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Transfer of choice model benefits: a case study of stream mitigation

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Abstract

Development activities place pressures on the natural environment that are very costly to avoid or remedy. In these cases, off-site mitigation may be used to address the effects of development. A choice model is applied to two different communities within a large metropolitan area to identify the values people place on stream attributes and to identify the types and scale of mitigation necessary to offset environmental damages. Tests of benefit transfer between the two communities identify significant, unexplainable differences in values for the same environmental changes. Pooled model tests were able to identify differences that could not be detected using overlapping confidence interval tests or value-difference tests with independently estimated models.

Key words: Choice model, mitigation, benefit transfer, Auckland

1. The Problem

Development Impacts on Waterways

Every year, hundreds of hectares of New Zealand's Auckland region are disturbed for transportation, housing, industrial, commercial and community amenity purposes. Major development activities are controlled by the Auckland Regional Council, which requires an earthworks consent for each development. Most applications for earthworks consents are associated with small first or second order soft-bottomed streams in retired pasture. These streams are usually ecologically degraded before any development occurs. Other developments involve activities in or near relatively pristine waterways, and disturbance or removal of native vegetation, which provides habitat and food sources for both terrestrial and aquatic species.

On-site activities commonly involve construction site earthworks, such as site contouring for residential subdivision development, stream channelisation, armouring and culverting. Impacts include complete loss of waterways (for example, when a stream is piped), and modifications to wildlife habitat, visual amenity and other waterway attributes, as well as off-site impacts, such as sedimentation.

Sedimentation is a particular concern in the Auckland region because of the combination of soils, weather, topography and receiving environment attributes. There is up to 100 times the sediment yield from construction sites compared to pastoral land. Adverse ecological effects of sediment include: modified or destroyed instream values; modified estuarine and coastal habitats; smothering and abrading of fauna and flora; changes in food sources; and interruption of life cycles. In addition, there may be damage to water pumps and other structures, the quality of water supplies usually diminish, localised flooding can occur, and there is loss of aesthetic appeal.

Projects in the Auckland Region involving land disturbance are required to incorporate "best practice" erosion and sediment controls. Best management practices include structural techniques such as sediment retention ponds, contour drains and silt fences. Best management practices are not 100% effective and even with appropriately designed and maintained systems in place significant sediment discharges and other environmental impacts occur. Residual sedimentation can lead to significant cumulative effects within catchments. In a practical sense, stream channels and associated riparian margins are damaged regardless of the use of best management practices.

Mitigation

In addition to requiring best management practices, the Auckland Regional Council has the authority to place conditions on earthworks consents, including specific offsetting mitigation requirements. Offsetting mitigation may augment stream quality at one site to compensate for adverse environmental effects associated with development at other sites. Enhancement could occur within the catchment undergoing development and/or possibly in other catchments. The idea is to use mitigation to achieve and sustain desired environmental outcomes.

Offset mitigation is a tool used to complement best management practices where some kind of ecological balance can be protected by enhancing stream quality in proximate areas. Requiring the consent holder to provide offset mitigation for the unavoidable damage caused by an activity is well established internationally. Typical examples of offset mitigation include riparian planting and stream bank retirement to offset water quality degradation, planting forests to offset greenhouse gas emissions, and creating or enhancing wetlands or indigenous bush to offset land drainage.

The method for establishing "appropriate mitigation" in Auckland is far from clear and generally relies on a "best professional judgement" approach based on ecological indicators such as species diversity, stream cover, flow rate, temperature, and so on. In order for the offset mitigation to function effectively as envisaged by New Zealand's Resource Management and Local Government Acts the community needs to have confidence in the mitigation process. However, very little is known about community preferences regarding alternative states of Auckland streams. Without information on community preferences it is not possible for the Auckland Regional Council to identify mitigation that reflects the environmental outcomes the community desires. Consequently, it is highly desirable either to quantify in dollar terms the costs of adverse effects at the site of development and the benefits of the offset mitigation, or to identify how the community is willing to trade off site attributes. Transparent quantification of costs and benefits ensures that the mitigation proposed offers the potential to offset, from both the ecological and the economic perspectives, the adverse effects generated. Choice modelling was employed to identify and evaluate important Auckland stream quality attributes. The following section provides a brief description of study design. It is followed by results and an evaluation of benefits transfer, which leads to discussion and conclusions. Kerr and Sharp (2003) provides full details of study design and results.

2. The Choice Model

Choice modelling entails several key steps:

1. Salient attribute identification
2. Choice model design
3. Data collection
4. Data analysis
5. Application to policy

Salient Attribute Identification

Salient attribute identification was undertaken using discussions with Auckland Regional Council personnel, and using focus groups conducted in the two case study communities (South Auckland and North Shore). Council staff provided several perspectives. They are extremely familiar with the physical and ecological systems and the impacts of developments upon them. Further, Auckland Regional Council is the agency responsible for environmental management and its staff receive ongoing feedback from developers, community and environmental groups, placing them in an advantageous position for monitoring community and interest group perceptions and values. Focus groups were important to get direct input from the community about their concerns over stream management, their salient attributes, and their willingness to undertake and ability to complete choice questions about stream management. The likelihood of self-selection to focus groups on the basis of personal preferences vis-à-vis stream management was minimal because participants had no prior information on the specific purpose of the focus group meetings. Details of the procedure followed at each focus group meeting are reported in Kerr and Sharp (2002). Responses from the two focus groups were similar, with the following stream attributes mentioned in discussion.

- Water clarity
- Safety

- Flow of water
- Quality of the stream bank
- Access
- Surrounding land use
- Habitat for wildlife
- Natural shape of the stream

Strong views were expressed that the people creating degradation should be held responsible and should be required to pay for mitigation. However, community funding of stream improvement activities was considered to be acceptable if there was an element of "publicness" associated with enhancement. The focus group studies indicated that stream attributes could be described in relatively simple terms that could be understood by the general population. Participants understood the idea of a choice game and were prepared and able to consider carefully the tradeoffs involved and make meaningful choices. The choice game format used in the focus groups provided the basis for developing the survey questionnaire.

Choice Model Design

Choice models typically employ a linear utility function of the form:

$$V_k = V(Z_k, Y_k) = \beta_0 + \beta_1 Z_{1,k} + \beta_2 Z_{2,k} + \ldots + \beta_{n-1} Z_{n-1,k} + \beta_Y Y_k = \boldsymbol{\beta Z'} \quad (1)$$

Where V is the observable component of utility and the Z_i are choice attributes (or transformations of choice attributes). Y is the cost to the individual. The subscript k indexes the choice. Attributes differ between choices, but coefficients in the utility function do not. Data analysis entails selection of the coefficient vector $\boldsymbol{\beta}$ that maximises the probability of obtaining the observed choices.

The primary study objective was to identify if off-site attributes could be used as mitigation for specified on-site environmental changes. Consequently, attributes needed to vary simultaneously at two sites. Extending the utility function to incorporate two sites (suppressing $_k$ for clarity) yields:

$$V = \beta_0 + [\beta_{11} Z_{11} + \ldots + \beta_{(n-1)1} Z_{(n-1)1}] + [\beta_{12} Z_{12} + \ldots + \beta_{(n-1)2} Z_{(n-1)2}] + \beta_Y Y \quad (2)$$

Where β_{ij} is marginal utility of attribute i at site j and Z_{ij} is the level of attribute i at site j. On-site mitigation requires that a change in an attribute at site 1 (say Z_{11}) is offset by changes in other attributes at site 1 (i.e. by changing attributes Z_{m1} where $m \neq 1$). Off-site mitigation entails changing attributes at the other site. A change in an attribute at site 1 (say Z_{11}) is offset by changes in attributes at site 2 (i.e. by changing attributes Z_{j2} where j includes all attributes at site 2). In order to identify willingness to trade-off attributes between sites the utility function must include attributes at both sites. For similar sites, this effectively doubles the number of attributes in the utility function compared with single site models. While this model form allows identification of off-site mitigation, an extremely useful by-product is the ability to evaluate the adequacy of on-site mitigation (or a mixture of on-site and off-site mitigation) using the same model. Inclusion of the cost attribute (Y) allows monetary measurement of the non-market costs of adverse development impacts and the non-market benefits of stream enhancements. Knowledge of these values may not be important, particularly if monetary compensation is not relevant or permitted. Auckland Regional Council wanted to estimate monetary values of impacts, so a cost attribute was included in the choices presented to citizens.

Recent choice studies typically incorporate 4-6 attributes. With these numbers of attributes, survey designs are available to estimate interaction effects between the attributes. For example, willingness to pay for additional fish species might be expected to depend upon the amount of fish habitat available, suggesting an interaction between number of fish species and available fish habitat. This study did not allow the possibility of interaction effects of this type. The requirement for attributes to vary at two sites, along with the number of attributes that were identified in the focus groups as being potentially significant, and the requirement for a money cost attribute resulted in selection of the ten choice attributes in Table 1.

Table 1: Choice Attributes

Attribute	Attribute values: Natural Stream	Attribute values: Degraded stream
Water clarity	Clear, Muddy	Clear, Muddy
Native fish species	1,3,5	2, 3, 4
Fish habitat	2km, 3km, 4km	1km, 2km, 3km
Native streamside vegetation	Little or none, Moderate, Plentiful	Little or none, Moderate, Plentiful
Channel form	Natural	Straightened, Natural
Cost to household	$0/year, $20/year, $50/year	

Note: Currency is New Zealand Dollars

Because of the large number of attributes in the choice sets, the number of choice events faced by each individual was limited to five to reduce fatigue. The fractional factorial, main effects statistical design adopted (Hahn and Shapiro, 1966) required six different versions of the survey, with some choice sets occurring in more than one version. In each choice event survey participants were able to choose between the status quo (clearly labeled as such) and two unlabeled alternatives. Inclusion of a third alternative provides more information from each choice event, which improves model fit and the accuracy of coefficient estimates (Rolfe and Bennett, 2003). The first alternative in each choice event was developed from the statistical design plan. The second alternative was the fold over of the first alternative.

The payment vehicle was regional council rates. Justification for this vehicle was provided with the following introduction, which was read out by the interviewer. The statement was designed to ensure that survey participants were aware that it is not always possible to identify the people responsible for environmental degradation, yet the community may benefit from improving damaged environments. It also sought to introduce the concept of opportunity costs through environmental trade-offs.

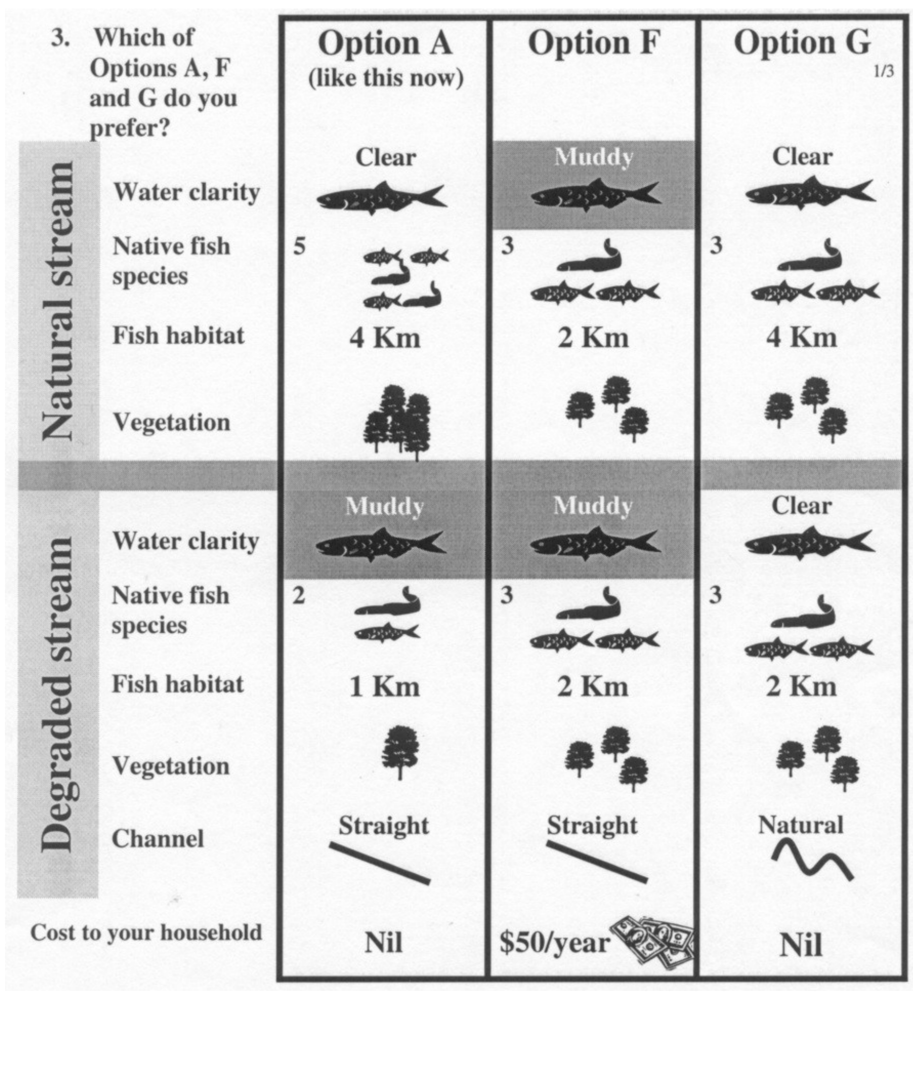
> *Stream restoration and management can be expensive. Sometimes it is obvious who has caused stream changes and they can be made to pay to restore the condition of the stream. In other cases, the changes occurred a long time ago or have been caused by things done for the whole community. In these cases the condition of streams is a community responsibility. Regional Council rates could be raised to allow extra stream restoration activities to be undertaken. If this happened then costs to your household would increase through your rates bill or, if you are renting your house, through having to pay higher rent to your landlord.*
>
> *While the condition of some streams continues to decline because of new and ongoing activities, other streams are getting better because of management actions. Stream managers have to decide whether it is better to try to protect streams that have not been changed much, or to restore streams that have already been degraded. Sometimes it is much easier and cheaper to restore streams that have already been degraded. Restoring degraded streams can mean there is less money available to manage other streams, so their condition can decline.*

Data Collection

Data were collected in personal interviews conducted at the respondent's own home by a professional research agency. The sample was obtained by randomly drawing individual names and addresses from registered voters in postal zones 1701 and 1702 (South Auckland) and 1309-1311 (North Shore). Sixty start point addresses were used in each location, with a quota of five interviews per start point. From the start point interviewers turned left and followed the pavement, approaching every second house. At least two calls were made to each house where no response was obtained. Response rates were 44% in North Shore and 40% in South Auckland, with 308 interviews completed on the North Shore and 311 completed in South Auckland. Surveying was undertaken in January and February 2003.

The survey drew heavily on design parameters that have proved to be successful in similar Australian studies (Whitten & Bennett, 2001). Attribute levels were communicated wherever possible by the use of icons to allow visual identification of the trade-offs being made. In order to ensure that all respondents were reacting to the same stimuli a two-sided A4 glossy brochure was given to each survey participant to read at their own pace before commencement of choice questioning. The brochure provided photographs of representative stream conditions alongside labeled icons.

Figure 1: Choice question



Large, coloured show cards were used to present the choice questions (Figure 1). The interviewer described the items on the card and explained the choices that were available to the respondent. In order to test for socio-economic effects, data were collected on sex, age, income, education, ethnicity and number of residents in the household. Three questions probed respondent and interviewer perceived difficulty of the choice questions.

Sample Characteristics

Differences between population and sample distributions were tested using population data from the 2001 census for people 20 years of age or older. The sampling frame was a specific address and the participant was randomly selected from people 20 years or older resident at that address. Consequently, the sample should ideally conform to household level census data. The two surveys obtained responses that are representative of home ownership rates and the sex and age distributions within the populations. People with a university degree were more likely to respond than others. The South Auckland sample was over-representative of people from households with incomes less than $50,000 per year, whereas on the North Shore, the sample closely matched population incomes. Large households were over-represented in both samples, possibly a result of the higher probability of finding someone at home in a larger household.

3. Results

Site-specific models are reported in Table 2. Where possible, the Heteroscedastic Extreme Value model (HEV) was fitted to avoid potential independence of irrelevant alternatives problems. However, the HEV offered no improvement over the standard Multinomial Logit model (MNL) for North Shore, so the MNL model is reported in Table 2. Scale parameters are reported for the South Auckland HEV model, but these are not significantly different to the scale parameter for the third option, which is identically set to unity. These models forced inclusion of all stream attributes and the money attribute, but each model includes different interaction effects. While all possible interaction effects were tested for each model, only significant effects have been retained in the models presented in Table 2.

The coefficients on Money are highly significant and of the expected negative sign, indicating that any particular option is less likely to be selected if it costs more. While the models are relatively poor fits overall, the significance of stream attribute coefficients is generally strong, with only three of 22 stream attribute coefficients not being significant. The relatively low goodness of fit for these models indicates that there are explanatory factors that have not been included in the models, or that there is considerable underlying inter-personal variance (or both).

Alternative Specific Constants (ASCs) are significant when factors other than independent variables in the model are important determinants of choice. The choice models used here arbitrarily set the ASC for the third choice to zero. In each choice situation the first option was labelled as the status quo, while the other two options were unlabeled. Second-option ASCs are not significant. Status quo ASCs are positive, and significant, indicating a preference for the status quo. The hypothesis that the status quo is preferred to either of the options entailing change was tested by utilisation of models that included an ASC on the status quo and no ASC on either of the other options. Results mirrored those in Table 2, indicating a significant preference for the status quo, with no significant change to other coefficients. Since these alternative models contain less information, the more general models that allow detection of all order effects are presented in Table 2.

Table 2: Site-specific models

	Attribute	North Shore	South Auckland
Natural Stream Attributes	Water Clarity (N1)	0.6509***	0.6420***
	Fish Species (N2)	0.1082***	0.04667**
	Fish Habitat (N3)	-0.3969***	-0.001452
	Moderate Vegetation (N4A)	0.2759**	0.1567
	Plentiful Vegetation (N4B)	0.2105**	0.5116***
Degraded Stream Attributes	Water Clarity (D1)	0.7706***	0.5996***
	Fish Species (D2)	0.2640**	0.09391*
	Fish Habitat (D3)	0.1315***	0.2098***
	Moderate Vegetation (D4A)	0.2110	0.3447**
	Plentiful Vegetation (D4B)	0.1977**	0.5258***
	Channel (D5)	0.3213***	0.3042***
	Money	-0.009828***	-0.009545***
Personal Attributes	Age x D2	-0.004970**	
	Age x N3	0.007976***	
	Degree x N3	0.1548*	-0.3144***
	Degree x D1	0.3798**	
	Degree x D5	-0.4428***	
	People x D1	-0.1188**	
	People x N4B		-0.08021**
	Homeowner x D3		-0.2394***
	High Income x D5	0.5985***	
	Very High Income x N4B		0.8449**
	Very High Income x D1		0.6737**
	Very High Income x D2		-0.6100***
	Very High Income x D5		0.6585**
Alternative-specific constants	Status Quo	0.2984*	0.5740**
	Second option	0.01845	-0.0955
HEV Scale Parameters	Status Quo	na	1.473
	Second option	na	0.867
N		1331	1281
LL_R		-1433.81	-1388.87
LL_{UR}		-1305.79	-1273.40
Rho^2		0.089	0.083

Significance levels * (10%), ** (5%), *** (1%)

Interaction effects allow detection of the influence of individual or household-specific characteristics (such as respondent age and household income) on the probability of selecting a particular option. Interaction effects were tested in several ways.

- Firstly, interacting the variables High Income and Very High Income with the variable Money provided a test of income effects. The effects were significant in all cases and supported prior beliefs that wealthier respondents would be prepared to pay more for any given environmental enhancement.
- Secondly, independent variables were interacted with ASCs to test whether personal characteristics influenced choice between the options, particularly between the status quo and either of the two change options. None of these interactions was significant.
- Thirdly, personal characteristics were interacted with each of the site attributes to identify whether particular groups of individuals valued attributes differently. Significant interactions are reported in Table 2. Interaction effects vary significantly between models.

The personal attributes that significantly affect choices are:

- Age — Respondent's age in years
- People — Number of people in the household
- Degree — 0,1 Dummy: 1 if respondent has a university degree
- Homeowner — 0,1 Dummy: 1 if residence is owned by the inhabitants
- High Income — 0,1 Dummy: 1 if household income exceeds $50,000 per year
- Very High Income — 0,1 Dummy: 1 if household income exceeds $100,000 per year

The sign of the interaction effect indicates how the characteristic affects the importance of the relevant attribute. For example, the North Shore interaction (High Income x D5) is highly significant and positive, indicating that North Shore High Income households place a higher value than other households on natural channel form in degraded streams.

Table 3 presents part worth estimates and their 95% confidence intervals for the models in Table 2. In each case setting the attribute levels equal to their respective population means has incorporated the impact of individual and household-specific attributes.

Table 3: Part worths ($/household)

		North Shore Mean	**95% confidence interval**	**South Auckland Mean**	**95% confidence interval**
Natural Stream	Water clarity	$66	$43~$110	$67	$42~$114
	Native fish species	$11	$6~$20	$5	$0~$12
	Fish habitat	-$1	-$12~$9	-$3	-$15~$8
	Moderate vegetation	$28	-$1~$68	$16	-$10~$49
	Plentiful vegetation	$21	$2~$50	$41	$17~$75
Degraded Stream	Water clarity	$48	$28~$84	$73	$47~$123
	Native fish species	$4	-$6~$17	$0	-$13~$14
	Fish habitat	$13	$5~$27	$5	-$6~$18
	Moderate vegetation	$21	-$5~$53	$36	$8~$76
	Plentiful vegetation	$20	$0~$48	$55	$28~$97
	Channel	$58	$38~$97	$42	$21~$73

New Zealand Dollars, first quarter 2003.

Several part worths are not significantly different from zero. Water clarity, channel form and plentiful streamside vegetation part worths are significant in all cases. The abundance of native fish species is significant on natural streams, but not for degraded streams. Availability of fish habitat is only significant on North Shore degraded streams. Moderate streamside vegetation is significant only on South Auckland degraded streams.

Marginal rates of substitution between any two attributes can be identified from the coefficients in Table 2. The increase in attribute i required to offset a one-unit decrease in attribute j is the ratio β_j/β_i. For example, on the North Shore it is necessary to increase native fish habitat by about 0.8 km on a degraded stream to offset the loss of one native fish species on a natural stream [β_j/β_i = N2/D3 = 0.1082 ÷ 0.1315 = 0.823]. Marginal rates of substitution are relevant guides for policy where mitigation occurs through manipulation of the natural environment. Of course, there is an infinite combination of attributes that yield the same level of utility, allowing design of alternative mitigation scenarios. Part worths are necessary for identifying monetary mitigation (compensation) measures.

Understanding

Application of choice modelling to evaluate mitigation is novel. Because the large number of attributes involved places a significant burden on respondents, and the existence of two streams in the one model is conceptually more difficult to grasp than comparing two different types of sites (such as a forest and a wetland), the question of respondent understanding arises. Related is the ease or difficulty of making choices between three alternatives with 10 attributes each. These potential concerns were addressed by inclusion of two self-evaluation questions and one interviewer evaluation question, each measured on a 1-10 scale, with 1 being extremely easy to make choices and extremely understandable.

Responses are consistent across all three measures. Differences between locations are not significant for respondent-evaluated understanding or respondent-evaluated ease of making choices. However, interviewer evaluation response distributions do differ between North Shore and South Auckland, with interviewers judging North Shore interviewees to have had better understanding. Respondents typically found choices moderately easy to make, with median scores of 4 and modal scores of 2 for both locations.

In general, most respondents appear to have understood the choice task quite well. In order to detect any potential biases because of differences in understanding, part worths have been estimated for three groups of North Shore respondents. The groups are:

- Respondents who evaluated their own understanding with a score of 3 or less (very high understanding).
- Respondents who evaluated their own understanding with a score of 5 or less (moderate understanding).
- All respondents, regardless of level of understanding

There are no significant differences between estimated part worths for the three scenarios. While the reduced numbers in the high understanding category result in broad confidence intervals, point estimates are very similar. There is no evidence to suggest that use of information from respondents with lower levels of understanding has systematically biased results. Whilst it is acknowledged that the choice tasks presented to survey respondents were relatively difficult, most respondents appear to have understood what was requested of them and have been able to make well-reasoned choices.

4. Benefit Transfer

The expense, skills and time involved in undertaking choice studies provide ample motivation for benefit transfer. This study utilised two separate, and quite different, populations to test the possibility of benefit transfer, with the view to using study results across the region should the outcome be favourable.

Two separate study sites within the same metropolitan area have been used. The sites differ in several respects. People living on the North Shore are generally more affluent and better educated than South Auckland residents. While age and sex distributions and home ownership rates are very similar, North Shore households are more likely to consist of only 1 or 2 people. Large households are more common in South Auckland. The ethnic mixes of the two communities are also different. These two diverse communities were chosen to test for potential differences in values, and to provide a test of value transfer between communities.

Benefit transfer is based upon the underlying assumption that socio-economically similar people in different locations hold similar values for the same items in the same context. Tests of the underlying assumption are frequently undertaken by assessing convergent validity – testing whether benefits measured at one site are the same as those predicted at another. As with non-market valuation method convergent validity tests, it is important to control for as many factors as possible in order to remove explainable reasons for differences. Some of the sources of difference include (Boyle & Bergstrom, 1992; Brouwer, 2000; Brouwer & Spaninks, 1999; Desvousges *et al.*, 1992; Loomis, 1992; Oglethorpe *et al.*, 2000; Shrestha & Loomis, 2001):

1. The nature of the valued sites themselves
2. The changes valued at each of the sites
3. Valuation methods (hedonic, contingent valuation, choice model, …)
4. Time of study (season or year)
5. Availability of substitutes and complements for each of the sites
6. Differences in the people valuing the sites (demographic, social, economic, cultural, …)

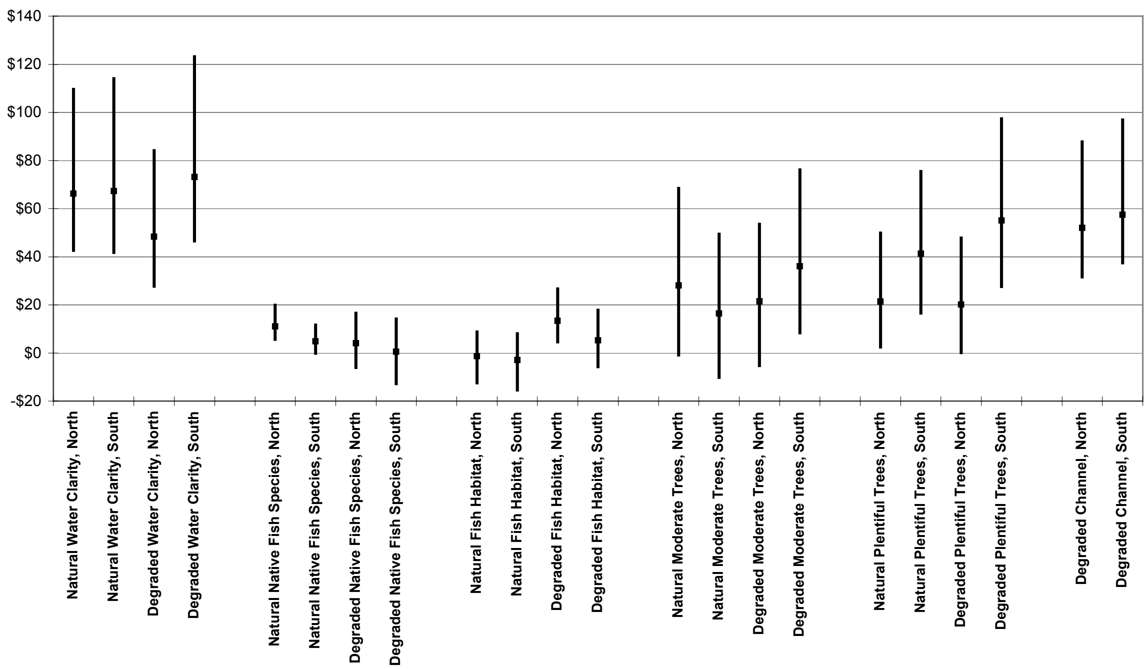
The choice model study of Auckland streams valued identical changes to streams with identical characteristics at each site. Furthermore, identical methodology was employed concurrently at each site to avoid elicitation method and temporal impacts that could have affected estimated values. Population differences arising from the influences of age, sex, ethnicity, household size, home ownership and education can be controlled for statistically. Substitutes, complements, and other contextual differences cannot be controlled using the Auckland study design. Because it removes sources of differences 1-4 and provides partial control over 6, the Auckland study provides an opportunity to measure the convergent validity of benefit measures at the two sites.

The three principal methods of transferring benefits from a study site or sites to a policy site are direct transfer, benefit function transfer, and meta-analysis. In direct transfer mean values estimated at the study site, or several study sites, are used directly at the policy site, without adjustment to reflect policy site characteristics. For benefit function transfer a valuation function derived at the study site is applied to the policy site using policy site parameters. Meta-analysis is another form of valuation function benefit transfer. It uses results from valuation studies completed at many sites to identify statistically the influences of site and personal attributes. Direct transfer and benefit function transfer are both possible using the Auckland Stream study results, but there are insufficient data to apply meta-analysis. Benefit function transfer provides control over site and/or population differences, and is generally thought to be more accurate than direct benefit transfer (Rosenberger & Loomis, 2003; VandenBerg *et al.*, 2001).

Transferring the Auckland benefit estimates

The simplest convergent validity test of benefit transfer accuracy, which fails to account for any of the reasons benefits are expected to differ between sites, is comparison of benefit estimate confidence intervals for the two sites. Non-overlapping confidence intervals are indicative of potential problems with benefit transfer. There are no cases where North Shore and South Auckland part worth confidence intervals do not overlap (Figure 2). Only one item (plentiful trees on degraded streams) has part worth confidence intervals that come close to non-overlap. Consequently, this test does not signal concerns about part worth benefit transfer.

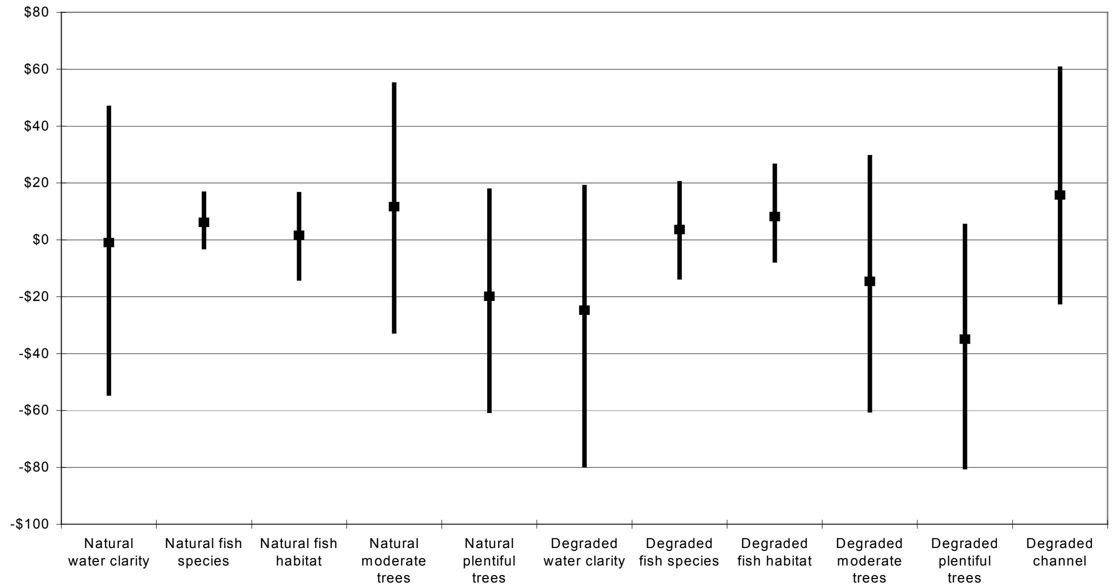
Figure 2: Part worth 95% confidence intervals



However, the overlapping confidence intervals test is relatively weak. The possibility of drawing two results in the opposite tails of the distributions is much less than the significance level of the individual confidence intervals (in this case 5%) (Poe *et al.*, 1994). Consequently, it is possible for confidence intervals to overlap even if differences in part worths are significantly different from zero. Figure 3 depicts part worth difference confidence intervals. Rather than reporting two separate distributions for part worths, each developed independently using a Monte Carlo procedure, a single distribution of part worth differences is developed by subtracting the vector of Monte Carlo part worths for one site from the vector of Monte Carlo part worths for the other site (Poe *et al.*, 2001).

None of the distributions of part worth differences is significantly different from zero at the 5% level, although degraded stream plentiful trees is significant at the 10% level. These results indicate that, because of the large variability of value estimates at each site, it is not possible to identify significant benefit estimate differences between locations. However, non-significant differences do not imply that benefit estimates at one site are good predictors of benefits at the other site.

Figure 3: Part worth difference (North – South) 95% confidence intervals



Point benefit transfers

An alternative measure of the merits of direct benefit transfer validity is the error in using one point estimate to predict another point estimate (Rosenberger & Loomis, 2003; Vandenberg *et al*., 2001). Errors arising from using point estimates at one location to predict point estimates at the other location using the direct transfer approach (Table 4) show wide variability, with errors ranging from 2% to 704%. These error magnitudes are similar to those found in other studies (Rosenberger & Loomis, 2003).

Care should be exercised in interpreting these results. Several part worths are not significantly different from zero. Consequently, a small change in one part worth can result in large percentage differences. Further, even changes in sign may not be significant. When consideration is given only to cases in which both part worth point estimates are significantly different from zero the errors are somewhat smaller. Benefit transfer errors in these cases range from 2% to 93%.

Benefit function transfers

The picture for valuation function transfers is very similar to that for point estimate transfers (Table 4). Valuation function benefit transfer results in some predictions better than and some predictions worse than direct benefit transfers. Consequently, function transfer benefit confidence interval estimates are not reported here. What is more, as with direct transfers, distributions of part worth differences estimated from transferred benefit functions are not significantly different from zero at the 95% level. Degraded stream plentiful vegetation part worths are the only ones to approach significance, with distributions of part worth differences being significantly different from zero at the 8% level.

Table 4: Direct and Valuation Function Point Benefit Transfer Errors

				Direct Transfer		Function Transfer	
		North Shore Part Worth (NSPW)	South Auckland Part Worth (SAPW)	Error in predicting SAPW from NSPW	Error in predicting NSPW from SAPW	Error in predicting SAPW from NSPW	Error in predicting NSPW from SAPW
Natural Stream	Water Clarity	$66.23	$67.26	-2%	2%	-2%	2%
	Native Fish Species	$11.01	$4.89	125%	-56%	125%	-56%
	Fish Habitat	-$1.32	-$2.89	-54%	119%	-12%	314%
	Moderate Vegetation	$28.08	$16.42	71%	-42%	71%	-42%
	Plentiful Vegetation	$21.42	$41.31	-48%	93%	-48%	114%
Degraded Stream	Water Clarity	$48.38	$73.12	-34%	51%	-38%	59%
	Native Fish Species	$4.10	$0.51	704%	-88%	704%	-169%
	Fish Habitat	$13.38	$5.25	155%	-61%	155%	-67%
	Moderate Vegetation	$21.47	$36.11	-41%	68%	-41%	68%
	Plentiful Vegetation	$20.12	$55.09	-63%	174%	-63%	174%
	Channel	$57.65	$41.94	37%	-27%	39%	-21%

New Zealand Dollars, first quarter 2003.
Population means of independent variables are used throughout
Not significantly different from zero at 5% level

Again, there is overlap on all measures. However, when either benefit function is used to produce part worths for the other location, the differences in part worths for degraded stream plentiful trees are significant at the 8% level. South Auckland residents appear to place higher value than North Shore residents on degraded stream plentiful vegetation.

Whether the, apparently, large errors in Table 4 are an indictment of benefit transfer is debateable. On the one hand, it is apparent that very large errors can occur from use of transferred point estimates. However, it should be acknowledged that the confidence intervals for individual study sites are large, meaning that use of point estimates at study sites is risky. Comparison of two uncertain values introduces the opportunity of compounding that error. Just as finding very low errors from point estimate transfers can arise by chance and consequently is no guarantee that benefits transfer is valid, large percentage errors in transferring point estimates do not necessarily indicate that benefits transfer is invalid. This conclusion is apparent from the part worth point estimates and confidence intervals in Figure 3, which apply to direct benefit transfer.

Whereas the simple overlapping confidence interval test offers an unjustified, overly enthusiastic endorsement of benefit transfer, errors associated with transfer of point benefit estimates is likely to provide an overly pessimistic view of the reliability of benefit transfer. Benefit difference confidence intervals provide an approach that is intermediate to these extremes and is a better indicator of the reliability of benefit transfer. Using this approach with valuation function benefit transfer indicates significant differences (albeit at a low level of confidence) between locations for the value of plentiful trees alongside degraded streams.

Pooled Models

Further tests of benefit transfer are provided by pooled models, which allow detection of location differences. The different interaction variables occurring in Table 2 indicate that location differences are likely to occur, with only DEGN3 being significant at both locations.

Test 1

The hypothesis that one utility function applies to both locations is tested by fitting the same model to each location, as well as to the pooled responses from both locations (Table 5). The interactions specified in these models include all significant interactions identified in the individual location models fitted in Table 2.

A likelihood ratio test measures the significance of improvement in fit from use of separate models. The test statistic is distributed χ^2 with degrees of freedom equal to the number of estimated parameters.

$$\chi^2 = -2*(LL_{Pooled} - (LL_{North\ Shore} + LL_{South\ Auckland})) = 68.026$$

The result is highly significant, refuting the hypothesis that the same model applies to both locations.

Test 2:

A Pooled model is developed that includes location dummy variables interacted with site attribute and personal characteristics. These location-related interactions take two forms. Two-way interactions (e.g. South x N2) show the direct impact of location on the value of the attribute. Three way interactions (e.g. South x Degree x N3) show differences by location in the way personal characteristics influence the values of specific attributes. Results are reported in Table 6. The likelihood ratio test [$\chi^2 = -2*(LL_{Restricted\ Model} - LL_{Full\ Model})$] indicates that location variables are highly significant as a group.

Five personal characteristics (High Income, Age, Degree, Homeowner, Household Size) affect attribute values independent of location. Three attribute part worths differ between locations, independent of personal characteristics. The value of fish species abundance in natural streams is greater for North Shore residents, while South Auckland residents place higher values on high levels of streamside vegetation at both types of stream. The significant two-way interactions between attributes and location (South x N2; South x N4B; South x D4B) indicate that, despite overlapping 95% confidence intervals, part worths for Natural Stream Fish Species and Plentiful Vegetation on both stream types are significantly different at the 95% confidence level.

Table 5: Pooled and independent models

	Attribute	North Shore	South Auckland	Pooled
Natural Stream Attributes	Water Clarity (N1)	0.6035***	0.6940***	0.6245***
	Fish Species (N2)	0.09836***	0.0517*	0.07523***
	Fish Habitat (N3)	-0.3447***	-0.1621	-0.2590***
	Moderate Vegetation (N4A)	0.2268*	0.1998	0.1947**
	Plentiful Vegetation (N4B)	0.04974	0.6627***	0.3322***
Degraded Stream Attributes	Water Clarity (D1)	0.6473***	0.8107***	0.6497***
	Fish Species (D2)	0.2298*	0.1145	0.1905**
	Fish Habitat (D3)	0.1683**	0.2052**	0.1901***
	Moderate Vegetation (D4A)	0.1735	0.3750**	0.2507***
	Plentiful Vegetation (D4B)	0.1629*	0.5854***	0.3317***
	Channel (D5)	0.2843***	0.3999***	0.3314***
	Money	-0.009232***	-0.01039***	-0.008975***
Personal Attributes	Age x D2	-0.004082*	-0.000378	-0.002755
	Age x N3	0.006911***	0.003714	0.005613***
	Degree x N3	0.1358	-0.4023**	0.01309
	Degree x D1	0.3582**	0.1393	0.2145*
	Degree x D5	-0.4202***	-0.2229	-0.3451***
	People x N4B	0.03691	-0.1128**	-0.04474
	People x D1	-0.08636*	-0.04657	-0.0475*
	Homeowner x D3	-0.07346	-0.2286**	-0.1435**
	High Income x D5	0.5055***	-0.09889	0.2621***
	Very High Income x N4B	0.1828	1.0363*	0.3982**
	Very High Income x D1	-0.005306	0.8662**	0.1486
	Very High Income x D2	-0.07834	-0.7153**	-0.2081**
	Very High Income x D5	0.2913	0.9144*	0.5302***
ASCs	Status Quo	0.4417**	0.4706	0.4098**
	Second option	0.1154	-0.2026	0.02127
HEV Scale Parameters	Status Quo	1.4645	1.0943	1.2268
	Second option	1.1302	0.7605	0.9916
N		1331	1256	2587
$LL_{\text{Constants only}}$		-1433.811	-1361.700	-2797.702
LL_{Model}		-1302.836	-1242.487	-2579.336
Rho^2		0.091	0.088	0.078
LR test	$\chi^2 = 68.026$	$P(\chi^2,29) = 0.0000562$		

Significance levels * (10%), ** (5%), *** (1%)

Table 6: Pooled model with location variables

	Attribute	Coefficient
Natural Stream Attributes	Water Clarity (N1)	0.6481***
	Fish Species (N2)	0.1169***
	Fish Habitat (N3)	-0.2699***
	Moderate Vegetation (N4A)	0.2029**
	Plentiful Vegetation (N4B)	0.2096**
Degraded Stream Attributes	Water Clarity (D1)	0.7401***
	Fish Species (D2)	0.06415*
	Fish Habitat (D3)	0.2030***
	Moderate Vegetation (D4A)	0.2656***
	Plentiful Vegetation (D4B)	0.2221**
	Channel (D5)	0.3301***
	Money	-0.009675***
Personal Attributes	High Income x D5	0.5542***
	Age x N3	0.006293***
	Degree x D5	-0.3006***
	Homeowner x D3	-0.1588***
	People x D1	-0.05473**
Location Variables	South x N2	-0.07247**
	South x N4B	0.3624**
	South x D4B	0.2662**
	South x Degree x N3	-0.4010***
	South x People x N4B	-0.09739***
	South x High Income x D5	-0.5880***
	South x Very High Income x N4B	0.9515**
	South x Very High Income x D1	0.8140**
	South x Very High Income x D2	-0.6058***
	South x Very High Income x D5	0.7664**
Alternative-specific constants	Status Quo	0.4341**
	Second option	-0.03630
HEV Scale Parameters	Status Quo	1.24674
	Second option	0.929484
N		2587
LL $_{\text{Constants only}}$		-2797.702
LL $_{\text{Model}}$		-2557.721
Rho^2		0.086
LR test of location variables	$\chi^2 = 67.184$, $P(\chi^2,10) = 1.55\times10^{-10}$	

Significance levels * (10%), ** (5%), *** (1%)

There are seven three-way interactions that differentiate the impact of personal characteristics by location. Of particular note is the diverse influence on degraded stream channel form because of income. High Income causes increased willingness to pay for a more natural channel form on the North Shore (β=0.5542), but has no effect in South Auckland (β=0.5542-0.5880). However, South Auckland displays a strong impact from Very High Income that does not occur in North Shore.

Table 7 displays site-specific part worth estimates and 95% confidence intervals from the pooled model for each location. In each case, results are modelled for a 45-year old respondent with a university degree from a high-income, home owning household of three people.

Table 7: Part Worths – Pooled Model ($/household)

45-year old homeowner with a degree. Household income more than $50,000 p.a. 3 people in household.		**North Shore**	**95% confidence interval**	**South Auckland**	**95% confidence interval**
Natural Stream	Water clarity	$67	$46 ~ $96	$67	$46 ~ $96
	Fish species	$12	$7 ~ $19	$5	$0 ~ $11
	Fish habitat	$1	-$6 ~ $9	-$40	-$72 ~ -$13
	Moderate vegetation	$21	$3 ~ $46	$21	$3 ~ $46
	Plentiful vegetation	$22	$4 ~ $45	$29	$8 ~ $53
Degraded Stream	Water clarity	$60	$42 ~ $85	$60	$42 ~ $85
	Fish species	$7	-$1 ~ $15	$7	-$1 ~ $15
	Fish habitat	$5	-$4 ~ $14	$5	-$4 ~ $14
	Moderate vegetation	$27	$8 ~ $50	$27	$8 ~ $50
	Plentiful vegetation	$23	$5 ~ $47	$50	$29 ~ $80
	Channel	$60	$36 ~ $95	$0	-$30 ~ $33

New Zealand Dollars, first quarter 2003.

The shaded cells in Table 7 highlight attributes for which part worths are invariant between locations for a household with these characteristics. Degraded stream water clarity and fish species do not differ in the case reported in Table 7 because their differential effects only occur for very high-income households. The simple non-overlapping confidence interval test indicates highly significant differences between locations for degraded stream channel form and natural stream fish species part worths. The other three part worths that are affected by personal characteristics exhibit confidence interval overlaps.

Table 8 has been derived from Monte Carlo simulation of the differences in part worths for the five attributes in Table 7 that differ by location. In each case the estimated South Auckland part worth has been subtracted from the estimated North Shore part worth to yield a simulated distribution of part worth differences. In only one case (Natural Stream Plentiful Vegetation) does the 95% confidence interval include zero. These results indicate that, even after controlling for personal characteristics, North Shore residents in this demographic profile place significantly higher values on abundance of native species in natural streams, availability of fish habitat in natural streams, and degraded stream channel form. South Aucklanders value plentiful vegetation alongside degraded streams more highly than do North Shore residents.

Table 8: Pooled model part worth differences

45-year old homeowner with a degree. Household income more than $50,000 p.a. 3 people in household.	Part Worth Differences (North minus South)	95% confidence interval
Natural Stream Fish Species	$7	$1 ~ $15
Natural Stream Fish Habitat	$41	$16 ~ $70
Natural Stream Plentiful Vegetation	-$7	-$31 ~ $14
Degraded Stream Plentiful Vegetation	-$28	-$54 ~ -$0
Degraded Stream Channel	$61	$27 ~ $103

New Zealand Dollars, first quarter 2003.

Results vary by demographic profile. Consequently, the non-significance of natural stream plentiful vegetation has no particular significance. For example, changing household income to more than $100,000 per annum (while leaving all other characteristics unchanged) produces significant part worth differences for this attribute, as well as for degraded stream water clarity and fish species abundance.

5. Conclusions

This study has used choice modelling to identify community willingness to trade-off stream attributes. People have understood the tasks asked of them and have given consistent responses that have allowed estimation of utility functions, marginal rates of substitution, and stream attribute part worths. The values estimated allow the design of mitigation to offset damages in Auckland streams. Part worth estimates provide the information necessary for the assessment of mitigation options. Thus community values can be associated with degradation/mitigation options. For example, using the point estimates of part worths in Table 3, a development that impacts on a natural stream by muddying clear water ($66) and causing the loss of one fish species from that stream ($11) creates environmental costs of $77. Proposed mitigation activities on a nearby degraded stream, including water clarification ($48), reintroduction of two fish species ($8), extension of fish habitat by 1km ($13) and planting to obtain moderate streamside native bush ($21) yields total mitigation benefits of $90 per household - more than enough to offset the $77 cost. In view of this outcome a developer may amend the mitigation plan by deleting the proposal for fish reintroductions. This would be cheaper for the developer, but would still produce a net welfare gain from the community perspective. A range of mitigation scenarios can be evaluated, provided cost data are available, to identify the cheapest mitigation option available to offset project impacts.

A limitation of the existing approach may be the use of a linear utility function without interactions between site attributes. The resultant identity between willingness to pay and willingness to accept compensation measures is not consistent with theoretical or empirical results (Horowitz and McConnell, 2002). Errors introduced by this restriction are likely to be small when part worths are small relative to income. They are also likely to be avoided to a certain extent by the design of the study. By definition, natural stream attributes could only get worse when moving from the status quo, while degraded stream attributes could only improve. Consequently, the framing of the study predisposes it to estimate willingness to accept measures for damages to the natural stream, and willingness to pay measures for enhancements to the degraded stream. This is consistent with the policy question frame.

The study provides important insights into benefit transfer. Point estimate transfers, whether direct or benefit function transfers, resulted in some very large errors. However, point transfers do not account for uncertainty in the estimates at either site and so percentage errors of point transfers provide poor tests of benefit transfer. Overlapping part worth confidence intervals indicate similar values at the two sites, but provide an overly optimistic view of benefit transfer when compared to confidence intervals of attribute part worth differences. Tests of part worth differences and pooled model tests were used to overcome deficiencies in point estimate and overlapping confidence interval tests. Part worth difference tests identified significant, albeit at low levels, differences in part worths using both direct and benefit transfer approaches.

Two different pooled model tests have been used to show that the same utility function does not apply to both locations. Because the pooled model with location variables has a larger sample size and the ability to control for other factors, tests based on it have more power to identify differences than do tests based on independently estimated models for each site. In addition, pooled models identify the sources of part worth differences. Part worth difference distributions from the pooled model that includes location effects are significantly different from zero, consistent with the significance of location variables in the model. The pooled models indicate that errors will arise from transfer of benefits between locations. Those errors were not identified by independent model overlapping confidence interval tests or part worth difference tests.

Unlike studies of the type conducted here, when benefit transfer is undertaken for policy purposes it is not known what the true value at the policy site is, or even the range of values that include the true value. If that information were available there would be no need for benefit transfer, and it would not be possible to test the validity of benefit transfer by fitting pooled models, comparing value distributions, or comparing point estimates of value. The analyst has three options – undertake direct benefit transfer, undertake valuation function transfer, or don't transfer benefits at all. What would happen if valuation functions or point estimates were transferred in these cases? It is not possible to provide an unambiguous answer to that question - it depends on the policy proposal being evaluated. When off-site mitigation is undertaken, several attributes may change at each stream, which means that errors may compound - or they may cancel each other out. While the potential to be wrong is moderated in this situation, the implications of being wrong may be very serious. It is apparent that use of point estimates has the potential to produce highly biased results. The implications when part-worth confidence intervals are used to identify welfare changes are less likely to be problematic, but, because errors may compound across several attributes, still has the potential to provide extremely misleading indicators of welfare change or, more likely, to be unable to unambiguously sign welfare change.

Overall, the evidence presented here, which identifies unexplained differences in welfare changes from identical environmental changes, adds weight to the growing literature that has identified large potential errors from benefit transfer, even under close to ideal conditions.

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