something other than a pool), and
- to otherwise recreate in a water setting.

The survey will ask for the breakdown between the number of day trips versus the number of trips that included at least one overnight stay. Then, for each of these classes of primary purpose trips, the survey will include a last trip profile. Each “profile” will ascertain destination information (i.e., name of the water body; closest city or town to the waterside; type of water body, that is, lake, stream, wetland or ocean\bay; and additional information needed to construct the travel cost and travel time variables). Pertinent to this case study, the fishing trip profiles will distinguish between types of fishing (i.e., cold water, warm water, or saltwater) and whether the angler used a boat to fish.

Depending on fishing participation rates and how they are allocated between saltwater and freshwater destinations, this survey can lead to a small sample of recreational fishing trips in the regions affected by acidic deposition. The data will also support predictions of the relevant fishing population. Finally, in addition to using these data in combination with existing data sources, the population weights from these data may be useful for weighting the observations on samples from outside of the policy region (see Cameron, 1992).

The sample size may or may not be sufficient to support econometric tests of the validity of parameter estimates for each and every application of the data. Then sensitivity analysis must reveal whether the magnitude of the benefit estimates is sensitive to ranges in the values for the suspect parameters. Conceivably even after such a detailed benefit transfer exercise; the policy context may dictate an original study.

RESEARCH NEEDS

This exercise in designing a benefit transfer research protocol highlights the need for several changes in the direction of applied research. First, benefit transfers do not eliminate the need for data; rather, their success depends on researchers adopting practices to ensure the more efficient utilization of existing data. In particular, no matter what research objective is pursued, data sharing should become one of the goals of the research. Second, research on methods of combining information is needed and should both reflect the type of data that have been collected in the past and influence how data are collected in the future. Third, emphasis on statistical significance should not overshadow emphasis on factors that influence the magnitude of benefit estimates. This suggests that research on reducing uncertainty should focus on the factors that most affect the magnitude of the estimates. Meta-analysis may be particularly useful for identifying those factors. Finally, methods of quantifying the uncertainty of the estimates are needed. In general, research to substantiate the scientific basis for conducting benefit assessments will "transfer" directly to improved benefit transfers.

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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

$$\text{Welfare}_i = \text{TRIPS}_i\,(\text{CPUE}\,[\text{ASI}]) \times \text{WTP}_i\,(\text{CPUE}\,[\text{ASI}]) \qquad (1)$$

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]

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

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

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[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.

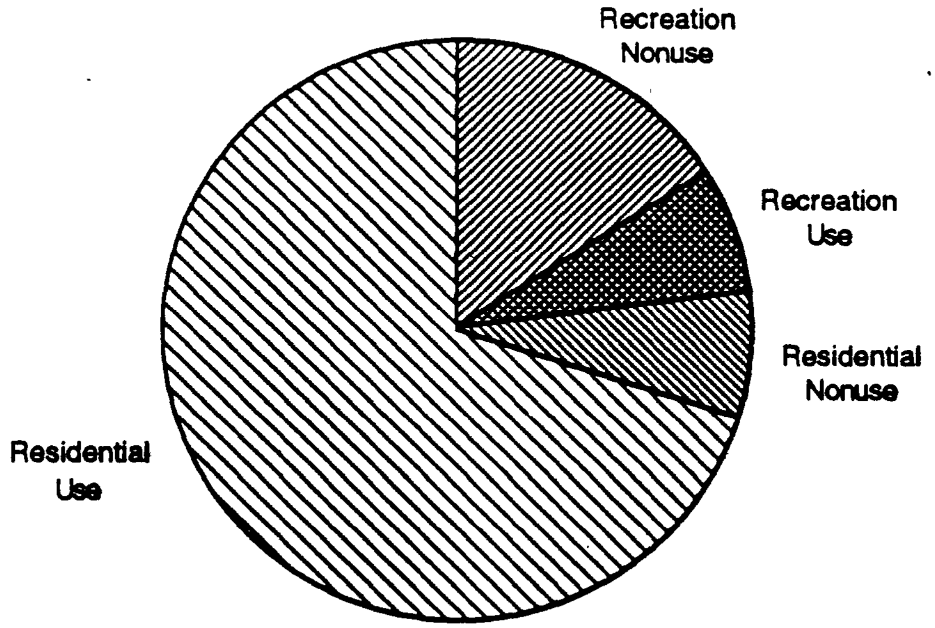

Figure 1. Possible Relative Size of Eastern Visibility Benefit Components

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.

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

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.

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[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):

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

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

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

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

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

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

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 $\delta, \rho, \lambda_1,$ 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

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[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)

P: 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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FUNDAMENTAL ISSUES IN BENEFIT TRANSFER AND NATURAL RESOURCE DAMAGE ASSESSMENT

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ABSTRACT

In this paper, we address three pertinent questions for benefit transfer. Can we reliably measure benefits within the original study context? To what extent can benefit measures that are reliable within the study context be transferred to provide reliable estimates for the policy site? How can we improve benefit transfers to make them more reliable under a wider set of conditions? Researchers must establish that the benefits estimates they are transferring are defensible themselves. Researchers should also test the adequacy of benefit transfers. by quantifying their accuracy. Finally, we need to improve our methods of transferring benefit estimates, perhaps by developing a wider range of calibration variables.

Benefit transfer estimates values in a policy context using available information from studies carried out in another context (the study context). For example, we may have an estimate of the value of recreational fishing derived from a study of coho salmon fishing in Oregon and attempt to transfer this result to estimate the value of king salmon fishing in Alaska.

Participants at the AERE workshop agree that, for practical reasons, benefit transfer is a necessary component of policy analysis. In many situations the expense of carrying out an original study cannot be justified, or the funds or time simply aren't available. Yet some information is needed to support decision making.

In a sense, even site-specific studies are a form of information transfer, where data from the sample is transferred to a more general population. In many cases, the same kinds of issues arise (e.g., Loomis, 1987). For example, researchers must be careful that the sample is representative of the larger population. In cases where the sample is not representative, researchers frequently adapt results, often using socioeconomic characteristics of the sample and the population.

Therefore, the relevant concern for economists is not *whether* to do benefit transfer; instead, we suggest three pertinent questions for benefit transfer. The first is whether we can reliably measure benefits within the original study context. We certainly shouldn't consider transferring benefit estimates that are unreliable even within their own context. The second is to what extent benefit measures that are reliable within the study context can be transferred to

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provide reliable estimates within the policy context. Reliability will depend on the extent to which values vary between the study and policy site, the extent to which we can explain and correct for these differences, and the standard of accuracy for benefit estimation. The third question is how we can improve benefit transfers to make them more reliable under a wider set of conditions.

The answers to these questions will depend on the context of the benefit transfer, where different standards might be applied in different contexts. In many arenas, our institutions have set differing standards of accuracy or burdens of proof for different kinds of social decisions. For example, society has established the most rigorous burden of proof for criminal cases, requiring the evidence to prove the case “beyond a reasonable doubt.” This standard applies independent of associated penalty and holds for criminal fines, as well as loss of personal freedom through prison sentences or the death penalty.

A weaker standard has been placed on other cases, such as in civil suits, where the standard is preponderance of the evidence. Here, the judge or jury will side with the stronger case. This standard will differ to some degree for cases that include a rebuttable presumption where a result is assumed to be correct unless a preponderance of evidence to the contrary exists.

Finally, the weakest standard of proof exists for policy decisions, where the agency making the decision only needs to show that it is not being "arbitrary and capricious." An action by an agency is considered arbitrary and capricious when the agency has

> relied on factors which Congress has not intended it to consider, entirely failed to consider an important aspect of a problem, offered an explanation for its decision that runs counter to the evidence before the agency, or is so implausible that it could not be ascribed to a difference in view or the product of agency experience. (Motor Vehicle Manufacturers Association versus State Farm Mutual Insurance Company 463 U.S. 29, 43, 103 S.Ct. 2856, 2867, 77 L.Ed.2d 443, 458 [1983])

In contrast, an agency’s judgment will generally be accepted when it can show that it “examine[d] the relevant data and articulate[d] a reasoned basis for its decision" (NRDC v. Harrington 247 U.S. App. D.C. 340, 370, 768 F.2d 1355, 1385 [1985]). Hence, in developing regulations or in policy analysis, the agency is given considerable latitude for judgment and need not demonstrate, for example, a “preponderance of the evidence” or an absence of a "reasonable doubt”

These legal doctrines may provide one basis for establishing different standards of accuracy or acceptability of benefit transfer within different contexts. An alternative standard may be provided by a form of benefit-cost analysis whereby a higher standard of accuracy might be required when the costs of making a bad decision are high. A lower standard of accuracy might be acceptable when costs are lower, such as when the information from the benefit transfer is only one of number of sources of information, or when benefit transfer is used as a screening device for the early stages of a policy analysis.

Hence, the acceptability of benefit transfer depends not only on how appropriate the estimated value but also on the institutional context. A number that may be "good enough" to be used as part of agency judgment for a screening study may be judged to be inadmissible in a criminal case or even in a civil case, such as in litigation surrounding a natural resource damage assessment (NRDA).

However, even for screening studies, we need to apply sensible standards of accuracy. We cannot allow ourselves to accept the proposition that "some number is better than no number," particularly because an unreliable number may be given undue credibility. Benefit transfer will obstruct, rather than facilitate, rational planning and will lose credibility if we apply misinformation. In some cases we are better off acknowledging that we have no reliable estimate for a particular factor, and we can then either collect information to estimate this factor or account for it in qualitative terms.

FRAMEWORK FOR EVALUATING BENEFIT TRANSFER

The basic goal of benefit transfer is to estimate benefits for one context by adapting an estimate of benefits from some other context. Consider the example discussed above, where we have an estimate of the value of recreational fishing for coho salmon in Oregon, and we attempt to transfer this result to estimate the value of king salmon fishing in Alaska. The estimate of the value of coho fishing in Oregon may not accurately measure the value for king salmon fishing in Alaska for at least three reasons:

- The preferences of participants in Alaska may differ from the preferences of participants in Oregon.
- The characteristics of the king salmon fishing experience in Alaska may differ from the characteristics of the coho salmon fishing experience in Oregon.
- The *estimated* value of coho fishing in Oregon may not measure the *true* value of coho fishing in Oregon.

The first two reasons imply that the value of fishing in Oregon differs from the value of fishing in Alaska, while the third implies that the *estimated* value in Oregon is incorrect.

Figure 1 formalizes these three sources of variation. Individual variation denotes variation across people that might arise because of differences in preferences. The value of

	"Mean" Value	Individual Variation	Commodity Variation	"Other" Variation
Fixed Component	μ	μ_I	μ_C	μ_O
Random Component		ε_I	ε_C	ε_O

Figure 1. Framework for Benefit Transfer

Alaskan king salmon fishing may differ from that of Oregon coho fishing because anglers in Alaska may have different preferences than anglers in Oregon. Some of this variation may be due to fundamental differences in tastes across individuals, while other components may be due to differences in socioeconomic characteristics like income or age.

Commodity variation denotes variation across commodities that might arise because of differences in their characteristics. The value in Alaska may differ from the value in Oregon because of differences in the two experiences. For example, on average, differences may exist in catch rates, scenery, congestion, size of fish, or other characteristics.

The third source of variation is meant to capture any variation that is independent of preferences or the commodity and thus includes "bias" or "error" in measuring value. Various sources of bias and error have been recognized in the literature. For example, using an incorrect functional form can bias regression results and subsequent value estimates. Similarly this form of variation may arise when survey respondents do not correctly express their values in a contingent valuation survey or when people act in ways that do not allow us to infer their true values through revealed preference methods.

The issue of bias has been most carefully considered for contingent valuation (e.g., Mitchell and Carson, 1989). but important biases may also exist for revealed preference methods, such as the travel cost approach (e.g., Bockstael, 1984; Smith, 1989). Many studies have attempted to test reliability and validity of benefit estimation techniques within the context of a specific study (e.g., Bishop and Heberlein, 1979; Loomis, 1989). To our knowledge, Cummings, Brookshire, and Schulze (1986) are the only ones who have taken a broad look at the issue of accuracy. We are aware of two studies that look at accuracy within the context of benefit transfer (Loomis, 1992; Downing and Ozuna, 1992).

In Figure 1, each source of variation is composed of “fixed” components and random components. The fixed components are the components of variation that in some cases can potentially be estimated and corrected for, while the random components cannot be explained.

For example, the value of recreational fishing may vary systematically over individuals because of differences in age or income. By including age and income as explanatory variables in the demand function, these sources of differences in value between the study and policy contexts can be explained, predicted, and corrected. However, tastes may differ randomly and unexplainably across individuals between the study context and the policy context,

The Oregon estimate will misrepresent Alaskan values if the distribution of these random components of participants' tastes is different in Alaska than in Oregon, after correcting for identifiable differences in the populations (e.g:, age, income). In some cases we may be able to place confidence intervals on this variation. For example, our Oregon data may allow us to estimate the variance in tastes over participants. However, we cannot guarantee that our policy site will fall within the confidence intervals because sources of variance may exist between the study and policy sites that we cannot observe within the data for the study site only. Thus, to the extent that values in the study and policy contexts differ because of random differences in tastes, we may be unable to adjust our benefit estimates to reflect these differences.

A similar problem may arise if the contribution of “identifiable” factors differs across the two sites. That is, using the Oregon coho study, we may be able to estimate how age and income affect the value of fishing in Oregon. However, these characteristics may have different effects on the value of fishing in Alaska. For example, if the weather is colder during the fishing season in Alaska, age may be a more significant factor in Alaska. Similarly, two regions may have cultural differences, so that in one region participants in some age group would not be “caught dead" fishing, while this attitude may not be a factor in the other region. Again information obtained in one region may not be transferable to another region. Furthermore, if no studies are available in the policy region, we may have no systematic means of identifying or measuring these sources of variance.

The three sources of variation may be viewed somewhat differently in terms of three components of benefit transfer. The first component consists of the "knowns," or the differences between the study context and policy context for which information is available and that can be estimated. For example, we may be able to estimate how the value of fishing varies with income, age, and catch rates. Using the known (or knowable) information, such as demographic information and characteristics of the activity, we can adjust the estimates of value obtained for the study context to produce estimates for the policy context.

The second component consists of the "known-unknowns," which might include the random components of the individual or commodity variation. For example, preferences may differ in ways that we cannot explain, but we may nevertheless be able to estimate the variance due to these effects at the study site. Thus these random components may be accounted for by using confidence intervals on the estimates. Alternatively, known-unknowns might also arise because of variables that are known to affect value but for which no data are available at the policy site. We may know how income affects value, but we may not have data on income of participants at the policy site. One way of accounting for these effects would be to use sensitivity analysis to place plausible upper and/or lower bounds on these variables.

Finally, "unknown-unknowns" could arise in the original study from the "other" sources of variation discussed above, or from unobservable or unknown differences between the two populations and/or commodities. Limiting the magnitude of the unknown-unknowns is crucial to the success of the benefit transfer. However, the magnitude of these sources of variance is, by definition, not known to the researcher, and the researcher generally has no way to quantitatively account for them in the transfer, short of carrying out a study at the policy site.

In the case of unknown differences between the study context and policy context, one possible approach is to use a pilot study to assure that results appear to be transferable. Of course, the cost of carrying out such a study may negate much of the cost savings that may come from benefit transfer.

Thus, the answers to the first two questions posed earlier-whether we can reliably measure benefits in the original study context and whether we can reliably transfer benefit estimates-depend on the types of variation that occur and their magnitudes and on how well we can identify and measure them. For benefit measures to be suitable for transfer, unexplained variation must be limited to an "acceptable" level. The margin of error that is "acceptable" will depend on the appropriate reliability standard, as described above.

TESTING AND IMPROVING BENEFIT TRANSFERS

We might judge our confidence in the soundness of a benefit transfer in several ways. Generally, statistical tests are used to evaluate the original study. These tests include statistical significance of explanatory variables, the equation R^2, and the size of prediction intervals. The significance of important explanatory variables, such as the travel cost coefficient, is necessary but not sufficient proof of the validity of value estimates. In addition, the model must have acceptable explanatory power, which is indicated by the R^2 and prediction intervals. Typically, economists focus on statistical significance and tend to ignore R^2 and prediction intervals.

These statistics suggest the relative magnitudes of the knowns and the known-unknowns, but they will not measure the effects of the unknown-unknowns. Therefore, we can only really be certain about negative test results. If a model has poor explanatory power for the study site, we will not have much confidence in its soundness for benefit transfer. However, a model may have good explanatory power, but extrapolation of its results outside of the original sample may imply that we cannot measure important components of the variance-the unknown-unknowns-so that the model may not provide good benefit estimates for the policy site.

Given the above problems, researchers should place greater emphasis on testing and calibrating benefit transfers. Socioeconomic variables, which are typically used as calibrating variables in transfers, often have very low explanatory power, implying that they are not good calibrating variables for benefit transfer. Consequently, we need to be more creative in the variables used for transfer and focus research efforts on finding variables that better explain variations in preferences.

For example, attitude statements about the importance of an activity or the experience level of participants might be one type of variable that would improve the explanatory power of models and transfers. Travel cost and contingent valuation surveys could include a series of attitude statements, answered on a scale of one to ten, about the importance of an activity or the respondent's experience level. If these variables have good explanatory power they could be used to calibrate the transfer.

One reason that socioeconomic variables are generally used to calibrate transfers, despite their low explanatory power, is that these are the variables for which data are easily available. To use other calibrating variables researchers might conduct a small "calibration" survey for the policy site, where respondents are only asked to answer the same series of attitude/experience questions asked in the original study. The results from the original study could then be weighted by the attitude/experience values for the policy site to calibrate the transfer. Again, we should be

Anchorage oil spill cost nearly $250,000 to conduct, but natural resource damages were estimated at $32,000 (Washington State Department of Ecology, 1987).

In recognition of these issues, researchers have developed a variety of structures for benefit transfer. For example, the Department of Interior (DOI) has developed the Natural Resource Damage Assessment Model for Coastal and Marine Environments (NRDAM/CME), which is a structure for benefit transfer based on a computer model that simulates the physical fates of a spilled substance, the biological effects of this spill, and the resultant economic damages (e.g., Grigalunas, Opaluch, French and Reed, 1989; Jones, 1992). Alaska and Washington State have developed more *ad hoc* approaches for simplified damage assessment that use damage indexes based on the properties of the substance spilled and the environment in which the spill occurs. In formulating the regulations for the Oil Pollution Act (OPA), the National Oceanic and Atmospheric Administration (NOAA) is considering using compensation tables, the NRDAM/CME model, and other means of "expedited" damage assessment. Many damage assessments have been based on more "traditional" applications of benefit transfer, where available estimates of impacts, such as body counts or lost beach days, are combined with available estimates of the values of the resources to estimate damages (e.g., Washington State Department of Ecology, 1987).

Most of the NRDA work by economists attempts to calculate the value of lost services due to a spill. This approach is based on the usual definition of Hicksian compensation:

$$C = E(P, NR^0, U^0) - E(P, NR^1, U^0) \quad (1)$$

where C is monetary compensation required to make the individual whole, $E(\bullet)$ is the expenditure function, P is a vector of market prices, NR^0 is the without-spill vector of natural resources, NR^1 is the with-spill vector of resources, and U^0 is the without-spill level of utility. Thus, monetary compensation is the difference between the with-spill and without-spill levels of expenditure needed to achieve the fixed level of utility. The aggregate level of compensation required can be calculated by aggregating over all individuals. This level is often calculated by estimating compensation required by a "representative" individual and then multiplying by the size of the affected population.

However, under CERCLA and OPA, a strong preference is expressed for making the public whole by restoring injured natural resources rather than providing monetary compensation (e.g., Mazzotta, Opaluch, and Grigalunas, 1992). Additionally, all funds collected, including

The cost-effective restoration program that makes the public whole is defined by

$$\min_{R} C(R)$$

s.t.

$$\begin{aligned} U(P, Y, NR^0) &= U(P, Y, NR^1 + R) \\ C(R) &< F_{GP} \cdot [E(P, NR^0, U^0) - E(P, NR^1, U^0)] \end{aligned} \qquad (3)$$

where C(R) is the cost associated with restoration program R, E is the expenditure function, and F_{GP} is a factor of gross proportions, as described below. The first constraint requires that the public be made whole through resource restoration, R, and the second constraint requires that the cost of restoration not be "grossly disproportionate" to the value of the resource. This sort of constraint is implicit in the Ohio Decision, where the court suggests "the rule might for instance hinge on the relationship between restoration cost and use value (e.g., damages are limited to three-times the amount of use value)" (U.S. Court of Appeals, 1989, footnote 7. p.21). Thus, the Court's suggestion for grossly disproportionate would be based on a factor of gross proportions (F_{GP}) of 3.

Equation system (3) is equivalent to the traditional expenditure minimization problem of utility theory with two exceptions. First, OPA and CERCLA's restriction that the funds must be used to "replace, restore, rehabilitate or acquire the equivalent" implies that the resulting expenditure function is restricted in the commodities that can be purchased. This restriction is reflected in the fact that the minimization is over R, not over all possible commodities. Second, the purchases are constrained to those sets that are not "grossly disproportionate" to the value of the resource.

In practical terms, the solution to this problem would progress in stages. For example, researchers could fast identify a number of feasible restoration plans and estimate the time path of recovery for various resources under each plan.

Next, researchers could identify "equivalent" resources to restore, in terms of social preferences. Here, researchers could use standard discrete choice models, where a sample of respondents are presented with alternative programs for restoration, described in terms of the resources and time frame for each. The respondents would then be asked to choose the most preferred restoration programs or to rank alternative programs. Standard methods of discrete choice analysis (McFadden, 1973) could then be applied to determine the levels of restoration for

> compensate fully for the injury. Congress refusal to view use value and restoration cost as having equal presumptive legitimacy merely recognizes that natural resources have value that is not readily measured by traditional means. (U.S. Court of Appeals, 1989, p. 51)

This quote suggests that Congress' intention was not to suggest that full restoration always be carried out. "regardless of cost and regardless of whether anybody cares," but to make sure that the value of resources are not systematically understated.

Although the intentions of Congress are not stated clearly, an alternative to Hanemann's (1992) interpretation would allow for an anthropocentric approach such as that presented above, where the objective is to *make the public whole* in terms of maintaining the value *to the public* of the stock of resources and associated services, rather than to *make the environment whole* regardless of public values. This interpretation is also consistent with the idea of gross proportions.

Duffield also addresses this issue, discussing the fact that requiring full restoration of injured resources is based on an equity goal and is likely to result in losses in economic efficiency (Ward and Duffield, 1992). He states that Congress expressed a preference for *full* restoration, which will often be economically inefficient. Yet, the DOI proposed regulations under CERCLA do not require that damages be calculated as the cost of full restoration but that some combination of restoration and compensation be chosen. A "reasonable number" of alternatives must be considered, and these alternatives must include the possibility of "no action-natural recovery." Although restoration is still the preferred goal, combining *both* economic efficiency and the idea of restoration is possible under the proposed regulations.

Hanemann (1992) and others see restoration as based on the deontological principle so that "economic analysis plays only a minor role, associated with calculating restoration costs and cost-effectiveness. It is under the anthropocentric approach that economics moves to center stage" (p. 574). However, the notion of restoration as in-kind compensation is useful for framing the restoration problem as one of compensating the public in a cost-effective manner, while remaining compatible with the expressed Congressional preference for restoring damaged resources. If we view restoration from this anthropocentric viewpoint, economists play a critical role.

SUMMARY AND CONCLUSIONS

Benefit transfer is a necessary and important economic tool for practical policy analysis. However, to establish and improve the credibility of benefit transfer we need to place greater

BENEFITING BENEFITS TRANSFER: INFORMATION SYSTEMS FOR COMPLEX SCIENTIFIC DATA

Martin H. David*

ABSTRACT

In this paper, I suggest reorganizing the science on which we build benefits estimates. I advocate developing a system for sharing data, creating support for archiving scientific measurements, and making data easier to use.

This paper advocates reorganizing the science on which we build estimates of benefits. Reorganization implies four imperatives:

1. Build an effective system for sharing data, an Information System for Complex Data (ISCD).

2. Create necessary support for archiving scientific measurements.

3. Begin now. Deploy existing computer and software capabilities to reduce learning time for secondary use of data, to increase scope of questions that can be addressed to existing data, and to anticipate the arrival of new generations of software and hardware.

4. Change incentives.

WHY BUILD ISCD?

Positive Reasons

Benefits transfer is applied science, statistical science, implying the following:

- Estimates of benefit are simulations based on empirical fact Observations and models of those observations are used to simulate out-of-sample forecasts for benefits transfer.

- The procedure for benefits transfer must be reproducible. Reproductibility keeps the estimates out of court and away from accusations of fraud.

- Bounds on error in estimates are needed to tell us how good the estimate is. We have more certainty about the value of the salmon fishery, governed by market prices, than we have about the value of wilderness, whose nonmarket externalities preserve options, species, and perhaps even climate.

- Learning-by-doing. Over time we expect the error of benefit estimates to decline. The scope of estimates will increase as the range and quality of measurements increases.

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benefit estimation and will likely lose credibility as a policy tool. This potential effect suggests that we should focus our attempts at benefit transfer on obtaining a smaller number of studies that fit the policy context most closely, rather than obtaining the largest number of studies possible, where many may not fit the policy context.

Other interesting issues regarding benefit transfer arise within the context of NRDA. Because the statutes express a strong preference for restoration of resources over monetary compensation, we need to develop methods to evaluate restoration alternatives. More specifically, we need to identify restoration programs that will make the public whole in the least costly manner and whose costs are not grossly disproportionate to the value of the injured resources. We also need to determine the extent to which these measures of compensation are transferable across contexts.

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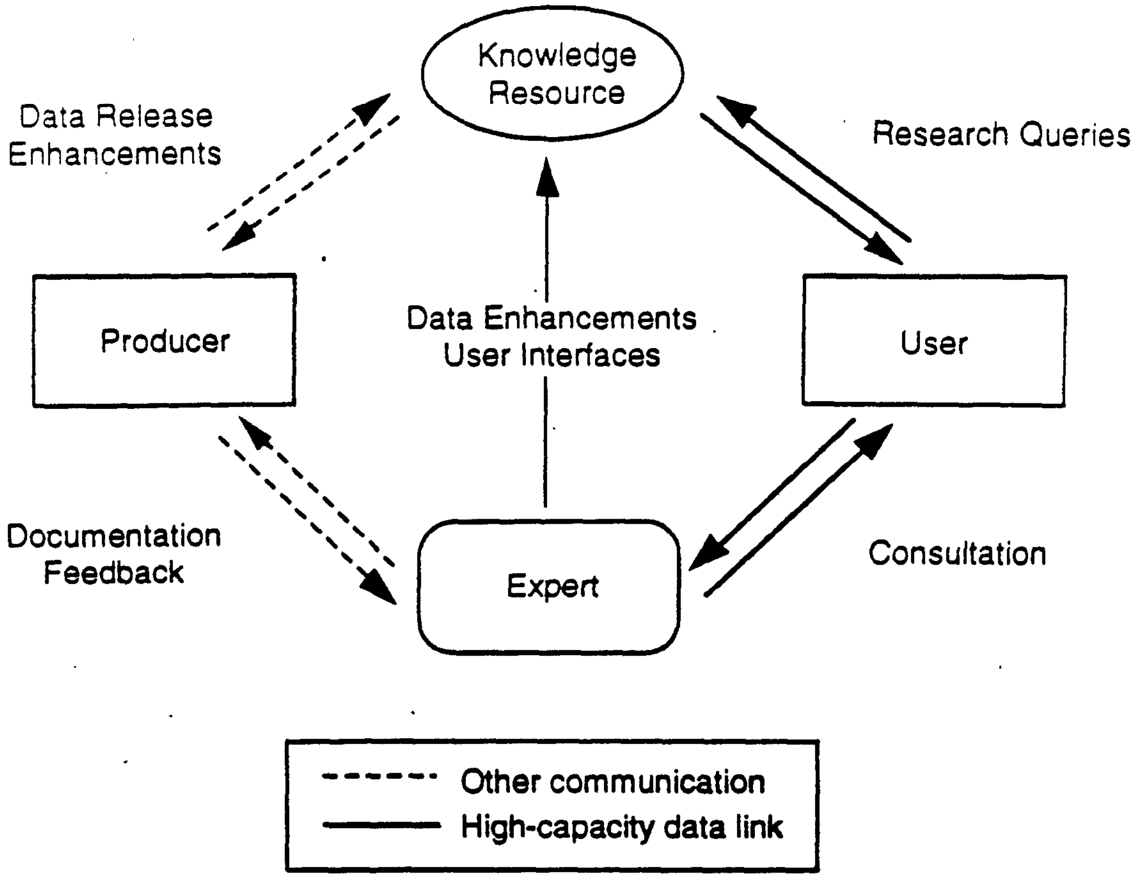

Figure 1. An Information System for Complex Data

scientists call a domain specialist, a diagnostician who can solve problems in interpreting data in one-on-one consultation or who can alter the computational capability to teach many users to solve the problem for themselves. (This keeps cost down.)

The knowledge resource integrates software and data in a system that can respond to inquiries from users. Pre-programmed artificial intelligence and carefully designed data structure (the database schema) speed the recovery of frequently used data and description. The knowledge resource includes several critical elements: a body of data accessible for statistical analysis (e.g., a SAS system file), descriptions of the data that provide necessary support, an archive of reports generated from the data, and bibliographic databases that can be searched for citations, data sources, and subject arc crucial to the process of learning about and using data. At Wisconsin many of these capabilities were organized in a relational database management system (RDBMS). The power of those systems is explained in the Appendix.

- Conceptual level-When are the numbers real? When are numbers imputed? When are numbers randomly altered, “fuzzed” (to limit disclosure)?

- Consequences of using each datum: What unusual interpretations? When are zeroes null? When are values truncated?

- Inference from the data: How can honest inferences be made from the data? Does selection bias inference from reports? Does variance in the measurement process mask real world phenomena? Is the measurement process biased by moral hazard?

All of this information can be embedded in and linked to the RDBMS that contains the measurements. Table 1 contains a summary of the kinds of information that should be stored in an ISCD to provide necessary support for the secondary data researcher.

WHAT PAYOFFS DO ISCD NECESSARY SUPPORT CREATE FOR BENEFITS TRANSFER?

Three kinds of payoff follow from organizing data on economic benefits in an ISCD: discovering the state of the art of benefit measurement will be less costly, synthesizing benefit measurements will be easier, and incorporating superior methodology in estimating models on larger sets of data will be possible.

State-of-the-Art

Garner’s bibliographic database (circulated for the AERE conference) represents an important step towards an ISCD for benefit measurements. Citations to reports about what we already have discovered are accessible. The perspective of the ISCD, says Garner, should add one element to the bibliographic database-a title for each dataset exploited in each report Titling and citing datasets are the only ways to establish the empirical foundation for any analysis. The title concept is implemented in Roistacher et al. (1980) but has not found its way into accepted referencing for scientific publication or into bibliographic databases. The perspective of an ISCD implies that the database is complemented by electronically stored files containing each of the reports and articles cited. Electronic preservation of reports allows any user to review any document cited. Archiving scientific work in this way assures permanence for the published record.

Because many excellent datasets are collected to pursue contractual obligations, reports containing important datasets are difficult to find-even in the contractor’s archives. This makes electronic archiving of reports critical.

Synthesizing Measurements

Smith and Huang (1991) undertook to synthesize measures of willingness to pay for air quality from data on the housing market in areas with differing levels of air quality. Their analysis searched over fifty statistical studies spanning two decades of observations. The response that Smith and Huang seek to estimate is the marginal rate of substitution between price paid for housing and particulate deposition. Underlying that measure of response is a model of the price paid by individuals for residential housing units in various urban areas of the U.S.

Smith and Huang develop an excellent "meta-analysis" *of models fit to the underlying data.* Their work synthesizes past investigation but cannot recover much of the variability in underlying data (because each model is a projection of the underlying data into a small number of dimensions). Furthermore, the technique fails to recover any direct information about the dynamics of willingness to pay; all human response to pollution is inferred from differences in prices paid by similar people buying housing in different places.

Crippling Problems

This study faced extreme difficulties and I admire the authors for their perseverance:

- Assembly. The study required assembling 26 journal articles, 5 unpublished papers, 5 dissertations, and 1 edited volume.
- Incomplete estimates of response to air quality. Many studies did not contain responses to ozone, SO_2, and other indicators of air pollution The meta-analysis is confined to understanding response to particulates (arguably the most obvious aspect of air quality). Models that did not include particulates had to be excluded.
- Reuse of data. The same data were used to estimate several models, both within and between research teams. For that reason models estimated are not independent.
- Incomplete documentation. Some papers failed to describe either the data or estimating method in sufficient detail to permit meta-analysis. Contact with one researcher filled some lacunae. In other cases pollution data were augmented; still other models could not be included in the meta-analysis.

Limitations of the Approach

Some of the studies are based on measures of house value and air pollution that are aggregated over space (e.g., Census tracts). A second problem is that the studies use a variety of measures of willingness to pay: samples of sales data, samples of FHA-mortgaged properties, samples derived from the Census self-reported house values, and the Annual Housing survey.

"documented " and "titled" Funding institutions can also require the deposit of completed publications in a data-oriented library. Funding institutions are in a position to provide necessary, resources and to enforce their agreements with data collectors.

Funding institutions cannot proceed without support from the professions. Journals need to require citation of data sources. They also need to require datasharing that permits replication of published findings. Some journals have already adopted this point of view *(AER, JHR, and JEEM).*

These changes in institutions and journals are easy. Change in our own professional conduct is also needed. While the computational capability to create low-cost datasharing is available on most desktops, social conventions need to be forged to support effective datasharing. Just as we have conventions to drive on the right and stop at the red signal, we need conventions on a common system for organizing shared data. Up to now, we have been unable to specify completely what is required for data-sharing. Concepts from computer science clarify what is needed at the same time that those concepts forged the technology that we can now use to organize data.

Experience at Wisconsin shows the efficacy of ISCD. Computer science has given us the relational data model, which organizes data and necessary support for data in a common framework. The geniuses of Silicon valley have given us technology that makes the computational costs of ISCD trivial in comparison to the cost of professional time. So long as we do not implement ISCD, much professional time will be wasted in searching for the right data, the right model, and implementing the simulation required for benefits transfer. Do we really want to waste scarce resources for learning about the environment?

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APPENDIX A
RELATIONAL DATABASE MANAGEMENT SYSTEMS-RDBMS

In the past dozen years computer scientists have discovered important principles for storing and retrieving large volumes of numerical data and smaller volumes of text. Their ideas culminated in relational database management systems (RDBMS) technology that is now available to every PC owner for about the same price as a spreadsheet program.

RDBMS denotes a system with several essential features, starred in Table A-1. The systems were designed to meet needs for commercial “transactions processing," whose requirements are somewhat different from scientific statistical processing, although the commonalities are much greater than most social scientists understand. The systems are designed for multiple users-both multiple data suppliers (i.e., points of data entry) and multiple researchers. RDBMS are designed to support interactive use of the data at all times and maintain an unambiguous outcome for statistics (reports in the RDBMS jargon) that are generated at any point in time. This feature is called data concurrency.

A mandatory requirement for RDBMS is dynamic independence. Adding new data to the system without restructuring the existing data must always be possible. For example, successive measures of pollution control and abatement expenditures (PACE) can be loaded into the system without knowing about or interfering with older data. Contextual data can be added to the system without determining the attributes used to link those data to individuals in advance. Thus interview data obtained from households can be loaded without knowing that their report of industry affiliation might subsequently be used to assign worker exposure to safety risks or that geography might later be used to assign prevalence of radon exposures.

Data entry is controlled by logical rules that can draw on any part of the existing data to enforce consistency; consistency may be applied to individuals, households, firms, activities (other entities), and combinations of entities. Consistency rules are called integrity constraints on the database. Referential integrity implies that adjustments to the database do not leave garbage in the system. For example, if an individual is found to be associated with the wrong address, all traces of that individual are dissociated from that address when the address is corrected.

For researchers the most important property of RDBMS is its "query language." Requests for information are written in the query language, which has a simple structure derived from concepts of mathematical logic. Query languages support *any* logical operation on *any* mathematical or lexical function of the attributes or variables in the database. Query languages are compact, and SQL has been adopted as an industry standard that will be supported by all database vendors.[1]

RDBMS provide permanent housekeeping that is essential when multiple points of entry and multiple users must be accommodated. Finally, the RDBMS support sophisticated security and reporting. Users can be restricted, from access to particularly sensitive data. Operations can be monitored continuously by reports on the capture of interviews, error-rates, outliers, and interviewer comments.

The logic of RDBMS results in "flat files," rectangular arrays that are easy to move outside of the RDBMS environment. Furthermore, the RDBMS encompass two capacities that aid a complex data collection through a nation-wide system. The databases support "distributed databases" whose parts may reside on different computers. For example, the database required for sampling can be separated from the data generated by interviewing. The second capability is "platform independence" that assures the system operates in the same manner on all hardware using identical programs or applications.

The most important feature of RDBMS for a complex data collection is that it maintains a vocabulary of names for each measurement, each transformation, and each relationship encompassed in the database, no matter how many users are proceeding to make independent uses of the data.[2]

Table A-1 lists aspects of RDBMS that are critical for successful processing of scientific data pertaining to the environment

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1 RDBMS apply artificial intelligence to minimizing the cost of executing the query. Therefore, execution of particular requests does not proceed in the procedurally defined manner of scientific programming languages and statistical processors. This feature implies that embedding scientific programming languages in the database (and all RDBMS support such capabilities) causes poor performance. Understanding the strengths of the RDBMS, however, allows us to design interfaces to statistical processors (e.g., SAS and SPSS) that permit the RDBMS to locate required data efficiently while permitting the aggregation of data across entities to proceed equally efficiently. The merit of such interfaces is that inefficiencies of data management and storage in statistical processors can be eliminated without eliminating the finely tuned calculation of estimates that those processors support.

2 This capability makes it possible to generate new databases from the existing metadata that describe the survey instrument and automate the evolution of the database as each panel proceeds and as new panels are created. The result is greater productivity in manipulating on-going change to the structure of the database and greater clarity in the documentation and diagnostics produced for the documentation of data-processing steps.

APPENDIX A

ECONOMIC ANALYSIS AND RESOURCE BRANCH ENVIRONMENTAL BENEFITS DATABASE

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