Valuation for Environmental Policy: Ecological Benefits

A Workshop sponsored by U.S. Environmental Protection Agency's National Center for Environmental Economics (NCEE) and National Center for Environmental Research (NCER)

Crowne Plaza Washington National Airport Hotel
1480 Crystal Drive
Arlington, VA 22202

April 23-24, 2007

Disclaimer

These proceedings are being distributed in the interest of increasing public understanding and knowledge of the issues discussed at the workshop. The contents of this document may not necessarily reflect the views of the U.S. Environmental Protection Agency and no official endorsement should be inferred.

U.S. Environmental Protection Agency (EPA)
National Center for Environmental Economics (NCEE) and
National Center for Environmental Research (NCER)
Valuation for Environmental Policy: Ecological Benefits

Crowne Plaza Washington National Airport Hotel
1480 Crystal Drive
Arlington, VA 22202
(703) 416-1600

April 23-24, 2007

Agenda

April 23, 2007: Valuation for Environmental Policy

8:00 a.m. – 8:30 a.m.	**Registration**	
8:30 a.m. – 8:45 a.m.	**Introductory Remarks** Rick Linthurst, National Program Director for Ecology, EPA, Office of Research and Development	
8:45 a.m. – 11:30 a.m.	**Session I: Benefits Transfer** Session Moderator: Steve Newbold, EPA, NCEE	
	8:45 a.m. – 9:15 a.m.	Benefits Transfer of a Third Kind: An Examination of Structural Benefits Transfer George Van Houtven, Subhrendu Pattanayak, Sumeet Patil, and Brooks Depro, Research Triangle Institute
	9:15 a.m. – 9:45 a.m.	The Stability of Values for Ecosystem Services: Tools for Evaluating the Potential for Benefits Transfers John Hoehn, Michael Kaplowitz, and Frank Lupi, Michigan State University
9:45 a.m. – 10:00 a.m.	**Break**	
	10:00 a.m. – 10:30 a.m.	Meta-Regression and Benefit Transfer: Data Space, Model Space and the Quest for 'Optimal Scope' Klaus Moeltner, University of Nevada, Reno, and Randall Rosenberger, Oregon State University
	10:30 a.m. – 10:45 a.m.	Discussant: Matt Massey, EPA, NCEE
	10:45 a.m. – 11:00 a.m.	Discussant: Kevin Boyle, Virginia Tech University
	11:00 a.m. – 11:30 a.m.	Questions and Discussion
11:30 a.m. – 12:45 p.m.	**Lunch**	

April 23, 2007 (continued)

12:45 p.m. – 3:30 p.m.	**Session II: Wetlands and Coastal Resources** Session Moderator: Cynthia Morgan, EPA, NCEE	
	12:45 p.m. – 1:15 p.m.	A Combined Conjoint-Travel Cost Demand Model for Measuring the Impact of Erosion and Erosion Control Programs on Beach Recreation Ju-Chin Huang, University of New Hampshire; George Parsons, University of Delaware; Min Qiang Zhao, The Ohio State University; and P. Joan Poor, St. Mary's College of Maryland
	1:15 p.m. – 1:45 p.m.	A Consistent Framework for Valuation of Wetland Ecosystem Services Using Discrete Choice Methods David Scrogin, Walter Milon, and John Weishampel, University of Central Florida
1:45 p.m. – 2:00 p.m.	**Break**	
	2:00 p.m. – 2:30 p.m.	Linking Recreation Demand and Willingness To Pay With the Inclusive Value: Valuation of Saginaw Bay Coastal Marsh John Whitehead and Pete Groothuis, Appalachian State University
	2:30 p.m. – 2:45 p.m.	Discussant: Jamal Kadri, EPA, Office of Wetlands, Oceans, and Watersheds
	2:45 p.m. – 3:00 p.m.	Discussant: John Horowitz, University of Maryland
	3:00 p.m. – 3:30 p.m.	Questions and Discussion
3:30 p.m. – 3:45 p.m.	**Break**	
3:45 p.m. – 5:45 p.m.	**Session III: Invasive Species** Session Moderator: Maggie Miller, EPA, NCEE	
	3:45 p.m. – 4:15 p.m.	Models of Spatial and Intertemporal Invasive Species Management Brooks Kaiser, Gettysburg College, and Kimberly Burnett, University of Hawaii at Manoa
	4:15 p.m. – 4:45 p.m.	Policies for the Game of Global Marine Invasive Species Pollution Linda Fernandez, University of California at Riverside
	4:45 p.m. – 5:00 p.m.	Discussant: Marilyn Katz, EPA, Office of Wetlands, Oceans, and Watersheds
	5:00 p.m. – 5:15 p.m.	Discussant: Lars Olsen, University of Maryland
	5:15 p.m. – 5:45 p.m.	Questions and Discussion
5:45 p.m.	**Adjournment**	

April 24, 2007: Valuation for Environmental Policy

8:30 a.m. – 9:00 a.m.	**Registration**	
9:00 a.m. – 11:45 a.m.	**Session IV: Valuation of Ecological Effects** Session Moderator: William Wheeler, EPA, NCER	
	9:00 a.m. – 9:30 a.m.	Integrated Modeling and Ecological Valuation: Applications in the Semi Arid Southwest David Brookshire, University of New Mexico, Arriana Brand, Jennifer Thacher, Mark Dixon,Julie Stromberg, Kevin Lansey, David Goodrich, Molly McIntosh, Jake Gradny, Steve Stewart, Craig Broadbent and German Izon
	9:30 a.m. – 10:00 a.m.	Contingent Valuation Surveys to Monetize the Benefits of Risk Reductions Across Ecological and Developmental Endpoints Katherine von Stackelberg and James Hammitt, Harvard School of Public Health
10:00 a.m. – 10:15 a.m.	**Break**	
	10:15 a.m. – 10:45 a.m.	Valuing the Ecological Effects of Acidification: Mapping the Extent of Market and Extent of Resource in the Southern Appalachians Shalini Vajjhala, Anne Mische John, and David Evans, Resources for the Future
	10:45 a.m. – 11:00 a.m.	Discussant: Joel Corona, EPA, Office of Water
	11:00 a.m. – 11:15 a.m.	Discussant: David Simpson, Johns Hopkins University
	11:15 a.m. – 11:45 a.m.	Questions and Discussion
11:45 a.m. – 1:00 p.m.	**Lunch**	
1:00 p.m. – 4:15 p.m.	**Session V: Water Resources** Session Moderator: Adam Daigneault, EPA, NCEE	
	1:00 p.m. – 1:30 p.m.	Valuing Water Quality as a Function of Physical Measures Kevin Egan, Joe Herriges, John Downing, and Katherine Cling, Iowa State University
	1:30 p.m. – 2:00 p.m.	Cost-Effective Provision of Ecosystem Services from Riparian Buffer Zones Jo Albers, Oregon State University; David Simpson, Johns Hopkins University; and Steve Newbold, NCEE
2:00 p.m. – 2:15 p.m.	**Break**	
	2:15 p.m. – 2:45 p.m.	Development of Bioindicator-Based Stated Preference Valuation for Aquatic Resources Robert Johnston, Eric Shultz, Kathleen Segerson, Jessica Kukielka, Deepak Joglekar, University of Connecticut; and Elena Y. Besedin, Abt Associates

April 24, 2007 (continued)

	2:45 p.m. – 3:05 p.m.	Comparing Management Options and Valuing Environmental Improvements in a Recreational Fishery Steve Newbold and Matt Massey, NCEE
	3:05 p.m. – 3:20 p.m.	Discussant: Julie Hewitt, EPA, Office of Water
	3:20 p.m. – 3:35 p.m.	Discussant: George Parsons, University of Delaware
	3:35 p.m. – 4:05 p.m.	Questions and Discussions
4:05 p.m. – 4:15 p.m.	**Final Remarks**	
4:15 p.m.	**Adjournment**	

Integrated Modeling and Ecological Valuation: Applications in the Semi Arid Southwest[1],[2]

David S. Brookshire[3], L. Arriana Brand, Jennifer Thacher, Mark D. Dixon, Karl Benedict, Juliet C. Stromberg, Kevin Lansey, David Goodrich, Molly McIntosh, Jake Grandy, Steve Stewart, Craig Broadbent and German Izon

May 17, 2007

I. Introduction

Conservation of freshwater systems is critical in the semi-arid Southwest where groundwater and flood regimes strongly influence the abundance, composition, and structure of riparian (streamside) vegetation. At the same time these systems are in high demand for competing human use (Stromberg et al. 2007, Alley et al. 2002). To address this conflict, natural scientists must evaluate how anthropogenic changes to hydrologic regimes alter ecological systems. A broad foundation of natural science information is needed for ecological valuation efforts to be successful. The goal of this research is to incorporate hydrologic, vegetation, avian, and economic models into an integrated framework to determine the value of changes in ecological systems that result from changes in hydrological profiles.

[1]This research is supported by the U.S. Environmental Protection Agency, "Integrated Modeling and Ecological Valuation," EPA STAR GRANT Program #2003-STAR-G2 and in part by SAHRA (Sustainability of semi-Arid Hydrology and Riparian Areas) under the STC Program of the National Science Foundation, Agreement No. EAR-9876800 (work related to the avian component), and with in kind contributions from the U.S. Department of Agriculture Research Service, Hawks Aloft Inc and The Nature Conservancy. We would like to thank, John Loomis and Bonnie Colby who participated in a workshop in Albuquerque 2006 and offered significant insights and suggestions to the overall survey design.
[2] Presented at the USEPA "Valuation for Environmental Policy: Ecological Benefits" workshop April 23, 24, 2007 in Washington D.C. Comments are welcome. Please send to David Brookshire (brookshi@unm.edu)
[3] Respectively, Professor of Economics and Director of the Science Impact Laboratory for Policy and Economics, University of New Mexico (UNM); Research Associate, Sustainability in semi-Arid Hydrologic Riparian Areas, University of Arizona (UA); Assistant Professor of Economics (UNM); Assistant Professor of Biology, University of South Dakota; Senior Research Scientist, Earth Data Analysis Center, (UNM); Associate Professor, School of Life Sciences, Arizona State University; Professor of Civil Engineering, (UA); Research Scientist, US Department of Agriculture; Attorney at Law and Bilingual Mediation and Facilitation, NM; Middle Rio Grande Conservancy District, Research Scientist, Sustainability in semi-Arid Hydrologic Riparian Areas, (UA), Research Assistant, (UNM); and Research Assistant, (UNM).

We have developed a hydro-bio-economic framework for the San Pedro River Region (SPRR) in Arizona that considers groundwater, stream flow, and riparian vegetation, as well as abundance, diversity, and distribution of birds within a protected area encompassing the San Pedro Riparian National Conservation Area (SPRNCA). In addition, we are developing a similar framework for the Middle Rio Grande of New Mexico (MRG). Distinct valuation studies are being conducted for each site with benefit-transfer tests to be conducted between the two sites. This research is novel in that it provides much more detailed scientific information for economic valuation models than is typically available

In the absence of integrated science information, stated-preference valuation studies are typically must rely on vague program descriptions and imperfect measures of the change in resource quality or quantity. The lack of a scientific foundation for economic valuation studies typically occurs either because (1) targeted scientific research on the topic of interest is lacking, or (2) scientific studies that do exist have not been adequately designed to directly inform valuation questions. Ideally, existing scientific information should provide forecasts for the area of interest, contain well-defined timescales, and speak in terms that are relevant and understandable to the lay public. This study attempts to address these issues through use of an integrated scientific/economic framework. The research team includes hydrologists, ecologists, ornithologists, geospatial geographers, facilitators, and economists, most of whom are centrally involved in varying degrees with research projects in both the SPRR and the MRG.

There are five research components for this project: (1) scenario specification and the hydrologic model, (2) the riparian vegetation model, (3) the avian model, (4) methods for displaying the information gradients in the survey instrument, and (5) the economic framework. As such, our modeling framework begins with the identification of factors that influence spatial

and temporal changes in riparian vegetation on the two rivers. For the SPRR this is principally through impacts on the availability of surface water and groundwater, while in the MRG the impacts are through regulation of flooding and human restoration activities. We use the construct of "current conditions" as a basis for making spatial predictions of vegetation change and avian populations in both river systems through linked modeling frameworks. This framework utilizes the best available information through the direct focus on science-based linkages between flow regimes, habitat quality, birds, and human values.

The goal of this paper is to provide a brief overview of the research project to date and discuss some of the issues that have been encountered in designing an integrated framework for each river system. In addition we broadly discuss issues relating to the workings of an interdisciplinary team, issues associated with defining appropriate attributes to be valued based on the scientific information available as well as how the definition of the attributes might change depending upon the goals of the valuation exercise.

II. Study Areas

This project required the added complexity of selecting study areas based on natural science considerations in addition to demographic and socio-economic concerns with selecting a benefit transfer site. It was necessary, from the science perspective, to restrict the transfer site to a region having similar physical and ecological conditions to the SPRR; thus our focus was on lowland (<5,000 feet), semi-arid, Southwestern riparian vegetation. This provides sites where conflicts between human use and riparian needs are most pronounced, visitation characteristics are similar, and riparian vegetation in the recent past (i.e. past century) was historically dominated by cottonwood, willow and mesquite. On each river, environmental stresses (e.g. groundwater depletion, altered flood regimes) have led to partial replacement of these species by

non-native species better suited to the effects of anthropogenic change, specifically stands of salt cedar or Russian olive. Further, given the types of data required for the valuation exercise, we were also limited by areas for which appropriate datasets (e.g. vegetation maps, bird transect data) were available.

Two study areas for this project were selected based on both natural and social science concerns. The SPRNCA in southern Arizona encompasses an approximately 40-mile stretch of the San Pedro River between the U.S.- Mexico border and St. David, Arizona. The San Pedro flows north from Cananea, Mexico, enters the U.S. near Sierra Vista, and eventually reaches the Gila River, a tributary to the Colorado River (Figure 1). The San Pedro is a free-flowing river containing stretches of gallery riparian forest and represents an extremely important semi-arid flyway. The SPRR provides critically important habitat for resident, breeding, and migratory birds, but may be threatened by groundwater decline due to pumping of the regional aquifer. Over 400 bird species have been recorded in the SPRR; more than 200 of these are neo-tropical migrants (Krueper 1999).

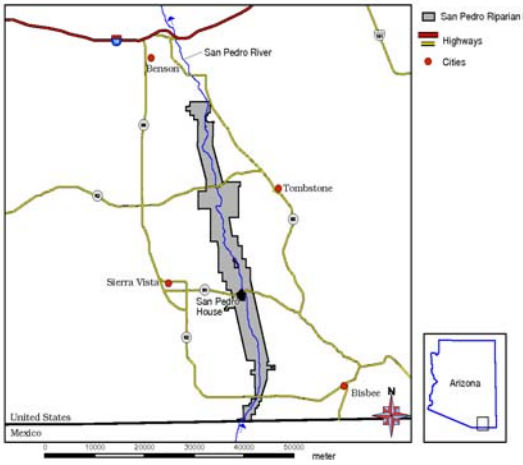


Figure 1: SPRR and SPRNCA

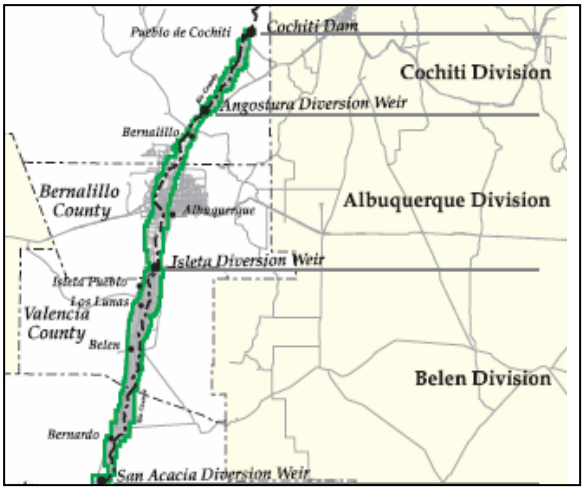


Figure 2: Middle Rio Grande

The MRG covers the area from Cochiti Dam (North of Albuquerque) to the San Acacia gage (above Elephant Butte reservoir). The

study area is approximately 140+ miles of river and includes the Rio Grande State Park, located in the Albuquerque vicinity (Figure 2). As in the SPRR, the riparian system is essentially a wooded riparian area (bosque). Even though there have been serious impacts on the riparian corridor through agricultural activities and urban development, it remains a biologically diverse community in the Southwest, providing a wealth of habitat for breeding, wintering, and migrating birds.

III. Overview of Project Components

a. Ecosystem Alteration Drivers, Decision Support Frameworks, and Scenarios

Extensive human use of dryland rivers has resulted in many changes to their biota. For example, on parts of the SPRR groundwater depletion and overgrazing by livestock have contributed to shifts from cottonwood-willow (*Populus-Salix*) forests to *Tamarix* shrub lands (Stromberg 1998; Lite et al. 2005). The riparian ecosystem on the MRG has been impacted by flood control facilities, river channelization, land clearing, and agricultural activities. More recently, mechanical removal of introduced invasive species, motivated by both aesthetics and fire control, has influenced vegetation patterns in the MRG. Significant research effort has been allocated toward understanding the impacts of groundwater pumping on the SPRR biota and developing policy options that could be used to mitigate the impacts of groundwater pumping. Since agricultural activities have largely been eliminated from the SPRNCA region, the focus on policy options falls into four principal categories:

1) Infrastructure changes: changing the location of subdivisions and groundwater wells or recharge basins in order to reduce groundwater declines near the river;

2) Water augmentation: increasing the amount of water in the basin via inter-basin transfers;

3) Water conservation: decrease the consumption in the region through regulations and incentives;

4) Combination of all of the above

A Decision Support System (DSS) has been developed with the aid of systems dynamic modeling software (Tidwell et al., 2004 as an illustrative application of a DSS) by the San Pedro Partnership to provide the basis for understanding the impacts of alternative policy decisions and to identify the effectiveness of alternative water conservation measures for the Upper SPRR (Sumer and Lansey, 2004; Ritcher 2006[4]). The DSS, designed with the aid of systems dynamic modeling software, incorporates a USGS groundwater model, surface water supply, groundwater storage, and residential/commercial water uses. It allows temporally and spatially variable future population growth and associated water consumption. Each policy measure or combination of policies can be simulated for a 50 year period or less. The impacts of activities such as groundwater pumping can be determined spatially relative to specific river reaches.

Our research places additional demands upon the DSS, particularly the need to understand groundwater levels as well as changes in riparian vegetation with more spatial and temporal precision than is needed by SPRR water managers. Because the DSS is funded primarily by other entities, the more sophisticated features that this research requires can only be incorporated into major revisions of the DSS.

While operational, the DSS is still undergoing development. Additional features such as the condition class model, upon which much of this research is based, are being added to each new version of the model. Because the current version of the DSS does not include the condition class model to generate vegetation changes, we relied upon scientists' (D. Goodrich, personal communication) best estimate of the magnitudes of likely groundwater level changes in status quo, high growth and low growth/high conservation scenarios garnered from the understanding

[4]The USPP DSS has not been published in its entirety as it is still be vetted by the Upper San Pedro Partnership.

of the USGS groundwater model currently incorporated in the DSS (scenarios 4 - 7) in addition to uniform (scenarios 1 – 3), and end-member cases (scenarios 8 and 9) groundwater changes.

Scenario 1 = 0.5 m uniform decline in groundwater;

Scenario 2 = 1 m uniform decline in groundwater;

Scenario 3 = 0.5 m uniform increase in groundwater;

Scenario 4 = Continued and increased agricultural pumping near Palominas; new developments in unincorporated areas of Palominas and Hereford near SPRNCA;

Scenario 5 = Increasing cone of depression in Sierra Vista, Ft. Huachuca, and Huachuca City with impacts toward the lower Babocomari and northern SPRNCA;

Scenario 6 = Large increases in groundwater due to recharge and conservation efforts in Sierra Vista and Bisbee;

Scenario 7 = combined from scenarios 4 & 5, representing effects of both agricultural pumping in the south and increasing cone of depression;

Scenario 8 = Low extreme - river essentially dries up;

Scenario 9 = High extreme - river essentially has surface flows throughout SPRNCA[5].

Figure 3 depicts the impact on SPRNCA of the above hydrologic scenarios. Each graph shows SPRNCA divided into 14 reaches. Based on research from project ecologists, reaches have been classified into one of three types (condition classes): wet, intermediate, dry. This classification reflects variables such as annual surface water permanence, depth to groundwater, and vegetation composition (Lite and Stromberg 2005, Stromberg et al. 2006). The SPRNCA currently consists primarily of wet and intermediate reaches; in our scenario analysis we assume

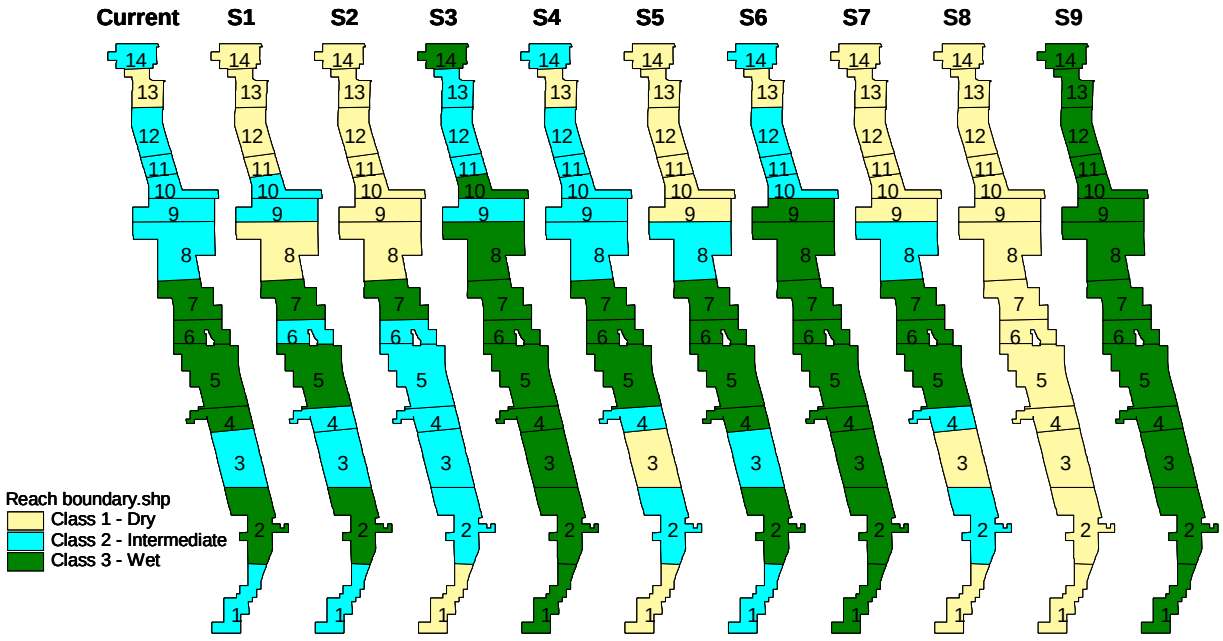
[5]The importance of developing plausible scenarios became apparent during the May 2006 focus groups where participants were generally frustrated with the choice question because the scenarios causing the changes in attribute levels was intentionally left ambiguous.

that changes in groundwater levels from actions such as pumping and recharge results in shifts between stream classes.

b. Riparian and Avian Components

One of the core challenges of this project has been to quantitatively link models across the natural science disciplines, and in turn, provide usable outputs for ecological valuation. The

Figure 3: Changes in San Pedro Riparian Condition Classes by Scenario



riparian and avian components each began with different goals. The objective of the riparian component was to determine how riparian vegetation distribution, composition, and structure respond to changes in surface flow and groundwater levels in the SPRNCA. As noted above, prior riparian research yielded a condition class model based on underlying hydrologic conditions. The objective of the avian component was to determine the impact of hydrologic and vegetation changes on bird populations and communities for the different reaches of the SPRNCA, and then express these outputs in terms of bird abundance as inputs into the ecologic

valuation models. Bird abundances were assessed by migratory status, nest height, and the degree of water-dependence.

The next step was to link the riparian condition class model with avian datasets. The modeling framework used the raw data that was available for vegetation and birds (e.g. average proportion of different habitat types within a condition class and bird densities by habitat type and hydrologic class), and projected how changes in groundwater, as reflected in the condition class vegetation model, would impact bird abundances as a function of the different hydrologic scenarios by reach. While the components of this work were not new (for example, the developed methodology applied some basic approaches in space-for-time substitution modeling and the delta method to calculate errors propagated across the vegetation and bird modeling levels), the development and programming of this model was specific to the data and problem at hand. This linkage was the key step required to provide a scientific foundation to the economic valuation effort[6].

c. Survey Component

The foundation of the survey research program is framed by the following questions:

1) What is the ideal set of physical, natural, and social science information on which to build an economic research program to value ecological service flow changes?

2) Can alternative suites of natural science information coupled with socio-behavioral information lead to a better understanding of both intra-site and inter-site benefit transfer functions?

The research incorporates two stated preference techniques, Contingent Valuation (CVM) and Choice Modeling (CM), with three alternative information gradients, "Fine", "Coarse" and

[6]Linking models across disciplines is inherently challenging and requires quantitative skill. As such, future interdisciplinary efforts should not underestimate the work involved in developing methods to link disciplines, since each effort is likely to require a novel methodology and approach. The research team feels that because of their quantitative nature, such efforts would also be enhanced by hiring a qualified, experienced statistician to aid with the development of methodology and programming.

"Traditional" for each technique. To date there have been few published comparisons of CVM and CM (Stevens et al. 2000; Margat et al. 1998; Barret et al. 1996; Boxall et al. 1996; Ready et al. 1995; Mackenzie 1993; Desvousges et al. 1987). All of these studies found substantial differences in willingness to pay (WTP) estimates between the various forms of CVM and CM analyses for equivalent policies. Various reasons for the disparity have been offered: first, CVM is a one shot procedure vs. the iterative nature of the CM (Takatsuka 2003); second, the presentation of alternative policies in the CM format suggests substitute (alternative) policies not available in CVM (Boxall et al. 1996; Ready et al. 1995); third, CMs allow explicit recognition of complements that CVMs may not (Morrison 2000, Stewart et al. 2002); fourth, the effects of data structure used for conditional logit vs. standard logit estimation vary (Stewart et al. 2002). In addition to these comparisons, benefit transfers will be conducted between the two test sites. The literature on benefit transfers predominately relies on the science as given (Desvousges et al. 1998). Few studies have examined the role of models across disciplines in a benefit transfer setting (Brookshire et al., 2007; Brookshire and Chermak, 2007), while few cross-method comparisons exist (Boxall et al. 1996; Stevens et al. 2000; Takatsuka, 2003).

CM, a variant of conjoint analysis, elicits an individual's preferences by asking the subject to consider a series of alternatives. In contrast to CVM, which asks individuals to explicitly state their willingness to pay for a proposed policy change, CM requires the individual to choose from a series of possible alternatives, each having different levels of the attributes (birds, in-stream flow, riparian vegetation and cost, for example). This allows the researcher to obtain the marginal value (implicit price) of each attribute, as well as welfare measures for any policy that has attributes contained within the span of those presented in the survey. Both the CVM and CM models utilize a random-utility framework to explain individuals' preferences for

alternative profiles and are directly estimable from the CVM and CM data (Roel et al. 1996; Stevens el at. 1997). Several iterations of the coarse scale CM surveys have been drafted with emphasis on the educational and scenario components. The educational component forms the foundation of all three information levels for both the CM and CVM surveys.

Information gradients are represented through different levels of spatial representation and / or levels of detail of ecological attributes. The "Traditional" scale will provide minimal spatial representation of the attributes[7], the "Coarse" scale will provide reach scale spatial representation[8] with the "Fine" scale providing reach scale spatial representation giving survey participants the option to 'drill-down' to more detailed information on hydrologic, vegetation, and avian attributes[9]. In this regard different levels of scientific information are coupled with the ability to present the attributes in more advanced forms. To ensure that responses are representative of the population, both mail and internet versions of the surveys are being developed. Figure 4 shows the types of comparisons that can be made across modeling

[7] The notion of the traditional scale is that much of the scientific research has enabled an understanding of the ecological processes of the river systems in spatial detail. If this work had not been done, we would have been faced with what might be a more traditional informational setting. That is, rather than being able to divide the river into stretches as they relate to groundwater levels, we would have been faced with information such as 35% is cottonwood, 50% mesquite, etc.

[8] Coarse scale information uses the best available science in a spatial setting but omits within the survey some of the available detail such as reference to all types of birds.

[9] The fine scale incorporates within the structure of the attribute set all of the available information. For instance, the 'drill-downs' will allow the respondent to examine in detail changes in a particular bird species.

approaches and the types of tests that can be conducted using a benefit transfer.

Figure 4: Benefit Transfer Tests

		Traditional Survey	Coarse Survey	Fine Survey
Choice Questions	San Pedro	No spatial vegetation and bird information	*Spatial vegetation and bird information*	*Spatial vegetation and bird information, plus the ability to drill down by reach for additional information*
	Rio Grande		Spatial vegetation and bird information	
DC / CVM	San Pedro		*Policy attribute chosen by scientist*	
	Rio Grande		Policy attribute chosen by scientist	

Educational component is the same

Educational component is the same

d. Focus Groups

To date, three focus groups have been conducted using a draft of the "Coarse" scale CM SPRNCA survey. These focus groups aimed to obtain specific written and oral feedback for each section of the survey as well as comments on the overall structure of the survey. Feedback indicated that although the cognitive burden of the survey was high due to the complexity of the issue, many participants wanted access to more information. Interestingly this desire was in contrast to their desires for the survey to be shorter. This apparent conflict prompted the inclusion of 'drill-downs' in the "Fine" scale surveys. Feedback also indicated that the overall presentation of the material needed to be changed to reduce redundancy and eliminate irrelevant information to reduce the cognitive burden of the survey. This feedback has significantly streamlined the surveys. At the writing of this paper future focus groups have been planned for the SPRNCA CM survey, utilizing laptops for presentation purposes.

IV. Reflections on the Interdisciplinary Process for Organizing the Science Information

An overarching goal of this project is to build a broad foundation across the natural and social sciences that will allow us to address the critical issue of conservation of riparian systems in the Southwest. This project has tackled the challenging task of identifying a set of feasible policy options that lead to groundwater changes that, in turn, affect vegetation and birds. The survey then presents the resulting scientific information for an educational component for survey respondents about the scientific details of the attributes to be valued within the CM framework. An important lesson learned from this process has been that the goals of the valuation process affect the instruments' attribute structure. Consider four possible stylized goals of the valuation process:

1) Focus only on the SPRR ecosystem: The valuation process will use the best available science information to uniquely reflect the attributes in the SPRR. No consideration will be given in the design to the issues associated with transferring the valuation results to other semi-arid riparian areas. This would lead to a more traditional benefit transfer exercise where the transfer from the SPRR to MRG are only a "rough" fit with regards to the attributes.

2) Focus only on the MRG ecosystem: The valuation process will use the best available science information to uniquely reflect the attributes in the MRG. No consideration will be given in the design to the issues associated with transferring the valuation results to other semi-arid riparian areas.

3) Design the valuation instruments with the SPRR as a base, attempting to account for the disparity in scientific information between the SPRR and the MRG (e.g. differences in types and amounts of scientific information and differences in the ecosystems themselves including the different species assemblages found in the two areas). This would engender a more robust set of benefit transfer exercises.

4) Design the valuation instruments in tandem, with the goal of creating a set of ecosystem values that are transferable to most semi-arid regions in the Southwest.

Depending on the goal desired, one would follow a different process, where the results of each goal may be in conflict with each other. Below we outline in more detail the oppositional nature of these goals and the process by which a compromise was achieved.

a) Idealized Representation of the Scientific Knowledge

In defining the attributes, the research team faced the immediate problem that the scientists ideally would like a more complete representation of the ecological processes and outputs. For instance, in the development of the SPRNCA condition class model, 9 different riparian vegetation attributes are measured (Stromberg et al 2006; Lite and Stromberg 2005) where only 4 vegetation attributes are represented in the economic survey. Likewise the avian component estimated over 45 possible single-species and 21 grouped-species abundance attributes for breeding and migratory birds as well as species richness and nest success with only 3 attributes being used in the ecological valuation study.

Clearly the level of detail normally addressed by science goes far beyond the cognitive burden of survey respondents and beyond the study design requirements for the ecological modeling effort. Structuring and simplifying the science inputs from the ecologic models has required an iterative and multi-pronged process. First, based on the initial attempts of the ecologists, plant and bird species were isolated and aggregated into groups that best represent the primary impacts of hydrologic and/or restoration change profiles on both birds and vegetation. Second, feedback from focus group surveys were presented back to the ecologists. Finally, simplification of the science has depended on the needs of the experiment and study design of the ecological valuation models. Thus, the final set of vegetation and bird attributes represent a compromise between maintaining a foundation in meaningful and accurate scientific

findings and simplifying the results so that survey designers and respondents can handle the cognitive burden.

Different Goals would Lead to Different Approaches

In what follows, we will briefly detail the compromise from the scientific perspective, first noting the key "drivers" of ecological change (e.g. ground water depletion) followed by a discussion as to the resulting structure of the information for vegetation and birds. We will then discuss the compromises from the perspective of designing a CM framework followed by extracted text from the "Coarse" SPRNCA survey to illustrate the final form that the compromise took.

i. Goal 1-Focus only on the SPRR:

Physical Drivers: The master variable that is driving changes in the SPRR riparian ecosystem is availability of surface water and groundwater. Groundwater pumping in concert with natural variations in stream hydrogeomorphology has created gradients of depth to groundwater along the river.

Vegetation: The riparian vegetation, in response to changes in surface and groundwater hydrology, change species composition and growth form. To best represent this, vegetation information attributes have been presented for each river reach in terms of:

1. Abundance of tall, flood-dependent, wetland trees (i.e., Fremont cottonwood and Goodding willow);
2. Abundance of short, flood-dependent, drought-tolerant shrubs (i.e., saltcedar);
3. Abundance of wetland ground cover and stream surface water.

Birds: Riparian birds, in response to both the physical drivers and changing vegetation, have changed in bird species composition and abundance. To best represent this, bird attributes would be presented for each river reach in terms of:

1) Canopy vs. non-canopy, where canopy nesting birds decline with the loss of tall trees on the SPRNCA occurring from the transition of wet or intermediate reaches to dry reaches.

2) Degree of water dependence, where water obligate birds (e.g. wading, swimming, or shorebirds) decline with loss of perennial surface water, this occurs from the transition of condition class from wet to intermediate or dry reaches.

3) Migrating birds, which have an overall decline with the loss of tall trees.

ii. Goal 2-Focus only on the MRG:

Physical Drivers: The master variable that is driving changes in the MRG riparian ecosystem is alteration of the flood disturbance regime. Secondarily, human restoration actions are driving changes, where changes in the system have occurred as a result of channelization, land clearing, agricultural use, and urban use.

Vegetation: As a result of the reduction in river flooding caused by dam management, the species composition of the riparian vegetation has changed and the density of the vegetation has increased. Some parts of the MRG floodplain support tall, old, flood-dependent cottonwood forests with a very dense understory of smaller, flood-intolerant trees. Some of the understory trees are introduced species (such as Russian olive); others are native (such as New Mexico olive). As a result of changes in the pattern of river flooding (and perhaps in water table depth), other parts of the floodplain no longer support cottonwood but support dense stands of the shrub salt cedar. Restoration actions are shaping the vegetation by mechanically clearing non-native

plants in the dense mid-story vegetation. To best represent this goal, the information would be presented by each river reach in terms of:

1. Abundance of tall, flood-dependent, wetland trees (i.e., Fremont cottonwood and Goodding willow);

2. Abundance of short, flood-intolerant trees.

    a. Abundance of short, flood-intolerant trees that are native

    b. Abundance of short, flood-intolerant trees that are introduced

3. Abundance of short, flood-dependent, drought-tolerant shrubs (i.e., saltcedar)

Birds: As a result of changing vegetation, riparian birds change in terms of composition and abundance. To integrate the response of vegetation, information should be presented for each river reach in terms of:

1. Canopy, mid-story and understory (ground/low-shrub) nesting birds. The canopy nesting birds are predicted to increase with removal of monotypic stands of salt cedar and restoration of tall cottonwood-willow forests in the southern study area of the MRG. Mid-story and possibly understory nesting birds decline with mechanical thinning of the non-native mid-story in the short term.

2. Migrating birds may show an overall decline with loss of tall trees or from the loss of understory shrubs or trees due to mechanical thinning.

The distinct physical differences and anthropogenic pressures between the MRG and the SPRR illustrate that goals 1 and 2 would lead to a different set of vegetation and bird attributes if each site were considered individually. For vegetation this is exemplified by the different stressors, physical drivers, and species present at the two sites. On the SPRR natural flood regimes exist with the stressor of concern being groundwater decline. The vegetation attributes of concern are those related to changes in groundwater depth (shifts from cottonwood-willow to saltcedar) and surface flow permanence (loss of herbaceous wetland plants). On the MRG, the

alteration of flood regimes by upstream dams and bank stabilization structures is the primary stressor, with groundwater having a lesser role. This necessitates a shift in focus from plant traits related to drought tolerance/groundwater depth on the SPRR, to one dealing with responses to flooding or the lack thereof (i.e., increased abundance of flood intolerant smaller trees) on the MRG. In addition, the functional group approach, rather than a species-based approach, becomes necessary when both systems are considered, because of the differences in the species present in the SPRR and MRG (e.g., Russian olive is absent from the SPRR).

For birds, emphasis on canopy versus non-canopy nesting birds for the SPRR would need to be expanded for the MRG to emphasize the differences that occur in the mid-story and understory from mechanical thinning of the vegetation. The different attributes show how different physical and anthropogenic drivers on two river systems (alteration of groundwater regime on the SPRR; active mechanical thinning on the MRG) impact the difference in bird attributes. While the degree of water dependence is an important variable for the SPRR as obligate birds decline with loss of perennial surface water, this group would likely not be as important on the MRG as there is less expected variation in availability of surface water between current conditions and restoration scenarios. While little is known thus far how migrating birds will respond to vegetation changes on the MRG, they are included as an attribute since feedback from the focus groups have emphasized migrating birds.

iii. Goal 3 - The SPRR is the base, but a close eye is kept on the MRG as a transfer site:

Physical Drivers: Groundwater and flood regimes are two key driving variables that structure dryland riparian ecosystems across the SPRR and MRG river systems, while mechanical

thinning of understory vegetation ("restoration") is an important physical driver for the MRG.

Vegetation: To capture the effects of changes in these master variables on riparian vegetation of unconstrained, low gradient, historically perennial rivers of the American Southwest, information should be presented for each river reach on:

1. Abundance of tall, flood-dependent wetland tree species (e.g., Fremont cottonwood, Goodding willow);
2. Abundance of short, flood-dependent drought-tolerant shrub species (e.g., saltcedar);
3. Abundance of short, flood-intolerant trees (e.g., Russian olive, velvet mesquite);
4. Abundance of herbaceous wetland vegetation and surface water.

Birds: The master variables that are driving changes on SPRR and/or MRG bird communities are availability and composition of riparian vegetation and surface water availability. To capture these more general influences, information should be presented on the union of attributes from the SPRR and MRG:

1. Canopy, mid-story and understory (ground/low-shrub) nesting birds. The canopy nesting birds decline with loss of cottonwood on the SPRR, while they increase with clearing of monotypic stands of salt cedar and restoration of tall riparian trees (e.g., cottonwood forests) in the southern study area of the MRG. Mid-story and possibly understory nesting birds decline with mechanical thinning of the non-native under story in the short term on the MRG.
2. Degree of water dependence. Water obligate birds decline with loss of perennial surface water on the San Pedro; this group will not likely be as important on the MRG as on the San Pedro.Water obligate birds decline with loss of perennial surface water on the SPRR; this will not likely to be a very important group on the MRG.
3. Migrating birds decline with loss of tall trees on the SPRR, and may or may not show an overall decline with loss of tall trees on the MRG.

The distinction between goals 1 or 2 with goal 3 show that the set of vegetation and bird attributes would need to be the union, or combination, of attributes for the two individual rivers systems. If each site were considered individually it would be important to have the set of attributes that best represented the specific physical drivers occurring on that river system. However, when looking across river systems the attributes would need to be expanded accordingly.

iv. Goal 4 - Assume Goal 3 is satisfied but the taxonomy needs to be robust to all semi-riparian areas.

Environmental Drivers: There are many key variables that shape semi-arid riparian areas in the Southwest such as hydrologic regimes (groundwater flows, base flows, flood flows) and geomorphic regimes (sediment flows and other geomorphic processes). Other key drivers include water quality (including salinity and nutrients), fire, climate, and activities of mammals including beavers (an ecosystem engineer), large herbivores, and people (including restoration actions). The approach would need to encompass the wide range of flows regimes (ephemeral, intermittent, perennial), watershed sizes and stream orders (flood magnitude), stream geomorphologies (stream gradient, floodplain width), elevations and geographic locations found throughout the region.

Anthropogenic Changes: A taxonomy of the major types of human actions that can alter riparian areas in the Southwest needs to be created. Key actions include those that would alter water availability (diversions, pumping, interbasin transfers), flood patterns (dams, land use changes), water quality (effluent discharge, agricultural and urban runoff), stream morphology

(channelization, berming), vegetation area (conversion to agriculture, urban), and herbivory levels (livestock grazing).

Vegetation: To link changes in vegetation attributes to the above anthropogenic changes, one would create a taxonomy of riparian ecosystem types in the Southwest. One would then gather empirical and/or theoretical information pertaining to vegetation responses to changes in the environmental drivers addressed above. Efforts have been undertaken to link specific environmental changes to riparian vegetation response for specific stream types, but many scientific gaps remain.

Birds: To develop riparian bird attributes across Southwestern rivers it would be necessary to assess how birds respond to the larger set of physical drivers It would then be possible to develop a meta-analytic dataset (pulling in existing data from the literature) to look at ecological and life-history traits of birds that respond strongly to changes in riparian vegetation across all riparian areas in the Southwest. This would encompass, among other things: variations in response of birds to vegetation composition, structure and arrangement, availability of surface, water, livestock grazing, and surrounding land cover. Grouped species predictions would then be possible, however probably only in some sort of index form such as a ranking of bird abundances (not absolute abundances).

One primary distinction between goals 1 and 3 versus goal 4 is that we likely won't have an original dataset that spans Southwestern rivers. Thus implementation of goal 4 would require the development of some sort of index to predict what is going on in a new river system without collecting a lot of additional data. Prediction to novel locations, based on existing empirical or theoretical knowledge in the natural sciences (both vegetation and birds) represents a major scientific endeavor. Because of its difficulty and novelty the scientific effort required to provide

prediction to new locations as foundation to ecological valuation work should not be taken for granted or underestimated.

Indices are often used in ecological valuation and benefit transfer studies as proxies for specific benefits since there is often insufficient time and resources to study each attribute for which ecological valuation studies would be beneficial. Ecological indices may provide an efficient means to guide management and conservation decisions. Indices based on a relatively small set of ecological metrics have been used as substitutes for more intensive and/or expensive measurements of ecological conditions (O'Connell et al. 2000, Canterbury et al. 2000; Stromberg et al. 2004). While indices deliberately simplify complex ecological systems, they are intended to provide an efficient means to assess broad regions when more detailed studies are impractical or impossible (Karr 1991, Canterbury et al. 2000). From the natural science perspective, creation of meaningful ecological indices requires prediction of conditions in previously unstudied locations. While identification of larger ecological principles that may be operating across sites within a given region is one of the key goals of the science of ecology, it is by no means simple (Côté and Reynolds 2002).

In order for an index to be meaningful, it needs to be founded in ecological theory and be empirically based. For this project developing a predictive approach for the natural science inputs to the benefit transfer was a monumental task. Development of an appropriate index would have required collection of data across Southwestern riparian systems facing different physical drivers, and if only from the literature were available the use of meta-analysis would be required. Since the distribution of many species of birds may not cover an entire region of interest, use of ecological traits of species would have provided a means to predict expected responses of birds to changes in hydrologic and vegetation conditions across sites (Brand 2004).

Similarly, because species composition of riparian plants varies across the region, classification of plants by functional traits would have provided a means to predict riparian vegetation responses across sites. In addition to the substantial effort and time required to develop such indices, the primary stumbling block that we faced was that the structure of the ecological attributes would have been very different if an index were used for the benefit transfer site, while a non-index (e.g. bird abundance estimated from data) was used for the SPRR. Future efforts can and should be allocated to the development of predictive models in the natural sciences that begin to fulfill the need in ecological valuation for ecological indices that are meaningful across sites within a region, and are empirically and theoretically based.

V. Issues from the Choice Modeling Perspective

From the CM perspective, the biggest issues faced have been:

1. Accurately portraying the science results in a way that is comprehensible to survey respondents;

2. Defining the good in a way that keeps the 'best science' available from SPRNCA but allows transfer to other sites;

3. Removing the inherent correlation that comes from using integrated scientific results.

Based on feedback from the focus groups and considerations arising from the benefit transfer we drafted a new version of the coarse SPRNCA CM survey. We sought to find a balance between the vast detail of information available from the scientific outputs and respondent comprehension level. This version was shared around the research team so that all could check the greatly "aggregated" science content for accuracy in presentation.

To put this in perspective, we had available data on 33 individual species of birds by reach with over 15 different ways that our ornithologist could potentially group this species-specific data. The final attributes that were chosen for selection in the choice question include:

1. Miles of surface water;
2. Three possible condition classes of riparian vegetation with a spatial distribution;
3. Bird abundance by condition class;
4. Cost.

This final choice of attributes represents a trade-off between scientific detail, benefit-transfer needs, and CM requirements. For example, the condition classes represent the 'best available science' at the coarse level of the SPRNCA, where the identification of a reach as wet, dry, or intermediate is based on a large number of variables that include groundwater, surface water, and vegetation types. This aggregation of information into one of three types was both a blessing and a challenge in terms of survey design. On the positive side presentation of these three types encapsulated a good deal of information in a way that was easy for individuals to understand. However this starting point created significant challenges for the economists.

A goal of the study was to determine a marginal value of water. We dealt with this by separating out surface water as an attribute and emphasizing the ground water/vegetative components of the condition classes. Although we spent significant time and energy identifying a Southwestern riparian area that was similar in many ways to the SPRR, as noted earlier, the policy drivers and the issues of concern are very different along the SPRR and MRG. In some ways the SPRR is quite unique. The 'best science' for the SPRR was designed so as to best describe the SPRR, not necessarily other Southwestern rivers.

As discussed above, the challenge facing benefit transfer in this study, just as with any study, is that the models you would choose with benefit transfer in mind may be very different than what you would choose to describe a particular study area. What drove the best science at the SPRR is not necessarily the most salient issue in the MRG. Without conducting primary

science on the MRG, it is essentially impossible to create riparian condition classes that are comparable to the SPRR. This fact has caused us to emphasize the vegetative characteristics of the condition classes. This has also resulted in additional complexity in the SPRNCA survey, as we bring in an additional vegetative component (short, flood-intolerant trees such as mesquite on the SPRR and Russian olive on the MRG) that did not change among the condition classes in the SPRNCA but varies among sites and is a focus of vegetation manipulations on the MRG.

While birds have been significantly easier to deal with from a transfer perspective, they have resulted in a fair amount of additional complexity. For example, we have six different bird categories: breeding/low-shrub; ground, breeding/high-shrub, breeding/canopy, breeding/water-dependent; breeding/non-water-dependent and migratory. Originally we had chosen categories of breeding/canopy, breeding/non-canopy, breeding/water-dependent and breeding/non-dependent to best capture the actual important changes that would occur in the SPRR from groundwater pumping. As total number of birds was predicted to stay relatively constant, total number of species did not capture the whole story; instead the important difference was in the composition of birds. Migratory was included because of the importance that focus groups bestowed on this category. Once the benefit transfer site was included, non-canopy had to be widened to encompass the real changes that are happening on the MRG. More specifically, while groundwater pumping that affects birds may be the primary concern in SPRR, it is restoration in response to fire concerns that affects birds in the MRG. The types of birds that are affected by these two policies are not the same. Thus, non-canopy was further sub-divided into low-shrub/ground and high-shrub. In trying to cover just two sites, the complexity has increased remarkably.

Finally a comment must be made from the choice-modeler's perspective. A goal of efficient CM is to create a design with independence between attributes. This is completely at odds with the idea of ecosystem services, which by their very nature are strongly linked; the desire for attribute independence has been troubling to the economists . The very heart of the scientific model employed in this study was to link disparate disciplines in creating an integrated model. Vegetation modelers linked their results to groundwater models and bird modelers based their model on the condition class model. What is the independent-attribute choice modeler to do? By its very design, the attributes of bird density are linked to condition class. One way we have tried to break these correlations is through the information presented to respondents. For example, respondents will be presented with information on miles of surface water; while this depends on condition class, it is not perfectly linked because of uncertainty in the surface water estimates and the spatial nature of the condition classes.

The agreement that has been made is that traditional design methods will be used, ignoring the correlations. The choice pairs will then be presented to the scientists for their review, so as to weed out any blatantly unobtainable combinations. Tests will then be run to check that the remaining combinations in the design will allow the economists to estimate the marginal values of interest. Because of the underlying science, we will then be able to use the estimated marginal values to estimate willingness to pay for scientifically predicted outcomes from potential groundwater changes. Once the marginal values are obtained, WTP estimation will be based on the scientific estimation of attribute levels. This represents the primary difference between traditional CM methods and our integrated approach.

VI. The Surveys

In the following section, we present some extracted text from the "Coarse" SPRNCA survey, to illustrate the final form of the compromise.

a. The "Coarse" SPRNCA Survey

The structure of the "Coarse" SPRNCA CM and the CVM survey will have the following:

1. Introduction, and discussion of the importance of riparian zones;
2. Background information of three important characteristics of the SPRNCA;
3. Discussion of water (focusing on surface and groundwater interactions), vegetation (focusing on types and relationships to water availability) and birds (focusing on types and relationship to vegetation cover);
4. Current conditions for the three riparian condition classes;
5. Relevant policy measures (appropriate variations for CVM);
6. Choice or dichotomous questions (appropriate variations for CVM)
7. Socio/economic/activity information.

Respondents are presented with a summary of each of the current condition classes, and provided with information about the average surface flow and density of birds by type. This is shown in Figures 5 through 7. Figure 5 shows this information for the wet condition class depicting which reaches of the SPRNCA are currently classified as wet. Figure 6 shows this information for the intermediate condition class depicting which reaches of the SPRNCA are currently classified as intermediate. Figure 7 shows this information for the dry condition class depicting which reaches of the SPRNCA are currently classified as dry.

Figure 5: Wet condition class

Characteristics of Average Wet Stretch

Surface Water Flow:
•99% of the year

Mix of Vegetation
No salt cedar
Predominantly cottonwood-willow (89%)
Some mesquite (11%)
Contains river marsh grasses

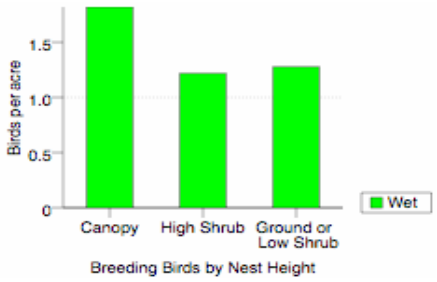
Birds
•Breeding birds by nest height
- Canopy: 1.8 per acre
- High Shrub: 1.2 per acre
- Low Shrub/Ground: 1.3 per acre

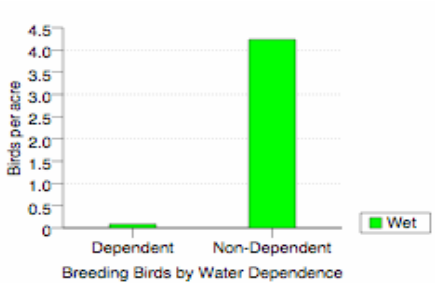
•Breeding birds by surface-water dependency
- Non-dependent: 4.2 per acre
- Dependent: 0.1 per acre

• Migratory birds: 3.3 per acre

Current Conditions for Wet Stretches in SPRNCA

- 5 wet stretches, consisting of 601 acres (30 % of the total area of SPRNCA)
- On an average day, 14.5 miles of surface water
- 3.3 migratory birds per acre





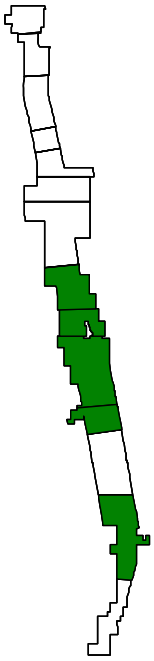


Figure 6: Intermediate condition class

Characteristics of Average Intermediate Stretch

Surface Water Flow
•70% of the year

Mix of vegetation
21% salt cedar
63% cottonwood-willow
16% mesquite
Contains no river marsh grasses

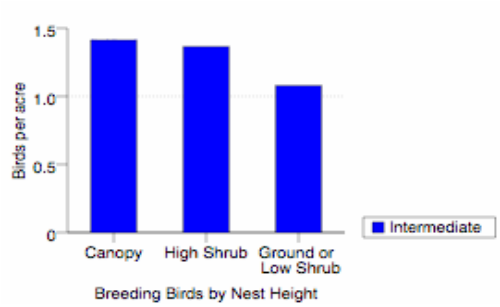
Birds
•Breeding birds by nest height
- Canopy: 1.4 per acre
- High Shrub: 1.4 per acre
- Low Shrub/Ground: 1.1 per acre

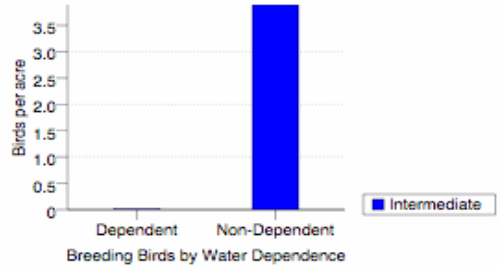
• Breeding birds by surface-water dependency
- Non-dependent: 3.9 per acre
- Dependent: 0.02 per acre

Migratory birds: 3.3 per acre

Current Conditions for Intermediate Stretches in SPRNCA

- 8 intermediate stretches, consisting of 1175 acres (60% of the total area of SPRNCA)
- On an average day, 14.9 miles of surface water
- 3.3 migratory birds per acre





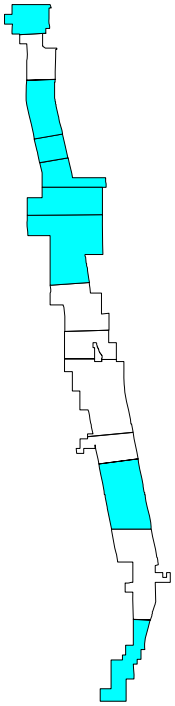


Figure 7: Dry condition class

Characteristics of Average Dry Stretch

Surface Water Flow
• 46% of the year

Mix of vegetation
Primarily salt cedar (73%)
17% mesquite
10% cottonwood-willow
Contains no river marsh grasses

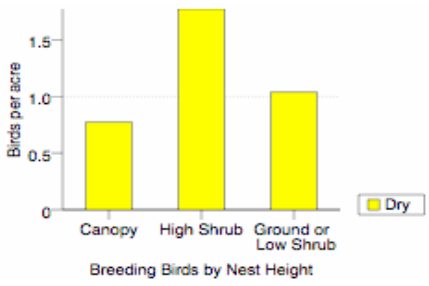
Birds
•Breeding birds by nest height
  • Canopy: 0.8 per acre
  • High Shrub: 1.8 per acre
  • Low Shrub/Ground: 1.0 per acre

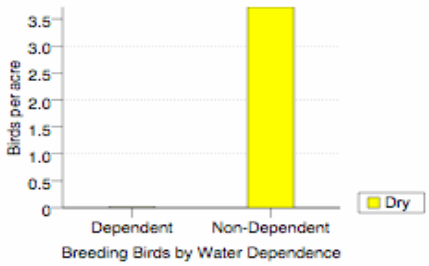
• Breeding birds by surface-water dependency
  • Non-dependent: 3.7per acre
  • Dependent: 0.01 per acre

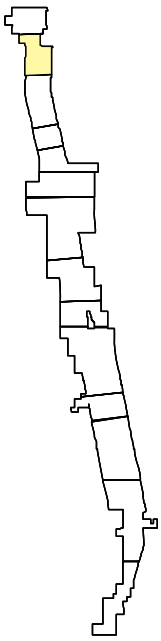
• Migratory birds: 3.8 per acre

Current Conditions for Dry Stretches in SPRNCA

- 1 dry stretch, consisting of 196 acres (10 % of the total area of SPRNCA)
- On an average day, 1.1 miles of surface water
- 3.8 migratory birds per acre







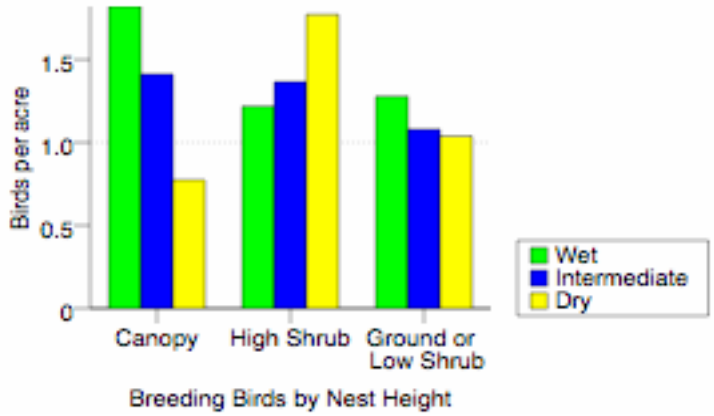
b. Current Conditions Summary

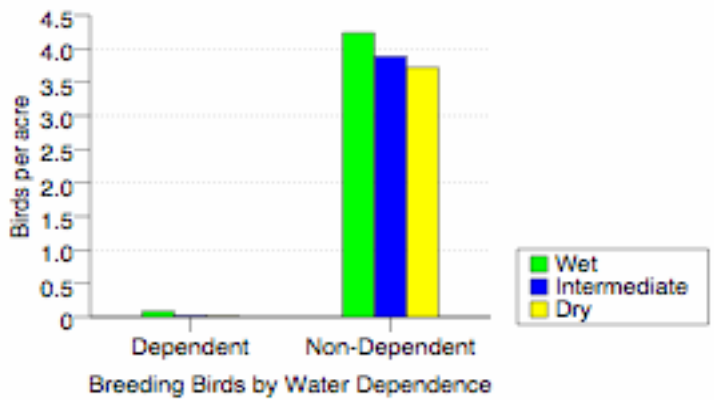
The information from each of the condition classes is then summarized into a single graphic (Figure 8). This graphic forms the status quo alternative and shows the format that is used to describe each of the choice alternatives.

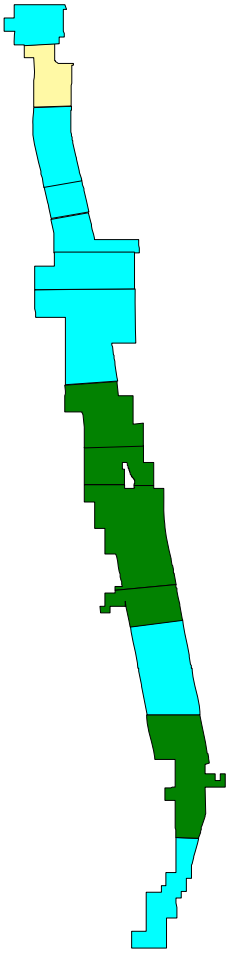
Figure 8: Current condition class

Current Conditions for SPRNCA

- Consists of 5 wet stretches totalling 601 acres (30% of SPRNCA), 8 intermediate stretches totalling 1175 acres (60% of SPRNCA), and 1 dry stretch of 196 acres (10 % of SPRNCA)
- On an average day, there are 30.5 miles of surface water
- 3.4 migratory birds per acre







VII. Reflections

This paper has presented a case study, highlighting some of the complexity involved in creating an integrated scientific/economic framework. As discussed in this paper, difficulties in creating such a framework for a single site include: the inherent contradictions in separately valuing ecosystem services as distinct, independent attributes; the cognitive difficulties posed for survey research in having primary scientific output; the challenges of integrating disparate disciplines; and the need to develop novel methods for connecting the output between the disciplines. These difficulties, while surmountable, are made even more challenging when the goal is to conduct benefit transfer between sites, as the 'best science' is traditionally geared towards understanding a specific site as opposed to broadly describing a set of sites. Accommodating scientific differences between sites and trying to remain scientifically accurate increases the cognitive burden placed on survey respondents while limiting the level of detail at which the problem can be addressed. The necessary result has been a number of pragmatic compromises.

While we present this experience with the hope of sparking discussion, we do so retaining the belief that while complex, the effort to integrate the disciplines remains essential. Working with other disciplines has been an interesting experience, highlighting the lack of full understanding of natural systems that economists bring to valuation exercises. In order to develop meaningful welfare estimates that can contribute to policy discussion, economists must better understand the possible trade-offs resulting from policy choices. In order for the science results to have policy impact, scientists must strive to make their results understandable and transferable. Additionally they must engage with policymakers. Better environmental policy requires integrated research.

VIII. References

Alley, W. M., R. W. Healy, J.W. LaBaugh, and T. E. Reilly., 2002. Flow and Storage in Groundwater Systems. Science 296 (5575): 1985 - 1990.

Barret, C., T.H. Stevens, and J. Willis., 1996. "Comparison of CV and conjoint analysis in groundwater valuation." Ninth Interim Report, W-133 Benefits and Costs Transfer in Natural Resource Planning, Ames, IA: Department of Economics, Iowa State University.

Brand, L. A., 2004. Prediction and assessment of edge response and abundance for desert riparian birds in southeastern Arizona. Ph. D. Dissertation, Colorado State University.

Boxall, P.C., W.L. Adamowicz, J. Swait, M. Williams, J. Louviere., 1996. "A comparison of stated preference methods for environmental valuation." *Ecological Economics* 18:243-253.

Brookshire, D., and J. Chermak., 2007. "Conceptual issues of benefit transfers and integrated modeling," *Environmental Value Transfer: Issues and Methods,* Vol 9, in the Kluwer Publishers series entitled The Economics of Non-Market Goods and Resources, ed. by S. Navrud, R. Ready, and O. Olvar. New York, NY: Kluwer Academic Publishers.

Brookshire, D., J. Chermak, and R. DeSimone., 2007. "Uncertainty, benefit transfers, and physical models: a Middle Rio Grande Valley focus" *Environmental Value Transfer: Issues and Methods*, Vol 9, in the Kluwer Publishers series entitled The Economics of Non-Market Goods and Resources, ed. by S. Navrud, R. Ready and O. Olvar. New York, NY: Kluwer Academic Publishers.

Canterbury, G. E., T. E. Martin, D. R. Petit, L. J. Petit, and D. F. Bradford., 2000. Bird communities and habitat as ecological indicators of forest condition in regional monitoring. Conservation Biology 14(2): 544-558.

Côté, I. M., and J. D. Reynolds., 2002. Predictive Ecology to the Rescue? Science 298: 1181-1182.

Desvousges, W.H., V.K. Smith, and A. Fisher., 1987. "Option price estimates for water quality improvements: a contingent valuation study for the Monongahela River." *Journal of Environmental Economics Management* 14: 248-267.

Desvousges, W H.; F.R. Johnson, and H.S. Banzhaf., 1998. *Environmental Policy Analysis with Limited Information: Principles and Applications of the Transfer Method*. Cheltenham, U.K: American International Distribution Corporation.

Karr, J. R., 1991. Biological Integrity: A long-neglected aspect of water resource management. Ecological Applications 1:66-84.

Krueper, D. J., 1999. Anotated checklist to the birds of the upper San Pedro River valley. Report prepared for San Pedro Project Office, BLM.

Mackenzie, J., 1993. "A comparison of contingent preference models." *American Journal of Agricultural Economics* 75:593-603.

Margat, W.A., W.K. Viscusi, and J. Huber., 1998. "Paired comparison and contingent valuation approach to morbidity risk valuation." *Journal of Environmental Economics and Management* 15:395-411.

Morrison, M., 2000. "Aggregation biases in stated preference studies." *Australian Economic Papers* 39(2):215-30.

Lite, S.J. and J.C. Stromberg., 2005. Surface water and groundwater thresholds for maintaining *Populus - Salix* forests, San Pedro River, Arizona. Biological Conservation 125: 153-167.

O'Connell, T. J., L. E. Jackson, and R. P. Brooks., 2000. Bird guilds as indicators of ecological condition in the central Appalachians. Ecological Applications 10(6): 1706-1721.

Ready, R.C., J. Whitehead, and G. Blomquist., 1995. "Contingent valuation when respondents are ambivalent." *Journal of Environmental Economics and Management* 29(2):181-96.

Richter, H.E., 2006, Participatory learning on the San Pedro: Designing the crystal ball together. Southwest Hydrology, Special Issue on Decision Support Systems, Vol. 5, No. 4, p 24-25.

Stevens, T.H., R. Belkner, D. Dennis, D. Kittredge, and C. Willis., 2000. Comparison of contingent valuation and conjoint analysis for ecosystem management. *Ecological Economics* 32(1):63-74.

Stewart, S., Y. Takatsuka, and J. Kahn., 2002. "Choice model and contingent valuation estimates of the benefits of ecosystem protection." Knoxville, TN: University of Tennessee Working Paper.

Stromberg, J. C., R. Tiller, and B. Richter., 1996. Effects of groundwater decline on riparian vegetation of semiarid regions: The San Pedro, Arizona. Ecological Applications 6(1): 113-131.

Stromberg, J., M. Briggs, M. Scott, and P. Shafroth., 2004. Riparian ecosystem assessments. Pages 314-329 in M. Baker Jr., P. Ffolliott, L. DeBano, and D. G. Neary, editors. Riparian Areas of the Southwestern United States: Hydrology, Ecology, and Management. Lewis Publishers (CRC Press), Boca Raton, Florida.

Stromberg, J. C., 1998. Dynamics of Fremont cottonwood (*Popilis fremontii*) and saltcedar (*Tamarix chinensis*) populations along the San Pedro River, Arizona. Journal of Arid Environments 40: 133-155.

Stromberg, J. C., S. J. Lite, T. J. Rychener, L. R. Levick, M. D. Dixon, and J. M. Watts., 2006. Status of the riparian ecosystem in the upper San Pedro River, Arizona: application of an assessment model. Environmental Monitoring and Assessment 115: 145-173.

Sumer, D., H. Richter, and K. Lansey., 2004. "Evaluation of Conservation Measures in the Upper San Pedro Basin," published and presented at the 2004 Environment and Water Resources Institute Conference, Salt Lake City.

Takatsuka, Y. 2003. "A comparison of iterative contingent valuation and choice model willingness to pay." Knoxville, TN: University of Tennessee Working Paper.

Tidwell, V.C., H.D. Passell, S.H. Conrad, and R.P. Thomas, 2004. Systems dynamics modeling for community-based water planning: An application to the Middle Rio Grande, J. of Aquatic Sciences, 66:357-372.

CONTINGENT VALUATION SURVEYS TO MONETIZE THE BENEFITS OF RISK REDUCTIONS ACROSS ECOLOGICAL AND DEVELOPMENTAL ENDPOINTS

Katherine von Stackelberg and James Hammitt, Harvard Center for Risk Analysis, Harvard School of Public Health, 401 Park Drive, Landmark 404C, Boston, MA 02215, 617.998.1037, kvon@hsph.harvard.edu

ABSTRACT: We report the results of several contingent valuation (CV) surveys to develop willingness-to-pay (WTP) estimates to reduce environmental risks facing wildlife and unborn children as a result of hypothetical exposure to polychlorinated biphenyls (PCBs) in fish. Three surveys are developed: Two have a parallel structure in which respondents are first asked about a single endpoint, either ecological (EcoFirst), or human (HHFirst), and a second set of questions asks about the combined effects across endpoints. The third survey asks only about the combined effects (combined). We randomize two ecological and human health endpoints for each survey: the ecological endpoints include reducing risks associated with potential reproductive effects of PCBs on eagles, and the second is based on a "species sensitivity distribution" (SSD) that quantifies the risk reduction across all bird species. The human health endpoints include a probability of a 6-point reduction in IQ, and the other a probability of a 7-month reduction in reading comprehension. We evaluate sensitivity of WTP to the magnitude of the risk reduction for each endpoint. Survey respondents were willing to pay incrementally more for human health endpoints in the EcoFirst survey than they were for ecological endpoints in the HHFirst survey, but the results for the combined versus single endpoints are not statistically distinguishable. The survey results show that WTP for an individual endpoint is approximately proportional to the magnitude of the risk reduction for the Eagle and IQ as endpoints, but not for SSD and reading comprehension endpoints.

This is the first survey that evaluates WTP for potential risk reductions associated with exposure to chemicals in the environment specifically in terms of ecological or developmental health benefits within a risk assessment context. We reported the results of the human health endpoints previously. The focus of this paper is on the ecological endpoints.

1.1 Introduction

Risk assessment is the process of quantifying the probability that humans or animals will develop adverse health effects as a result of exposure to stressors, such as chemicals, in the environment. Increasingly, there is pressure to defend proposed risk-protection regulations or policies designed to reduce exposure to chemicals (*e.g.,* Superfund cleanups) on the basis of cost-benefit or cost-effectiveness (EPA *et al.,* 2000; EPA-SAB, 2000). Although the benefits associated with risk reductions do not require monetization, monetary units facilitate comparison across disparate endpoints and costs. In the absence of observable markets for risk reductions, CV and other stated preference methods that rely on an analysis of the hypothetical choices made by individuals are virtually the only means for deriving economic values for the benefits associated with predicted risk reductions.

Human health effects resulting from environmental exposures can be acute (immediate) or chronic (longer term). Acute effects can often be ameliorated if the source of the exposure is removed (*e.g.*, asthma attacks as a result of air pollution), while chronic effects by definition tend to extend beyond the period of exposure (*e.g.*, the asthma itself,

or developmental effects). In addition, with chronic effects, there can also be a latency period (*e.g.*, cancer, liver disease and other diseases that might not reveal themselves until long after exposure has ceased). The bulk of the CV studies found in the literature are for respiratory exposures (Van Houtven *et al*., 2003 provide a meta-analysis of 136 studies) leading to episodes of asthma or angina attacks, and there were no studies identified that specifically addressed mild cognitive deficits. Likewise, ecological CV studies tend to focus on endangered species or biodiversity, and we were unable to identify any studies that evaluated a reduction in potential reproductive effects. This study is designed to evaluate willingness-to-pay for a subtle effect (in humans) that occurs with a fairly large probability (20% chance if exposed) relative to typical cancer risks at Superfund sites, and to evaluate willingness-to-pay for a significant effect in ecological receptors (reproductive capability), consistent with the risk assessment framework.

The contingent valuation surveys presented here are designed around a case study of exposure to PCBs in the environment using the modeling tools and dataset available for the Hudson River Superfund Site. This case study provides the specific endpoints and risk reductions to serve as the basis for the valuation questions to demonstrate the feasibility of integrating WTP with risk assessment results to monetize the benefits associated with risk reductions.

1.2 Methods

1.2.1 Survey Design and Development

The surveys were designed over a one-year period and involved several informal pilot surveys, focus groups, and a pretest. The surveys were designed to be administered over the Internet using a professional survey firm, Knowledge Networks. The research goal was to evaluate whether a CV might provide a feasible method for obtaining economic values for endpoints consistent with how they are expressed in a typical risk assessment framework (drawing from the experience of the lead author at an actual Superfund site) and explore how people respond to questions regarding potential effects to children and wildlife as a result of exposure to a specific chemical in the environment. To that end, the surveys asked numerous open-ended questions for which respondents could provide comments as they progressed.

The primary objective of the surveys was to elicit an approximation of the monetized loss in utility experienced by respondents resulting from potential effects associated with exposure to PCBs in the environment that would be consistent with economic theory. Another objective of the surveys was to measure WTP for risk reductions, consistent with the results that an existing set of modeling tools provided. The surveys were designed so that members of the general public could follow and understand the issues, and the surveys asked various questions throughout to gauge what respondents already knew (or thought they knew) concerning chemicals in the environment and how they felt, in a general sense, about exposure to chemicals (*e.g.*, whether they thought it was a serious

issue, or even feasible that the kinds of effects described in the survey could really occur). The surveys are based on a hypothetical, generic site located in the respondent's State (there are numerous actual PCB-contaminated freshwater systems across the United States and it is likely that there is at least one in the general area in which the respondent lives). Respondents are left to consider which specific waterbody the surveys refer to, and despite the generic nature of the site, the surveys were designed to be plausible and the payment vehicle realistic and believable.

Respondents to the survey are first told that government officials in their State are responsible for allocating resources and are interested in individual opinions to inform potential policies. The first question asks respondents to rate the importance of several issues facing regulators. The second question asks respondents to consider whether current State budget allocations should be reduced or increased, keeping in mind that overall expenditure cannot be increased without an increase in revenue. Respondents are reminded that State policy makers are responsible for allocating resources, and that people may feel differently about these allocations depending on their own beliefs and knowledge. Respondents are told that State policy makers are interested in learning how taxpayers feel about specific issues.

The survey then proceeds to frame the specific valuation question, which involves the potential effects of a specific chemical (PCBs – we ask "have you ever heard of PCBs?") in a large, unnamed freshwater system in the state in which the respondent resides. This system is contaminated, and the company or companies ostensibly responsible went out

of business some years ago. Therefore, the State is contemplating setting up a special "cleanup" fund to be funded through a one-time increase in the State income tax.

The question states that the risk will decrease if the cleanup is conducted if the income tax is raised by the bid amount for all, not just for the respondent (Johansson-Stenman, 1998), which has been shown to generate values consistent with economic theory. However, not all States have an income tax, and this was not explicitly acknowledged. The cleanup is described as occurring over several years, and the survey also states that even after cleanup is complete, it will still take several years for concentrations in fish to decrease, and for wildlife receptors to recover. In addition, the risks will never decrease to zero as there will always be some residual contamination.

A particular issue that arises with double-bounded CV estimates from the literature is a failure to achieve consistency (Hanemann, 1991; Hanemann and Kaninnen, 2001; McFadden and Leonard, 1993). We used a double-bounded dichotomous choice (Hanemann, Loomis and Kanninen, 1991) which has been shown to substantially increase the statistical power of the WTP estimate, at the expense of a downward bias in the estimate because the second response is not incentive-compatible (Carson *et al*., 2003). There is evidence that in some cases, responses to the second bid are inconsistent with responses to the first bid. Some authors (*e.g.,* Alberini, 1995a; 1995b; 1995c) have shown that pooling the responses to the first and second bids leads to some bias in the coefficient estimates, but a gain in efficiency. Respondents are presented with an initial bid randomized from a bid vector ranging from $25 to $400. If the respondents agree to

the initial bid, they are presented with a bid that is double the first bid (if they agree to $400 initially, then they are asked if they would be willing to pay at $800). If respondents do not agree to the initial bid, then they are presented with a bid that is half as much ($10 if they did not agree to $25 initially).

The bid vector for the total valuation question across all endpoints in the EcoFirst and HHFirst surveys takes as its starting point the next highest bid that was agreed to for the individual endpoint valuation question. One could randomize the bid vector, but true randomization would inevitably lead to a bid being offered for the combined valuation that could be less than what a respondent had already agreed to for an individual endpoint. One could randomize the bid amount offered for the combined endpoints starting with the next highest bid above what had already been agreed to, but that cannot be considered true randomization. Therefore, we offered respondents the next highest bid following the one already agreed to for the single endpoint (except in the case where a respondent said No-No to the first bid: in that case, we randomized the total valuation bid as well). Table 1 shows the relationship between the bid amounts for the individual endpoints in the first part of each survey and the bid amounts for the total valuation question across both endpoints for the EcoFirst and HHFirst surveys. The combined survey uses this same bid vector.

The next set of questions asks about respondent confidence for stated WTP for the endpoints individually and jointly. Another question asks whether respondents feel they can separately consider ecological and human endpoints from a valuation standpoint.

Another set of questions asks about familiarity with PCBs, concern about chemicals in the environment, and whether the respondent believes that exposure to PCBs really can cause these effects. Finally, respondents are asked to rate their trust on a one to five scale concerning the information they receive from a number of sources, including different web sites, print media and television.

We develop three versions of the survey: EcoFirst (n=405), in which WTP for risk reductions to ecological receptors (randomized by eagle, SSD, and specific risk reduction) are asked first, followed by the total WTP for both human and ecological endpoints; HHFirst (n=400), in which WTP for risk reductions to unborn children (randomized by IQ, RC, and specific risk reduction) are asked first, followed by the total WTP for both human and ecological endpoints; and combined (n=200), a survey which does not attempt to separate human and ecological endpoints but provides a risk reduction for each endpoint and questions respondents about total WTP across endpoints.

1.2.1.1 Endpoint Selection

The specific endpoints for this survey are taken from the risk assessment case study. The individual ecological and human health endpoints are discussed next.

Ecological Endpoints

For the ecological outcomes, we are interested in how people perceive environmental threats to ecological resources, what they might be willing to pay to reduce that threat, and how those results can be incorporated into a risk assessment.

While Superfund human health risk assessment typically focuses on the "hypothetical" individual, ecological risk assessment strives to evaluate the potential for risk in terms of the population or ecosystem (EPA-RAF, 1998). There are two distinct ways in which ecosystem structure and function are typically evaluated within a risk assessment context and these are used as the basis for developing the CV questions so that the economic values derived from the surveys can be integrated into a risk model. The first focuses the analysis on a set of single species that have been selected to represent high-end exposure and sensitivity. Within the ecological risk assessment framework, the assessment endpoints (that which is being protected) generally do not define specific species (*e.g.*, a typical assessment endpoint is the protection and sustainability of wildlife populations). The associated measurement endpoint(s) for that assessment endpoint might include comparing predicted doses to the selected species with doses from the toxicological literature associated with specific effects. This deterministic analysis can be expanded to include a joint probability model that quantifies the probability of an increasing magnitude of effect using a dose-response model for a single species (*e.g.*, reduction in fecundity). Alternatively, the probability of exceeding a threshold value can also be

modeled. Under this approach, a valuation for a single "high-profile" species will implicitly value those aspects of the ecosystem that support this species (Loomis and White, 1996). The valuation questions respondents on their willingness-to-pay to reduce the probability of an effect on a single species. Management actions are designed to reduce risks for the presumed highest risk species. We evaluate potential risks specifically to the eagle, following the ecological risk assessment for the Hudson River (EPA, 2000b), and this endpoint is referred to as "eagle" in the surveys.

The second approach is slightly different. Rather than relying on a single dose-response relationship for one species, the analysis develops species sensitivity distributions (SSD). These distributions quantify the probability of the proportion of species that will be affected (*e.g.,* there is a 20% probability that 80% of the species will experience adverse reproductive effects). Under this approach, the analysis does not focus on one particular species but rather considers the probability of impacting multiple species. This is referred to as the "SSD" endpoint in our surveys.

Human Health Endpoints

The weight-of-evidence for a relationship between *in utero* polychlorinated biphenyl (PCB) exposure and developmental outcomes has been well established and continues to grow (Schantz *et al*., 2003; EPA, IRIS). Both epidemiological as well as animal studies demonstrate statistically significant increases in developmental delays and effects with increasing maternal PCB exposure (Jacobson and Jacobson, 2002b; Jacobson *et al.,* 2002;

Levin *et al.,* 1988; Schantz *et al*., 1989, 1991; ATSDR, 2000). These effects can be seen in newborns as measured by the Bayley Scales of Infant Development to older children, measured either directly in terms of IQ or from other, related tests.

Much of our understanding of the implications of slight declines in cognitive ability across a population is based on work done relative to lead exposures (Schwartz *et al*., 1985; Schwartz, 1994). The research conducted in this area shows that slight declines in IQ, which are difficult to detect in individuals and which may or may not lead to noticeable adverse effects on an individual basis, are significant on a population level in terms of a population shift in IQ. Other cognitive effects include other kinds of developmental delays such as declines in reading comprehension to levels below grade level, low scores on analytical tests and tests of simple math problems, and behavioral responses.

The risk reductions used in the surveys are based on the results from Jacobson *et al*. (2002) who present a linear relationship between lipid-normalized breast milk concentration of PCBs and outcomes including a 6-point reduction in IQ and a 7-month deficit in reading comprehension as evidenced by scores on the WISC-R at eleven years for the Michigan cohort. This dose response relationship is used together with exposure assumptions from the risk assessment case study (Chapter 4) to obtain the specific risk reductions used in the survey.

1.2.1.2 Sensitivity to Scope and Risk Reduction

Sensitivity of estimated WTP to the magnitude of the risk reduction is one technique used as a diagnostic test of the performance of the survey instrument (Arrow *et al.*, 1993; Hammitt and Graham, 1999). Sensitivity to scope can take several forms. Typically, these are referred to as *regular* embedding, (part-whole bias), and *perfect* embedding, (sensitivity of WTP to the stated risk reduction, *e.g.,* demonstrating a higher WTP for a larger risk reduction). There are two "part-whole" aspects to these surveys: one is within an endpoint, and the other is across endpoints. Within an endpoint, ecological part-whole bias is easier to evaluate through the difference between WTP for the specific ecological endpoint. That is, we evaluate the difference between WTP for eagle and SSD, controlling for risk reduction. The human health endpoints do not demonstrate additivity since the potential human health effects of *in utero* exposures to PCBs include a panoply of developmental effects, all or some of which may or may not occur.

There has been increasing discussion in the CV literature concerning the effect of the placement of a particular good or endpoint within a valuation sequence and the influence that has on respondent valuation (Carson and Mitchell, 1995; Diamond, 1996; Bateman and Willis, 2001). Different WTP estimates are obtained depending on the order in which the benefits are presented, and additionally, the summation of the individual WTP values is often not the same as the overall WTP obtained without specifying individual endpoints. This is the issue of embedding, or part-whole bias, across endpoints. We explore this by administering three different versions of the survey.

We evaluate perfect embedding by randomizing two different risk reductions for each endpoint across respondents as shown in Table 2. That is, each respondent sees only one risk reduction per developmental and ecological endpoint, but there are two risk reductions for each endpoint randomized across each subsurvey. We focus a number of the analyses on the risk reduction coefficient across surveys and endpoints.

Figure 1 provides a sample from the survey for effects to eagles, and Figure 2 shows a sample for the species sensitivity distribution. The values in brackets are the final risks, thus, the risk reductions in each case are 15 in 100 and 10 in 100 (0.15 and 0.10) for eagles, and 25 in 100 and 40 in 100 (0.25 and 0.40) for SSD. Risks are described both as a probability (percentage) and as a frequency (one in some number). There is a substantial body of evidence showing that people are generally more capable of understanding frequencies than they are probabilities, and this is the focus of much research in the "innumeracy" literature (Gigerenzer, 2002).

1.2.1.3 Motivation Questions

The survey contains a number of questions related to respondents' knowledge and beliefs regarding chemicals in the environment, PCBs in the environment, potential effects of PCBs, and trust in different sources of information (*e.g.*, industry scientists, media, academia). The survey contains several followup questions designed to elicit motivation for agreeing to a particular bid. One question asks respondents to rate on a scale from not important to very important some specific reasons why they might be willing to pay to

reduce potential risks to wildlife, while another asks the same question about developmental effects. We asked this follow-up question if the respondent answered N-Y, Y-N, or Y-Y (*e.g.,* they agreed to any bid amount). Likewise, for those respondents who answered N-N and were not willing to pay any amount, we questioned their motivation.

These kinds of motivational questions are important for evaluating how and why respondents made the decisions they did, and allow us to test hypotheses concerning the role of behavior in eliciting preferences relative to WTP (Dubourg *et al.,* 1997; Nunes and Schokkaert, 2003; Heberlein *et al.,* 2005).

We evaluated the responses to the "motivational" questions using factor analysis to determine whether those responses should be represented by few variables since it is likely that these responses are correlated and originate from a common behavioral denominator. We used varimax rotation as this assumes independence across factors and provides the most convenient and suitable interpretation of results. We fail to reject the hypothesis that four factors are sufficient across all nine questions from the pooled dataset as shown in Table 3. The first three questions showed the highest loading (altruism, bequest, nonuse) representing, broadly speaking, a nonuse component to the motivation. The correlation across these responses suggests that they have a common motivational origin. The second factor is most highly loaded on a broad-based support for a cleanup irrespective of risk or WTP. The third factor is most highly loaded on altruism for potential effects in children exposed to PCBs. Finally, the last factor is most highly loaded on use or option to use the ecological resource (*e.g.,* the respondent enjoys

seeing eagles and wildlife or rates highly the option of doing so). Based on these results, each respondent is assigned a value for each factor based on the combination of responses to each individual motivational question, and these factors are used in the regression models in place of the original responses. These results are consistent across both datasets as shown in Table 3.

1.2.1.4 Survey Administration

A professional survey firm, Knowledge Networks (KN), administered the survey to a panel representative of the US general population via a web-based survey mechanism during Spring 2005. The statistical foundation of the research panel stems from the application of probability-based sample selection methodologies to recruit panel members. The KN web-enabled panel is the only available method for conducting Internet-based survey research with a nationally representative probability sample (Couper, 2001; Krotki and Dennis, 2001).

The Knowledge Networks Panel, recruited randomly through Random Digit Dialing, represents the broad diversity and key demographic dimensions of the U.S. population. The web-enabled panel tracks closely the U.S. population on age, race, ethnicity, geographical region, employment status, and other demographic elements. The differences that do exist are small and are corrected statistically in survey data (*i.e.,* by non-response adjustments). The web-enabled panel is comprised of both Internet and non-Internet households, all of which are provided the same equipment for participation

in Internet surveys. Internet-based surveys are increasingly showing favorable comparisons to mail and telephone survey methods (Berrens *et al*., 2003).

1.2.2 Survey Analysis

The statistical model for CV responses must satisfy both statistical and economic criteria (Hanemann and Kaninnen, 2001). CV responses can be modeled as discrete dependent variables with binary responses since respondents can either state "yes" or "no" to a particular bid value. An equivalent but alternative modeling form takes the bid interval agreed to by an individual respondent as the dependent variable. In economic terms, the statistical model for CV responses must be consistent with the theory of utility maximization inherent in economic models. This assumes individuals show preferences for market commodities (x) and nonmarket amenities (q) as represented by a utility function $U(x,q)$ which is continuous and non-decreasing (Hanemann, 2001). Individuals face budget constraints based on income (y) and prices of the market commodities (p). Individuals are assumed to be utility-maximizers given a budget constraint (*e.g.*, disposable income). Willingness-to-pay, or the compensating variation (C) is the maximum an individual is willing to pay to secure an increase to the nonmarket amenity. In this case, the nonmarket amenity is expressed as a risk (r); therefore, a decrease in the risk increases utility $U(x, r)$.

Each respondent to the survey has an indirect utility function for which one can plot the tradeoff between risk and income while maintaining utility as given by the slope of that curve.

The economic measure of value is given as:

$$v(p, r_1, y\text{-}C) = v(p, r_0, y) \quad \text{(Eq. 1)}$$

where C = the amount of money at which the individual is indifferent between a lower probability of risk and higher income, and r_0 and r_1 are different levels of:

- Risk to the reproductive capacity of eagles (eagle)
- Risk to the reproductive capacity of an avian population (SSD)
- Risk of a 6-point reduction in IQ to an unborn child given maternal exposure (IQ)
- Risk of a 7-month deficit in reading comprehension given maternal exposure (RC)

We evaluate two different risk reductions across endpoints as shown in Table 2. The assumption is that a smaller risk relative to baseline improves well-being so compensating variation, or WTP, should be positive. Under this framework, expected utility is roughly proportional to risk; consequently WTP should be approximately proportional to risk reduction and we use the survey results to test this hypothesis. As individuals spend more money, the utility loss increases. However, WTP is likely small with respect to income and so an income effect is also likely to be negligible.

The double-bounded dichotomous choice elicitation format used here is analogous to interval-censored survival data in medical and engineering settings in which time to illness or failure of a component is modeled. In this case, we know the interval within which WTP for any individual respondent lies; for example, for the yes-yes response, it is known that the interval lies somewhere between the highest amount the respondent agreed to and their household wealth. The actual bid P_i that the respondent is willing to

pay is somewhere between the upper and lower bids or $P_L < P_i < P_U$. In addition, each respondent provides a vector of explanatory variables including bid amount (P_i), income, age, other sociodemographic variables, knowledge about chemicals and/or PCBs in the environment, and other attitudinal variables.

The WTP model takes the form:

$$LNWTP_i = \beta_0 + \beta_1 LN(\Delta Risk) + \beta_2 LNIncome + \beta_x X + \varepsilon \qquad \text{(Eq. 2)}$$

where

WTP = WTP for the i^{th} individual in the interval (intervals shown in Table 4)
ΔRisk = is the risk reduction (0.1 or 0.15 for Eagle; 0.25 or 0.4 for SSD)
Income = respondent household income
X = vector of respondent-specific attributes (as given in Table 6)
ε = error term

The log likelihood function can be maximized assuming a particular parametric distribution (*e.g,* lognormal) or by using the Turnbull nonparametric modification of the Kaplan-Meier estimator, which makes no assumptions about the shape of the underlying WTP distribution (Carson *et al*., 2003; Hanemann and Kanninen, 2001). We evaluate several parametric forms for each risk reduction variable and use both visual goodness-of-fit, statistical tests, and theory to determine the most appropriate parametric form.

As there are three distinct surveys (EcoFirst, HHFirst, and combined), we first test to determine whether the survey results can be pooled (Henscher *et al.,* 1999). We then develop two datasets: The first uses WTP for the single endpoint as the dependent variable with dummy variables for each endpoint (IQ, RC, Eagle, SSD), and whether the

survey asked about ecological endpoints or human health endpoints first. The second dataset uses total WTP across all endpoints with appropriate dummy variables for survey type (HHFirst, EcoFirst, or combined) and specific endpoint. We also develop models using the single endpoints from each individual survey. This paper focuses on the results for the ecological endpoints.

Parameter estimation is accomplished through maximum likelihood methods to obtain values of unknown statistical parameters most likely to have generated the observed data. All models use the interval-censored bid interval as the dependent variable. The first set of models includes only the risk reduction variable(s) and the dummy variables for survey order and endpoint. The second set of models includes all potential covariates of interest. Tests of significance are based on t-tests under the test of the null hypothesis that the slope parameter of an independent variable is equal to zero. Proportionality of the risk reduction with respect to WTP is evaluated by testing the hypothesis that $\beta_1 = 1$.

All analyses are conducted using S-Plus 6.2 (Insightful Corporation, 2004) and Microsoft Excel.

1.3 Results

1.3.1 Descriptive Statistics

Table 4 presents the frequencies of response to the bid vectors across the surveys. The frequency of Yes responses decreases as the offered bid increases, and a $\chi 2$ test rejects the null hypothesis that responses do not systematically vary with bid amount.

Table 5 provides a summary of the demographic characteristics of the sample stratified by endpoint from the first valuation question from each individual survey, and for comparison purposes, data from the 2000 census. In general, the demographics from the surveys compare favorably to the demographics of the general population. For the EcoFirst survey, the sample shows a lower proportion of individuals with less than a high school education as compared to the general public, and a higher proportion of individuals with at least an associate's degree. When considering the error associated with these percentages, they still compare favorably, and it is not clear that more traditional survey methods (*e.g.,* direct mail and/or telephone) would have reached a higher proportion of this fraction of the population.

Table 6 provides a brief summary of potential covariates in the model, and provides means from the surveys, stratified by specific endpoint.

1.3.2 Models of WTP

Figures 3 and 4 present the visual goodness-of-fit plots across distribution types for the ecological and human health endpoints, respectively. Figures 5 and 6 show the WTP functions for the ecological and human health endpoints, respectively. Of the parametric model forms, the Weibull and lognormal assumptions provide the most explanatory power across distribution types, but are not statistically distinguishable. In addition, both parametric models lead to statistically indistinguishable coefficients for the covariates

across models; therefore, we present only the lognormal results as this distributional assumption has favorable properties in terms of the interpretation of the results.

Table 7 presents the results using the results of the single endpoint (ecological) questions from the EcoFirst survey. This table shows that the risk reduction coefficients are positive for the eagle and negative for SSD, although neither is statistically significant in Model 1, which includes all potential covariates of interest. Positive statistically significant predictors for the eagle as endpoint in Model 1 include motivational variables, such as concern about PCBs in the environment, belief that PCBs can cause reproductive effects to eagles, and the motivational factor scores. A different picture emerges for the SSD endpoint as shown in the next column of Table 7. In this case, the same motivational factors are statistically significant predictors, but the risk reduction coefficient is negative, and is closer to significance than the risk reduction coefficient for the eagle endpoint at p=0.17.

Model 2 was only run for the Eagle endpoint since the risk reduction coefficient for the SSD endpoint is negative, which violates economic theory and is difficult to interpret within a policy context. Model 2, which includes a stepwise deletion of all nonsignificant predictors, Table 7 shows that the "motivational" variables are more highly statistically significant than the single socioeconomic statistically significant predictor (dual income). The risk reduction coefficient is significant at the 0.10 significance level (p=0.08) eagle and is proportional, consistent with what classical macroeconomic theory would predict.

Table 8 presents the results of the pooled model for the first valuation question. EcoFirst indicates whether the endpoint was human or ecological. IQ indicates whether the specific human endpoint was IQ or reading comprehension (RC), while Eagle indicates whether the specific ecological endpoint was Eagle or the species sensitivity distribution (SSD). Each of the models includes the four risk reduction variables.

This first column in this table (the reduced model) shows that none of the risk reduction coefficients are statistically significant, and the coefficients for RC and SSD are actually negative. Although both the Eagle and IQ risk reduction coefficients are not statistically significant (p=0.7 and p=0.14), they are positive.

The second column shows the results for the model including all potential covariates. When including all potential covariates, the risk reduction coefficients remain insignificant but change in magnitude. In the reduced model, the risk reduction coefficient for IQ is nearly proportional but insignificant at p=0.14, while in the full model, it is less than proportional and insignificant at p=0.4. For the eagle risk reduction coefficient, the reduced model shows that it is much less than proportional and insignificant, while in the full model, it is nearly proportional but still insignificant (p= 0.17). Statistically significant predictors in the full model include predominantly motivational and attitudinal variables, including concern about PCBs in the environment, confidence in the stated WTP, concern about PCBs specifically with regard to exposure by children, and altruism as a motivating factor (only for the Y-N, N-Y, and Y-Y respondents).

Table 9 presents the results for the models using total WTP across all endpoints. This model pools the results from all three surveys (EcoFirst, HHFirst, and combined). The first column presents the reduced model using just the risk reduction variables and dummy variables indicating survey order and endpoint as predictors. The risk reduction coefficients show the same pattern as the models for individual endpoint WTP. Eagle and IQ are positive; while SSD and reading comprehension are negative. Only the SSD coefficient in the stepwise model is statistically significant (column 2 of Table 9).

In both the reduced and full models, the EcoFirst survey leads to higher total WTP. Those respondents who answered questions concerning ecological receptors first had approximately 80% higher WTP than the HHFirst survey respondents. IQ and Eagle as endpoints are associated with significantly higher WTP than SSD and RC. Statistically significant predictors in the full model (column 2) include the specific endpoint, age, and motivational variables such as concern about chemicals, and PCBs specifically, in the environment, concern about PCBs and children, and concern about the risks facing children. Significant predictors are related to child exposure rather than wildlife exposure.

The risk reduction coefficients are more stable for the combined (total) endpoint valuation shown in Table 9 than in the single endpoint valuation shown in Table 8. That is, the magnitude and potential significance of the risk reduction coefficients are very different across models in Table 8, and much less so in Table 9.

1.3.2.1 Median Household WTP

Median WTP per household is estimated from the regression models at the sample mean of the covariates. Median WTP is typically quite stable at the covariate means and is reasonable to estimate even if individual coefficients are not significant. We used the reduced models (*e.g.*, risk reduction variables, and dummy variables for survey type and endpoint) to estimate WTP. Table 10 and Figure 7 present these results. The letters on the x-axis in Figure 7 refer to the specific risk reductions and endpoints as shown in Table 10. For example, "A" refers to the total WTP across both the Eagle and reading comprehension endpoints from the EcoFirst survey, and the risk reduction 0.1 in both cases.

These results show that although the combined survey total WTP is higher than for the individual endpoints, the results are not statistically significant. In addition, there is very little difference between the total and individual endpoint median WTP from the individual surveys.

1.4 Discussion

These survey results show that when evaluated as a whole, WTP is not particularly sensitive to risk reduction across endpoints. Typically, this kind of insensitivity to scope is attributed to survey design and elicitation format (Bateman and Brouwer, 2006; Smith and Osbourne, 1996). Others have argued that respondents do not demonstrate well-

constructed preferences and therefore the CV method does not achieve the goals necessary to develop estimates of WTP consistent with standard economic welfare theory (Bateman and Brouwer, 2006). Both the IQ and eagle endpoints consistently demonstrate positive coefficients, suggesting that respondents understood the survey questions as presented to them, which makes the interpretation of the consistently negative coefficients for reading comprehension and SSD slightly more problematic (*e.g.,* it is difficult to argue that respondents were unable to understand what was presented to them, since they appear to demonstrate an understanding of two of the four endpoints).

As shown in Table 7 for the single ecological endpoint model from the EcoFirst survey and employing a stepwise backward selection method which removes the most insignificant variable until all remaining variables are significant the p=0.10 level results in a model for which the risk reduction coefficient for eagle is both proportional and statistically significant at p=0.09. On the one hand, both of these results suggest at scope sensitivity under some assumptions for eagle and IQ as endpoints. On the other hand, the instability of the risk reduction coefficients and the inconsistency across models and stratification variables highlights the tenuous nature of the sensitivity to scope and the obvious concern in using such results as justification for policy development or remedy selection.

Interestingly, there is a statistically significant difference in the self-expressed confidence that respondents had in their responses to bids. Table 11 shows that those respondents who answered Yes-Yes (*e.g.*, did not provide the highest bid amount they would be

willing to pay) had a statistically significant higher confidence in their responses than did the No-No or Yes-No/No-Yes respondents (Kruskal-Wallis $\chi 2$ $p<0.001$ across surveys) for total WTP. The No-No respondents had the lowest confidence in their results, and this difference was statistically significant.

We ran several stratified models as shown in Table 12 using the results for the single endpoint valuation question to evaluate differences in responses across the stratification variables. Stratifying the data on the basis of whether respondents were able to think about ecological endpoints separately from human health endpoints showed that for those respondents who indicated they were *not* able to think about ecological and human endpoints separately, the risk reduction coefficient for the IQ endpoint was positive and statistically significant in Model 1 (first valuation question). In a model of total WTP across both human and ecological endpoints (second valuation question), Model 3 shows that again, respondents who indicated they were not able to separately consider human and ecological endpoints showed positive and statistically significant risk reduction coefficients for both eagle and IQ. For those respondents who indicated they *were* able to think about the endpoints separately, the risk reduction coefficients were negative for RC and SSD across both the single endpoint model (Model 2) and the total endpoint model (Model 4). In that case, the negative coefficients for reading comprehension and SSD were statistically significant for the total valuation in Model 4. For Model 2, the single endpoint model, none of the risk reduction coefficients were statistically significant. Those respondents who admitted that it was difficult, if not impossible, to separately value human health and ecological outcomes had more consistent responses for two of

the endpoints, in terms of economic theory and *a priori* expectation than did those respondents who felt confident that they were able to separately evaluate the endpoints.

The results presented here lend themselves to several interpretations. On the one hand, the insensitivity to scope lends support to critics of the CV method that fundamental assumptions of economic welfare theory are violated. On the other hand, these surveys were designed to be exploratory, including four endpoints (two human, two ecological), two risk reductions per endpoint, many independent variables, and the generally unfamiliar nature of the survey (*e.g.,* potential risks associated with exposure to chemicals, with risks experienced by ecological receptors and babies). Given these constraints, the models are not designed to achieve the power necessary to be directly applicable in a policy context. Therefore, these results do not necessarily undermine the CV method, nor are they necessarily shortcomings of the survey itself. Rather, these results suggest ways in which the CV method might be refined in order to be successfully applied in a risk assessment context. Although two-thirds of respondents felt they were able to provide WTP estimates for human health and ecological endpoints individually, the analysis revealed poor performance.

One result of these surveys is that respondents were willing to pay an additional amount when asked about ecological effects first and human health effects second, but were not willing to pay an additional amount when asked about human health endpoints first and ecological endpoints second. This observed order effect across endpoint type is not particularly surprising. This result highlights the potential difficulties in asking

respondents about ecological effects, and the role of risk reductions to ecological receptors in situations in which there are benefits across receptor types.

The concept of risk remains a difficult one for individuals to grasp under any circumstances. In this case, respondents were asked to consider risks to ecological receptors (species-wide or specifically to eagles) or to children exposed *in utero*. In terms of the ecological receptors, respondents were not asked to consider extinction, which has a very explicit definition, but rather the more nebulous concept of population viability. Respondents were informed that species would have "trouble reproducing" as opposed to being in any particular danger of extinction.

Corso *et al*. (2001) tested several graphic forms for conveying risk reductions, and found that the form of the visual aid is a statistically significant predictor of WTP. In the case of the SSD, the visual aid we used (Figure 2-2) is difficult to understand, and likely presents too much information to the respondent. However, it is also possible that respondents did not find the larger risk reduction believable or plausible, in which case one would expect a smaller WTP for the larger risk reduction. Respondents may also have flat preference functions over the range of risk reductions evaluated, although in the case of SSD, the risk reductions are substantial. Another issue may be "metric bias" (Boyle *et al.,* 1994; Mitchell and Carson, 1989) which can arise when a respondent measures the risk reduction on a different scale than was intended by the researcher.

For those respondents who had a stated WTP (*e.g.,* Y-Y, Y-N, or N-Y), we asked them to rate on a scale of 1 to 5 (not important to extremely important) their motivation for agreeing to a particular bid. Across both the EcoFirst and HHFirst surveys, more than half the respondents with a positive WTP indicated that they supported a cleanup of the environment on principle. 53% of respondents rated seeing birds in general as extremely important as compared 32% who rated seeing eagles in particular as extremely important. More respondents for the SSD endpoint rated bequest value as extremely important than for the eagle endpoint (53% versus 45%). These results are shown in Table 13.

For those respondents who did not have a stated WTP (*e.g.,* N-N), we asked them why they didn't agree to any bid amount (Table 14). Respondents were also allowed an "open ended" response in which they could type in their thoughts as to why they did or didn't agree to any bid amount. In the EcoFirst survey, 46% (of 140 respondents) and 48% (of 86 respondents) chose to type in a response for the single and combined endpoints, respectively. Overwhelmingly, these responses indicated a level of distrust that the government would "spend the resources wisely." Some felt that the "one-time tax" referendum was merely a ruse and that the government would find other ways to keep the tax year after year. A typical (verbatim) open ended response was: "The government wants to do things only if we pay for it, this should be done and that's it. I think the government already receives enough revenue to do this clean up. They have plenty of money to go to war!!!!!!!!!!!!!" Several respondents indicated that the risk reduction that would be achieved was not enough to warrant the cost, while several others indicated that the predicted cost (per taxpayer) was too low and therefore it was not believable that the cleanup program would work. For human health effects, a number of respondents

indicated that because there were fish consumption advisories in place in their particular State, they felt the risks were lower than what had been portrayed in survey, although the survey clearly states that the risks are only to those individuals who consume fish. The implication was that since there are institutional controls in place, actual risks are lower.

There was considerable resistance on the part of the No-No respondents to various aspects of the payment, including resistance to the tax vehicle ("They need to learn to manage the insane amount of tax money we already pay now," "The money never goes to such things," "Business should pay," and so on). This suggests a potential bias arising from a framing effect (Kahneman *et al.,* 1999). This set of surveys utilized one payment vehicle (*e.g.,* a one-time increase in the State income tax), thus, it is not possible to test for the effect of the payment vehicle. However, the results suggest this is an issue for further exploration.

In addition to distrust of the government, approximately 70 of these open-ended responses suggested that the "companies responsible" should pay. A few individuals remarked that they would be willing to pay to reduce risks to humans but not to animals (this question, of course, having been asked prior to the questions related to WTP for developmental effects). Another factor is that costs are borne by all (*e.g.,* a one-time increase in the State income tax earmarked for a cleanup), but the developmental benefits are only experienced by those who are actually exposed (*e.g.,* consume freshwater fish), and the ecological benefits likely have very little direct relevance for most respondents.

A possible hypothesis for the negative association between risk reduction and WTP for the SSD endpoint might be that respondents are insensitive to the actual risk reduction because they support a cleanup irrespective of the actual risks. In a pooled model using the interval-censored bid amount for a single endpoint regressed against risk reduction, endpoint, and level of support for a cleanup (the original motivational variable prior to the factor analysis), the cleanup coefficient is positive and statistically significant, but none of the risk reduction coefficients were statistically significant.

Another hypothesis is that respondents did not find the larger risk reduction plausible. In this case, we would expect a smaller WTP for a larger risk reduction. Although we cannot directly test for whether respondents found the risk reduction plausible, we do have information on how significant respondents perceive the risk to be (one question is "do you believe PCBs can cause these kinds of effects?" and another question asks respondents to rate on a scale of one to four how serious the risks are facing ecological and human receptors), and these are included as predictors in the models. 35% of respondents felt that the risks facing wildlife were "very" or "extremely" serious, and 37% of respondents felt that the risks facing unborn babies were "very" or "extremely" serious. Most respondents felt that the risks were "somewhat" serious (38% for wildlife and 33% for unborn children).

There are several complicating factors specifically with regard to the assumptions inherent in utility maximization in this particular case. Risks to ecological receptors are, of course, risks not directly experienced by the respondents. The risk is framed in terms

of a risk to the reproductive capacity of the eagle population specifically or the avian population generally. The implication, although never directly stated, is that the *number* of eagles, or avian species overall, would likely decrease given these risks, but the absolute number of animals that could or would be affected is not given, consistent with the risk assessment format. There have been a number of other CV studies that have asked respondents directly about numbers of animals and these have led to the current controversy in the literature regarding insensitivity to scope.

Dubourg *et al*. (1997) found that stated preferences for road safety exhibited considerable imprecision and were insensitive to variations in the quantity and quality of the safety improvements offered to respondents. In that study, respondents were asked to value a *personal* safety, as opposed to the endpoints evaluated here. Those authors argue that assuming a precise preference structure is unrealistic, given that they were unable to elicit values even for a personal good, and using an instrument that had been shown to be robust and well-designed. Payne *et al.* (1999) argue that "preference measurement is best viewed as an architecture," rather than an elicitation of deeply-held values, and present a set of "building codes" to follow when designing surveys.

Respondents' environmental preference structures are not necessarily linked to biophysical needs (Limburg and Folke, 1999) and are likely lexicographic in that "some things are more important than others, and cannot be substituted for lower level wants or needs." (Farber *et al*., 2002). This means that respondents may only have a WTP for a reduction in risk to ecological endpoints insofar as higher-order preferences have already

been met. Existence, bequest, and option values are considered "services" that the ecosystem can provide, but these are likely to go largely unrecognized by respondents. That is, "the intrinsic values of natural system features and processes within the natural system itself may possess different abundance and functional value properties than their corresponding economic values." (Farber *et al.,* 2002).

These results may lend credence to the argument that WTP estimates obtained using CV are not consistent with economic theory and should not be used as the basis for policy development. We take a more circumspect view. The evidence that contingent valuation represents a reasonable approach continues to grow, particularly as more surveys are done, people become more familiar with the method, respondents become better survey-takers, and analysts develop more sophisticated modeling approaches to characterize the results. Further, denying the contingent valuation method, or having argument with its results, in no way changes the fact that there are ecosystem service flows that have economic benefit, and therefore value, which cannot (currently) be quantified in any other way (*e.g.,* particularly nonuse values such as existence, bequest, option), and therefore have significant implications for policy development. Those who would argue that costs (*e.g.,* of restoration) should form the basis of valuation fail to make the distinction between cost and value.

This is, to our knowledge, the first CV survey to pose valuation questions in a way that allows an explicit linkage to the results of a hypothetical risk assessment. In addition, rather than asking about a certain outcome, this set of surveys allowed for a risk that does

not go to zero. The closest survey of this kind was conducted under the Natural Resource Damage Assessment for the Montrose site in California (NRDA, 1994b) and elicited WTP for time to recovery for selected species. The time to recovery was given as a fixed number of years under different remedial scenarios. In our surveys, there is always a small reproductive risk associated with exposure to PCBs because it is acknowledged that the contaminated water body can never be completely remediated.

1.5 Conclusions

The results of the surveys show insensitivity to scope as demonstrated by statistically insignificant risk reduction coefficients across endpoints in the pooled models. There is some suggestion that eagle and IQ as endpoints fared better than reading comprehension and SSD, which actually showed a negative relationship between risk reduction and WTP, by developing individual models for single endpoints from each survey individually. For SSD, it is likely that the graphic used to convey the risk reduction was inadequately understood by respondents. However, that is not the case for reading comprehension which used the same graphic as eagle and IQ. Stratifying the combined endpoint total valuation model on the basis of whether respondents thought they could separately evaluate ecological and human health endpoints resulted in greater than proportional statistically significant risk reduction coefficients for eagle and IQ as endpoints for those respondents who admitted they were *not* able to separate the endpoints.

In developing environmental policies and deciding how to best allocate scarce resources, it is necessary to develop estimates for the benefits of risk reductions, and ideally these

estimates should be monetized to facilitate comparison to costs, for cost-effectiveness ratios, and to compare across disparate endpoints. For nonmarket "goods" such as existence and bequest value, or for morbidity endpoints for human health, stated preference methods are the primary tool for eliciting these values under the theoretical framework of utility maximization. However, respondents in these surveys are probably not revealing a structured set of preferences, as utility theory requires, but rather constructing their preferences in response to the questions being posed. Does that necessarily invalidate the results of CV surveys? What are the options? Much more needs to be done in this area, but using CV methods represents a reasonable approach to developing monetary estimates of benefits associated with management actions, particularly regarding risk reductions. Risk assessment is a process that is used in many contexts to determine the potential human health and ecological impacts of contaminants in the environment, including permitting and development of remedial alternatives. Therefore, it is important to explore methods that link risk assessment and economics in ways that benefit both disciplines and continue to conduct studies that further our understanding and basis for decisionmaking.

When CV surveys fail to show sensitivity to scope in whatever form, the first criticism is always imperfect questionnaire design, followed closely by invalidation of the method overall. Despite the results presented here, we are not inclined to argue either view. The basis for the questionnaire was reasonable and represents the situation at a number of sites across the United States. The risk reduction coefficients for two of the endpoints

(IQ and eagle) are positive, and under some assumptions and model forms, statistically significant.

The number of risk reductions, endpoints, and randomization lead to small sample sizes for any given survey (approximately 200). These sample sizes are too small to have much power. However, they provide an initial evaluation into the question of benefits associated with potential risk reductions, and in particular, ecological benefits, which tend not to be quantified let alone monetized and yet which may represent a significant proportion of the overall benefit of management actions taken to mitigate or manage environmental contamination.

Successful integration of analyses across disciplines requires attention to the form of the outputs from each analysis. The goal of this effort was to explore one possible method for integration, namely, eliciting WTP for a particular set of risk reductions. It may be that the risk reductions need to be translated into a set of benefits that are less cognitively burdensome to survey respondents. For example, instead of asking about a probability of an impact to a percentage of species (as in the species sensitivity distribution approach), it may make more sense to translate the difference in risks across alternatives to a difference in the fraction of species affected. On the other hand, although the listerature suggests it is difficult for most people, even "technical" people, to work with probabilities, there is a very real and, in some ways, misleading difference between describing a probability of an effect (which never actually goes to zero) and the certainty of a small effect (*e.g.,* a certain difference in the fraction of species affected). In

addition, there are cognitive issues associated with probabilities and frequencies (Gigerenzer, 2002), although individuals don't seem to have a problem reading the odds for sports teams or playing such games as *Deal or No Deal*, a current television program popular with many Americans. In the environmental context, engaging people through surveys of this kind, publications, and the media moves the dialogue forward and is a continuing source of education to people about the potential impacts of chemicals in the environment and the allocation of scarce resources for the purpose of directing environmental policy.

The results presented here also highlight the importance of obtaining and evaluating behavioral and motivational variables when developing CV models. Virtually none of the socioeconomic variables were statistically significant in the regression models, but the behavioral and motivational variables were highly statistically significant predictors of WTP. Other studies have shown that these variables can account for a lack of sensitivity to scope (*e.g.,* Nunes and Schokkaert, 2003; Heberlein *et al.,* 2005). Further cross-disciplinary efforts between survey researchers, behaviorists, and economics will increase our understanding of what motivates people to make the tradeoffs for potentially unfamiliar goods that we ask them to make through these surveys.

The limitations discussed in each of the papers highlights the difficulties of developing CV surveys and interpreting the results. However, limitations of the method in no way deny the fact that there are nonuse benefits associated with particular ecosystem service flows, and that these benefits have a value. The only question is, how can the methods

for eliciting these values be improved, and are there other economic paradigms (e.g., "steady-state" versus "consumption and growth") that will lead to other theoretical constructs suitable for developing environmental policies.

1.6 References

ATSDR (Agency for Toxic Substances and Disease Registry). 2000. Toxicological profile for polychlorinated biphenyls (PCBs). US Department of Health and Human Services, Public Health Service. Prepared by Syracuse Research Corporation, November.

Alberini, A. 1995a. Optimal designs for discrete choice contingent valuation surveys: single-bound, double-bound, and bivariate models. *Journal of Environmental Economics and Management* 28:287-306.

Alberini, A. 1995b. Efficiency vs bias of willingness-to-pay estimates: Bivariate and interval data models. *Journal of Environmental Economics and Management* 29:169-180.

Alberini, A. 1995c. Testing willingness-to-pay models of discrete choice contingent valuation survey data. *Land Economics* 71(1):83-95.

Arrow, K., R. Solow, P. Portney, E. Leamer, R. Radner and H. Schuman. 1993. Report of the NOAA Panel on contingent valuation. *Federal Register 58*:4601-4614.

Bateman, I.J. and K.G. Willis, Eds. 1999. Valuing environmental preferences: Theory and practice of the contingent valuation method in the US, EU, and developing countries. New York: Oxford University Press. 645 pp.

Bateman, I.J. and R. Brouwer. 2006. Consistency and construction in stated WTP for health risk reductions: A novel scope-sensitivity test. *Resource and Energy Economics* 28:199-214.

Berrens, R., A. Bohara, H. Jenkins-Smith, C. Sliva and D. Weimer. 2003. The advent of Internet surveys for political research: A comparison of telephone and Internet samples. *Political Analysis* 11(1):1-22.

Boyle, K.J., W.H. Desvousges, F.R. Johnson, R.W. Dunford and S.P. Hudson. 1994. An investigation of part-whole biases in contingent-valuation studies. *Journal of Environmental Economics and Management* 27:64-83.

Carson, R.T. and R.C. Mitchell. 1995. Sequencing and nesting in contingent valuation surveys. *Journal of Environmental Economics and Management* 28:155-173.

Carson, R.T., R.C. Mitchell, M. Hanemann, R.J. Kopp, S. Presser and P.A. Ruud. 2003. Contingent valuation and lost passive use: Damages from the Exxon Valdez oil spill. *Environmental and Resource Economics* 25:257-286.

Corso, P.S., J.K. Hammitt and J.D. Graham. 2001. Valuing mortality-risk reduction: Using visual aids to improve the validity of contingent valuation. *Journal of Risk and Uncertainty* 23:165-184.

Couper, M.P. 2001. Web surveys: the questionnaire design challenge. Proceedings of the 53rd session of the ISI. Retrieved February 14, 2002 from http://134.75.100.178/isi2001/

Diamond, P. 1996. Testing the internal consistency of contingent valuation surveys. *Journal of Environmental Economics and Management* 30:337-347.

Dubourg, W.R., M.W. Jones-Lee and G. Loomes. 1997. Imprecise preferences and survey design in contingent valuation. *Economica* 64:681-702.

EPA-RAF (United States Environmental Protection Agency, Risk Assessment Forum). 1998. Guidelines for ecological risk assessment. EPA/630/R-95/002F. April.

EPA *et al.* (United States Environmental Protection Agency, Government of Canada, American Chemistry Council, International Council on Metals and the Environment, Society for Risk Analysis, Resources for the Future, The Proctor and Gamble Company and the Organization for Economic Cooperation and Development (OECD)). 2000. Proceedings of the Workshop on the Convergence of Risk Assessment and Socioeconomic Analysis to Better Inform Chemical Risk Management Decisions. Workshop organized May 1-2, 2000, in Arlington, VA. http://www.riskworld.com/Nreports/2000/RA-EAWorkshopMay2000.pdf

EPA-SAB (United States Environmental Protection Agency, Science Advisory Board). 2000. Toward integrated environmental decision-making. EPA-SAB-ED-00-011, August 2000. www.epa.gov/sab.

EPA (United States Environmental Protection Agency). 2000b. Further Site Characterization and Analysis, Volume 2E - Revised Baseline Ecological Risk Assessment (ERA), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by Menzie-Cura & Associates, Inc. and TAMS Consultants, Inc., www.epa.gov/hudson "reassessment reports".

Farber, S.C., R. Costanza, and M.A. Wilson. Economic and ecological concepts for valuing ecosystem services. *Ecological Economics* 41:375-392.

Gigerenzer, G. 2002. How to know when the numbers deceive you: calculated risks. New York: Simon and Schuster, 310 pp.

Hammitt, J.K. and J.D. Graham. 1999. Willingness to pay for health protection: inadequate sensitivity to probability? *Journal of Risk and Uncertainty* 18:33-62.

Hanemann, W.M. 1991. Willingness to pay and willingness to accept: How much can they differ? *American Economic Review* 81(3): 635-647.

Hanemann, W.M., J.B. Loomis and B.J. Kanninen. 1991. Statistical efficiency of double-bounded dichotomous choice contingent valuation. *Am J Ag Ec* 73:(4)1255-1263.

Hanemann, W.M. and B. Kanninen. 2001. Statistical analysis of discrete-response CV data. In *Valuing Environmental Preferences*, Bateman, I.J. and K.G. Willis, Eds. New York: Oxford University Press.

Heberlein, T.A., M.A. Wilson, R.C. Bishop and N.C. Shaeffer. 2005. Rethinking the scope test as a criterion for validity in contingent valuation. *Journal of Environmental Economics and Management* 50:1-22.

Jacobson, J.L. and S.W. Jacobson. 2002b. Association of prenatal exposure to an environmental contaminant with intellectual function in childhood. *Clinical Toxicology* 40(4):467-475.

Jacobson, J.L., J. Janisse, M. Banerjee, J. Jester, S.W. Jacobson and J.W. Ager. 2002. A benchmark dose analysis of prenatal exposure to polychlorinated biphenyls. *Environ Health Perspect* 110(4):393-398.

Kahneman, D., I. Ritov and D. Schkade. 1999. Economic preferences or attitude expressions?: An analysis of dollar responses to public issues. *Journal of Risk and Uncertainty* 19(1-3):203-235.

Krotki, K. and M.J. Dennis. 2001. Probability-based Survey Research on the Internet. Presented at the August 2001 Conference of the International Statistical Institute.

Levin, E.D., S.L. Schantz and R.E. Bowman. 1988. Delayed spatial alternation deficits resulting from perinatal PCB exposure in monkeys. *Arch Toxicol* 62: 267-273.

Limburg, K.E. and C. Folke. 1999. The ecology of ecosystem services: introduction to the special issue. *Ecological Economics* 29:179-182.

Loomis, J.B. and D.S. White. 1996. Economic benefits of rare and endangered species: summary and meta-analysis. *Ecological Economics* 18:197-206.

McFadden, D. and G. Leonard. 1993. Issues in the contingent valuation of environmental goods: methodologies for data collection and analysis, In Hausman, J.A. Ed. *Contingent Valuation: A Critical Assessment*. New York: North-Holland, 165-215.

Mitchell, R. C. and R.T. Carson. 1989. *Using Surveys to Value Public Goods: The Contingent Valuation Metho*d, Resources for the Future, Washington, D.C.

NRDA (Natural Resource Damage Assessment, Inc.). 1994b. *Prospective interim lost use value due to DDT and PCB contamination in the Southern California bight*. Prepared for the National Oceanographic and Atmospheric Administration.

Nunes, P.A.L.D. and E. Schokkaert. 2003. Identifying the warm glow effect in contingent valuation. *Journal of Environmental Economics and Management* 45:231-245.

Payne, D., J.R. Bettman and D.A. Schkade. 1999. Measuring constructed preferences: Towards a building code. *Journal of Risk and Uncertainty* 19(1-3):243-270.

Schantz, S.L., E.D. Levin, R.E. Bowman. 1989. Effects of perinatal PCB exposure on discrimination-reversal learning in monkeys. *Neurotoxicol Teratol* 11: 243-250.

Schantz, S.L., E.D. Levin and R.E. Bowman. 1991. Long-term neurobehavioral effects of perinatal polychlorinated biphenyl (PCB) exposure in monkeys. *Environ Toxicol Chem* 10: 747-756.

Schantz, S.L., J.J. Widholm and D.C. Rice. 2003. Effects of PCB exposure on neuropsychological function in children. *Environ Health Perspect* 111(3):357-376.

Schwartz, J. 1994. Societal benefits of reducing lead exposure. *Environmental Research* 66:105-124.

Schwartz, J., H. Pitcher, R. Levin, B. Ostro and A.L. Nicholas. 1985. *Cost and Benefits of Reducing Lead in Gasoline: Final Regulatory Impact Analysis*. Washington, D.C.: Office of Policy Analysis, Environmental Protection Agency.

Smith, V. K. and L.L. Osborne. 1996. Do contingent valuation estimates pass a "scope" test? A meta-analysis. *Journal of Environmental Economics and Management* 31: 287-301.

Van Houtven, G., M. Rousu, J-C. Yang, C. Pringle, W. Wagstaff and J. DePlatchett. 2003. Valuation of morbidity losses: Meta-analysis of willingness-to-pay and health status measures. Final Report, Prepared for the Food and Drug Administration by Research Triangle Institute.

TABLES

TABLE 1: Initial Bid Vectors and Followup Bids for the CV Surveys

	Bid vectors based on final response in first section and are given as initial bid, upper, lower:			
Initial Bid	Y-Y[1]	Y-N[1]	N-Y[1]	N-N
$25	C ($100, $200, $50)	B ($50, $100, $25)	A ($25, $50, $10)	random
$50	D ($200, $400, $100)	C ($100, $200, $50)	B ($50, $100, $25)	random
$100	E ($400, $800, $200)	D ($200, $400, $100)	C ($100, $200, $50)	random
$200	F ($800, $1000, $400)	E ($400, $800, $200)	D ($200, $400, $100)	random
$400	G ($1000, $1500, $800)	F ($800, $1000, $400)	E ($400, $800, $200)	random
$800	H ($2000, $1500, $800)	G ($1000, $1500, $800)	F ($800, $1000, $400)	random

Notes:
1 – It is possible, in the followup, to respond “no” to a value for the total that had already been agreed to in the previous section. In that case, respondents are shown the following prompt: “You already agreed you'd be willing to pay this amount for ecological benefits alone. Now we’re asking about the total you’d be willing to pay”

TABLE 2: Risk Reductions in the Surveys

Endpoint	Context	Small Risk Reduction	Large Risk Reduction
Eagle	Probability of reproductive impairment significant enough to affect viability of the population	10 in 100	15 in 100
Species Sensitivity Distribution (SSD)	Probability of reproductive significant reproductive effects to 20% of all avian species in a freshwater ecosystem	25 in 100	40 in 100
Reading Comprehension	Probability of reading at approximately 7 months below grade level	10 in 100	15 in 100
IQ	Probability of a 6-point reduction in IQ	10 in 100	15 in 100

TABLE 3: Factor Analysis for the Motivational Responses (N-Y, Y-N, Y-Y)

	EcoFirst and HHFirst pooled (n=808)				All data pooled (n=1003)			
	Factor 1	Factor 2	Factor 3	Factor 3	Factor 1	Factor 2	Factor 3	Factor 4
Question	Loading	Loading		Loading	Loading	Loading	Loading	Loading
Altruism	**0.83**	0.21	0.14	0.24	**0.84**	0.22	0.13	0.21
Bequest	**0.76**	0.18	0.19	0.28	**0.76**	0.18	0.16	0.27
Nonuse	**0.78**	0.30	0.21	0.26	**0.80**	0.3	0.17	0.23
Use	0.47	0.13	0.15	**0.83**	0.52	0.11	0.14	**0.73**
Option	0.30	0.28		**0.38**	0.33	0.27		**0.40**
Eco Cleanup	0.31	**0.84**	0.18	0.18	0.29	**0.87**	0.13	0.17
My Child			0.37				0.36	
HH Altruism	0.12	0.18	**0.82**		0.13	0.23	**0.82**	
HH Cleanup	0.20	**0.49**	0.47		0.21	**0.60**	0.38	
Proportion of Variance:	26%	40%	53%	65%	28%	43%	55%	65%
	$\chi 2$=5.6, df=6, p= 0.46				$\chi 2$=10.4, df=6, p =0.11			

Rate on a scale of 1 to 5 where 1 is not important and 5 is very important

TABLE 4: Proportion of Respondents in Each Bid Interval for the Ecological Endpoints

ECOFIRST SINGLE	**EAGLE (n=193)**					**SSD (n=210)**				
Bid Amount	n	Y-Y	Y-N	N-Y	N-N	n	Y-Y	Y-N	N-Y	N-N
A ($25, $50, $10)	36	12%	3%	3%	1%	37	11%	1%	1%	4%
B ($50, $100, $25)	38	10%	3%	3%	4%	36	9%	4%	1%	3%
C ($100, $200, $50)	22	2%	7%	1%	2%	30	3%	4%	1%	6%
D ($200, $400, $100)	32	5%	6%	2%	5%	34	3%	6%	1%	6%
E ($400, $800, $200)	33	2%	4%	3%	9%	39	4%	5%	2%	8%
F ($800, $1000, $400)	32	3%	4%	2%	8%	34	4%	1%	2%	9%

HHFIRST TOTAL	**Eagle (n=211)**					**SSD (n=191)**				
Bid Amount	n	Y-Y	Y-N	N-Y	N-N	n	Y-Y	Y-N	N-Y	N-N
A ($25, $50, $10)	11	1%	2%	0%	1%	12	1%	2%	1%	3%
B ($50, $100, $25)	20	1%	1%	3%	4%	23	2%	3%	3%	5%
C ($100, $200, $50)	50	5%	5%	9%	6%	44	6%	5%	8%	4%
D ($200, $400, $100)	39	3%	2%	7%	7%	27	2%	3%	4%	5%
E ($400, $800, $200)	30	1%	3%	5%	5%	33	1%	3%	8%	7%
F ($800, $1000, $400	37	2%	1%	9%	7%	29	2%	3%	5%	6%
G ($1000, $1500, $800)	12	2%	1%	2%	1%	10	1%	2%	1%	1%
H ($1500, $2000, $1000)	7	2%	0%	1%	0%	8	3%	0%	1%	0%

TABLE 2-4: Proportion of Respondents in Each Bid Interval for Human Health Endpoints

HHFIRST -- Single Endpoint	**IQ (n=208)**					**RC (n=196)**				
Bid Amount	n	Y-Y	Y-N	N-Y	N-N	n	Y-Y	Y-N	N-Y	N-N
A ($25, $50, $10)	35	11%	3%	0%	3%	35	12%	2%	1%	4%
B ($50, $100, $25)	36	8%	4%	1%	5%	32	7%	5%	4%	2%
C ($100, $200, $50)	27	3%	3%	2%	5%	21	3%	1%	2%	3%
D ($200, $400, $100)	30	4%	3%	2%	4%	33	4%	4%	2%	7%
E ($400, $800, $200)	41	2%	5%	4%	8%	40	4%	5%	2%	10%
F ($800, $1000, $400)	33	4%	1%	1%	9%	32	3%	4%	2%	7%

ECOFIRST -- Total Bid for Both Endpoints	**IQ (n=194)**					**RC (n=208)**				
Bid Amount	n	Y-Y	Y-N	N-Y	N-N	n	Y-Y	Y-N	N-Y	N-N
A ($25, $50, $10)	11	0%	2%	2%	2%	14	2%	0%	1%	3%
B ($50, $100, $25)	16	2%	3%	2%	3%	18	1%	3%	2%	2%
C ($100, $200, $50)	37	11%	5%	6%	3%	47	10%	5%	5%	3%
D ($200, $400, $100)	47	6%	8%	7%	4%	39	3%	8%	6%	2%
E ($400, $800, $200)	30	0%	7%	5%	4%	31	3%	2%	4%	5%
F ($800, $1000, $400	32	3%	1%	6%	8%	32	5%	1%	6%	3%
G ($1000, $1500, $800)	10	2%	2%	2%	0%	11	1%	1%	3%	0%
H ($1500, $2000, $1000)	5	2%	0%	1%	0%	9	3%	0%	1%	0%

TABLE 2-4, continued: Proportion of Respondents in Each Bid Interval for the Combined Survey

COMBINED	**Combined (n=204)**				
Bid Amount	n	Y-Y	Y-N	N-Y	N-N
A ($25, $50, $10)	37	11%	4%	0%	3%
B ($50, $100, $25)	41	9%	6%	0%	5%
C ($100, $200, $50)	23	4%	2%	1%	4%
D ($200, $400, $100)	34	5%	4%	2%	5%
E ($400, $800, $200)	35	2%	5%	1%	9%
F ($800, $1000, $400)	29	3%	3%	0%	8%

TABLE 5: Demographics for Each Subsurvey and the US Census

	ECOFIRST		HUMANFIRST		COMBINED	
Demographic	Eagle (n=193)	SSD (n=210)	RC (n=196)	IQ (n=208)	Combined (n=204)	US Census Data[1]
Some high school, no diploma	7%	8%	19%	11%	16%	20%
High school	29%	30%	29%	35%	32%	29%
Some college, no degree	23%	20%	21%	24%	21%	21%
Associate's degree (AA, AS)	15%	12%	7%	5%	6%	6%
Bachelor's degree	17%	19%	16%	19%	14%	16%
Master's degree	4%	7%	7%	5%	9%	6%
Other	5%	4%	2%	2%	1%	3%
Black, Non-Hispanic	10%	12%	12%	15%	12%	12%
Hispanic	9%	15%	17%	9%	11%	13%
Other, Non-Hispanic	5%	5%	4%	4%	5%	0%
White, Non-Hispanic	76%	68%	67%	72%	72%	75%
Female	57%	50%	48%	51%	52%	51%
Male	43%	50%	52%	49%	48%	49%
Income						
Less than $10,000	12%	10%	12%	13%	13%	10%
$10,000 to $14,999	11%	5%	9%	8%	4%	6%
$15,000 to $19,999	5%	4%	5%	4%	8%	6%
$20,000 to $24,999	8%	10%	6%	8%	5%	7%
$25,000 to $29,999	8%	7%	10%	6%	5%	6%
$30,000 to $34,999	7%	7%	5%	4%	8%	6%
$35,000 to $39,999	4%	10%	10%	10%	9%	6%
$40,000 to $49,999	9%	11%	10%	6%	15%	11%
$50,000 to $59,999	10%	9%	7%	13%	7%	9%
$60,000 to $74,999	10%	9%	8%	12%	12%	10%
$75,000 to $99,999	11%	9%	12%	6%	7%	10%
$100,000 to $124,999	2%	3%	5%	5%	5%	5%
$125,000 to $149,999	1%	2%	1%	1%	2%	3%
$150,000 to $174,999	1%	1%	1%	0%	2%	2%
$175,000 or more	2%	2%	2%	0%	1%	2%
Divorced	12%	15%	13%	20%	14%	10%
Married	52%	50%	48%	46%	52%	54%
Separated	2%	2%	3%	4%	1%	2%
Single (never married)	26%	28%	28%	26%	29%	27%
Widowed	7%	5%	7%	4%	3%	7%

1: Data provided for males and females combined (except gender); therefore, percentages may not equal 100 due to combining. Data from: factfinder.census.gov, 2000 Census

TABLE 6: Means for the Covariates across Surveys

		Eagle (n=193)	SSD (n=210)	IQ (n=208)	RC (n=196)	Combined (n=204)
		ECOFIRST		HHFIRST		COMBINED
Parameter	Parameter Name	Mean	Mean	Mean	Mean	Mean
Education (1 for college and above, 0 otherwise)	EDUCAT	0.53	0.61	0.55	0.53	0.50
White (1 for yes, 0 otherwise)	WHITE	0.76	0.68	0.72	0.67	0.71
Black (1 for yes, 0 otherwise)	BLACK	0.09	0.12	0.15	0.12	0.22
Hispanic (1 for yes, 0 otherwise)	HISPANIC	0.09	0.15	0.09	0.17	0.14
Gender (1 if Female, 0 if Male)	MALE	0.57	0.50	0.52	0.48	0.52
Natural log of income	LNInc	10.36	10.46	10.41	10.41	10.38
Married (1 if yes, 0 otherwise)	MARRIED	0.52	0.50	0.46	0.48	0.52
Live in a metropolitan area (1 if yes, 0 if no)	METRO	0.83	0.82	0.83	0.84	0.79
Natural log of ecological risk reduction	LNEcoRR	-2.09	-1.17	-1.67	-1.60	-2.11
Natural log of human health risk reduction	HHLNRR	-2.09	-2.09	-2.09	-2.09	-2.09
Have you ever heard of PCBs (1 if yes, 0 otherwise)	PCBs	0.48	0.50	0.45	0.43	0.41
Confidence in response to single endpoint valuation (scale of 1 to 5 where 1 is not confident and 5 is very confident)	ConfWildlife	4.39	4.16	3.70	3.62	na
Confidence in total	ConfTotal	4.55	4.06	3.67	3.60	3.31
Are you able to think about ecological endpoints separately from human (1 if yes, 0 if no)	eco.sep	0.78	0.72	0.71	0.77	na
Are you able to think about ecological benefits separately from human health benefits? (1 if yes, 0 otherwise)	eco.ben.sep	0.62	0.63	0.62	0.64	na
Concerned about chemicals in the environment (1 if yes, 0 otherwise)	ChemConcern	3.12	2.96	3.04	2.89	3.03

TABLE 6: Means for the Covariates across Surveys

Concerned about PCBs in the environment (1 if yes, 0 otherwise)	PCBConcern	2.96	2.77	2.69	2.62	2.87
Do you believe PCBs can cause reproductive effects in wildlife? (1 if yes, 0 otherwise)	PCBWildlife	0.66	0.59	0.59	0.60	0.60
Do you believe PCBs can cause developmental effects in children exposed *in utero* ? (1 if yes, 0 otherwise)	PCBChild	0.61	0.54	0.65	0.60	0.59
Rate the risks facing eagles in this state (0 = not sure, 1 = not serious, 2 = somewhat serious, 3 = very serious, 4 = extremely serious)	risk.wldlf	2.14	2.04	1.94	1.94	2.08
Rate the risks facing unborn babies in this state (0 = not sure, 1 = not serious, 2 = somewhat serious, 3 = very serious, 4 = extremely serious)	risk.baby	2.22	2.01	2.17	2.11	2.16
How often do you watch programs on television about wildlife (1 = never, 2 = rarely, 3 = sometimes, 4 = often)	tv.wldlf	2.99	2.91	2.75	3.03	2.90
Do you live near freshwater (1 = yes, 0 = no)	live.fw	0.69	0.64	0.60	0.60	0.66
How much time do you spend on a river, lake, or stream? (1 = never, 2 = rarely, 3 = sometimes, 4 = often)	time.fw	2.60	2.65	2.49	2.61	2.62
How often do you eat recreationally caught fish (0 = never, 1 = a few times a year, 2 = a few times a month, 3 = a few times a week)	eat.fish	2.50	2.53	2.51	2.47	2.57
How much confidence do you have in information you receive from government sources (1 = none, 2 = some, 3 = a lot)	conf.gov	1.85	1.78	1.93	1.85	1.85

TABLE 6: Means for the Covariates across Surveys

How much confidence do you have in information you receive from industry scientists (1 = none, 2 = some, 3 = a lot)	conf.sci.ind	1.88	1.82	1.85	1.81	1.86
How much confidence do you have in information you receive from university scientists (1 = none, 2 = some, 3 = a lot)	conf.sci.univ	2.25	2.27	2.21	2.20	2.31
How much confidence do you have in information you receive from television sources (1 = none, 2 = some, 3 = a lot)	conf.tv	1.70	1.68	1.72	1.70	1.71
How much confidence do you have in information you receive from government web sites (1 = none, 2 = some, 3 = a lot)	conf.gov.web	1.87	1.78	1.87	1.83	1.81
How much confidence do you have in information you receive from commercial web sites (1 = none, 2 = some, 3 = a lot)	conf.comm.web	1.69	1.62	1.61	1.59	1.65
How much confidence do you have in information you receive from nonprofit web sites (1 = none, 2 = some, 3 = a lot)	conf.np.web	2.10	2.09	2.04	2.02	2.05
How much confidence do you have in information you receive from university web sites (1 = none, 2 = some, 3 = a lot)	conf.uni.web	2.21	2.20	2.12	2.06	2.15
How much confidence do you have in information you receive from print media (1 = none, 2 = some, 3 = a lot)	conf.print	1.86	1.88	1.84	1.81	1.88

TABLE 7: Model Results for Ecological Endpoints in EcoFirst Survey

	Model 1 All Covariates for the Eagle Endpoint β (std error)	Model 2 All Covariates for the SSD Endpoint β (std error)	Model 3 Stepwise Model for the Eagle Endpoint β (std error)
Intercept	1.6 (2.2)	-0.5 (2.7)	2.6 (1.4)*
Risk Reduction	0.9 (0.7)	-0.9 (0.7)	1.0 (0.6)*
Age	-0.002 (0.009)	-0.005 (0.01)	
Dual Income Household	0.4 (0.3)	0.4 (0.3)	0.5 (0.2)*
Education	-0.2 (0.3)	0.6 (0.4)*	
Race (reference = White)			
Other	0.7 (0.6)	0.06 (0.7)	
Black	0.06 (0.5)	-0.8 (0.5)	
Hispanic	0.9 (0.5)*	0.5 (0.4)	
Male	0.07 (0.3)	-0.06 (0.3)	
Confidence	0.4 (0.1)***	0.5 (0.2)**	0.3 (0.1)**
Married	-0.1 (0.3)	-0.04 (0.4)	
Live in a metro area	0.5 (0.4)	0.1 (0.4)	
Concerned about PCBs	0.7 (0.2)****	1.2 (0.3)****	0.8 (0.1)****
Watch television on wildlife	0.2 (0.2)	0.3 (0.2)*	0.3 (0.1)**
Live near freshwater	0.2 (0.3)	-0.5 (0.4)	
Spend time near freshwater	0.1 (0.1)	-0.1 (0.2)	
Nonuse	-0.4 (0.1)***	-0.2 (0.2)	-0.4 (0.1)***
Use/Option	0.2 (0.1)*	-0.02 (0.2)	0.2 (0.1)*
Cleanup	-0.2 (0.2)	-0.1 (0.2)	
-2*Log-Likelihood	462	472	470
	n=192	n=208	n=193
* p<0.10, ** p<0.05, *** p<0.01, **** p<0.001			

Dependent variable is interval-censored WTP for a single endpoint

TABLE 8: Model Results Using Pooled Dataset
for the Single Endpoint Valuation Question[1]

	Model 1 Reduced Model β (std error)	Model 2 Full Model β (std error)
Intercept	4.6 (1.6)***	-0.03 (1.6)
EcoFirst	0.4 (2.5)	1.9 (2.4)
IQ	2.6 (2.2)	1.5 (2.1)
Eagle	-0.0009 (0.3)	-0.4 (0.3)
Eagle Risk Reduction	0.2 (0.8)	1.0 (0.7)
SSD Risk Reduction	-0.4 (0.6)	-0.7 (0.6)
IQ Risk Reduction	1.1 (0.7)*	0.5 (0.7)
Reading Comprehension Risk Reduction	-0.1 (0.7)	-0.2 (0.7)
Age		-0.004 (0.005)
Education		0.2 (0.2)
Race (ref = White)		
Other		0.5 (0.4)
Black		0.03 (0.2)
Hispanic		0.4 (0.2)*
Income		0.04 (0.2)
Married		0.07 (0.2)
Live in a metropolitan area		0.2 (0.2)
Heard of PCBs?		-0.4 (0.2)**
QALY		0.1 (0.04)****
Confidence		0.3 (0.08)****
Concerned about PCBs Generally		0.7 (0.2)****
Concerned about Chemicals Generally		0.2 (0.1)*
Concerned about PCBs and Wildlife		0.07 (0.2)
Concerned about PCBs and Children		0.6 (0.2)***
Risks to wildlife		0.09 (0.1)
Risks to babies		0.09 (0.1)
Watch TV programs about wildlife		0.06 (0.09)
Live near freshwater		-0.03 (0.2)
Spend time at freshwater		-0.004 (0.08)
Consume self-caught freshwater fish		-0.01 (0.09)
Nonuse		-0.2 (0.08)***
Cleanup		-0.02 (0.08)
HH altruism		-0.3 (0.09)****
Use/Option		-0.04 (0.08)
-2*Log-Likelihood	2127	1833
	n=808	n=791
* p<0.10, ** p<0.05, *** p<0.01, **** p<0.001		

TABLE 9: Model Results using Pooled Data for Total WTP (HH and Eco Endpoints)[1]

	Model 1 Reduced Model β (std error)	Model 2 Full Model β (std error)
Intercept	2.9 (0.9)***	0.08 (0.9)
Combined (no single endpoint)	-0.2 (0.2)	0.02 (0.2)
EcoFirst	0.4 (0.1)****	0.4 (0.1)***
IQ	2.6 (1.3)**	2.5 (1.3)**
Eagle	1.4 (0.9)	1.7 (0.9)*
Eagle Risk Reduction	0.3 (0.4)	0.4 (0.4)
SSD Risk Reduction	-0.6 (0.4)	-0.7 (0.5)*
IQ Risk Reduction	0.7 (0.5)	0.7 (0.5)
Reading Comprehension Risk Reduction	-0.6 (0.4)	-0.6 (0.4)
Age		-0.009 (0.004)**
Education		0.08 (0.1)
Race (ref = White)		
Other		-0.2 (0.3)
Black		0.05 (0.2)
Hispanic		0.2 (0.2)
Income		0.02 (0.1)
Married		-0.03 (0.1)
Live in a metropolitan area		-0.02 (0.2)
Heard of PCBs		-0.2 (0.1)
Concerned about PCBs Generally		0.4 (0.1)****
Concerned about Chemicals Generally		0.3 (0.1)**
Concerned about PCBs and Wildlife		0.1 (0.2)
Concerned about PCBs and Children		0.5 (0.2)***
Risks facing wildlife		0.07 (0.08)
Risks facing babies		0.1 (0.07)**
Watch TV programs about wildlife		0.08 (0.07)
Live near freshwater		0.01 (0.1)
Spend time at freshwater		0.03 (0.07)
Consume self-caught freshwater fish		0.06 (0.08)
Nonuse		0.1 (0.07)
Cleanup		-0.04 (0.06)
HH altruism		0.03 (0.07)
Use/Option		0.02 (0.07)
-2*Log-Likelihood	3222	2952
	n=1003	n=992
* p<0.10, ** p<0.05, *** p<0.01, **** p<0.001		

1 - Dependent variable is interval-censored WTP for both endpoints (total WTP)

TABLE 10: Risk Reduction and Median WTP at Covariate Means Across Models

Model	Reading Comprehension Risk Reduction	Eagle Risk Reduction	WTP Median Prediction	WTP 95% LCL	WTP 95% UCL	Survey Identifier
Ecofirst -- Both Endpoints	0.10	0.10	$ 276	$ 198	$ 387	A
(n=403)	0.10	0.15	$ 241	$ 173	$ 336	B
	0.15	0.10	$ 263	$ 188	$ 368	C
	0.15	0.15	$ 229	$ 166	$ 317	D
Humanfirst -- Both Endpoints	0.10	0.10	$ 180	$ 128	$ 252	E
(n=404)	0.15	0.10	$ 171	$ 122	$ 240	F
	0.10	0.15	$ 157	$ 113	$ 218	G
	0.15	0.15	$ 149	$ 108	$ 206	H
Combined	0.10	0.10	$ 115	$ 64	$ 206	I
(n=204)	0.10	0.15	$ 150	$ 83	$ 270	J
	0.15	0.10	$ 127	$ 74	$ 218	K
	0.15	0.15	$ 165	$ 93	$ 295	L
Ecofirst -- Single Endpoint	na	0.10	$ 150	$ 114	$ 197	M
(Eagle; n=193)	na	0.15	$ 163	$ 128	$ 209	N
Humanfirst -- Single Endpoint	0.10	na	$ 118	$ 96	$ 146	O
(RC; n=204)	0.15	na	$ 146	$ 116	$ 184	P
Humanfirst -- Single Endpoint	0.10	na	$ 125	$ 85	$ 184	Q
(IQ; n=208)	0.15	na	$ 154	$ 106	$ 225	R
MINIMUM			$ 115	$ 64	$ 206	
MAXIMUM			$ 276	$ 198	$ 387	

TABLE 11: Confidence Level by Response Category

DBDC Response	n	Mean	Standard Deviation
<< ------- COMBINED SURVEY ----------->>			
Yes-Yes	70	4.4	0.9
No-No	71	2.2	1.4
Yes-No or No-Yes	62	3.3	0.8
<< ------- Pooled Data Across All Surveys ----------->>			
Yes-Yes	244	4.2	0.9
No-No	280	3.1	1.4
Yes-No or No-Yes	483	3.6	0.9

Kruskal-Wallis $\chi 2$ p <0.001 that means are significantly different

TABLE 12: Model Results for Stratified Models Using
Pooled Dataset for a Single Endpoint (Models 1 and 2) and Total Endpoint (Models 3 and 4)

	Model 1 Single Endpoint EcoSep = 0 β (std error)	Model 2 Single Endpoint EcoSep = 1 β (std error)	Model 3 Total Endpoint EcoSep = 0 β (std error)	Model 4 Total Endpoint EcoSep = 1 β (std error)
Intercept	9.4 (3.7)***	2.8 (1.8)	5.7 (2.2)***	0.8 (1.3)
Eco Endpoints First	-4.9 (5.5)	2.1 (2.8)	0.6 (0.3)**	0.4 (0.2)***
IQ	1.8 (4.8)	2.8 (2.6)	5.9 (2.9)**	2.9 (1.6)*
Eagle	0.2 (0.6)	-0.06 (0.3)	3.8 (2.4)*	0.7 (1.3)
SSD Risk Reduction	0.7 (1.2)	-0.8 (0.7)	0.2 (0.8)	-0.9 (0.5)**
Eagle Risk Reduction	-0.7 (1.7)	0.4 (0.8)	2.0 (1.0)**	-0.3 (0.5)
Reading Comprehension Risk Reduction	2.3 (1.7)	-1.1 (0.8)	0.3 (0.9)	-1.5 (0.6)***
IQ Risk Reduction	3.0 (1.5)**	0.3 (0.8)	3.0 (0.9)***	0.004 (0.5)
-2*Log-Likelihood	544	1556	684	1999
	n=205	n=597	n=204	n=597
* p<0.10, ** p<0.05, *** p<0.01, **** p<0.001				

EcoSep = 0; respondents not able to separately value human health and ecological endpoints
EcoSep = 1; respondents are able to separately value human health and ecological endpoints

TABLE 13: Responses to Y-N, N-Y, Y-Y Followup Questions

	Eco Valuation Questions (n=550)						HH Valuation Questions (n=576)		
Rating	Altruism	Bequest	Nonuse	Use	Option	Cleanup	Altruism	My Child	Cleanup
1 - Not Important	2%	3%	2%	5%	8%	2%	2%	34%	2%
2	3%	4%	4%	7%	10%	7%	4%	7%	6%
3	26%	22%	26%	24%	36%	21%	18%	16%	20%
4	26%	27%	29%	25%	21%	25%	21%	10%	27%
5 - Extremely Important	43%	44%	40%	39%	26%	46%	55%	33%	45%

Notes:
Altruism: I think it's important to preserve [EAGLES / WILDLIFE] not just for my enjoyment but for everyone
Bequest: I would like my children to have the opportunity to see [EAGLES / WILDLIFE]
Nonuse: I think it's important to protect [EAGLES / WILDLIFE] – it's important to me know that they are ok even if I don't see them directly
Use: I enjoy seeing [EAGLES / WILDLIFE]
Option: It's not very important to me right now if see [EAGLES / WILDLIFE], but I would like the option of doing so in the future of doing so in the future
Cleanup: I support a cleanup no matter what the risk might be (I don't like the idea of chemicals in the environment generally)
Altruism (HH): I'm worried about the potential risk to unborn babies generally
My Child (HH): I'm worried about the potential risk to my own unborn children
Cleanup (HH): I support a cleanup no matter what the risk might be (I don't like the idea of chemicals in the environment generally)

TABLE 14: Responses to N-N Followup Questions

Agree?	Ecological Valuation Questions (n=253)				HH Valuation Questions (n=230)			
	Not Worth the Money	Difficult for Household to Pay	Don't Believe a Cleanup Will Work	Some Other Reason	Not Worth the Money	Difficult for Household to Pay	Don't Believe a Cleanup Will Work	Some Other Reason
No	81%	62%	69%	59%	87%	62%	68%	56%
Yes	19%	38%	31%	41%	13%	38%	32%	44%

FIGURES

D.1. Scientists predict that eagles will have a 20 in 100 (or 1 in 5) chance of failing to produce young if exposed to PCBs. Put another way, if there are 100 eagles, then 20 of them will be unable to produce young. Each dot below represents one eagle. The red dots represent the eagles that won't be able to reproduce.

If the river is cleaned up, scientists predict that the risk will drop to [1 in 10 / 1 in 20], or that [10 out of 100 / 5 out of 100] animals will be affected. There will always be some chance that eagles will have trouble reproducing because the sediments can't be totally cleaned up. Each dot below represents one eagle: the red dots represent the eagles that will still have trouble reproducing after the river is cleaned up.

[APPROPRIATE DOTS]

FIGURE 1: "Dots" Graphic for Risk Reduction from the Surveys

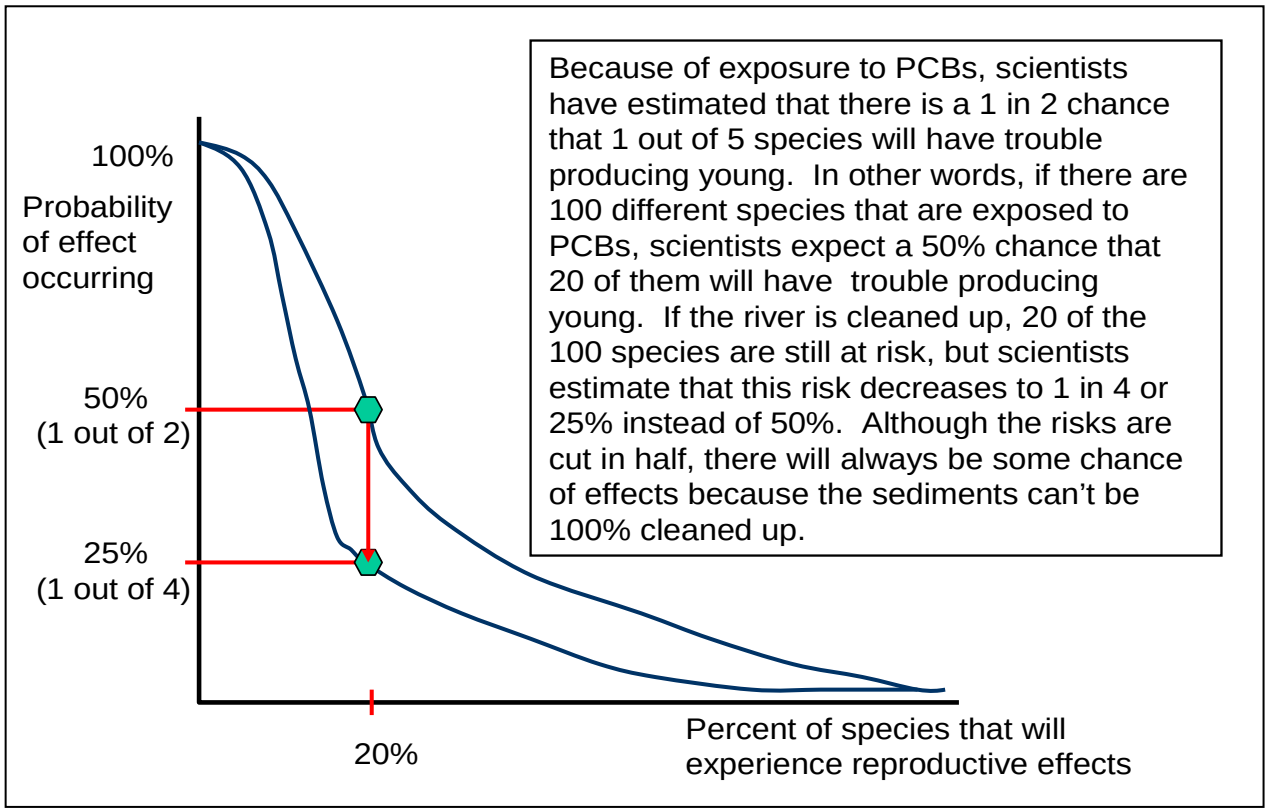


FIGURE 2: Species Sensitivity Distribution (SSD) Graphic from the Surveys

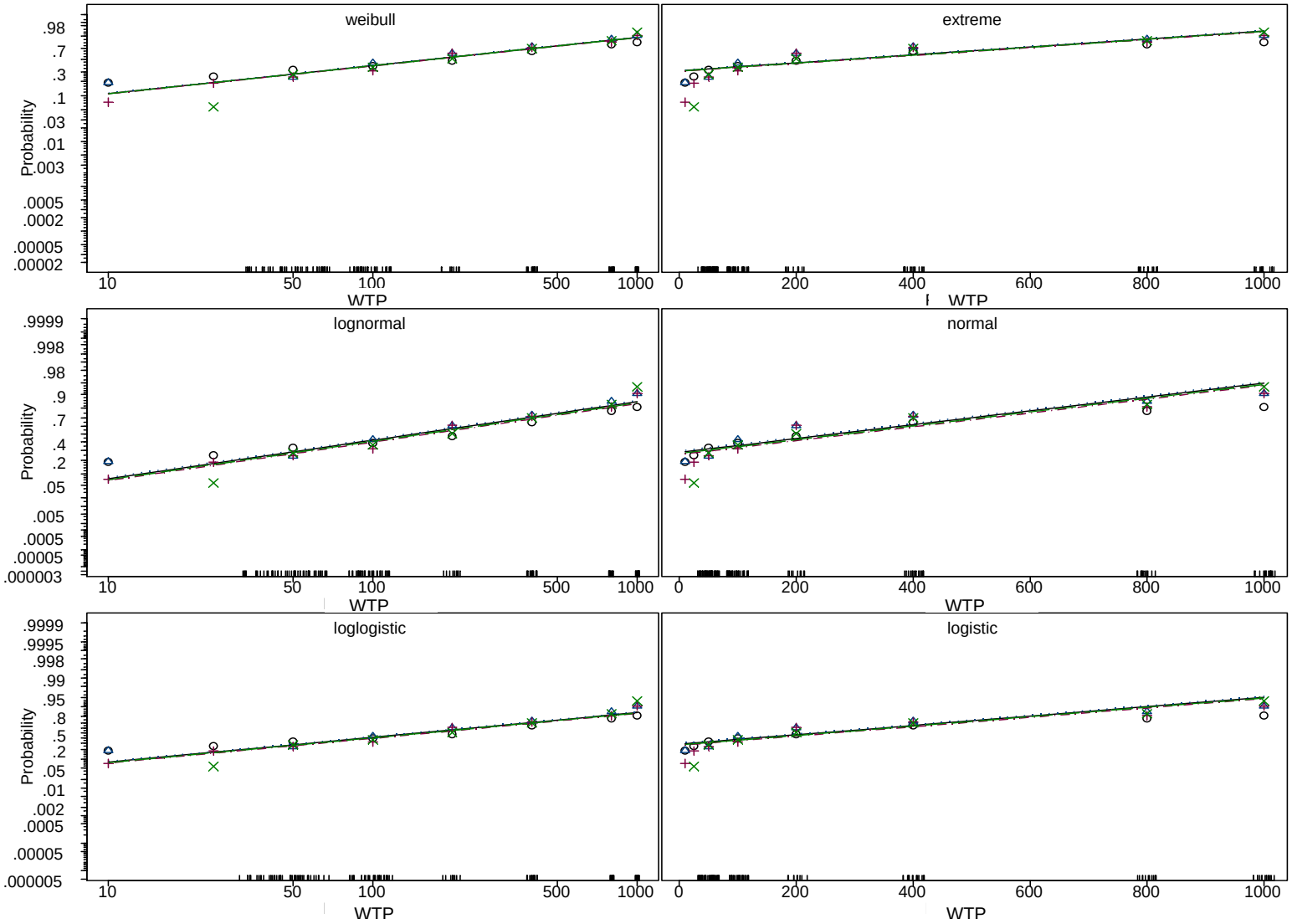


FIGURE 3: Probability Plots for the Ecofirst Single Endpoint

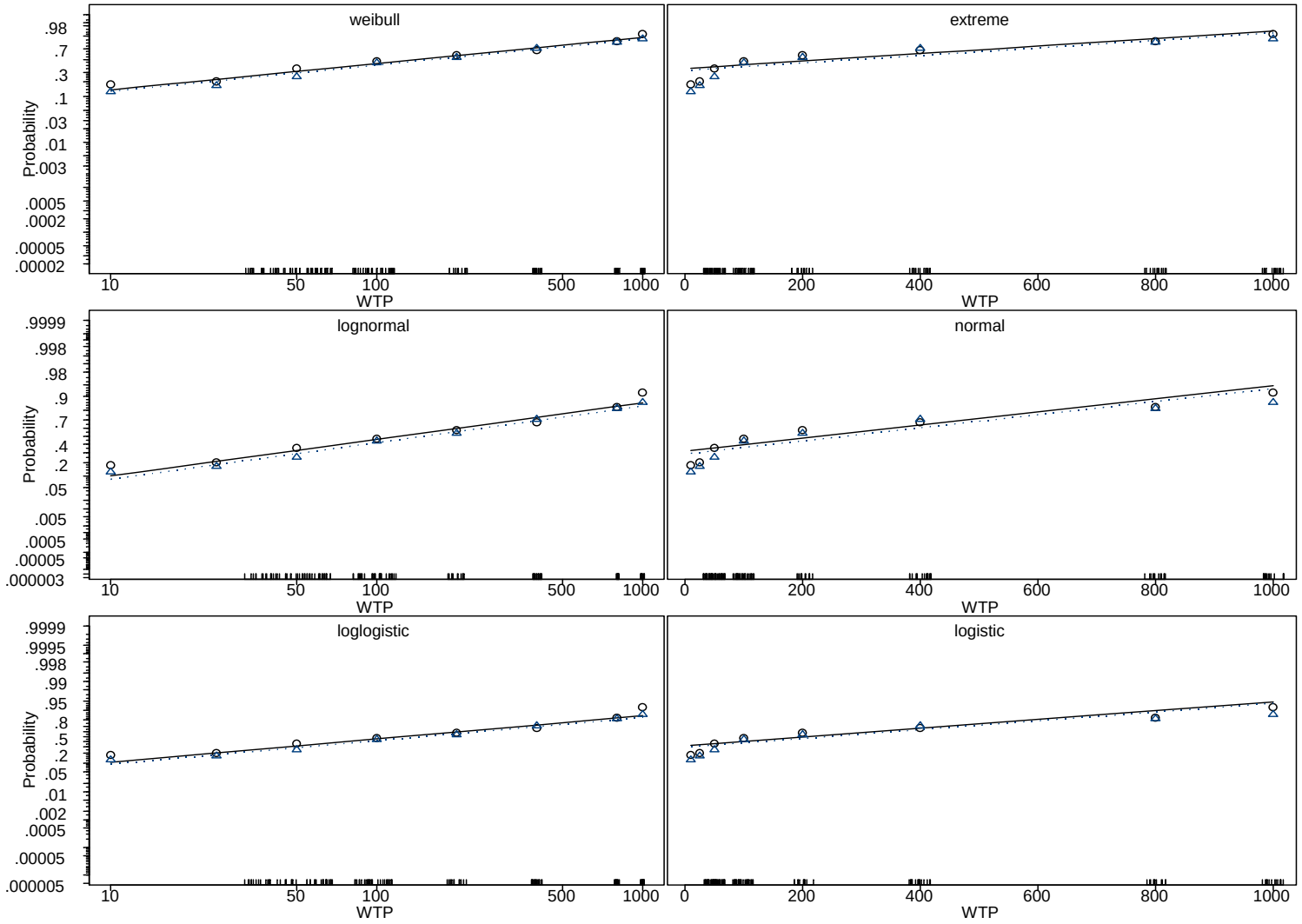


FIGURE 4: Probability Plots for the HHFirst Single Endpoint

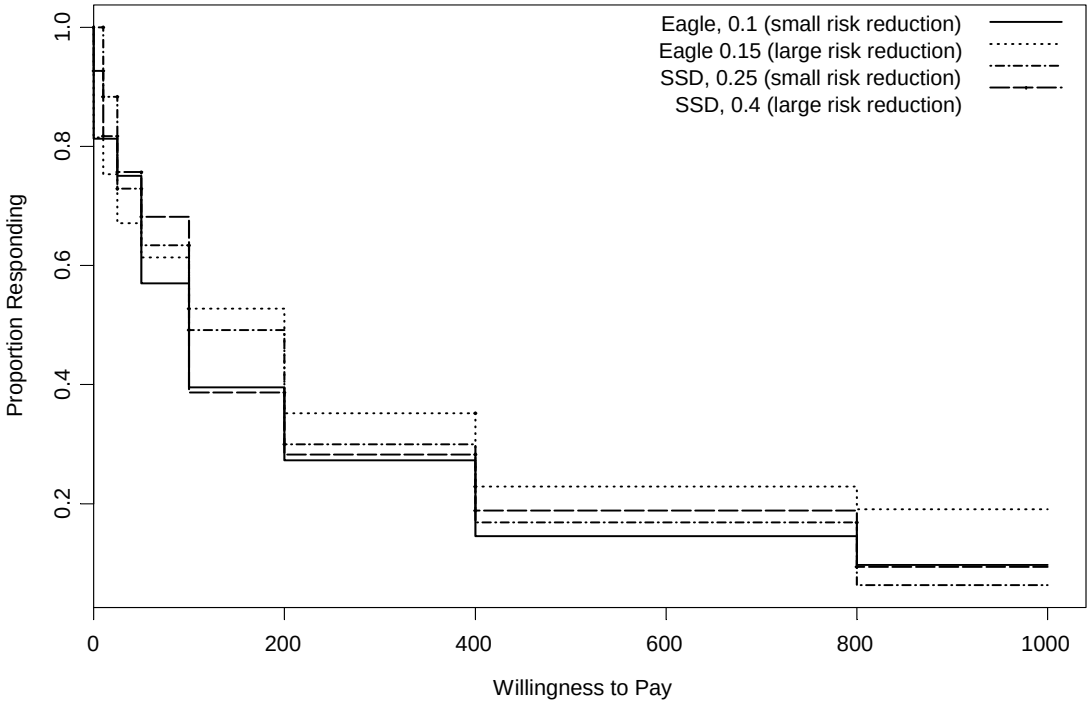


FIGURE 5: Willingness to Pay Across Risk Reductions for Ecological Endpoints

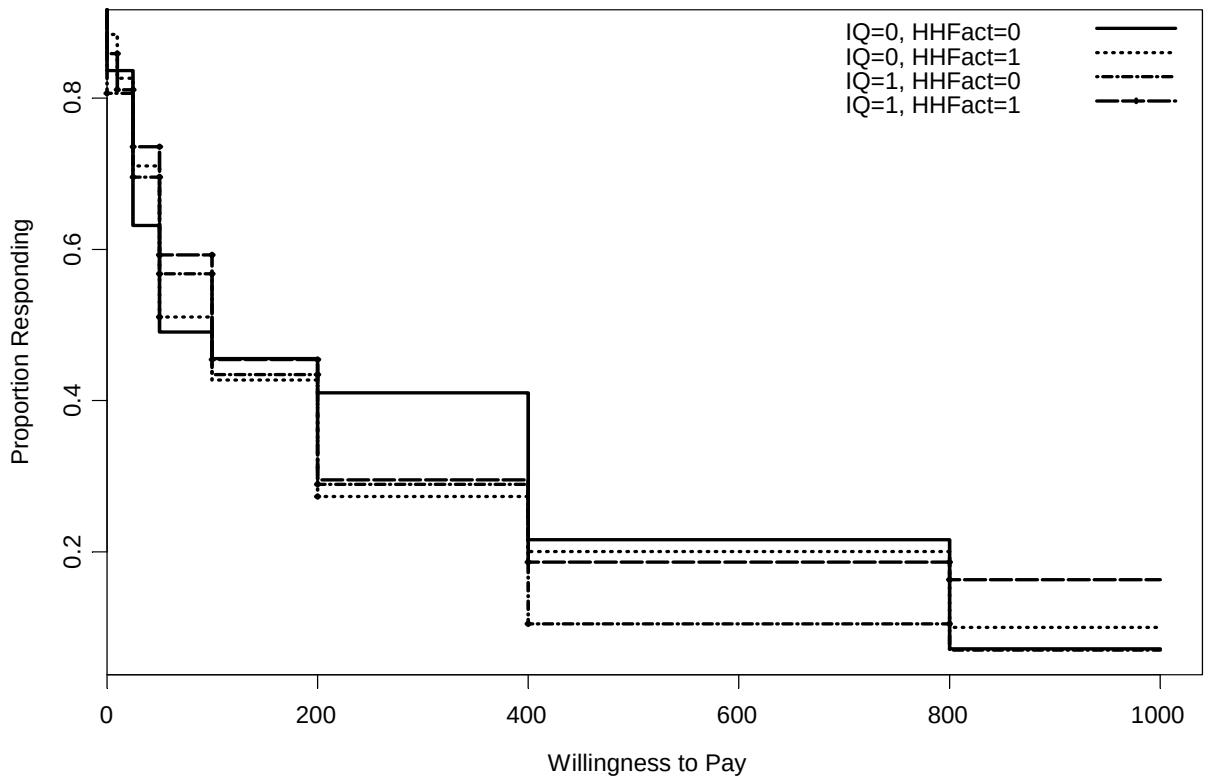


FIGURE 6: Willingness to Pay Across Risk Reductions for Human Health Endpoints

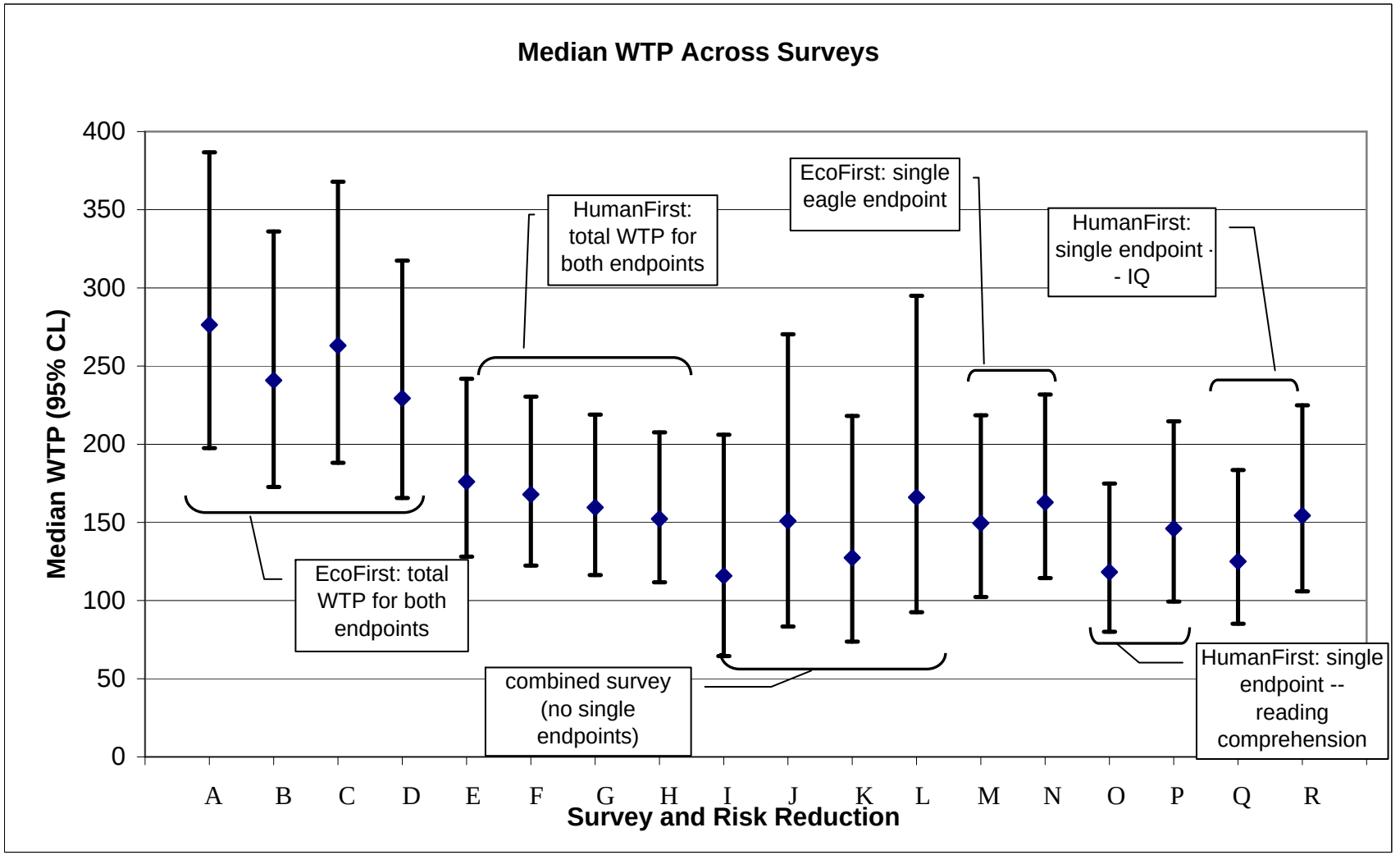


FIGURE 7: Willingness to Pay Across Surveys, Endpoints, and Risk Reductions

Valuing the Ecological Effects of Acidification

Mapping the Extent of Market and Extent of Resource in the Southern Appalachians

Shalini P. Vajjhala, Anna Mische John, and David A. Evans

5/28/2007

Prepared for:
Valuation for Environmental Policy: Ecological Benefits
Sponsored by NCER and NCEE, U.S.EPA
Crystal City, VA
April 23-24, 2007

Valuing the Ecological Effects of Acidification: Mapping the Extent of Market and Extent of Resource in the Southern Appalachians

Shalini P. Vajjhala, Anna Mische John, David A. Evans

Abstract

Identifying the appropriate survey population and defining the extent of resource are among the most fundamental design decisions for stated preference surveys. However, there is often little information on the perceptions of the general population regarding the scope of the resource being valued (extent of resource) and who in the population holds measurable value for the resource (extent of the market). This paper presents a novel approach using mental mapping interview techniques to provide information about the extent of market and the extent of resources for the design of stated preference surveys that elicit willingness to pay (WTP) for reducing environmental damages. The approach was developed and tested as part of an ongoing study on environmental degradation associated with acidification in the Southern Appalachian Mountain region. While damage from acidification in the study region is broad, it is not clear if residents of this region are particularly concerned about degraded resources in the states where they live, in neighboring states, on public lands, or more broadly across the region. Based on a pilot study with a convenience sample of former residents of North Carolina and Virginia, we find that participants' show a significant home-state preference in the number and size of natural areas that they value within the Southeastern United States and the larger Southern Appalachian region. This study lays the groundwork both methodologically and analytically for integrating spatial considerations into conventional contingent valuation and choice experiment designs.

Contents

Valuing the Ecological Effects of Acidification: Mapping the Extent of Market and Extent of Resource in the Southern Appalachians

Shalini P. Vajjhala, Anna Mische John, David A. Evans*

Introduction

Identifying the appropriate survey population and defining the resource to be valued are among the most fundamental design decisions for stated preference (SP) surveys. However, , a researcher does not necessarily know the distribution of those who hold measurable value for the resource or what particular part of the resource to focus on (i.e. the extent of the market and the definition of the commodity). Limited resources prevent casting a large net and capturing every potential individual or household that values the resource in question. Furthermore, there is often little information on the perceptions of the general population regarding the scope of the resource being valued. These challenges are particularly true for resources associated with significant nonuse values. Both of these drivers, limited sampling budgets and the desire for a credible payment vehicle, along with the preferences of the survey sponsor, often result in the use of convenient, implicit, or ad-hoc definitions of the extent of the market.

This paper presents a novel approach using mental mapping interview techniques from geography and psychology literature as a complement to traditional focus-group interviews to provide an early characterization of the extent of market and the extent of resources for the design of SP surveys that elicit willingness to pay (WTP) for reducing environmental damages in large regions. The approach was developed and tested as part of an ongoing study on environmental degradation associated with acidification in the Southern Appalachian Mountains. While damages from acidification in the study region are broad, it is not clear if residents of this region are particularly concerned about degraded resources in the states where they live, in neighboring states, on public lands, or more broadly across the region.

* The authors are respectively Fellow, Research Assistant, and Research Associate at Resources For the Future, 1616 P Street, NW, Washington, D.C. 20036-1400, USA, phone: +1 (202) 328-5000, corresponding author email: shalini@rff.org. Evans is also a Ph.D. candidate in the Department of Economics at the University of Maryland.
This research was funded in part by EPA STAR Grant RD-832422.

As a region that covers parts of eight different states, the Southern Appalachian Mountain region does not have clear jurisdictional boundaries, making it difficult to develop a standard and credible payment vehicle for all potential survey participants in region. In order to better characterize both the resource and the survey population before making instrument design decisions and engaging in focus group interviews, we developed a pilot study with a convenience sample of 30 former residents of either North Carolina or Virginia, currently living in the Washington D.C. metropolitan area.

Study participants were provided with a base map of the region, and asked during one-on-one interviews, to add information to the maps about their use of and value for different parts of the region. Respondents mapped features including 1) places that they visited regularly while living in the region, 2) the five natural areas in the region that they valued most and thought were most important, and 3) any areas they perceived as degraded. The resulting maps from each interview were then coded (in a process similar to transcribing an interview) to allow for quantitative evaluation and comparisons of the sizes, types, and locations of the areas/resources marked on participants' maps.

By providing preliminary spatial characterization of both the extent of market and the extent of resource, this approach demonstrates how mapping can inform the design of SP surveys of both contingent valuation and conjoint forms. Section 2 describes in detail the motivation for using spatial analysis as an introductory component of SP survey instrument design. Section 3 provides a review of the mapping literature and outlines the potential contributions of the method to the economic literature and SP research. Section 4 details the elements of our methodological approach and mapping study design. Section 5 then presents a pilot application evaluating the extent of market and extent of resource for damages from acidification in the Southern Appalachian Mountain region. Section 6 highlights our early analyses and findings, and Section 7 concludes with a discussion of the strengths and weaknesses of the method for wider application to different resources, regions, and related benefits-transfer techniques and also highlights several areas for further study.

Motivation for Spatial Analysis

Eliciting individuals' value for different environment attributes or areas is an inherently spatial problem dependent on the locations of key resources and populations. SP surveys, in particular, require clear definitions of the resource being valued and a careful consideration of the population from which to select a survey sample. However, a researcher often has little information about who cares about the resource ex-ante and therefore develops a definition of the

extent of the market (at least for sampling purposes) based on other objectives and study constraints. For example, in related valuation study focused on the Adirondack Mountains in upstate New York (Banzhaf et al. 2006), the survey population was defined as all New York State residents to allow for the use of an incentive-compatible payment vehicle (state income tax) that corresponded with a credible management agency (New York State) for the resource in question (the Adirondacks Park).[1] While New York State residents are likely to have higher average WTP for improvements to this resource, it is also likely that residents of neighboring states, like Vermont, would receive similarly significant benefits from improvements to the resource. Given the scale of the resource and the design complexities associated with surveying a larger population, it was decided that estimating Vermont residents' WTP was outside the scope of the study. These constraints, while typical, are particularly important in the case of very large resources, where unlike the Adirondacks, oversight and payment options are less obvious.

For some surveys, the resource of interest corresponds to a clear administrative authority through which management decisions and environmental improvements are made. If the jurisdiction encompasses all of those that have a measurable WTP for improvements to that resource, then the design the SP survey is relatively straightforward, as described above. But this is not always the case. The boundaries of many other natural resources do not correspond to administrative and jurisdictional boundaries under which resource management decisions are made. Instead these resources, including major national parks and forests, cross state boundaries and are surrounded by and encompass a variety of different populations, ecosystems, and land uses. Similar issues arise for resources that are encompassed by one jurisdictional boundary but managed by a higher level of government. In these cases, using mapping as a complement to traditional SP methods provides opportunities to elicit perceptions of the resource from a sub-set of the largest potential survey population to develop a baseline spatial characterization and assessment of the extent of both the resource and the market for the resource. Furthermore, because mapping interviews are typically open-ended, it is possible to use this approach to identify other resources for which residents could have significant nonuse values.

[1] While this study only estimated the WTP for improvements to the Adirondacks from reduced acid deposition from New York State residents, the information gathered by the survey is still very useful information when conducting a benefit-cost analysis of the benefits of reducing acid deposition precursors. The total WTP of all New York residents can be viewed as a lower-bound of the total value of the improvement to the resource.

Defining the commodity and understanding the extent of market

Two parallel challenges in developing a stated preference survey are 1) defining the commodity of interest and 2) determining the extent of the market (and thus who to survey). In cases where the resource is sufficiently large to encompass a variety of different attributes and features, it is unclear if individuals within a given distance of the larger area value, for example, the whole area or simply the parts of the resource closest to their home, the parts of the resource with the greatest amenities, or the parts of the resource that they have visited or used the most. In cases of valuing ecosystem improvements over large areas, it is beyond a study budget to conduct a survey where the definition of the commodity is the entire area of interest (in our example, the Southern Appalachians). In these cases, it is more realistic to consider multiple surveys, where each survey describes a particular commodity (or part of the larger region) whose improvement is particularly salient to the population of interest. Implementing this approach and determining which areas are valued within a larger, shared natural resource, requires a methodology that can elicit subjects' mental models and identify any systematic variations, preferences, or biases in how different sub-sets of a survey population might perceive or value parts of a larger resource differently.

Furthermore, individual use and existence values for different environmental resources (commodities) are not confined to geographic or political boundaries, and it is conceivable that almost anyone could have some value for a resource in question. Thus, the extent of the market could vary depending on whether or not people have any value for parts of a resource 1) far from their home, 2) in another state, and 3) with many other competing resources or substitutes available. Understanding who cares about a resource and how much is in part a feature of any given resource such as its size, quality and location. In most cases it is assumed that the market for a (non-market) resource is generally proximate to the resource itself, but this may not be the case. Cast over a wide population, the mapping approach proposed here can be used broadly to inform these questions and help identify the extent of the market for diverse commodities.

The process of conducting mapping interviews has additional related benefits with respect to interpreting WTP questions and designing the SP survey. For example, in order to be able to correctly interpret WTP responses from the survey, it is critical to have clear characterization of these potential differences *before* administering an SP survey. Moreover identifying a locally relevant incentive compatible payment vehicle is essential, and although there might be several federal agencies with authority over a large resource, in most cases a payment vehicle at a federal scale would be incompatible with smaller markets for a resource.

Defining the extent of resource

Without a clear, straightforward political or geographic definition of a resource it is impossible to assure that individuals share the same definition of a study area when responding to valuation questions. Moreover, it is unclear the extent to which individuals are able to identify with very large scale resources, resulting in problems if respondents consider only a limited sub-region that they associate with the larger resource or if they similarly cognitively truncate a larger area based on their prior experiences and perceptions (Fischoff et al. 1993).[2] To this end, the primary goal of this approach is to develop a method to elicit individuals' perceptions of the size and shape of a large resource and use it to inform SP instrument design decisions.

Defining the extent of the resource in the case of large resources refers to formally eliciting and evaluating 1) if potential survey participants identify with the resource in its entirety or with specific features or sub-regions within the resource instead, 2) where the boundaries of the resource are in their perceptions of the region, and 3) how these boundaries compare with other established political or geographic boundaries, such as state or national park borders.

Background on Mapping: A Review of the Literature

As a technique widely applied and tested both in geography and psychology literature, mapping is a tool that has the potential to reduce ambiguity about extent of market and extent of resource in valuation research. In psychology the process of cognitive mapping has been tested widely over many decades. Beginning in the 1940s with Tolman's (1948) landmark study that first recognized the term cognitive mapping, both geographers and psychologists have conducted experiments and studies to understand how individuals perceive different types and scales of spaces and to characterize systematic biases and distortions in map representations. A primary distinction between the two fields' approaches to mapping is the focus on *internal maps* in psychology versus *external maps* or representations of spaces in geography (Downs and Stea 1973, 1977; Golledge and Zannaras 1973; Golledge 1976).

More recently these literatures have come together around research on defining the theoretical underpinning of digital mapping tools, such as Geographic Information Systems

[2] With very large areas research has shown significant embedding effects, in that respondents in CV surveys are incongruently willing-to-pay the same amount for improvements to a large area as they are for improvement to a smaller sub-region of the same area. Fischhoff et al. (1993) describe several different methodological reasons for these effects and outline strategies for overcoming such biases.

(GIS), in order to develop and evaluate if the tools are responsive to how individuals navigate and think about spaces (Tversky 1993; Mark and Frank 1996). Although there has been significant research on variations in spatial perceptions and comprehension at different scales from the very small (a single room) to the very large (continent-level), a majority of research on spatial cognition to date has focused on built environments and less on natural environments. For this reason, we focus on bringing together elements from both the geography and psychology literature that focus on natural resources to develop an interview method to elicit a participatory map of a large, natural environment.[3]

The method applied here (Vajjhala 2005) extends traditional participatory mapping techniques using a semi-structured interview format to elicit survey respondents' individual maps of a region and their perceptions of a resource and to provide a quantifiable justification for follow-on SP instrument design. The potential contributions of this approach to SP literature and research include: extending valuation studies to larger scales more reliably and robustly, making more informed decisions about the relevant population to survey, helping to better understand what people think they are paying for, and laying the groundwork for further evaluation of benefits transfer methods. The next section describes our general approach to designing a mapping study as a front piece within a larger SP survey design and implementation process, and Section 5 details the implementation of this pilot methodology in the Southern Appalachians.

Study Design and Methodological Approach

The focus of this paper is both methodological (how to incorporate mapping into larger SP studies) and applied (what are the results of an application to an ongoing study in the Southern Appalachians). This section outlines our basic methodological framework for incorporating mapping into a planned SP survey project and the next section highlights our applied example. It is important to emphasize that this experiment is not a freestanding research effort; and although the instrument design framework outlined in this section can be used for full mapping studies, it is modified and tailored to SP survey design. Because this approach is intended to be as streamlined, the focus was on gathering essential baseline information from a small sub-set of the potential survey population as early in the design process as possible.

[3] A participatory map is typically defined very broadly as any map created through participation-based methods for eliciting and recording spatial data, including sketch mapping, scale mapping, and transect walking, among others (Chambers 1994; Craig et al. 2002). Maps resulting from a participatory process can vary from drawings on the ground with sticks or chalk to paper sketches to three-dimensional physical site models.

In order to most effectively contribute to the larger SP survey, we take a mental models interview approach (Morgan et al. 2002) and use a semi-structured format with selected open-ended questions to elicit sizes and locations of the natural resources that individual's value within a large region. Like most mental models studies we also find that a relatively small sample (~30 participants) provides a sufficiently complete characterization of a region to inform future research. Recognizing the time and budget limitations that constrain most survey projects, the approach described here uses 45-minute to 1-hour individual mapping interviews to elicit any systematic variations in how individuals characterize the types of areas and resources that they value within a larger region. There are many additional questions that could be asked, and the proposed approach is simply intended to serve as an outline for a wider range of applications.

Within an integrated mapping-SP methodology, some basic research questions will likely be consistent across all studies, including the following: Who cares about a resource? Where do individuals perceive boundaries of the resource? Is this perception consistent across the survey population or are there systematic differences in how people view and value the resource? Are there parts or sub-regions within a resource that people value and is there the potential for embedding and related biases when considering these areas? Addressing these questions requires (as with the design of any survey) that the research build on existing data to define hypotheses of how residents of a large region might value a shared resource. For example, in some regions recreation data might suggest that individuals use resources close to home most frequently, or conversely, that a single highly-visited or high-profile area dominates a larger region.

Depending on the hypotheses, the next steps in the design of the mapping study are to develop a mapping interview protocol and a base map. The base map is the main focus of the mapping interview and the primary medium in which interview responses will be recorded. As a result, it is extremely important that the map and protocol be developed in parallel with any relevant scientific constraints and careful consideration of scale and the features included in describing the region. Since the goal is to encourage participants to add as much information as possible by drawing on to the map itself, it is critical that the base map is sparse and serves primarily as a frame of reference. The map should not have so much information or text that it appears complete leading participants to re-create features already on the map or to refrain from adding information altogether because they assume it is already there.

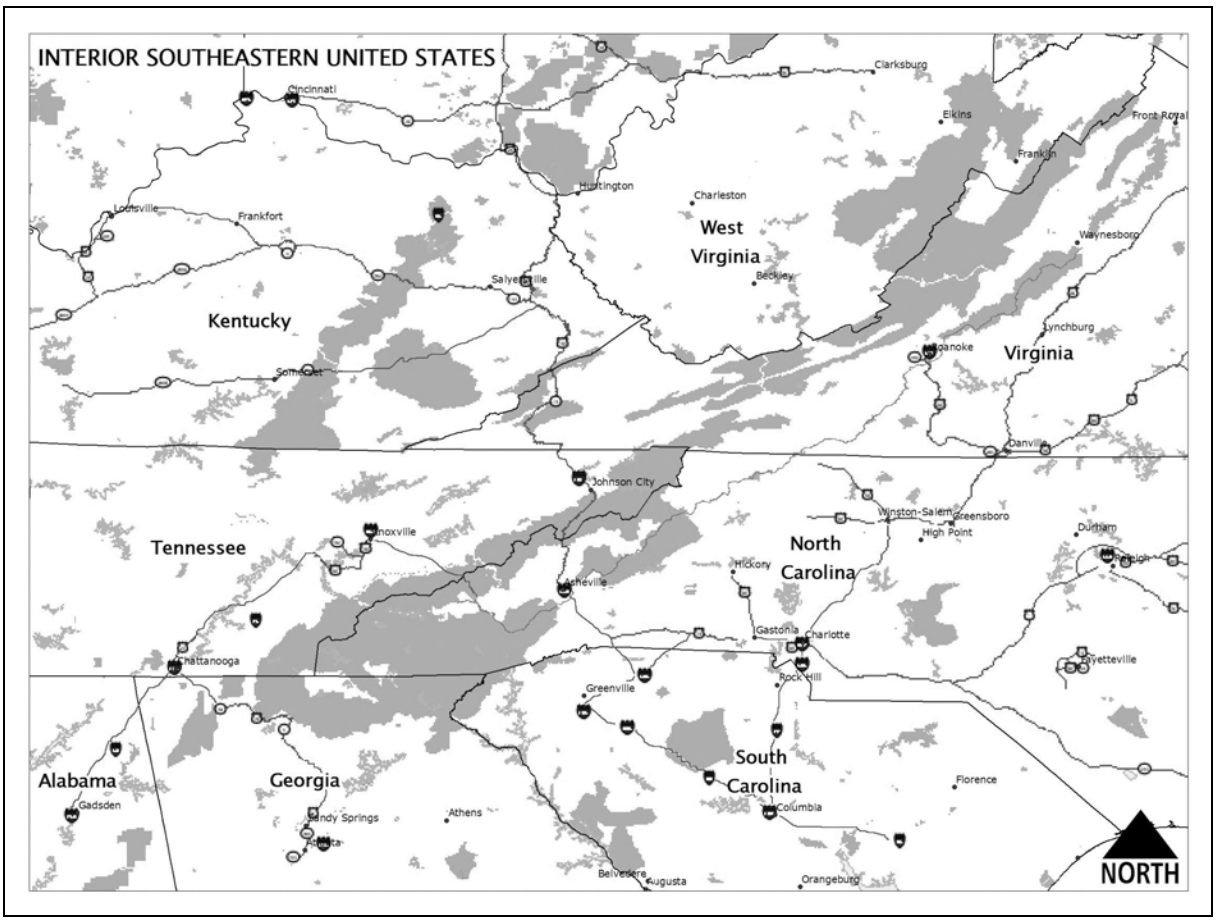


Figure 1. Base map with the Southern Appalachian Mountain Region at the center and portions of all eight states comprising the larger region. Geographic identifiers include state boundaries and names, shaded areas representing all national park and forestland, and selected major highways for spatial reference. Maps were labeled as "Interior Southeastern United States" to avoid framing effects when using the term "Appalachian."

The framing of the base map (what features are included, which ones are not, and at what scales) is highly likely to influence the scale of participants' responses. As a result, the overall area should be defined sufficiently broadly to encompass the resource being studied and relevant surrounding areas while still leaving room for new information, such as areas and boundaries at the edges of a study region that participants might identify. Similarly, the printed maps used in interviews should be sufficiently large-size, such as 18-inches by 24-inches, to allow participants to add information clearly at different scales. It cannot be emphasized enough that each base map must be tailored to the questions being asked, the region being evaluated, and the context of the larger study and extensively pre-tested in order to be effective.

Figure 1 is the base map used in this study. Existing data on the Appalachians ecosystems, acidification, and recreational patterns in the region suggest that the region includes large parts of eight states, extending from Alabama to Virginia, and this base map provides very basic information including state borders and names, major highways, and light shading highlighting general forest and water resources in the region. The map is deliberately designed without any labels to avoid framing and anchoring effects (Kahneman et al. 1982). Additionally, the map is titled "Interior Southeastern United States" to avoid leading participants to focus too narrowly on the Appalachians or any social, cultural or political association with the term and to avoid competing resources much less relevant to the study such as the Atlantic Coast.

As a complement to the base map, the interview protocol is divided into three main sections (see Appendix A for full protocol). The first section asks about patterns of use and travel in the study region to elicit basic spatial information, develop a general picture of individuals' use values for the resource, and allow individuals to grow accustomed to the process of adding information to the base map in response to interview questions. The second section of the protocol, the main focus of the study, asks individuals to think about areas that they value. There are a number of different, valid approaches to structuring these questions, and depending on the goal of the larger study, questions could focus on eliciting 1) a boundary for the region as a whole, 2) specific points people care about within the region, or 3) broader areas or sub-parts of the region. In order to allow for faster coding of the collected data, different colored markers and pens can be used to differentiate types of place added to the maps.[4]

In all cases the questions should be sufficiently broad to allow for follow-up once the participant has responded. This process is discussed further in the context of the particular application described below. The last section of the interview protocol focuses on degraded areas to determine how participants perceive the environmental damages being evaluated and identify any biases or common misconceptions. The final module of the proposed methodology is a short written survey including demographic questions, and basic ranking and follow-on questions relevant for the larger SP study (Appendix B).

Taken as a whole, this methodology, consisting of the design of a base map and implementation of a mapping interview protocol and survey, is intended to be part of a larger

[4] Because this methodology is applied to a small sample, we do not address any issues of inter-coder reliability that might emerge. All interviews and map coding for this study were completed by a single interview/transcriber.

effort, and the methods can be applied in as much or as little detail as a project requires. Because the goal of this approach is to provide a structured framework for informing and interpreting the results of larger focus group interviews, this section deliberately presents a very basic, streamlined approach to integrating mapping and SP survey design to inform, without duplicating, information being elicited in the larger survey about natural resources, damages and willingness to pay for improvements. The next section places the proposed methodology in context and discusses an application focused on the Southern Appalachians.

Acidification in the Southern Appalachians: An Application

The Southern Appalachian Mountain region (SAMR) is a large, mountainous area surrounding the Appalachian mountain chain that stretches from Alabama and Georgia in the South to Virginia and West Virginia in the North. The full region covers approximately 37 million acres (SAA 1996), encompassing parts of eight different states and a wide variety of ecosystems, land uses, and management authorities, including National Park and Forest Service lands, state parks and recreation areas, private properties, and agriculture lands, among others (see Figure 1 for reference). The region is characterized by at least two main anchors – the Great Smoky Mountain National Park (GSMNP) in North Carolina/Tennessee and the Shenandoah National Park (SNP) in Virginia. These two parks and the surrounding forest and stream resources in the region are currently at-risk of significant damages from acid deposition, and the issue has emerged as a policy priority for the affected states and the region as a whole.

The scale of this resource makes both environmental evaluation and policy making difficult, and the absence of estimates of the economic value of improvements in ecological systems has hindered policymakers' attempts to set efficient regulation and environmental policy goals. The larger study (to which this mapping pilot study is designed to contribute) focuses on characterizing the potential damages to forests and streams from acid deposition based on the best available science, and eliciting WTP estimates for environmental improvements in the region. The study includes contingent valuation (CV) as well as a choice experiment (CE) surveys to generate a lower-bound estimate of ecological improvements from reduced acidification. This work also builds closely on a recently completed CV study of the total value of ecological improvements from reduced acidification in the Adirondacks (Banzhaf et al. 2006), and allows for comparisons of the competing SP techniques, and to examine the potential for benefits transfer for different types of resources.

Although both the Adirondacks and the Appalachians are mountainous areas with similar forest resources and highly used recreational sites, containing sensitive ecological receptors that

have received high levels of acid deposition to date, the regions are fundamentally different from one another in scale and location. As discussed earlier, the Adirondacks are entirely contained within the state of New York, making the CV survey designed for the Adirondacks difficult to adapt and modify for use in an areas as large as the SAMR. Moreover, the types of aquatic features in both regions are significantly different with lakes dominant in Adirondacks and streams dominant in the Appalachians.

The greatest challenge for survey implementation in the SAMR is the multiple jurisdictional boundaries within the region. Since the resources of interest for this study are regional, and not easily defined by any single administrative boundary like the Adirondacks, the fundamental goals of a survey instrument design process are, 1) to construct a well-defined description of the affected area that is relevant to how people view the resource, and 2) to identify the primary survey population from which to sample. The later will help in the identification of an appropriate payment vehicle with which to elicit WTP estimates. The mapping methodology outlined above is applied here to provide a preliminary assessment of how residents perceive the region and its natural resources and to lay the groundwork for scenario development and sampling decisions in the larger study.

Survey Population

In this application and test of the methodology, our interview protocol focused on eliciting and characterizing the types, sizes, and location of places that individuals value in the larger Southern Appalachian region. Given the limited time and resources for this preliminary effort, we chose to sample from two Southern Appalachian Mountain Region states, North Carolina and Virginia. These two states were selected because they each contain a large national park affected by acid deposition, which comprise a sufficiently large portion of SAMR to provide different characterizations of the full region and resource. Furthermore, we hypothesized that residents of the region would focus on the GSMNP and the SNP as high-profile resources, and residents of the states containing those resources would likely have the greatest value for them compared with residents of other states across the region. To test this hypothesis we recruited a convenience sample of former residents of North Carolina and Virginia currently living in the Washington D.C. area.

Participants were recruited through online advertisements, and 15 respondents from North Carolina and 15 from Virginia were chosen from approximately 135 responses. All respondents were screened to select participants who had lived in the study region for a minimum of 5 years since the age of 16. Additionally, in order to avoid overlap between groups

of participants from the two states, candidates were screened to eliminate any prospective volunteers who had lived in both North Carolina and Virginia. Gender balance and geographic distribution with the state were also considered when recruiting participants. The interviews where conducted from October 2006 to January 2007.

The final sample included approximately equal numbers of men and women from each state aged between 23 years and 66 years old, averaging approximately 34 years of age. The sample also included participants from a wide range of educational backgrounds ranging from "some college, but no degree" to "post-graduate degree" with the majority of participants holding Bachelor's or Associate degrees. Median household income across all participants was in the $50,000 to $84,999 bracket.

Interview Process

Each mapping interview was scheduled and conducted on an individual basis, and began with a brief general introduction to the goals of the study as outlined in the attached protocol. The process was described as a "mapping interview" and no mention was made of the Appalachians, environmental degradation, or acid deposition. Study participants were then provided with a colored marker and an 18-inch by 24-inch base map of the region showing state boundaries, unlabeled shaded areas representing public lands, and select highways and cities (see Figure 1). Significant emphasis was placed on carefully considering the sizes, shapes, and relationships between locations they added to their maps.

As discussed earlier the semi-structured interview protocol asked participants to 1) identify places on the map that the participant visited regularly or as a significant destination while living in the region, 2) add the center points and boundaries of five natural areas in the region that they value or care about most to their maps, and 3) identify any areas and causes of improvement or environmental deterioration in the region. In this format the second set of questions was deliberately broad to encourage respondents to identify areas that they care about but may not actively use, thereby allowing for early identification of key resources and areas for which there may be nonuse values.

After adding the center point for a valued natural area, participants were prompted to carefully consider and explain what defined the size and boundary of the marked area. For example, prompts included *"I noticed that you didn't include this (town/highway/etc.) in the area you marked, do you consider it part of this resource? If not, what defines the start of this edge for you?"* Respondents were given time after adding each area to consider the size,

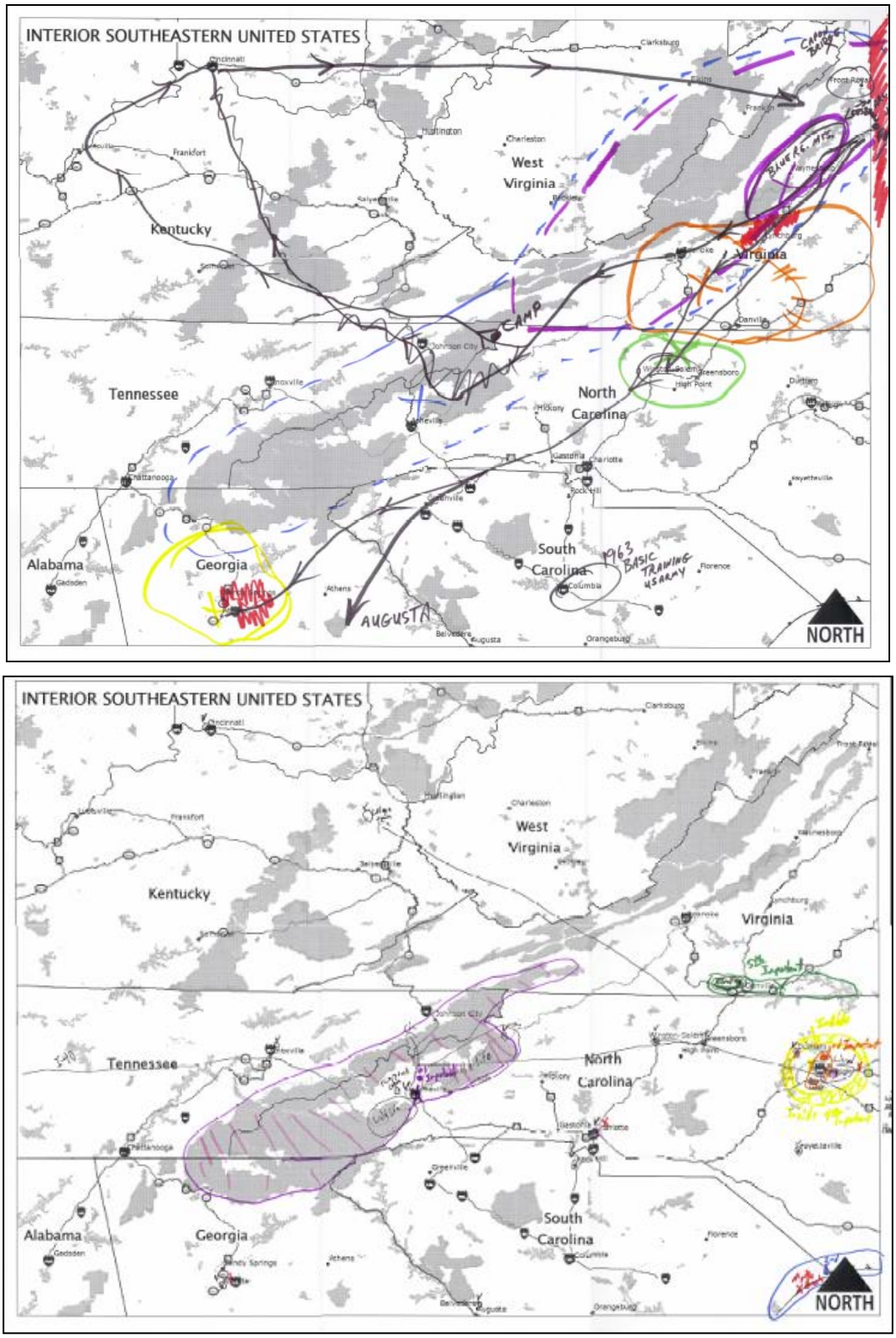
boundary, location and relationship to other areas and allowed to make any corrections or changes. At all points during the interview, participants were asked to both respond to questions by adding information to their maps and explaining their response verbally to allow the interviewer to follow-up and add prompts to keep the dialogue moving forward. Finally, each interview was followed by a short written survey with additional demographic questions and WTP and questions about the region and specific places marked on their own maps.

The pairing of the mapping interview and survey also allow for quantitative evaluation of the strength of respondents' preferences for maintaining or improving the environmental quality of different valued resources using implicit (by order of addition on their map) and explicit rankings (written survey question). Of central importance in these rankings is whether or not a respondent even included a particular resource or part of the region as a valued place on their map. By also asking respondents to identify an important natural resource outside of the mapped region and re-rank the five valued areas with this additional resource, the survey elicited the importance of potential substitutes or competing resources in the larger region (see Appendix B).

Overall, the information from the mapping interviews provides more general (ordinal, not cardinal) data than would typically be gathered from a SP survey focused on a specific researcher-defined resource. However, because the mapping protocol questions are not structured around questions soliciting WTP (i.e. a referendum) and limited to a single source of damages, they are more flexible and thus require less intensive sampling to get a sense of the extent of the market for a particular resource. This method is also an improvement on the use of recreational and market data to understand the extent of the resource as it does not preclude identifying significant nonuse values, which have been shown to be important components of average WTP in other studies (Banzhaf et al. 2006).

Maps, Data Analysis, and Study Results

Results from the 30 mapping interviews and written surveys were transcribed and coded after all interviews were completed. Data compiled from the maps included counts of places visited and valued by state, type of resource (forest, water, other), size of resource, and order in which places were added to the maps, among other more specific attributes. Figures 2 and 3 are examples of the types of maps collected during the study that show the diversity in the types and sizes of natural areas that individuals' marked as valued places. As participants were prompted to consider what defined the boundary of the area they cared about, participants highlighted a wide variety of defining characteristics for specific resources and areas.



Figures 2 and 3. VA participant map (above) and NC participant map (below) showing major areas visited and traveled (black), five most valued natural areas (multiple colors), and degraded areas (red).

For example, some participants referenced ecosystem characteristics in defining the boundaries of specific areas and areas were drawn to include all of a specific "type" of environment, such as the sandhills of North Carolina, which one participant stated "are a separate area because the topography and vegetation are difference from the area around it." Still other participants marked the borders of their valued areas where changes in natural features occurred, such as the increasing "hilliness" west of Asheville, NC as marking the start of the Smokies. Participants also used distances from cities, highways, and state boundaries to mark the start or edge of a natural area, and ownership or management (public versus private) to clarify why they had drawn their boundary at a specific location. In several cases, valued areas overlapped, partially or completely (like the two areas in Figure 3 marked near the Smokies), highlighting the potential for mapping to help with early identification of potential embedding problems.

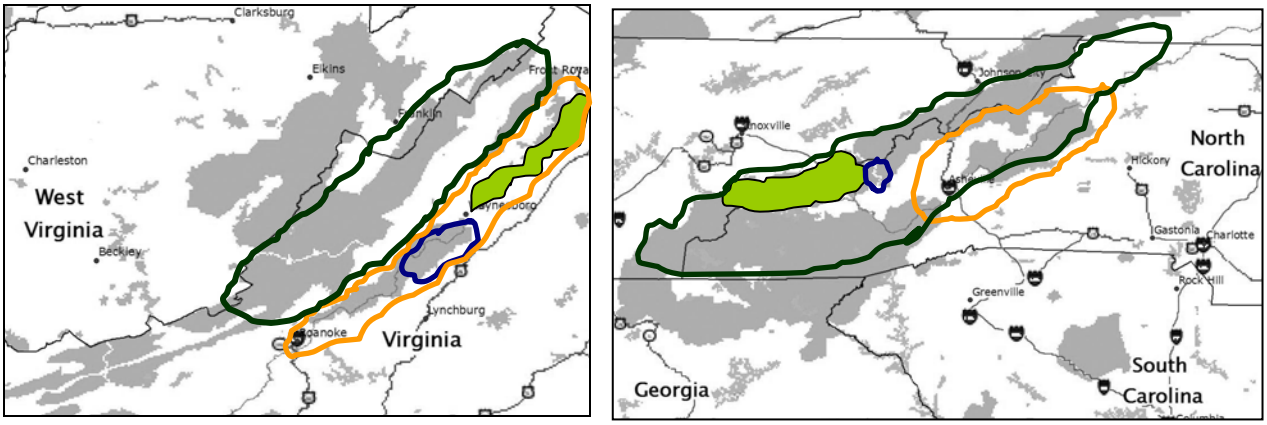


Figure 4. Sizes and locations of "the Shenandoah" relative to the SNP (left) and "the Smokies" relative to the GSMNP (right) as marked on selected participants' maps.

Across all participants, a large majority included either a natural area representing the Smokies or the Shenandoah; however, the sizes and shapes of the resources varied significantly. Figure 4 illustrates these differences and shows the SNP in solid green (left) and the GSMNP (right) overlaid with selected participants' boundaries and locations for valued areas they generally marked as "the Smokies" or "the Shenandoah".[5]

[5] The parks will serve as a frame of reference for the following discussion. This will simplify the discussion such that the focus can be on the information that can learned with the mapping protocol. That said, the SP surveys that this analysis will inform will not necessarily be limited to describing improvements in these parks. Indeed, the extent of market analysis is also intended to inform the scope of the resource that should be described in the survey. That is, is it necessary to solicit the WTP for improvements to ecosystems in national and private forests as well as national parks?

Extent of Market

Through the mapping interviews we hoped to inform the extent of the market question by learning if residents of a given state are only likely to value (or to assign greater value) to resources in their home states. For example, do North Carolinians mark only the GSMNP, or both the GSMNP and the SNP on their maps, and vice versa for Virginians? If residents of both Virginia and North Carolina marked both park areas on their maps, then this argues for the design of a common SP survey for both populations with scenarios of regional environmental improvements and correspondingly larger payment vehicles and management agencies.

Alternatively, if participants from one state marked both GSMNP and SNP and the majority of participants from the other state marked only one of these areas then two SP instruments could be used, one asking residents only about the resources within their home-state and a second asking residents about both resources. Finally, if participants only marked the park in their own state it would support a decision to administer different surveys to residents of each state with any environmental improvements described as occurring solely within their state.

To examine how participants valued areas vary by state, coded data from all maps was used to conduct basic statistical analysis, such as comparing the counts of visited and valued places added across all maps. Participants from both North Carolina and Virginia added an average of 18 places that they had visited or cared about in the study region. As Figure 5 shows, North Carolinians added more places to their maps on average, and a majority of these places were within North Carolina. The former Virginia residents marked fewer places on average and their maps also reflected greater out-of-state travel for the areas marked. Because the population surveyed includes only former residents of either state, we expect (that as people who have moved out-of-state) study participants are likely to be more highly traveled than other residents of the region. As a result, the balance between within-state and out-of-state additions to each map is likely to represent an

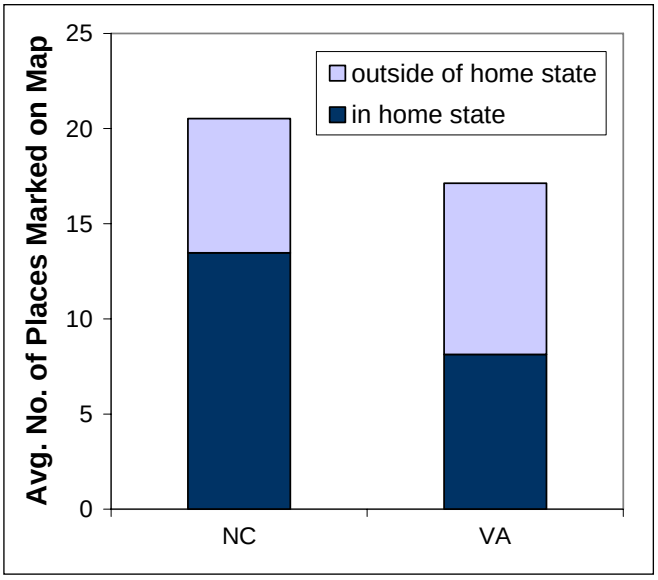


Figure 5. Differences in additions to respondents' maps.

upper bound for out-of-state additions, and we would expect an even stronger home-state preference to emerge with current residents of the region.

Similarly evaluating the five natural areas respondents marked on the maps reveals a home-state preference for valued as well as visited resources. Across all participants, more than 60% of the center points and areas that each individual marked among the areas that they valued were located entirely within their home state. This average was slightly higher for respondents from North Carolina who on average had 4 out of their 5 valued places in North Carolina. Participants were also far more likely to include the national park in their home state (the GSMNP in North Carolina and the SNP in Virginia) than the park outside their state.

Across all participants 53% of North Carolinians and 67% of Virginians only included the park in their state (see Figure 6), and one-third of all participants included both parks. The participants who included both park areas on their map, always ranked the park area within their own state higher than the other park.[6] None of the participants marked only the park outside of their home state, and all but one participant from each state included a general area, incorporating part or encompassing the whole park in their home state among the five areas that they valued.[7]

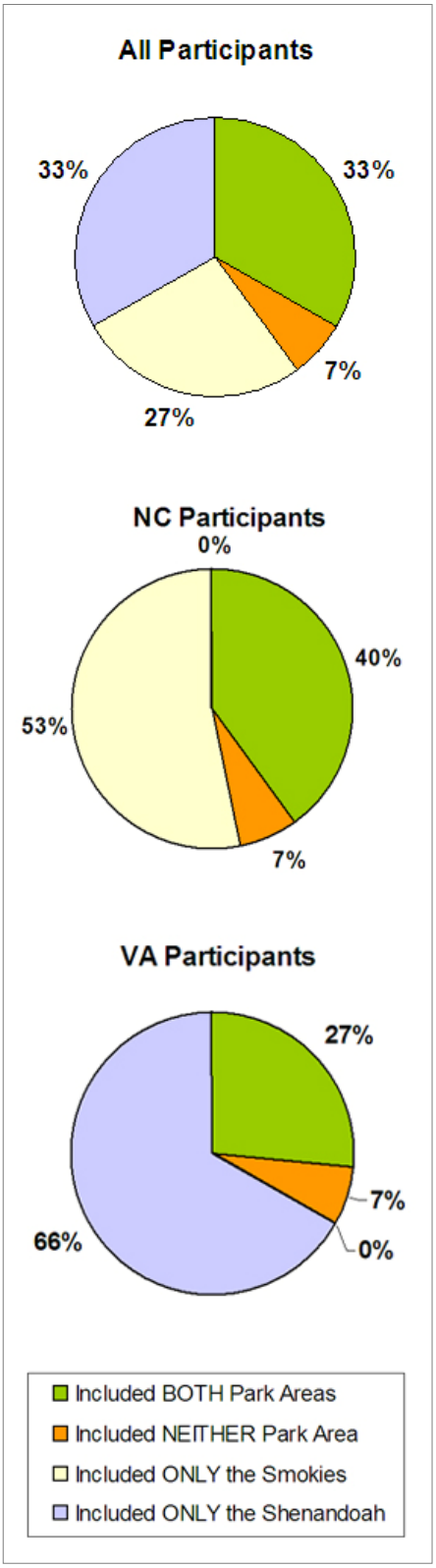


Figure 6. Percent of participants who value the GSMNP and/or SNP.

[6] Although we emphasized that respondents should respond as if they had the same prferences and perspective as when they were living in the study region, it is important to note that North Carolinians may have a higher percent of respondents that marked both parks because they now live closer to the resources in Virginia.

[7] When ranking their five valued areas implicitly or explitily, on average the ranking of the Smokies and the Shenandoah were at least 1.4 ranks apart with the resource in the home state ranked higher. This gap actually increased for those that put both parks on their map. However, this is too small number to treat as a reliable sample.

These results support the hypothesis that people are more likely to value natural resources in their own state than resources outside their state.[8] This further suggests that the extent of the market in the Southern Appalachian Mountain Region is affected by state boundaries, but not to the point where values for natural resources in different parts of the region are limited solely to the state with the resource. This is still a very preliminary stage of analysis and at this point, it is work is still in progress as to how these results should be interpreted in the context of the larger SP instrument design; however, these results do provide an important baseline suggesting that state WTP estimates are likely to be an upper-bound relative to all other states in a region, if one chooses to survey any given state's residents about only the resources in their own state.

Extent of Resource

Like the counts and locations of valued areas that allowed for a preliminary evaluation of the extent of market, analyses based on the sizes of the mapped valued areas were used to examine the extent of resource. Defining five size categories based on the sizes of areas on all maps with 1 corresponding to the smallest area (less than 500 square miles) to 5 corresponding to the largest areas (those greater than 8,000 square miles) the sizes of all of the valued area were estimated for each map and assigned codes for their equivalent size category. A majority of valued areas across all maps and participants were in the smallest two size categories, 1 or 2; however, most participants included a variety of area sizes on their maps.

Of those participants who marked either the Smokies or the Shenandoah on their maps, most marked the area that they valued as the GSMNP or SNP as significantly larger than the actual park boundaries, as highlighted in Figure 4. Interestingly, of those participants who included both parks on their maps, participants marked the area representing the park outside their home state as significantly larger than the corresponding park within their home state. As Figure 7 illustrates 75% of Virginians who included a GSMNP area on their map drew it larger than the park boundaries compared to 50% of North Carolinians; 100% of North Carolinians who included a SNP area on their map drew it larger than the park boundaries compared to 77% of Virginians. Additionally, the average sizes of both the GSMNP and the SNP as marked on

[8] Similar results have been shown in SP surveys where there is a discrete drop in the gradient of willingness to pay to the distance from the resource at the boundary of the jurisdiction in which the resource lies (Reed et al. 2001). It is unknown if this is due to preferences that are provincial in nature or because the individual outside the jurisdiction cannot influence the authority managing the resource.

participants' maps were substantially larger than the average size of all other valued areas that respondents marked on their maps.

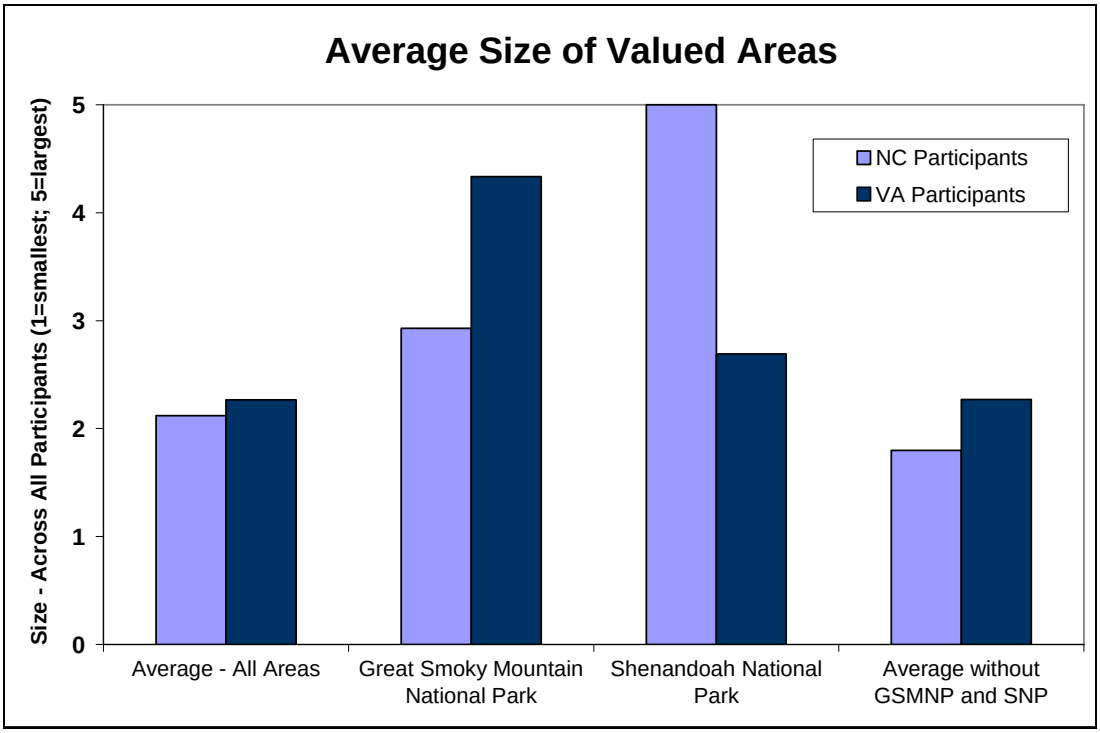


Figure 7. Of the participants who included either or both areas labeled or referenced as the Smokies or the Shenandoah among the five natural areas that they valued, the average sizes of these places were significantly different for participants from North Carolina and those from Virginia. Of the participants who marked the resource in the other state (either the Smokies or the Shenandoah) participants from both states marked this resource as much larger than their in-state counterparts.

It is interesting to note that participants seem to overestimate the size of the more distant resource. This distance-weighted relationship with the perceived size of a resource could indicate that residents may assign disproportionate value (based on a skewed perception of scale) to a less familiar and more distant resource.[9] This result, though preliminary, is in contrast to findings suggesting that WTP drops with distance, and further study is necessary to confirm these hypotheses. Together these initial analyses and results suggest that the extent of resource for the

[9] Generally speaking the researcher usually feels that they have defined the resource to be valued. However, we know that if the resource to described in the survey is particularly incongruent with the resource the respondent believes is most relevant, then embedding or a similar phenomena may occur that undermine the reliability of the WTP estimates.

Southern Appalachian Mountain region is significantly larger than current national park boundaries; however, residents do not necessarily value the region as a single large contiguous resource. Instead based on these early results, it appears that although a majority of residents have higher values for resources within their home states, a significant percentage of residents value other sub-parts of the resource, such as the GSMNP and the SNP suggesting that these two parks could be either complements or substitutes as regional natural resources.

Conclusions and Future Work

Taken as a whole, this study develops and illustrates a methodology for integrating mapping into SP survey design. Application of the proposed methodology to the Southern Appalachians reveals that the method does allow for preliminary analysis of extent of market and extent of resource issues; however, the scope of this study would need to be significantly expanded to further test the efficacy of the method for other applications and locations. At this point, initial results reveal that individuals value a greater number of resources in their home states and assign higher rankings to these resources than those in other states in the region. Based on this preliminary finding, we would expect that an SP instrument that focuses only on resources/damages in a single state would generate higher average WTP values from residents of that same state than those from other states.

Other analyses also show that using only national park or forest boundaries in an SP survey may underestimate the extent of the resource people value. Participants who indicated that they valued a mountainous area in North Carolina or Virginia overwhelmingly identified areas larger than corresponding national park boundaries for the Great Smokey Mountains National Park and Shenandoah National Park, respectively. All of the results presented here are based on very early stages of analysis, and further study to test both the method and evaluate the contributions to SP survey implementation are required. At this stage, by providing preliminary spatial characterization of both the extent of market and the extent of resource, this approach demonstrates how mapping can both inform the design of SP surveys and aid in the interpretation of WTP results.

References

Banzhaf, H.S., Burtraw, D. et al., 2006. Valuation of Natural Resource Improvements in the Adirondacks. *Land Economics.* **82** (3): 445-464.

Chambers, R., 1994. The Origins and Practice of Participatory Rural Appraisal. *World Development* **22**(7): 953-969.

Craig, W.J., Harris, T.M., and D. Weiner, 2002. Community Participation and Geographic Information Systems. New York: Taylor & Francis.

Downs, R.M. and D. Stea, 1973. Image and Environment: Cognitive Mapping and Spatial Behavior. New Brunswick: Aldine Transaction Publishers:.

Downs, R.M. and D. Stea, 1977. Maps in Minds: Reflections on Cognitive Mapping. New York: Harper and Row.

Morgan, M.G., Fischhoff, B. et al., 2002. Risk Communication: A Mental Models Approach. New York: Cambridge University Press.

Fischhoff, B., M.J. Quadrel, et al., 1993. Embedding effects: Stimulus representation and response mode. Journal of Risk and Uncertainty. **6** (3): 211-234.

Golledge, R G, 1976. "Methods and methodological issues in environmental cognition research" in Environmental Knowing: Theories, Research, and Methods, Eds. G T Moore, and R G Golledge, Stroudsburg, PA: Dowden, Hutchinson & Ross.

Golledge, R, and G Zannaras, 1973. "Cognitive approaches to the analysis of human spatial behavior", Environment and Cognition, Ed W Ittleson, New York: Academic Press.

Kahneman, D., P. Slovic, et al., eds., 1982. Judgment Under Uncertainty: Heuristics and Biases. New York: Cambridge University Press.

Mark, D. M., and Frank, A.U., 1996. Experiential and Formal Models of Geographic Space. *Environment and Planning, B*, **23**: 3-24.

Reed, J.F., R.W. Dunford, W.H. Desvousges, and M.R. Banzhaf, 2001. The Role of Knowledge in Assessing Nonuse Damages: A Case Study of the Lower Passaic River. *Growth and Change* 32: 43-68.

SAA, 1996. Southern Appalachian Assessment. http://samab.org/data/SAA_data.html.

Tolman, E.C., 1948. Cognitive Maps in Rats and Men. *The Psychological Review*. **55** (4): 189-208.

Tversky, B., 1993. Cognitive Maps, Cognitive Collages, and Spatial Mental Models. In Frank, A.U. and Campari, I. (eds.) *Spatial Information Theory: A Theoretical Basis for GIS Proceedings COSIT '93*. Lecture Notes in Computer Science 716: 14-24, Springer: Berlin.

Vajjhala, S.P., 2005. Mapping Alternatives: Facilitating Public Participation in Development Planning and Environmental Decision Making. PhD Dissertation, Carnegie Mellon University, Engineering and Public Policy: Pittsburgh, PA.

Appendix A: Mapping Interview Protocol

_____
Survey number

INTERIOR SOUTHEASTERN U.S. MAPPING INTERVIEW

Briefly introduce the project to the subject. Begin with a description of the type of maps the project is trying to collect and how the subjects' participation is important. The process should take less than 40 minutes. Participants will add information onto the base map in response to a series of interview questions. The primary goal is to gather information about the areas individuals "value" in the region. Emphasize that drawing skills or map-making skills are not required; however, the subject should carefully consider the sizes, shapes, and boundaries of the areas they add to the map and how they relate to one another.

Hello my name is Anna. I'm here today from Resources for the Future. We are conducting a study on the Interior Southeastern U.S. We would like you to help us by taking part in a mapping exercise. You don't have to have any experience with drawing or map-making, so please don't worry! What I would like you to think carefully about is the natural places you care about in this region. I'm going to ask you to add information onto the base map in front of you, and I'd like you to think about the sizes, shapes, and boundaries of these areas as you add them to your map and also how they relate to one another.

The goal of this whole interview is for you to create a map of the areas you care about, the places that are important to you, and spaces that you value in the Interior Southeastern United States. The base map in front of you shows parts of 8 states in this region, and there are colored markers here for you to use. First, take a minute to look over this base map. Do you have any questions?

As I ask you questions I'd like you to answer each out loud (there is a tape recorder here) and also to answer each question by adding the areas and locations that you identify on to your map. If you aren't sure about a specific answer – don't worry- you can always go back and add places, change your map, or make corrections. The point is just for you to carefully identify the natural areas that are important to you in this region and draw these areas on your map. Do you have any questions about the project? Okay, let's begin.

Places You Go [Black]

1. The first few things I am going to ask you are general questions about where you used to live in this region and any major places you went to regularly. For all of these questions, I would like you to focus only on the time during which you lived in this region. This is very important, so I really want to emphasize that I would like you to you think only about places you went when you lived in this area.

2. First, I'd like you to start by taking a look at the base map in front of you and begin by finding the general location for where you used to live (this doesn't have to be exact, just take your best guess). Here is a BLACK marker. Using this marker, mark the location of your home (when you lived in the region) on the map. You can use any symbol you would like to identify your home, and please write the name of the town and your former zip-code (if you remember it) next to your symbol.

3. *Have you lived in other places in this region? If so add these "homes" to the map as well and label them too.*

4. Now I am going to ask you a few questions about some of your activities and trips in this region during the time you lived here.

5. Think carefully about where you used to go outside of the town or city where you used to live in the region. These are places that you might have gone somewhat frequently, that were not part of your everyday routine, like work or the grocery store. *Please mark each place and label it. (Give the subject time to add a few places)* For example, are there any specific places you used to go at least once a month or a few times a year?

How about places you might have gone for *(say these prompts one at a time, give the subject enough time to think about it between each prompt and either add places or say "no")*…

- General recreation / outdoor activities? Parks? Campsites? Hunting? Fishing? Hiking?
- Observing wildlife/photography
- Vacations or other travel?
- Trips to visit family/friends?
- Seasonal activities? White water rafting? Fruit picking?

6. Look back on the places that you already have drawn on your map. Would you like to add any places in any of these **other states** *(point generally to blank areas on the subject's map)*?

   Is there any place that you went to often or think is important that is not already on the map? If there is, add it now.

Places You Value [Multiple Markers]

Ok, now I'm going to ask you to switch markers. Don't worry if there are places that you've forgotten to add up to this point, you can always go back and add these places. Remember this process is not about finding exact locations, instead its more important for you to think carefully about the size of each area you add to the map and where the edges are relative to the other points you've drawn on your map

*Now I would like you to think about the areas that you <u>cared about</u> in this region during the time you lived here. I would like you to focus on **natural places**, not cities or man-made destinations like a family farm or friend's home. Instead I would like you to think about any type of natural environment or area that was personally important to you. **This can include places you like and value <u>even if you never went there often or at all. It can even include places that you wanted to go to, but haven't visited.</u>***

*I am going to ask you to add your <u>five most important</u> areas to the map **one at a time**. Before you add any information to your map, try to think about how these spaces relate to one another. Each area can be as big or as small as is important to you.*

7. Now I'd like you to use the RED marker, and start by thinking about the first of these places you value. Begin by marking the center of this place on your map with an **X and labeling it**.

8. Now think carefully about the size of this whole "place" on your map. How big is the area that you cared about and think is important? What defines this area around the center point you selected? Now I want you now to draw a boundary of this space and explain what features define or form the edges or boundaries of this area. *What makes up the edge of this area?*

9. Why did you choose to add this area as a natural place you cared about?

10. Now here is a BLUE marker. I would like you to repeat this same process for the next place you care about and think is important. Start again by marking the center of this second natural place that you value on your map with an **X and label it**.

11. Again I'd like you to think carefully about the size of this place on your map and also how it relates to the first area you added. Draw the boundary of this area.

    What defines this boundary? (Take notes here at each of these explanations)

12. Why did you choose to add this area as a natural place you cared about?

*Continue with the third (ORANGE), fourth (YELLOW) and fifth (GREEN) places, always asking the subject to mark the center of each place on your map with an **X and a label**. Remind the subject to consider how each new place relates to the others already on the map, and then ask the subject to carefully draw the boundary of each area.*

13. With the orange/yellow/green marker mark the center/boundary of a third/fourth/fifth natural area that you most care about, even if you never visited it.

    Why did you choose that as the center?

    I noticed that you included/avoided

    Does that overlapping area include this other area you've marked over here?

14. Excellent. Now I want you to take a minute to look over your whole map. Is there anything you would like to add or to change about these places you value or their boundaries? Do you think that anything should be bigger or smaller? Are the center points where you would like them to be?

15. Have you visited any of these places on your map? If so, when/what for/how often? *(Take notes here)*

Negative and Deteriorated Places

1. For the last drawing section I would like you to use this PURPLE marker. Look closely at the region on your map and the five places that are important to you, and think about any major changes you saw during your time in the region. Are there any areas that you think were degraded or have deteriorated significantly while you lived in the region? If so, mark these areas on the map, and explain why you think these areas are degraded and what the causes are?

Okay, Congratulations- you're almost finished! I would like you to just take one final look at your map, and see if there is anything missing or anything you would like to change. Do you have any questions for me?

As a final wrap up, I have a brief written survey that I would like you to complete about the places on your map and some general demographic questions. This shouldn't take more than 5 minutes. As you go through the survey feel free to ask me any questions you might have, and you can just hand it to me when you are finished.

Once they've handed in their survey, explain the payment process… parking, etc.

Give them the letter and let them know that if they have any questions or would like to follow-up they can contact us at the email/phone on the letter, and thank them very much for their time…

Appendix B: Mapping Survey

INTERIOR SOUTHEASTERN UNITED STATES

---

1. **Of the five important natural places that you marked on your map, please rank these places in order of importance from 1 being most important to 5 least important. (Please write your answers in the spaces below using the same names that you used on your map. Feel free to refer back to your map.)**

   1. _____

   2. _____

   3. _____

   4. _____

   5. _____

2. **If you were to add any other natural place outside of this map region to the list of natural places that you care about, what would it be?** *(Please write your answer in the space below)*

   _____

3. **How would you rank this place relative to the other natural places you ranked above?** *(Check only one box.)*

   - ❑ Above number 1
   - ❑ Between numbers 1 and 2
   - ❑ Between numbers 2 and 3
   - ❑ Between numbers 3 and 4
   - ❑ Between numbers 4 and 5
   - ❑ Below number 5

4. How many years did you live in the entire region represented on your map <u>since you were 16 years old</u>?

- ❑ Less than 5 years
- ❑ 5-15 years
- ❑ 16-30 years
- ❑ More than 30 years

5. Please write the name of your home state (from the map) in the space below.

_____

6. How many years has it been since you last lived in this state?

_____ **years** *(Please write the total number of years in the space to the left.)*

7. How many years <u>total</u> did you live in this state only?

- ❑ Less than 5 years
- ❑ 5-15 years
- ❑ 16-30 years
- ❑ More than 30 years

8. If you were given $100 to distribute for making environmental improvements in the region on your map, how would you divide this money across the 8 states in the region shown on your map? ***(Please write a number in the blank next to each state, the total for all states should add up to $100.)***

_____ Alabama

_____ Georgia

_____ Kentucky

_____ North Carolina

_____ South Carolina

_____ Tennessee

_____ Virginia

_____ West Virginia

9. When you lived in the area on your map, did you ever <u>hunt</u> in your home state?

- ❑ No **(SKIP TO Question 11)**
- ❑ Yes (Continue to Question 10)

10. If yes, on average about how many <u>days per year</u> (from 1 day to 365 days) did you <u>hunt</u> in your home state? *(Write your answer in average number of days per year in the blank to the left.)*

_____ Days

11. When you lived in this area, did you ever <u>hunt</u> in any of the other states in the region *outside* of your home state?

- ❑ No **(SKIP TO Question 13)**
- ❑ Yes (Continue to Question 12)

12. If yes, on average about how many <u>days per year</u> (from 1 day to 365 days) did you <u>hunt</u> in each of the areas below? *(Write your answers in average number of days per year in the blanks below.)*

_____ in the <u>entire region</u> outside of your home state

_____ in Virginia only

_____ in North Carolina only

_____ in Tennessee only

13. When you lived in the area on your map, did you ever <u>fish</u> in your home state?

- ❑ No **(SKIP TO Question 15)**
- ❑ Yes (Continue to Question 14)

14. If yes, on average about how many <u>days per year</u> (from 1 day to 365 days) did you <u>fish</u> in your home state? *(Write your answer in average number of days per year in the blank below.)*

_____ days

15. When you lived in this area, did you ever <u>fish</u> in any of the other states in the region *outside* of your home state?

- ❑ No **(SKIP TO Question 17)**
- ❑ Yes (Continue to Question 16)

16. If yes, on average how many <u>days per year</u> (from 1 day to 365 days) did you <u>fish</u> in each of the areas below? *(Write your answers in average number of days per year in the blanks to the left.)*

_____ in the <u>entire region</u> outside of your home state

_____ in Virginia only

_____ in North Carolina only

_____ in Tennessee only

17. When you lived in the area represented on the map, did you ever <u>take</u> any trips at least one mile from your home to <u>observe wildlife</u> in your home state?

- ❑ No **(SKIP TO Question 19)**
- ❑ Yes (Continue to Question 18)

18. If yes, on average about how many trips at least one mile from your home did you make to <u>observe wildlife</u> in your home state? *(Write your answer in number of trips in the blank below.)*

_____ Trips per year

19. When you lived in this area, did you ever <u>take any trips to observe wildlife</u> in any of the other states in the region *outside* of your home state?

- ❑ No **(SKIP TO Question 21)**
- ❑ Yes (Continue to Question 20)

20. If yes, on average how many <u>trips per year</u> did you make to <u>observe wildlife</u> in each of the areas below? *(Write your answers in trips per year in the blanks to the left.)*

_____ in the <u>entire region</u> outside of your home state

_____ in Virginia only

_____ in North Carolina only

_____ in Tennessee only

21. Would you describe yourself as an environmentalist?

- ❑ Yes, definitely
- ❑ Yes, somewhat
- ❑ No

22. What is the maximum tax increase for your household that you would accept to pay for making improvements to parks and the natural environment in the entire area represented on your map? *(Write your answer in the box below.)*

I would accept a tax increase of at most $ per year for the next 10 years to pay for this program.

23. Please write your age in the space to the right. _____ years

24. What is your gender?

- ❑ Male
- ❑ Female

25. What is the highest degree or level of education that you have completed?

- ❑ Less than high school
- ❑ Graduated from high school - Diploma or Equivalent (GED)
- ❑ Some college, no degree
- ❑ Bachelor's degree or Associate degree
- ❑ Postgraduate degree

26. Please indicate the category that best represents your total household income in the past 12 months before taxes. Was it...

- ❑ Less than $19,999
- ❑ $20,000-$34,999
- ❑ $35,000-$49,999
- ❑ $50,000-$84,999
- ❑ $85,000-$124,999
- ❑ $125,000 or more

Thank you for completing this survey!

Please hand-in your completed survey to your map interviewer.

Valuation for Environmental Policy: Ecological Benefits

Session IV: Valuation of Ecological Effects

Joel Corona
US EPA
Arlington, VA
April 24 2007

Session IV: Valuation of Ecological Effects

- **Integrated Modeling** and Ecological Valuation: Applications in the Semi-Arid Southwest (Brookshire et al.)

- Contingent Valuation Surveys to Monetize the Benefits of **Risk Reductions** Across Ecological and Developmental Endpoints (von Stackelberg and Hammitt)

- Valuing the Ecological Effects of Acidification: **Mapping** the Extent of Market and Extent of Resources in the Southern Appalachians (Vajjhala et al.)

Brookshire et al.

- Integrated framework includes hydrological model, riparian model, avian model, survey instrument and valuation
  - Still in initial stages
  - Intention to test benefits transfer between two sites

<u>Value to EPA:</u>

- Integrated framework
- Different information gradients (traditional, coarse, fine)

von Stackelberg and Hammitt

- Estimates WTPs through CVs for both ecological and human health endpoints in a risk assessment framework
  - Issues with estimates (IQ, eagle positive, reading comprehension, SSD negative)
  - WTP higher when asked about ecological effects first

<u>Value to EPA:</u>

- Value in including both types of endpoints
- Value in using risk assessment framework

Vajjhala et al.

- Ongoing study, tackles extent of market and extent of natural resource through mapping
  - Initial results suggest individuals place higher value on within-state natural resources
  - Individuals identified areas larger than corresponding national park boundaries

Value to EPA:

- Concept of mapping during pilot to help set natural resource boundaries
- Mapping to help identify relevant populations

Overall

- Benefits Transfer
- Well-proven methods to new scenarios/endpoints
- Methodological Advances

Discussant Comment by David Simpson:

I was asked to discuss three papers on the valuation of ecological resources. It may, then, seem strange that the first image that popped into my head was of a man acting like a giant chicken.

By way of explanation, let me first say that the approach that each of these papers take involves stated preferences: conducting surveys to ask, either directly or indirectly, how much respondents value ecological resources at risk. Stated preference[1] methods in general remind me of an old joke. The adult children of an aging couple have not returned to the family farm for many months. When they do arrive, they're shocked by what they see. Their father is strutting about the yard, pecking and clucking. "Mom, what's happened to Dad?" the son asks.

"He thinks he's a chicken," the mother replies.

"Oh my goodness! This is terrible!" say the children. "Have you taken him to a doctor?"

Well, I've been meaning to," says the mother, "but I just need the eggs too bad."

What does this have to do with valuation using stated preferences? In short, "we just need the eggs too bad." We all recognize that there are things which we as a society care about preserving, but that, to borrow Douglas Larson's [1993] helpful characterization, do not leave enough of a "behavioral trail" for their values to be estimated using conventional (that is to say, "revealed preference") methods. What do we do in such "hopeless cases"?[2]

The answer to that question depends crucially not on whether we "*need* the eggs" – we certainly do – but on whether stated preference methods deliver them. The profession is deeply divided on this question. Some ten years ago now V. Kerry Smith wrote

> Indeed, there is a curious dichotomy in the research using C[ontingent] V[aluation] for nonmarket valuation. Environmental economists actively engaged in nonmarket valuation continue to pursue very technical implementation or estimation issues, while the economics profession as a whole seems to regard the method as seriously flawed when compared with indirect methods. They would no doubt regard this further technical research as foolish in light of what they

[1] I'll use the term "stated preference" broadly to encompass contingent valuation, choice modeling, and other approaches that ask respondents to consider hypothetical scenarios rather than inferring values from actual, budget-constrained, choices.

[2] This time I am adopting A. Myrick Freeman's [2002] characterization of situations in which separable preferences between market and nonmarket goods preclude conventional estimation.

judge to be serious problems with the method. (Smith, 1997; p. 42)

These issues seem no closer to resolution today than they were a decade ago. In fact, it would appear that many economists have, as Smith suggested, simply washed their hands of the whole issue, while a small but active group continue to pursue "further technical research". This is a deeply unsatisfying state of affairs. The papers I have been asked to discuss both underscore the divisions within the profession and point to some possible ways out of the impasse.

The von Stackelberg and Hammett paper reports on a number of interesting findings. The ones I want to focus on concern evidence on "embedding" in survey answers. They ask different respondents questions concerning their willingness to pay to prevent human health effects arising from contamination, and/or their willingness to pay to prevent ecological effects on nonhuman species. One of the intriguing answers they obtain is that people are, on average, willing to pay more in total for both programs when they are asked about ecological effects first and human health effects second.

To those of us who are skeptical about the reliability of stated preference studies, this finding has a read interpretation. First, respondents will, in general, want to express their willingness to do *something*; to "purchase moral satisfaction", in Kahnemann and Knetsch's memorable characterization. Second, however, respondents see human health as "important," saving wildlife as less so. Consequently, when you ask them about their willingness to pay for something "important" after asking them to pay for something more frivolous, they're likely to think "Oh, that's really important, I'd better pay something more". Conversely, if you ask them to pay for something more frivolous after already getting a pledge from them for something "important," they're more likely to say "Sorry, I've already given".

Now I hasten to point out that the explanation I've suggested is nothing more than my own subjective narrative, informed by nothing more than my own opinions and prejudices. Yet I offer it because it seems to me to be no less compelling than any other narrative offered to explain anomalous – or, for that matter, any other – stated preference results. The justification researchers often suggest for whatever results they derive is typically "that's what people told us".[3]

If I were to offer a criticism of the von Stackelberg and Hammett paper, then, it is that it pulls its punches when it has the opportunity to say something more concrete about the reliability of stated preference work. The authors note that the finding I have summarized above

> . . . may lend credence to the argument that WTP estimates obtained using CV are not consistent with economic theory . . . [but] We take a more circumspect view . . . denying the contingent valuation method . . . in no way changes the fact that

[3] I might note in passing that Harvard economist Edward Glaeser has recently reported very interesting work as to why people might profess some objectively very unreasonable things.

> there are ecosystem service flows that have economic benefit, and . . . therefore have significant implications for policy development. (p.33)

I fear that the authors are creating a false dichotomy. I, for one, do not quarrel with the view that "ecosystem service flows . . . have economic benefit". I think the more important question, though, is whether stated preference approaches of the type the report provide any useful information for prioritizing the sources of such benefits and choosing how to allocated limited conservation expenditures. I'm not convinced that they do. In any event, however, I'm disappointed that von Stackelberg and Hammett, having done a great deal of careful work come right to the brink of issuing venturing conclusive findings, but back down rather than join the controversy.

We do not yet have a sense from the Brookshire, *et al*., work as to whether it will speak to the reliability of the methods it employs. In his remarks David Brookshire concurred with the view that economists have simply agreed to disagree as to whether results from stated preference studies are inconsistent with received theory (a view associated with, among others, MIT economist Peter Diamond). I am concerned that no progress can be made under such circumstances. Results, if they are to be "scientific", must be *falsifiable*, and it is certainly problematic if the claim is simply that the answers simply are what they are, with no agreement as to when they would not be accepted.

For this reason, my main concern about the outline of work Professor Brookshire presented at the workshop is with the criteria that are being followed in refining the questions to be asked of respondents. It would appear that a great deal of work is being done to hone questions with focus groups, and this is certainly a worthwhile activity. However, I would be concerned if the purpose of these exercises cannot be phrased in more objective and operational terms. In discussion, Professor Brookshire indicated that (to the best of my recollection) questions were being refined so as to communicate the understanding that natural scientists on the project team deemed needed to be communicated. One can see the concerns that arise by considering slightly different phrases to describe what that might be: "respondents should *understand* the complexity of the systems involved" vs. "respondents should *appreciate* the complexity of the systems involved," for example. I don't mean to suggest that any such semantic slanting is underway – I certainly have no reason to suspect that it would be – but only to say that, given the state of the debate, it behooves one to be as circumspect as possible in avoiding any appearance of slanting results.

I found the Vajjhala, et al., paper perhaps the most interesting of those I was asked to review, and regret that I expended too much of my time at the workshop on the first two at the expense of the third. Most regrettably, I spent the time I had dwelling on the negative rather than the positive aspects of the paper. To quickly recap, the negative aspect of the paper is that, *from the perspective of received theory*, the mapping exercise reported in the paper might be obviated. The researchers asked people familiar with particular scenic and natural areas of the country to report on those areas' salient aspects. To the extent that such aspects are appreciated more by people in closer proximity to those areas, or at least with greater experience with them, valuation might be effectively

accomplished with revealed preference methods. For example, people who enjoy recreation in the Great Smoky Mountains National Park might choose to purchase year-round or vacation homes near the park, or to reveal their preferences with their travel choices. Hedonic pricing or travel cost methods might, then, be used to estimate values.

My sense, however, is that the real contribution of the paper may not lie in informing existing valuation methodologies so much as in illuminating the processes of decision-making. My own sense is that stated preference studies do not contribute enough to better decision-making as to be worth the expense of conducting them. Regrettably, however, I'm not entirely confident that revealed preference studies have much more to recommend them. I hasten to add that this is not for want of creativity and effort on the part of researchers. This is just extraordinarily hard work! We'd probably do well to remember that nonmarket goods are nonmarket goods precisely because of the great difficulties inherent in putting prices on them.[4]

Given this state of affairs, it seems to me that we should be thinking outside the box, or perhaps, in this case, "off the map" is a better way of putting it. In economics we would like to think of people making rational choices in response to well-formed information. However, work such as that undertaken by Vajjhali and her colleagues may prove to be more valuable by helping us think about how people form values rather than how to induce them accurately to report the values they have formed.

While I am optimistic about this work, however, I would like to see it made a little more transparent. It was clear *what* had been done: respondents indicated areas on maps and reported related information. However, it was not always clear, or I as a reader was not always sure, what was to be inferred from the markings, annotations, and responses people made. It would have been helpful to have had some more narrative in the paper as to what the exercises were intended to show, and perhaps some explicit hypotheses as to the patterns that might have been expected to, and/or which did, in fact, appear.

[4] Although non-excludability raises somewhat related, but distinct difficulties as well.